Drilling and Dam Construction Agency (DDCA)
Japan International Cooperation Agency (JICA)

DDCAP

Technical Manual for Drilling Works for Technical Support Plan for the Drillers in DDCA

Version 1

March 2013

Groundwater Development and Management Capacity Development (DDCAP) Project

Contents

Tables

Figures

1 INTRODUCTION

The baseline survey on DDCA's drilling organization was conducted in the course of the Project, for the purpose to reveal the current status of drilling works and the technical level of drillers in DDCA. The results of the baseline survey were compiled in the Technical Support Plan for the Drillers in DDCA (hereinafter referred to as "TSP") which was formulated in January 2013. This plan identified 15 technical areas which cover the drilling works of DDCA including eight technical areas necessary to be enhanced and two new technical areas to be needed, as shown in Table 1.

Table 1 Identified Technical Areas Covering Drilling Works of DDCA

No.	Technical Area	All Areas	Areas to be Enhanced	New Areas to be Needed
1	Site Mobilization	✔		
2	Drilling Tools and Equipment	✔	✔	
3	Drilling Drawbacks	✔		
4	Drilling Control	✔	✔	
5	Borehole Logging	✔	✔	
6	Casing Program / Installation	✔		
7	Gravel Packing	✔	✔	
8	Well Development	✔	✔	
9	Back-Filling & Surface Cementing	✔	✔	
10	Site Demobilization	✔		
11	Well Investigation	✔		
12	Tool Fishing	✔		✔
13	Well Rehabilitatation	✔		✔
14	Pumping Test	✔	✔	
15	Water Quality Analysis	✔	✔	

This Technical Manual for Drilling Works was prepared according the TSP and covers eight technical areas to be enhanced. This manual is expected to be utilized by the senior drillrs in DDCA in order to acquire the necessary technical knowledge and the proper work procedures. Furthermore, it forms a part of materials for the teaching guidance which is used for the technical instruction to both private drillers and DDCA's drillers. In the TSP, the technical areas were further divided into details namely technical items. Technical areas and items are the important basic units for the activities of technical training and guidance in the Project, in the respects of the manual formulation, training plan, technical evaluation and so on. They are commonly used between three major training related documents i.e. the Teaching Guidance, the Manual for Drilling Works and the Manual for Well Rehabilitation and Tool Fishing, as shown in Table 2.

Table 2 Technical Area / Item Covered by Teaching Guidance and Manuals

TA Code	Technical Area / Item	Teaching Guidance	Manual for Drilling Works	Manual for Well Rehabilitation and Tool Fishing
1	**Site Mobilization**	✔		
1-1	Site Preparation and Drilling Machine Setting-Out	✔		
2	**Drilling Tools and Equipment**	✔	✔	
2-1	Selection of drilling bit and drilling method	✔	✔	
2-2	Rotary Bits	✔	✔	
2-3	DTH and DTH Bit	✔	✔	
2-4	Rig Accessory	✔	✔	
2-5	Casing Tools	✔	✔	
2-6	Drilling Equipment	✔	✔	
2-7	Drilling Calculation	✔	✔	
2-8	Weight of drilling tools	✔	✔	
2-9	Rotary bit rotation speed and weight on bit	✔	✔	
2-10	DTH Bit rotation speed and weight on bit	✔	✔	

TA Code	Technical Area / Item	Teaching Guidance	Manual for Drilling Works	Manual for Well Rehabilitation and Tool Fishing
3	**Drilling Drawbacks**	✔		
3-1	Countermeasures against lost circulation during mud drilling	✔		
3-2	Countermeasures against lost circulation during DTH drilling	✔		
3-3	Countermeasures against bore wall collapse during mud drilling	✔		
3-4	Countermeasures against bore wall collapse during DTH drilling	✔		
3-5	Countermeasures against jamming of drilling tools	✔		
4	**Drilling Control**	✔	✔	
4-1	Mud control	✔	✔	
4-2	Mud Pump Operation	✔	✔	
4-3	Casing for mud drilling	✔	✔	
4-4	Drilling operation for mud drilling	✔	✔	
4-5	Bit control and repairing for mud drilling	✔	✔	
4-6	Air control for DTH drilling	✔	✔	
4-7	Air compressor operation	✔	✔	
4-8	Casing for DTH drilling	✔	✔	
4-9	Drilling operation for DTH drilling	✔	✔	
4-10	Bit control and repairing for DTH drilling	✔	✔	
5	**Borehole Logging**	✔	✔	
5-1	Borehole logging instruments	✔	✔	
5-2	Interpretation of borehole logging results	✔	✔	
6	**Casing Program / Installation**	✔		
6-1	PVC casing, screen pipe	✔		
6-2	Casing Program	✔		
6-3	Role of centralizer	✔		
6-4	Casing, screen pipe installation	✔		
7	**Gravel Packing**	✔	✔	
7-1	Determination of gravel size	✔	✔	
7-2	Calculation of gravel volume	✔	✔	
7-3	Gravel packing	✔	✔	
8	**Well Development**	✔	✔	
8-1	Well cleaning after drilling	✔	✔	
8-2	Single-tube method air-lifting	✔	✔	
8-3	Double-tube method air-lifting	✔	✔	
9	**Back-Filling & Surface Cementing**	✔	✔	
9-1	Back-filling	✔	✔	
9-2	Surface cementing	✔	✔	
10	**Site Demobilization**	✔		
10-1	Precautions upon site demobilization	✔		
11	**Well Investigation**	✔		
11-1	Necessary information of well rehabilitation plan	✔		
11-2	Well rehibilitation plan	✔		
12	**Tool Fishing**	✔		✔
12-1	Tool fishing plan	✔		✔
12-2	Fishing tools	✔		✔
13	**Well Rehabilitatation**	✔		✔
13-1	Phenomenan and causes of well deterioration	✔		✔
13-2	Methods of well rehabilitation	✔		✔
13-3	Usage of well camera	✔		✔
14	**Pumping Test**	✔	✔	
14-1	Purpose and methods of Pumping Test	✔	✔	
14-2	Pumping test equipment	✔	✔	
14-3	Selection of Submersible Pump	✔	✔	
14-4	Interpretation of test results	✔	✔	
15	**Water Quality Analysis**	✔	✔	
15-1	Purpose of Water quality analysis	✔	✔	
15-2	Item of water quality analysis	✔	✔	

2 DRILLING TOOLS AND EQUIPMENT (TA CODE 2)

2.1 SELECTION OF DRILLING BIT AND DRILLING METHOD (TA CODE 2-1)

2.1.1 PRICIPLES OF DTH, MUD AND CABLE AND TOOL DRILLING

(1) Types of Drilling Rig

Hydrogeology/ Drilling as an option has a major activities namely as;

1. Prospecting for groundwater
2. Drilling and well construction

Prospecting for groundwater deals with the investigation of groundwater existing at certain areas. The aim of this task is to allocate well sites to produce water for human consumption. But a geologist after this prediction is yet to prove weather his work is successful unless the water is exploited.

The task of exploitation is given to the drillers. The driller sinks the well through the earth to strike water from underground and takes it out to the surface to accomplish the task of drilling and well construction. This work is done by the aid of drilling machine called a rig.

What is a Rig

A rig is a device , which is used to penetrate through the earth to a certain depth underground to exploit minerals for human consumption.

Types of Rigs

1. Cable and tool percussive drilling (percussion)
2. Rotary drill rig (schramn, xu 600 , pilcon, Romanian, Diamond)
3. Percussive rotary drill rig (schramn, aquadrll etc)
4. Core rotary drill rigs(, xu 600, pilcon, diamond)
5. Reverse circulation rotary drill rigs (Romanian)

EXPLANATION OF DRILLING RIGS

a. **Rotary Rigs** ; This type of rig is designed to drill by applying rotation to the drilling head driven by hydraulic oil pressure, which eventually drives the drilling string to rotate . Bits like roller , alloyed bit and short bits are used.
b. **Percussive Rotary Rigs;** In this type of rig the rotation application is quite the same , except that the bit is connected
c. **Cable and tool Percussive Rig;** This type of drilling method is accomplished by regular lifting and dropping of a strings of tools. This phenomenon is aided by means of connecting rod crank mechanism of oscillating movement to the locker frame. The rocker frame ,the drum with a rope, which has the connection to the pulley and drilling string.
d. **Core Rotary Rigs** ; In this type of rig the drilling method is to drill and take out cores instead of rocks dust (rock cuttings) Hollow bit and core barrel are used drilling tools
e. **Reverse Circulation Method;** In this method of drilling, setting of the circulation system is reversible, that means the fluid flows hydraulically in the well, and then the cuttings are uplifted inside the drill pipe up to the swivel where the sucktion hose is connected to let out cuttings to the pump which eventually pumps the cuttings out to the mud pit.

(2) Drilling Methods

There are various drilling methods, because of geological conditions range from completely unconsolidated sediments such as alluvial sand and gravel to hard rock such as basalt and granite. It is obviously then , that no single drilling methods is best for all geological conditions and well installations successfully drilling in both , an art developed from long experience and application of good engineering practices.

Well construction usually comprises five distinct operations

a. Drilling operations
b. Installing the casing
c. Placing a screen and filter pack
d. Developing well to ensure sand free operation at maximum yield(pumping test)
e. Well completion

The term well drilling method is being used here to include all methods used in creating holes in the era and for well construction purposes. It includes methods like boring and driving which are not drilling methods in a pure sense.

Three drilling methods which are employed in DDCA are 1) DTH drilling method, 2) Mud rotary drilling method and 3) Cable and tool drilling method. Mud rotary drilling methods and Cable and tool drilling method are regarded as the types of Mud drilling methods. Cable and tool drilling rigs are used for cable and tool drilling method, while rotary cum drilling rigs are used for both Mud rotary drilling method and DTH drilling method. In this manual, drilling techniques of DTH drilling and Mud rotary drilling are described as the drilling equipment to be hired to the private drilling companies are of the type of DTH cum rotary. Principles of each drilling methods are described below.

1) DTH Drilling Method

The (DTH) down the hole hammer is rotary percussive tool, which operates at the bottom of the end of the hole being drilled. It is attached at the end of the drill string and powered by compressed air flowing down the center of the drill string into the hammer. The air operates a piston within the hammer, which strikes the rear end of the drill bit providing a percussive action. The pneumatic drill can be used on any standard rotary rig with an air compressor of sufficient capacity. It is used for fast and economical drilling of medium to extremely hard formation. Fast penetration results from the air piston blows are transmitted directly to the bit without losing energy through the string. Figure 1 show the mechanism of DTH drilling method.

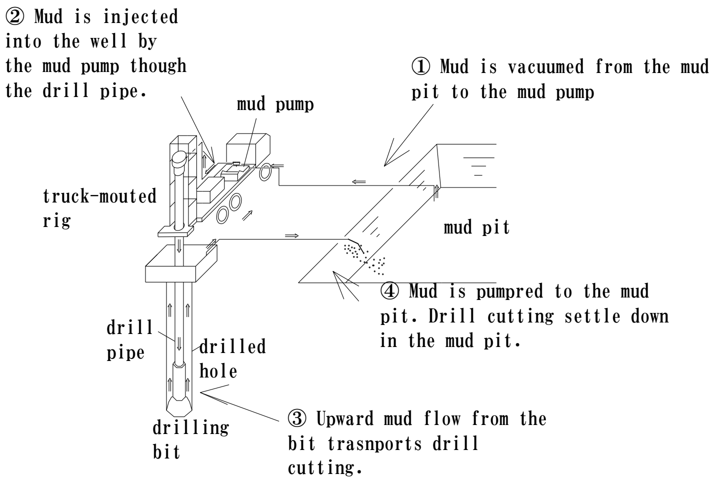


Figure 1 Mechanism of DTH Drilling Method

Performance varies with different makes of DHH but as an example a particular hammer provided with 8 BARS (116Psi) air pressure will deliver 15.5 blows per second at the piston striking the bit and with 14 BARS (250Psi) air pressure will deliver 23 blows per second.

In water well drilling particularly air pressure must also overcome ground water pressure when encountered. When drilling under the head of water, a back pressure is exerted against the air pressure of the hammer and as the air pressure is less the back pressure approaches the minimum operating pressure of the hammer penetration rates will gradually fall to zero, and in the fact the hammer will cease to operate.

2) Mud Rotary Drilling Method

In this method, action is accomplished by rotating a drill pipe by means of a power driven rotary table or top-head type swivel, with a bit cuts and breaks up the material as it penetrates the formation. Drilling fluid for mud is pumped through the rotating drill pipe and through the hole picking up material broken by the bit. Then flow upwards in the space outside the drill pipe, carrying the cutting to the ground surface, and clearing the hole. The greater fluid flow the faster the drilling. The drill pipe and bit move downward deepening the hole as the operation proceeds. At the surface, drilling mud flows into a ditch to a settling pit where the cuttings settle to the bottom. From the settling pit the fluid overflows into another pit from which it is picked up through the suction hose of the mud pump and re-circulated through the drill pipe. In thr mud rotary drilling method the casing pipe is not introduced until the drilling operations are completed. The walls of the hole are held in place by the pressure of the mud against the sides of the hole. ***Figure 2*** shows the mechanism of mud rotary drilling method.

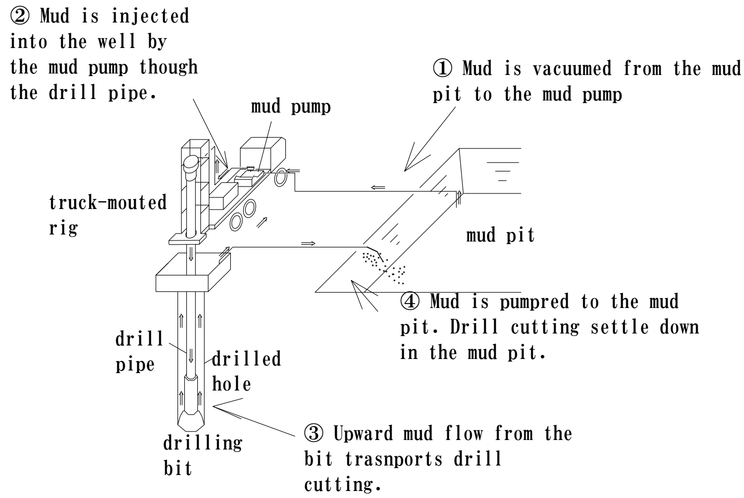


Figure 2 Mechanism of Mud Rotary Drilling Method

3) Cable Tool Method

The cable tool drills which drills by means of lifting and dropping as many as 60 times a minute, a drill bit to break-up and loose the material in well crushing and breaking the formation material

The cable tool method has survived for thousands of years because it is reliable for a wide variety of geological conditions. ***Figure 3***

The tool method offer the following advantages

1. Drilling are relatively inexpensive
2. Rig have low energy requirements
3. Rig are simple in design and require little sophisticated maintenance
4. Well are stabilized during the entire operation
5. Taking samples is possible from every depth
6. Well can be constructed with little chance of contamination
7. Only 2 person are needed to operate rig

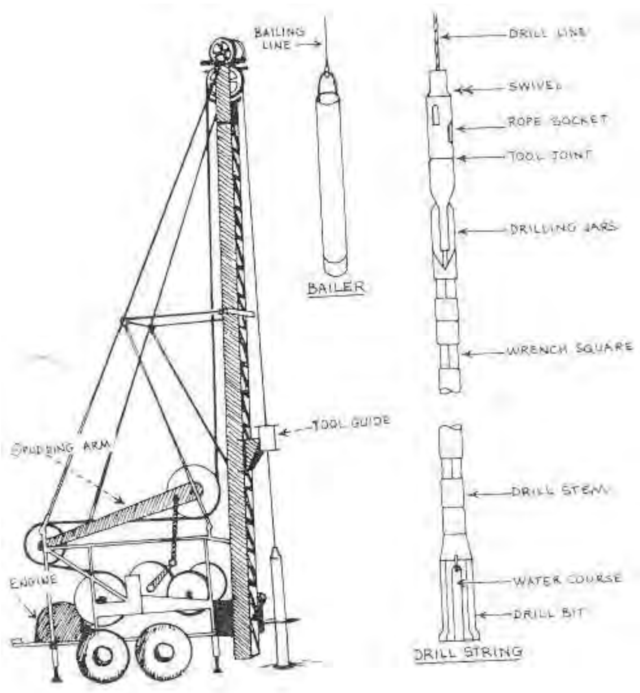


Figure 3 Structure of Cable and Tool Drilling Machine

8. Well can be drilled in area where little water exist
9. Rig can be operated in all temperature regions
10. Well can be drilled in formation where loosen circulation is a problem
11. Well can be bailed at any time to determine the approximately field

DISADVNTAGES OF CABLE TOOL METHOD / METHOD ARE

1. Productive output measured in hole produced per day is low
2. In hard rock's where penetration rate may be very low
3. When casing is required , deep drilling presents problems in keeping the casing free
4. The heavy hammering action causes disturbance and damage in same formation

2.1.2 SELECTION OF DRILLING METHODS AND BITS ACCORDING TO GEOLOGICAL CONDITIONS

A drilling method is to be selected principally based on their performance for types of geological formations, as shown in ***Table 3***.

Table 3 Drilling Performance of Drilling Methods for Type of Formation

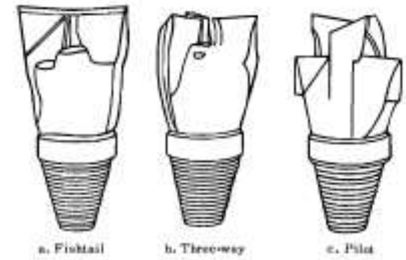
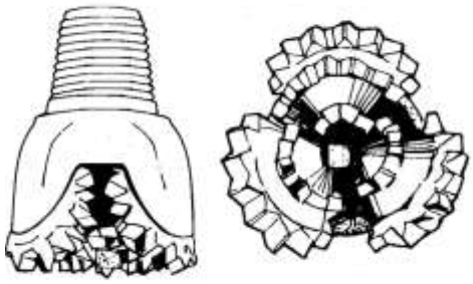
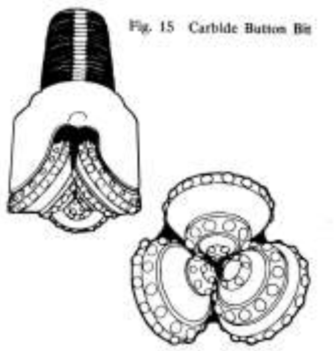
Type of Formation	Cable and Tool	Mud Rotary	DTH
Dune sand	Difficult	Rapid	Not recommended
Loose sand and gravel	Difficult	Rapid	Not recommended
Quicksand	Difficult, except in thin streaks. Requires a string of drive pipe.	Rapid	Not recommended
Loose boulders in alluvial fans or glacial drift	Difficult – slow but generally can be handled by driving pipe.	Difficult, Frequently impossible	Not recommended
Clay and silt	Slow	Rapid	Not recommended
Firm shale	Rapid	Rapid	Not recommended
Sticky shale	Slow	Rapid	Not recommended
Brittle shale	Rapid	Rapid	Not recommended
Sandstone – poorly cemented	Rapid	Rapid	Not recommended
Sandstone – well cemented	Fair	Slow	Not recommended
Chert nodules	Slow	Slow	Not recommended
Limestone	Slow	Rapid	Very Rapid
Limestone with chert nodules	Very Slow	Slow	Very Rapid
Limestone with small cracks or fractures	Very Slow	Slow	Very Rapid
Limestone cavernous	Very Slow	Slow to impossible	Difficult
Dolomite	Very Slow	Rapid	Very Rapid
Basalts, thin layers in sedimentary rocks	Slow	Slow	Very Rapid
Basalts – thick layers	Slow	Slow	Rapid
Metamorphic rocks	Slow	Slow	Rapid
Granite	Slow	Slow	Rapid

Source: Drillers Training and Reference Manual

Though the cable and tool method is effective for the collapsible and/or large size gravel layer, the mud rotary cum DTH method can cover larger range of geological conditions. Therefore, the major drilling methods which are used in DDCA are the mud rotary and the DTH methods.

Rotary cum DTH drilling rigs correspond to both DTH methods and mud rotary method. Therefore, suitable drilling method and bits are selected basically according to the hardness and collapsibility of the formations.

Table 4 Selection of Bit for Rotary Cum DTH Drilling

<table>
<tr><th>Formation</th><th>Drilling Method</th><th>Bit</th></tr>
<tr><td rowspan="2">Soft Formation</td><td rowspan="2">Mud Rotary</td><td>Drag Bits are used used for very soft and unconsolidated formations such as clay and sand.</td></tr>
<tr><td rowspan="3">Tri-cone tooth bits are used for soft to hard formations. The tooth of cone is long for soft formation and short for hard formation.</td></tr>
<tr><td>Medium Formation</td><td>Mud Rotary</td></tr>
<tr><td rowspan="3">Hard Formation</td><td rowspan="3">Mud Rotary</td></tr>
<tr><td>Carbide Button Bit is used for hard formation. This type of bits needs the certain weight on bit in order to obtain the proper drilling progress (more than 3 tons). Therefore it is not suitable for small capacity drilling rigs.</td></tr>
<tr><td rowspan="2">The down the hole hammer (DTH) is suitable for very hard and consolidated formations. They are used for waterwell drilling in most of the areas of the mainland of Tanzania.</td></tr>
<tr><td>Very Hard Formation</td><td>DTH</td></tr>
</table>

2.2 ROTARY BITS (TA CODE 2-2)

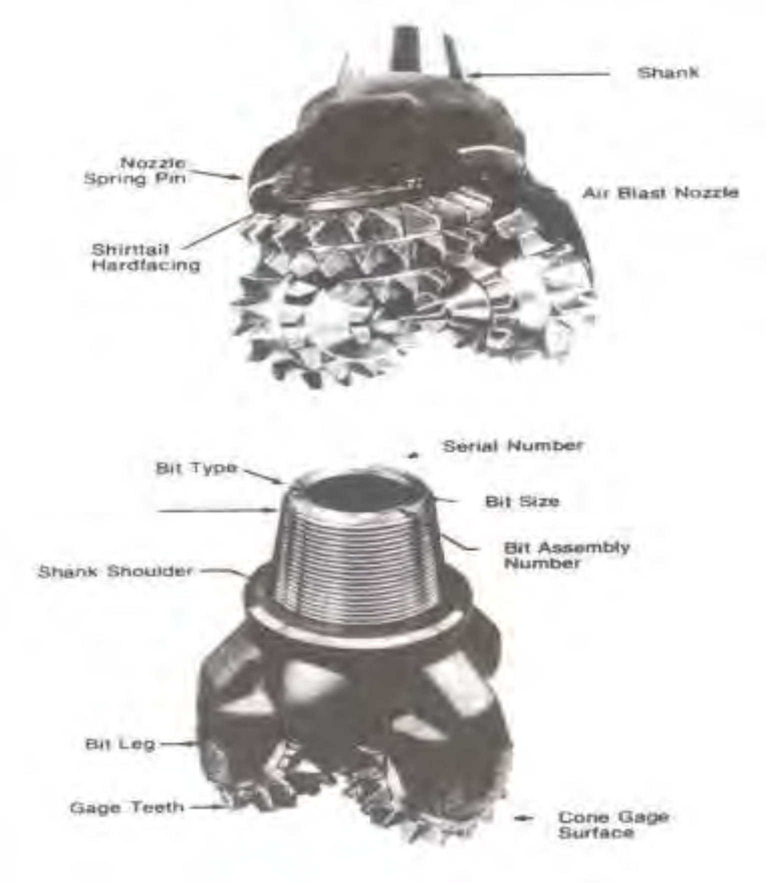
As shown in ***Table 4***, DDCA uses the three types of rotary bit i.e. drag bit, tri-cone tooth bit and carbide button bit. Commonly to each type of rotary bit, a bit has a pin connection of API Regular (Reg.) standard. The ***Table 5*** shows the connections of each size of the rotary bits.

Table 5 Connection of Rotary Bit

Bit Size	Connection
3-1/2” – 4-1/2”	2-3/8” Reg. Pin
4-3/2-4” – 5-1/8”	2-7/8” Reg. Pin
5-3/8” – 7-3/8”	3-1/2” Reg. Pn
7-7/8” – 9”	4-1/2” Reg. Pin
9-5/8” – 15”	6-5/8” Reg. Pin

Figure 4 shows the structure of tri-cone tooth bit. The drillers shall execute the following bit control to realize the proper drilling operation:

- Prompt checking of wearing and cleaning of bit after pulling-out from the hole,
- Checking of diameter to prevent from the decrease of hole diameter. In case of drag bits, standard diameter shall be kept by welding,
- Record of bit operation hours with necessary information such as rotation speed, weight on bit, pump pressure etc.



Source: Australian Drilling Industry Training Committee Limited

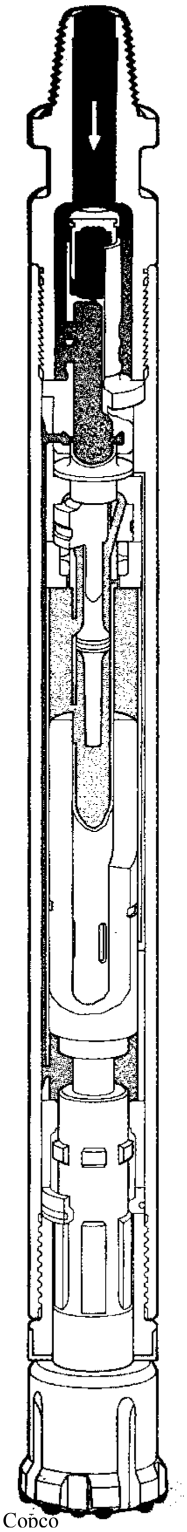
Figure 4 Structure of Tri-cone Tooth Bit

2.3 DTH AND DTH BIT (TA CODE 2-3)

Figure 5 shows the structure of DTH. The DTH is a rotary percussive tool which operates at the bottom of the hole being drilled. It is attached at the end of the drill string, and powered by compressed air flowing down the centre of the drill string into the hammer. The air operates a piston within the hammer which strikes the rear end of the drill bit providing a percussive action. Porting, and in some cases valves within the hammer cause the piston to return to the upward position and then strike again in a continuous sequence. The hammer and drill string is rotated by the drilling machine on the surface which also provides necessary feed force, or, in a deep hole feed hold back force. Air exhausted from the hammer operation and additional air by-passed through the hammer is then used to cool the drill bit and evacuate drill cuttings from the hole. The DTH is very effective in drilling hard rock and the essential difference to rotary drilling is that the percussive rock breaking effort is being conducted on the hole bottom. Feed forces are only required to keep to bit on the bottom of the hole and any further effort (feed force) will not increase penetration but damage the hammer tool. Experienced rotary drillers shold guard againt a natural tendency to overfeed.
Figure 6 shows the structure of DTH bits. Hammers provide light rigs with the ability to drill hard rodk; rock that cannot be drilled economically or quickly using any other method unless a much heavier rig is available.
For most hammer drilling, button bits provide lower costs per meter drilled as they give:

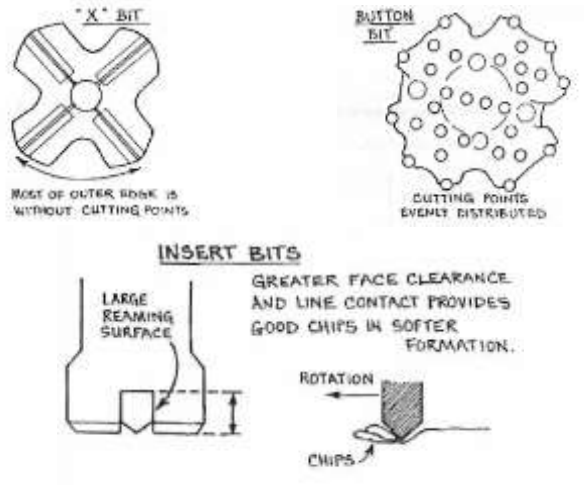
- Faster penetration and
- Longer runs between grinding.

The button bit drills more efficiently because the percussive forces are distributed over the bottom of the hole. Chisel or cross bits concentrate the energy at the centre of the hole. Most of the outer edge is without effective cutting points.



Source: Atlas Copco

Figure 5 Structure of DTH



Source: Australian Drilling Industry Training Committee

Figure 6 Structure of DTH Bits

However, cross “X” or insert bits are more resistant to heavy gauge wear. In some formations, insert bits drill straighter than button bits, and in softer formations which are “scooped out” rather than shattered, insert bits can give better penetration. Button bits are available, with buttons of varying sizes to suit different formations and to suit the energy output of the hammer. Button patterns are varied to suit the rock and the hole size. Bits with a cutting edge at the back shoulder are supplied to drill “backwards” when caving could be a problem.
In order to keep the good drilling progress, buttons of bit shall be kept being sharped. The drillers are required to execute the proper bit sharpening by referring the manufacturer’s manual of DTH.

2.4 RIG ACCESSORY (TA CODE 2-4)

2.4.1 CONTENTS OF RIG ACCESORY

The rig accessory shall consist of drilling string elements and handling tools. They are major tools for the drilling works to be attached to each drilling rig. ***Table 6*** shows the contents of rig accessories for a set of DDCA's new rotary cum DTH drilling rig of 150 m in capacity which are currently under procurement. Total of 6 rigs are to be procured and they are planed to be hired to the private drilling companies. The major components of rig accessory are drill pipes, drill collars, subs, DTHs, DTH bits, rotary bits etc. The quantities of each element in ***Table 6*** were calculated for the drilling of wells of 150 m in depth by using DTH drilling method and mud drilling method. This section describes the use and the specifications of each element for the purpose of proper use and selection by the drillers.

Table 6 Rig Accessories DDCA's New Drilling Rig of 150 m Capacity

No.	Description	Unit	Qty
1	Drill pipes 41/2" 0.D flush type with API 31 1/2"IF BOX and pin joints furnished with wrech squares and steel made protectors,6m long/pc	Pcs	30
2	Drilling collars 5"0.D,2"IF BOX and pin joints,furnished with wretch squares and steel protectors,6m long/pc	Pcs	3
3	Hoisting swivel API 1/2" IF Pin joint	Pcs	3
4	Hoisting plug API 1/2" IF Pin joint	Pcs	3
5	Drill pipes collar hanger	Pcs	3
6	Cross over sub API 3 1/2 IF BOX and pin	Pcs	3
7	DTH Hammer assembly for 6 1/4"(150mm) hole drilling API 3 1/2 Regular pin and 8" to 10" hole drillling	Assy	3
8	DTH Hammer assembly for 12"(300mm) hole drilling API 3 1/2 Regular pin	Assy	3
9	DTH Button Bit for 12"(300mm) hole drilling	Pcs	5
10	Bit sub for drill pipes/collar to 6 1/4" DTH Hammer API 3 1/2" Regular box and API 3 1/2" IF Box joint	Pcs	3
11	Bit sub for drill pipes/collar to 6 1/4" DTH Hammer API 3 1/2" Regular box and API 3 1/2" IF Box joint	Pcs	3
12	DTH Button bit for 6 1/4"(159mm) hole drilling	Pcs	10
13	DTH Button bit for 8 1/4"(216mm) hole drilling	Pcs	10
14	DTH Button bit for 10"(254mm) hole drilling	Pcs	5
16	Bit grindeer for button bit and body dressing,furnished with 15 m long high pressure air hose	Pcs	1
17	Tricone roller bits 6 1/2" dia	Pcs	4
18	Tricone roller bits 8 1/2" dia	Pcs	4
19	Tricone roller bits 10 1/2" dia	Pcs	4
20	Tricone roller bits 12 1/2" dia	Pcs	4
21	Roller bits 8 1/2" dia	Pcs	4
22	Roller bits 10 1/2" dia	Pcs	4
23	Roller bits 12 1/2" dia	Pcs	4
24	Roller bits 14 1/2" dia	Pcs	4
25	Drag bits three winged 8 1/2" dia	Pcs	4
26	Drag bits three winged 10 1/2" dia	Pcs	4
27	Drag bits three winged 12 1/2" dia	Pcs	4
28	Drag bits three winged 16 1/2" dia	Pcs	0
29	Roller bit 16" dia for soft formation	Pcs	0
30	Stabilizer for 6 1/4" hole body dia,1.5m long API 3 1/2 IF BOX and pin joints furnished with wretch squares and steel made thread protectors on both ends	Pcs	3
31	Stabilizer for 8 1/2" hole 5" body dia,1.5m long API 3 1/2 IF BOX and pin joints furnished with wretch squares and steel made thread protectors on both ends	Pcs	3
32	Stabilizer for 10" hole 5" body dia,1.5 long API 3 1/2 IF BOX and pin joints furnished with wretch squares and steel made thread protectors on both ends	Pcs	3

No.	Description	Unit	Qty
33	Stabilizer for 12" hole 5" body dia,1.5m long API 3 1/2 IF BOX and pin joints furnished with wretch squares and steel made thread protectors on both ends	Pcs	3

2.4.2 DRILL STRING ELEMENTS

The composition of different tools and elements as rotary subs, drill rods, stabilizers, drill collars, reamers, down the hole hammers with various bits, as well as tricone roller bit and drag bits, starting from the pin of the rotation head and ending with the bit on the bottom of the hole, is called “DRILL STRING”. The three major functions to be performed by the drill string are:

a. To transmit rotation from the drill unit to the drill bit
b. To transmit feed pressure (bit weight) from the drill unit to the drill bit
c. To provide passage for air or drill fluid to the bottom of the hole to operate the down the hole hammer, to cool the drill bit, to flush the cuttings and to lift them up to the surface.

Resulting from these three major functions, the drill string is subject to various kinds of stress such as torsion, tension bending, buckling and compression depending upon borehole depth, hole diameter directions etc.

Because of some fact, that almost the total length of the drill string is placed below the ground level, that all elements of the string are connected through threads and that of the above mentioned various kinds of stress are caused considerable wear on the whole drill string, care has to be taken that all elements but in particular threads are in good working condition in order to avoid any breaking in the string. Therefore it is the responsibility of the Driller in charge and of the Shift Operators to check various elements of the drill string carefully before being lowered in the borehole. It is once more emphasized that only equipment in proper working condition should be used in the borehole. But also drill string handling tools as bit brakers, clamps, chain wrenches, lifting caps, etc have to be checked before use and should also be in proper working condition.
The strongly requested checking and controls by the personnel concerned are considered as preventive measures at the drill sites in order to avoid difficult time and money consuming fishing work hindering drilling crews from good performance. ***Figure 7*** shows the standard assembly of drill string.

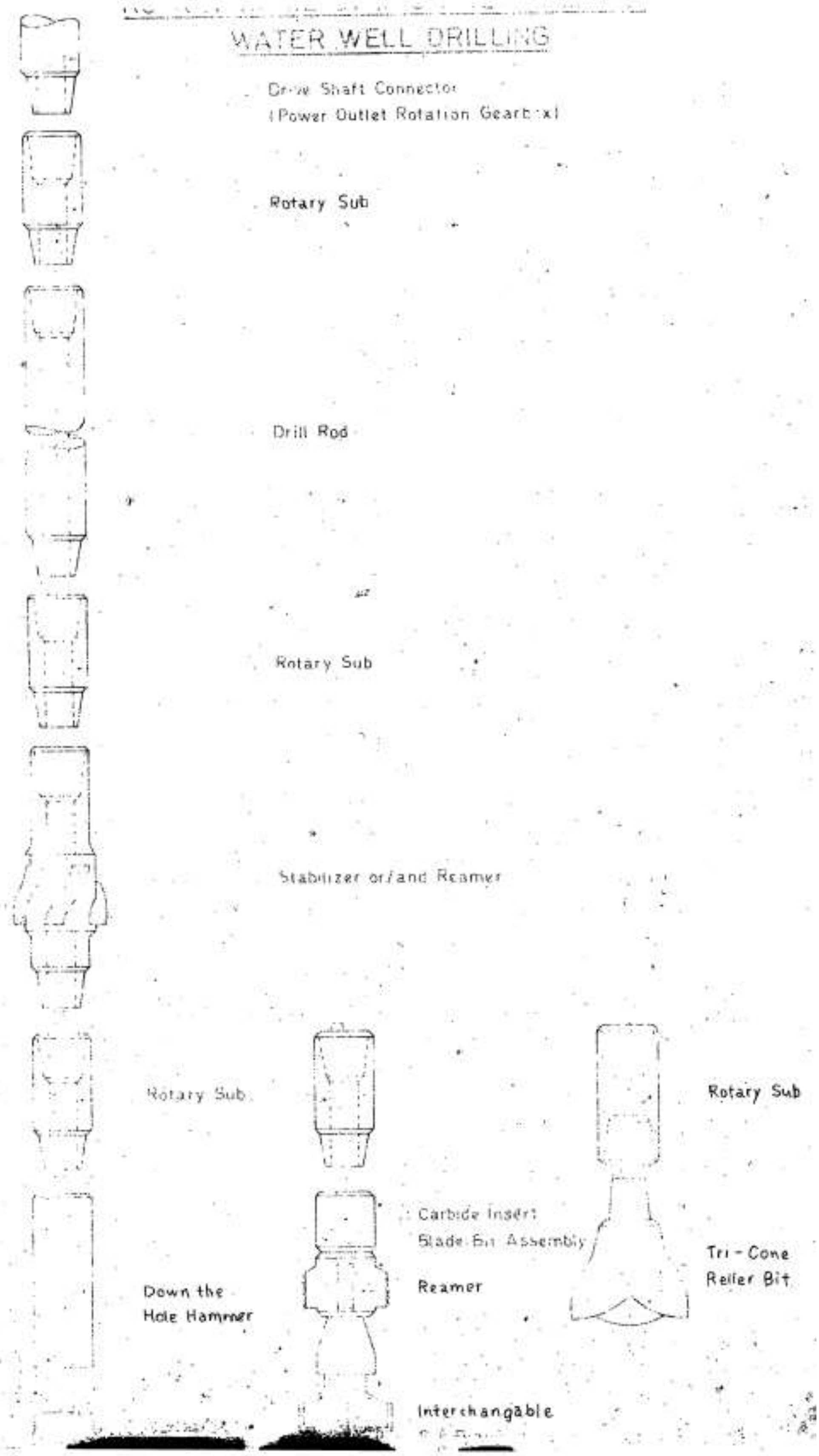


Figure 7 Standard Drill Sttring Assembly

- **Drive shaft**

The drive shaft pin of the rotation gear box is threaded with 31/2" API Reg. Pin and is the connector from the drill unit to the drill string.

- **Rotary Substitutes "SUBS"**

Rotary substitutes commonly known as "SUBS" are elements of the drill string and are used where threads of one size or type must be completed together with threads of another size or type. These subs are called "Cross Over subs". Other subs are used as wear prevention at connection points that are frequently made up and broken out. These subs are called "Saver Subs." Casing driver subs are to connect steel surface/conductor casing to the top drive head of the rig. This enables the drilling by the casing or the mud/air circulation to remove the sediment which disturbs the casing installation to the desired depth. DDCA has casing driver subs for 65/8", 85/8", 103/4", 123/4" and14" O.D casings with API 5L line pipe thread; the connector is 31/2 API IF Box.

Elements of the drill string which are used with our rotary rigs and which have to be coupled in the drill string with the help of subs are as follows:

- **Drill Pipes and Drill Collars**

Drill pipe is a type of piping used on a drilling rig. It helps with wellbore drilling, which is the process of digging a hole in the ground in order to access a particular natural resource, such as oil or water. The pipe pumps drilling fluid, which generates pressure to keep unwanted fluids out of the liquid pumped, removes drill cuttings, and helps to cool and clean the drill bit. It is one of the most significant member of the drill string. It is available in different diameters according to requirements, as FLUSH JOINT DRILL ROD AND UPSET DRILL ROD, (here the tool joint is larger in diameter than the pipe itself). Tool joints are threaded with male and female threads for connecting in the drill string. The material of drill pipes is considered of having the best physical properties and to provide a combination of hardness, strength and ductility.

DDCA has various size of drilling pipes such as:

- 51/2" O.D Fitted with 31/2" API IF Box Pin
- 51/4" O.D fitted with 31/2" API Reg. Box Pin
- 41/2" O.D fitted with 31/2" API Reg. Box Pin
- 31/2" O.D fitted with 23/8" API IF Box Pin
- 31/2" O.D fitted with 27/8" API IF Box Pin.

The drillers are required to correctly grasp the specifications of drill pipes which they use, i.e. nominal diameter, connection (API Reg. or IF), outside and inside diameters, unit weight. ***Table 7*** show the general capacity of API drill pipes

Table 7 Capacity of API Drill Pipe

Nominal Diameter	OD (mm)	ID (mm)	Threads / inch	Unit Weight (kg / m)
2-3/8”	60	47	4	11.0
2-7/8”	73	54.6	4	17.0
3-1/2”	88.9	70.3	4	21.0
4-1/2”	114.3	97.1	4	27.0
5-1/2”	139.7	121.4		32.7

Drill collar is heavy weight pipe which shall be connected between rotary bit and drill pipes. In water well drilling, one to three tons of drill collars is used and the weight on bit shall be within the total weight of drill collars. ***Table 8*** shows the general capacity of API drill collars.

Table 8 Capacity of API Drill Collar

Connection	OD (inch)	ID (inch)	Unit Weight (kg/m)
NC23-31	3-1/8"	1-1/4"	
NC26-35 (2-3/8 IF)	3-1/2	1-1/2"	39.7
NC31-41 (2-7/8 IF)	4-1/8"	2"	51.6
NC35-47	4-3/4"	2"	73.8
NC38-50(3-1/2 IF)	5"	2-1/4"	79.3
NC44-60	6"	2-1/4"	122.9
NC44-60	6"	2-13/16"	113.0
NC44-62	6-1/4"	2-1/4"	134.7
NC46-62(4IF)	6-1/4"	2-13/16"	124.7
NC46-65(4IF)	6-1/2"	2-1/4"	148.0
NC46-65(4IF)	6-1/2"	2-1/4"	138.1
NC46-67 (4 IF)	6-3/4"	2-13/16"	160.7
NC50-70 (4 1/2 IF)	7"	2-13/16"	174.1
NC50-70 (4 1/2 IF)	7"	2-13/16"	165.2
NC50-72 (4 1/2 IF)	7-1/4"	2-13/16"	178.6
NC56-77	7-3/4"	2-13/16"	208.3
NC 56-80	8"	2-13/16"	224.7
6-5/8REG	8-1/4"	2-13/16"	241.1
NC61-90	9"	2-13/16"	291.7
7-5/8R E G	9-1/2"	3"	322.9
NC70-97	9-3/4"	3"	342.3
NC70-100	10"	3"	361.6
NC77-110	11"	3"	445.0

- **Stabilizer or/and Reamer**

There are a number of stabilizers and reamers manufactured of different type and use in drilling boreholes. There is the rubber stabilizer used almost only in deep oil well or water well drilling. More common is the welded blade type stabilizer or reamer in shallow water well drilling. It is especially effective in soft formation where "balling up" of mud and cuttings on the drill string may be a problem. These stabilizers are generally used for the following purpose:

- To avoid crocked hole drilling
- To center the part of the drill string under weight (mostly drill collars) and to make the drill string more stiff although using more weight.
- To prevent the bit from wandering.

But there are also special reamers or hole openers known, placed immediately above the bit in order to stabilize the bit but also to enlarge the borehole immediately after the pilot bit. (e.g. Carbide Insert Blade Bit Assy.). DDCA has some kinds of stabilizer sucy as 6 5/8" O.D fitted with 4 1/2" API Reg. Box Pin.

- **Down the Hole Hammer (DTH), Bits, Drag Bits, Roller Bits**

These tools as members of the drill string are doing the actual drilling work on the lower end of the drill string on the bottom of the borehole. These tools are designed and manufactured in a wide variety in order to meet the demand originating from the property of the underground to be penetrated.

<u>DTH</u>

In order to overcome these problems which may result from lack of experience or proper knowledge of the matter by the rig operators in addition to the above given hints each driller shall refer to the operation and maintenance manual of the manufacturer of DTH. One copy will have to be with a driller incharge for the purpose of training his crew and the other copy always to be available at the drill site for the shift operators disposal in order to have information required when on duty. The operation and Maintenance Manual shall contain all necessary general information on:

- Preparation for Drilling

- Drilling Operation
- Maintenance(sharpening bit) which have to be studied and followed thoroughly by the rig operators and considered as a working guide in order to improve performance of this very expensive equipment. Emphasis has especially to be put on the "CAUTIONS" mentioned in the Operation and Maintenance Manual indicating the most decisive actions for proper operation service and maintenance of the equipment.
- In addition to the instructions and guidelines given above general cleanliness at the site proper handling of drill string as well as use of proper drill oil has to be put on the "CAUTIONS" mentioned in the Operation and Maintenance Manual indicating the most decisive actions for proper operation service and maintenance of the equipment.
- In addition to the instructions and guideline given above general cleanliness at the site proper handling of drill string as well as use of proper drill oil has to be maintained. Proper drill sting handling tools have to be used in order to avoid damages of Megadrills and Megabits and to avoid general failure. Consultation of Senior Inspector Drilling or Drilling Superintendent should get more common in future in case of problems with equipment or low penetration rate in order to seek advices for improving performance of tools.

DDCA has DTH such asMission Mega and Hammer drills as follows:

- Model A 53-15 fitted with 31/2" API Reg. Box
- Model A 63-15 fitted with 41/2" API Reg. Pin
- Model A 100-10 fitted with 65/8" API Reg. Pin
- Model A 51-20 fitted with 31/2" API Reg. Box
- Model A 43-15 fitted with 25/8" API Reg. Box

Drag Bits, Tri-cone Bits and Tri-cone Roller Bits

These three types of rotary bits are major types for DDCA's drilling works. Please refer to section 2-1 and 2-2 of this manual for the further explanation.

2.4.3 IDENTIFICATION OF SIZE AND TYPE OF THREADS

Operational trouble may sometimes be caused by not having the right tool-at the right place at the right time. But the Driller incharge as well as the stores staff must be able to identify threads of drill rods, bits, stabilizers and other tools of the drill string as well as threads of subs which are required to assemble the drill string. Identification of threads manufactured according to API-Standard is possible by measuring the PIN BASE DIAMETER and COUNTER BORE DIAMETER at box mouth as well as by determination of threads per inch. Table 9 shows an identification chart and instructions giving how to identify properly threads and how to determine on the subs required at drill sites for the drilling operation.

Table 9 Identification of API Threads

Thread Type		Thread per inch	Thread Angle	Pin diameter at base	Box diameter at counterbore
2-3/8	REG	5	60°	66.68	68.26
	FH	-	-	-	-
	IF	4	60°	73.05	74.61
2-7/8	REG	5	60°	76.20	77.79
	FH	-	-	-	-
	IF	4	60°	86.13	87.71
3-1/2	REG	5	60°	88.90	90.49
	FH	5	60°	101.45	102.79
	IF	4	60°	102.01	103.58
4-1/2	REG	5	60°	117.48	119.06
	FH	5	60°	121.72	123.83
	IF	4	60°	133.35	134.94
6-5/8	REG	4	60°	152.20	153.99

2.5 CASING TOOLS (TA CODE 2-5)

2.5.1 SIZE AND TYPE OF STEEL CASING PIPE

(1) Steel Casing Pipes

The steel casing pipes are used as the surface casing and/or the conductor casing. DDCA has various types and standards of steel casing pipes. Normally, casing pipes are used as temporary casings. Therefore they are pulled out from the borehole after the completion. In this reason casing pipes are with threaded flush for the easiness of the handling. Stadards of API 5L-B, JIS STPG Sch-40, JIS SGP, DIN Medium are popularly used for the steel casing. Their sizes are shown in ***Table 10***, ***Table 11***, ***Table 12*** and ***Table 13***.

Table 10 Size of API 5L-B Steel Pipes

ND (mm)	ND (inch)	OD(mm)	ID(mm)	Thickness (mm)	Unit Weight (kg/m)
	3-1/2"	88.9	80.9	4	8.37
	3-1/2"	88.9	79.3	4.8	9.95
	3-1/2"	88.9	77.9	5.5	11.31
	4-1/2"	114.3	104.7	4.8	12.96
	4-1/2"	114.3	103.9	5.2	13.99
	4-1/2"	114.3	103.1	5.6	15.01
	4-1/2"	114.3	102.3	6	16.02
	6-5/8"	168.3	158.7	4.8	19.35
	6-5/8"	168.3	157.1	5.6	22.47
	6-5/8"	168.3	154.1	7.1	28.22
	6-5/8"	168.3	152.5	7.9	31.25
	8-5/8"	219.1	207.9	5.6	29.48
	8-5/8"	219.1	206.3	6.4	33.57
	8-5/8"	219.1	205.1	7	36.61
	8-5/8"	219.1	203.3	7.9	41.14
	8-5/8"	219.1	202.7	8.2	42.65
	8-5/8"	219.1	201.7	8.7	45.14
	8-5/8"	219.1	200.1	9.5	49.1
	10-3/4"	273	260.2	6.4	42.09
	10-3/4"	273	258.8	7.1	46.57
	10-3/4"	273	257.4	7.8	51.03
	10-3/4"	273	255.6	8.7	56.72
	10-3/4"	273	254.4	9.3	60.5
	12-3/4"	323.8	311	6.4	50.11
	12-3/4"	323.8	309.6	7.1	55.47
	12-3/4"	323.8	308	7.9	61.56
	12-3/4"	323.8	307	8.4	65.35
	12-3/4"	323.8	306.4	8.7	67.62
	12-3/4"	323.8	304.8	9.5	73.65
	12-3/4"	323.8	303.2	10.3	79.65
	14"	355.6	342.8	6.4	55.11
	14"	355.6	341.4	7.1	61.2
	14"	355.6	339.8	7.9	67.74
	14"	355.6	338.2	8.7	74.42
	14"	355.6	336.6	9.5	81.08
	14"	355.6	335	10.3	87.71
	16"	406	393.2	6.4	63.13
	16"	406	391.8	7.1	69.91
	16"	406	390.2	7.9	77.63
	16"	406	388.6	8.7	85.32
	16"	406	387	9.5	92.98
	18"	457	442.8	7.1	78.77
	18"	457	441.2	7.9	87.49
	18"	457	439.6	8.7	96.18

ND (mm)	ND (inch)	OD(mm)	ID(mm)	Thickness (mm)	Unit Weight (kg/m)
	18"	457	438	9.5	104.84
	18"	457	436.4	10.3	113.46

Table 11 Size of JIS STPG Sch-40 Steel Pipes

ND (mm)	ND (inch)	OD(mm)	ID(mm)	Thickness (mm)	Unit Weight (kg/m)
80	3	89.1	78.1	5.5	11.3
90	3-1/2	101.6	90.2	5.7	13.5
100	4	114.3	102.3	6	16
125	5	139.8	126.6	6.6	21.7
150	6	165.2	151	7.1	27.7
200	8	216.3	199.9	8.2	42.1
250	10	267.4	248.8	9.3	59.2
300	12	318.5	297.9	10.3	78.3
350	14	355.6	333.4	11.1	94.3
400	16	406.4	381	12.7	123
450	18	457.2	428.6	14.3	156

Table 12 Size of JIS SGP Steel Pipes

ND (mm)	ND (inch)	OD(mm)	ID(mm)	Thickness (mm)	Unit Weight (kg/m)
80	3	89.1	80.7	4.2	8.794
90	3-1/2	101.6	93.2	4.2	10.089
100	4	114.3	105.3	4.5	12.186
125	5	139.8	130.8	4.5	15.015
150	6	165.2	155.2	5	19.754
175	7	190.7	180.1	5.3	24.2
200	8	216.3	204.7	5.8	30.1
225	9	241.8	229.4	6.2	36
250	10	267.4	254.2	6.6	42.4
300	12	318.5	304.7	6.9	53
350	14	355.6	339.8	7.9	67.7
400	16	406.4	390.6	7.9	77.6
450	18	457.2	441.4	7.9	87.5

Table 13 Size of BS Heavy Steel Pipes

ND (mm)	ND (inch)	OD(mm)	ID(mm)	Thickness (mm)	Unit Weight (kg/m)
80	3"	88.75	79.05	4.85	10.0
100	4"	114.05	103.25	5.4	14.4
125	5"	139.65	128.85	5.4	17.8
150	6"	165.2	154.4	5.4	21.1

Figure 8 shows the specifications chart giving indication on what tools and casings have to be used at drill sites in order to complete boreholes of the required final diameters as requested by the hydrogeologist. It will help the driller in charge to check at he site whether he has got the proper tools or to enable him to arrange for the required tools and casings respectively. It should be considered as general guideline when this type of casings is used for water well drilling.

Each of the columns is giving particulars on casings, couplings, drill bit as well as clearance in annular spaces required to allow the drill bit to pass, to allow proper running of casing and to insert gravel pack envelope around screens.

In column 2, 3, 4 and 7 are particulars of casings as O.D. Wall thickness and O.D of couplings listed. Column 5 is indicating the max. Diameter of drill bit which may be run in the casings with a clearance as shown in column 6. This clearance is a result from J.D casing column 4 and bit size column 5. It is important for the Drillers incharge and the Shift Operator to know as what is the bit clearance in order to avoid jamming of the drill string in the casings. In column 7 it is the O.D. of the casing coupling listed important for th be determination of the bit size required to run casings without problems. Now in columns 8 and 9 the required bit sizes are listed depending from the O.D of casings columns 2 and the O.D. of couplings column 9 in order to have the required clearance for running casings and inserting gravel pack.

The annular space listed in column 10 is the minimum clearance required which will enable the Driller incharge or Shift Operator to run casings without trouble provided he has not drilled a crooked borehole and the borehole has got throughout the same required diameter.

The annular space listed in column II between casing O.D. and borehole wall refers to artificially gravel packed boreholes drilled in unconsolidated soft soil formation where an effective gravel envelop around the screens is required in order to get sand free water out. As already mentioned above this chart is only giving general indication while in some instances special arrangements or combinations of bit size and casing diameter may be necessary. But even in this respect the listed diameter of casings and drill bits may help to find the correct decision.

SPECIFICATIONS OF STEEL CASTINGS ON ORDER (T6/75) AND ... A OF DRILL BITS TO BE USED

	CASINGS			DRILL BIT		CASINGS	DRILL BIT		ANNULAR SPACE		
1	2	3	4	5	6	7	8	9	10	11	1:
DIMENSIONS	O.D.	WALL THICKNESS	I.D.	MAX DIAMETER	ANNULAR SPACE 4 to 5	O.D. COLLAR	MIN. DIA WITHOUT GRAVEL PACK	MIN DIA WITH GRAVEL PACK	WITHOUT GRAVEL PACK 7 To 8	WITH GRAVEL PACK 7 to 9	REM
INCH	6 5/8	7/32	63/16	5 7/8	5/32	7 11/32	80 1/2	9 7/8	35/64	15/8	
INCH DECIMALS	6.625	.219	6.187	8.875	.156	7.405	8.500	9.875	.546	1.625	
mm.	168.3	5.5	157.2	145.2	4	188.0	215.9	250.8	13.9	41.3	
INCH	8 5/8	1/4	8 1/8	7 7/8	1/8	9 11/32	11	13	51/64	9 3/16	
INCH DECIMALS	8.625	.250	8.125	7.875	.125	9.405	11.00	13.00	.796	2.187	
mm.	219.1	6.4	206.3	200.0	3.15	238.9	279.4	330.2	20.3	55.5	
INCH	10 3/4	9/32	103/16	9 7/8	5/32	11 17/32	13	15	47/64	2 1/8	
INCH DECIMALS	10.750	.279	10.192	9.875	.156	11.530	13.000	15.000	.734	2.125	
mm.	273.0	7.1	258.8	250.8	4	292.9	330.2	381.0	18.6	54.0	
INCH	12 3/4	5/16	12 1/8	11 1/8	1/2	13 17/32	15	17 1/2	47/64	2 3/8	
INCH DECIMALS	12.750	.312	12.125	11.125	.492	13.530	15.000	17.500	.734	2.375	
mm.	323.9	7.9	308.1	282.6	12.5	343.7	381.0	444.5	18.6	60.3	
INCH	14"	5/16	13 3/8	13	3/16	14 25/32	17 1/2	18 1/2	23/64	2 1/4	
INCH DECIMALS	14.000	.312	13.376	13.000	.139	14.780	17.500	18.500	1.359	2.250	
mm.	355.6	7.9	339.8	330.2	4.9	375.4	444.5	469.9	34.6	57.2	
							*Minimum dia. to be used	**Gravel pack should be not less than 2" around the screens.			

Figure 8 Specifications of Steel Casings and Drill Bits

(2) PVC Casing and Screen Pipes

Most of the case in Tanzania, PVC pipes are used as the production casing and screen pipes. DDCA mainly use the product of the PVC manufacturer, PLASCO, of which the sizes are shown in ***Table 14.*** The products with the remarks of 4", 5", 6", 8" and 10" casing are the standard casing types. 5" casings are standard type for handpump wells and 6" casings are for wells for piped water supply schemes, respectively.

Table 14 Size of uPVC Pipes

Description	OD (mm)	ID	Thickness (mm)	Unit Weight (kg/m)	Remarks
FLUSH FITTING DIN4925 CASE	113	99	7	3.9	
FLUSH FITTING DIN4925 CASE	125	110	7.5	4.3	4" Casing
FLUSH FITTING DIN4925 CASE	140	124	8	5.2	5" Casing
FLUSH FITTING DIN4925 CASE	165	146	9.5	7.3	
FLUSH FITTING PLASCO CASE	165	150	7.5	5.9	6" Casing
FLUSH FITTING DIN4925 CASE	200	177	11.5	10.8	
FLUSH FITTING PLASCO CASE	200	182	9	8.6	
FLUSH FITTING DIN4925 CASE	225	199	13	13.7	
FLUSH FITTING PLASCO CASE	225	205	10	10.7	8" Casing
FLUSH FITTING PLASCO CASE	250	225	12.5	15	
FLUSH FITTING DIN4925 CASE	280	248	16	21.3	
FLUSH FITTING PLASCO CASE	280	255	12.5	16.9	10" Casing
FLUSH FITTING PLASCO CASE	315	285.4	14.8	22.4	

Source: Catalog of PLASCO

2.5.2 Casing Handling Tools

Steel or wooden clampes, or casing elevators (See ***Figure 9***) are usually used to install and/or pull out the casing string. In addition, wire slings and shackles shall be prepared on site according to the total weight of the casing string.

Figure 9 Casing Lifting Tools

2.6 DRILLING EQUIPMENT (TA CODE 2-6)

This section describes the major equipment for drilling works by rotary cum DTH drilling. It consists of drilling rig, mud pump, air-compressor, cargo truck and water tank truck. DDCA is currently procuring new drilling equipment including two drilling rigs of 300 m depth, six drilling rigs of 150 m depth and supporting equipment and trucks.

Drillers are required to evaluate the capacity of each equipment whether or not capable to drill a borehole of various depth, diameter and drilling method. The representative capacity of each equipment is described below.

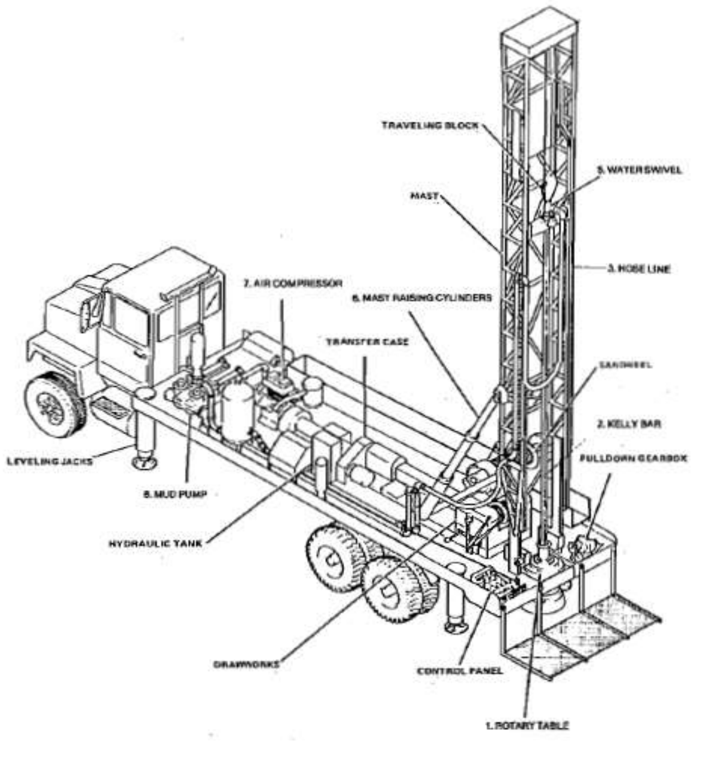
2.6.1 SPECIFICATION OF DRILLING RIG

Figure 10 shows the structure of standard truck-mounted drilling rig. Besides rig plan, generally either a mud pump or an air-compressor is equipped on the truck.

The representative capacity of a drilling rig is lifting capacity (ton). This capacity expresses the maximum length of drill string which can be hold and lifted up by the drilling rig. It is directly related to the maximum drilling depth.

If the drilling is to be executed by DTH down to 200 m with 4-1/2” drill pipes without drill collar, total weight of the drill string is:

97 kg /m x 200 m = 10 tons
With consideration of stucking of drill string, 10 to 15 % of surplus shall be considered as a safety factor. 10 % of safety factor is taken, necessary lifting capacity comes to be 11 tons.



Source: National Waterwell & Drilling Association of Australia

Figure 10 Structure of Truck-mounted Drilling Rig

Prior to the selection and preparation of the drilling equipment, drillers shall determine the necessary drilling tools such as drilling pipes, drill collars, bits, DTH etc. The total weight of the drill string is calculated and shall be evaluated whether or not within the capacity of the drilling rig.

2.6.2 CAPACITY OF MUD PUMP

Most of DDCA’s truck-mounted rigs are equipped with duplex mud pump, as shown in ***Figure 11***. The representative capacities of mud pump are the discharge rate and the pressure.

- **Discharge Rate**

Necessary discharge rate shall be calculated from the necessary annular velocity between drill pipe and hole diameter. In general, at least 10 m/min of annular

Figure 11 Structure of Mud Pump

velocity is necessary for the proper removal of drilled cuttings.

In case of drilling by 8” bit and 4-1/2” drill pipe:

Necessary Disharge Rate (L/min)

= Annular Volume 22 L/m x Annular Velocity 10 m/min =220 L/min

In case of drilling by 12” bit and 4-1/2” drill pipe:

Necessary Disharge Rate (L/min)

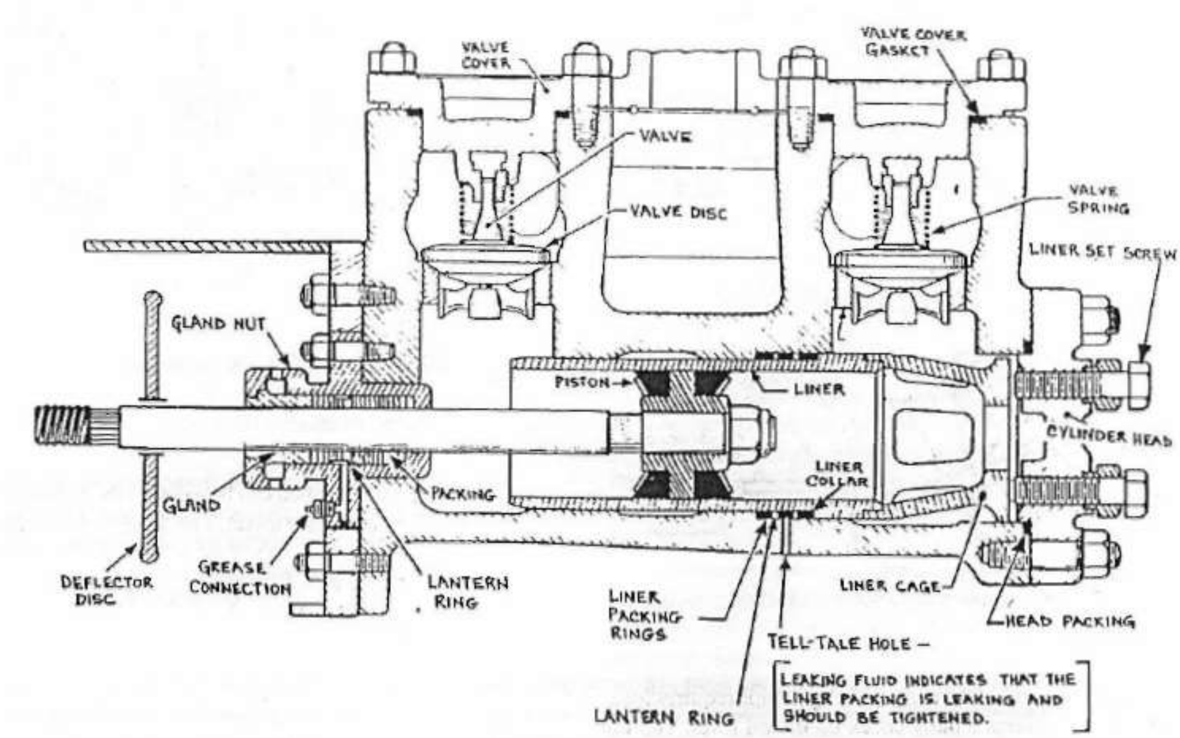
= Annular Volume 63 L/m x Annular Velocity 10 m/min =630 L/min

Therefore, approximately 600 L/min is necessary if 12” bit drilling is used.

- **Pressure**

Each pump has its maximum pressure according to the discharge rate. The maximum pressure of mud pump equipped on the DDCA’s new drilling rig of 150 m depth is 25 bar for 600 L/min of discharge rate. ***Figure 12*** shows an example of separated type duplex mud pump made by TONE and its specifications are shown in ***Table 15***. Discharge rate of a duplex pump is decided by piston (liner) diameter, stroke length and stroke speed (See ***Figure 13***). Drillers shall liner and piston of suitable diameter for the drilling diameter and depth.

Figure 12 Duplex Mud Pump NP-700 (TONE)



Source: Australian Drilling Industry Training Cmmittee

Figure 13 Internal Structure of Mud Pump

Table 15 Specifications of NP-700 Mud Pump

Cylinder Dia. (mm)	140 (5-1/2")	127 (5")	114 (4-1/2")	102 (4")	89 (3 一 1/2")
Discharge Rate (L/min)	615	505	405	315	235
Max. Pressure (bar)	22	27	34	43	58
Stroke r.p.m	80	80	80	80	80
Drive Shart r.p.m	395	395	395	395	395
Stroke Length (mm)	130				
Valve Type	Ball or Conical				
Suction Hose Dia. (mm)	100 or 75				
Delivery Hose Dia. (mm)	65 or 50				
Power (kw)	30-4P				
Total Weight (kg)	1600				
Dimension (mm)	3,040 (L) x 830 (W) x 1,575 (H)				

Discharge pressure is mainly caused by the friction loss of the inside of drill pipes. Therefore, the discharge pressure is effected by the discharge rate and inside diameter and length of drill pipes as the following:

- Disharge pressure increases, if the discharge rate is increases,
- Disharge pressure increases, if the pipe inside diameter becomes smaller,
- Discharge pressure increases proportionally to the length of the pipe for the constant discharge rate and pipe inside diameter.

Standard type of mud pump has the capacity of 600 L/min and 25 bar. They are sufficient for the drilling of medium scale borehole down to 150 m with 8" to 12". However, for large bore and/or deep borehole drilling more than 150 m, discharge rate not less than 1,000 L/min will be necessary. In this case, large pressure will occur if the small diameter drill pipes such as 3-1/2" are used. Drillers are required to always check the relationship between pipe size, depth, discharge rate and pressure to utilize such information for the proper selection of drill pipes and rig capacities.

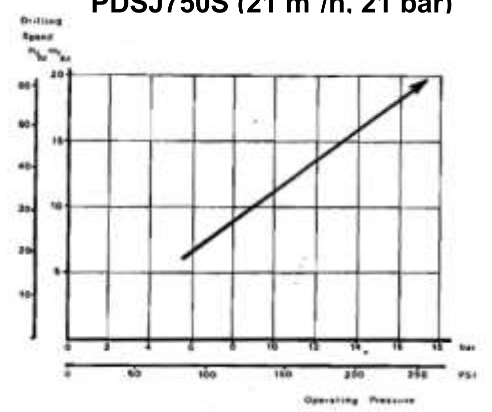
Figure 14 Rotary Screw Air-Compressor PDSJ750S (21 m^3/h, 21 bar)

2.6.3 CAPACITY OF AIR COMPRESSOR

Air-compressors for DTH drilling are of type of either reciprocating or rotary screw. Nowadays, rotary screw type air-compressors are mainly used. Representative capacities of the air-compressor are air delivery and maximum pressure. DDCA's new compressor for the drilling down to 150 m has the capacities of 18.4 m^3/min (650 CFM) and 17 bar (246 psi). ***Figure 14*** show another type of PDSJ750 air-compressor, of which air delivery is 21 m3/min and the maximum pressure is 21 bar.

Air delivery shall be determined from the necessary annular velocity for the proper removal of cuttings. The optimum annular velocity is thought to be 1,220 m/min. The maximum pressure shall be not less than the hydro static pressure of water in borehole. If the borehole depth is 150 m, the compressor of not less than 15 bar is preferable to be selected.

However, if the water level is deep, hydro static pressure becomes lower. The pressure to drive



Source: National Waterwell & Drilling Association of Australia

Figure 15 Change of Drilling Speed by Operating Pressure of DTH

the DTH shall be considered as well. More pressure will give the better progress of the drilling. ***Figure 15*** shows typical performance improvement on a hammer's speed in hard granite at varying air pressures. Performance varies with different makes of DTH but as an example a particular hammer provided with 7 bar air pressure will deliver 15 blows per second of the piston striking the bit and with 14 bar air pressure will deliver 23 blows per second. In this instance where the piston weighs 5 kg and has a stroke of 50 cm before striking the bit, some idea of the power of a DTH can be appreciated.

2.6.4 Capacity of Water Tank Truck

In general, capacity of tank of water tank truck for water well drilling is 5,000 to 6,000 L. Necessary water volume for the drilling work is though to be three times of bore volume. The estimation examples are shown below:

<u>8" x 150 m</u>

Unit bore volme: 8 x 4 = 32 L/m

Total bore volume: 32 L/m x 100 = 3,200 L

Total necessary water: 3,200 L x 3 = 9,600 L

(2 times of transportation)

<u>12" x 150 m</u>

Unit bore volme: 12 x 6 = 72 L/m

Total bore volume: 72 L/m x 100 = 7,200 L

Total necessary water: 7,200 L x 3 = 21,600 L

(4 to 5 times of transportation)

2.6.5 Capacity of Cargo Truck

The representative capacities of cargo truck are gross vehicle weight and payload. The payload is the maximum load acceptable to the truk. The gross vehicle weight is the total of truck weight and the payload. DDCA's new cargo truck has a capacity of 10 tons of payload (See ***Figure 16***). This can load approximately 370 m of 4-1/2" drill pipe (unit weight 27 kg/m).

Figure 16 DDCA's New Cargo Truck

2.7 DRILLING CALCULATION (TA CODE 2-7)

2.7.1 UNIT CONVERSION

During the drilling works, drillers are required to observe and calculate the various values from materials and equipment actions such as weight, pressure, discharge rate etc. These values are expressed in different unit system such as metric, imperial etc. Therefore, drillers shall acquire the knowledge of the conversion between different unit systems. This section describes the major units to be used for the drilling works and gives the reference for the unit conversion. Examples of unit conversion using conversion tables are given below:

Length

100	inch	=	2.54	mm
100	mm	=	3.937	inch
10	ft	=	3.048	m
50	m	=	164.05	ft

Discharge

1000	gal/hr	=	3.785	m3/hr
1	m3/hr	=	264.2	gal/hr
1	m3/day	=	0.04167	m3/hr
25	m3/hr	=	600	m3/day
200	l/min	=	12	m3/hr
48	m3/hr	=	800	l/min
100	m3/hr	=	27.78	l/s
100	l/s	=	360	m3/hr

Pressure

1,000	Kgf/cm2	=	98.1	MPa
5	MPa	=	51	Kgf/cm2

<u>Conversion Table</u>

Length

	m	ft	in
m	1	3.281	39.37
ft	0.3048	1	12
in	0.0254	0.0833	1

Volume

	m3	gal
m3	1	264.17
gal	0.003785	1

Pressure

	kgf/cm2	bar	kN/m2 (kPa)	lbf/in2(psi)
kgf/cm2	1	0.981	98.1	14.223
bar	1.02	1	100	14.504
kN/m2 (kPa)	0.0102	0.0098	1	0.145
lbf/in2(psi)	0.0703	0.0689	6.89	1

In the following pages, useful conversion factors and conversion tables are provided.

Table 16 Conversion Factors – Imperial to Metric

CONVERSION FACTORS - IMPERIAL TO METRIC

	Metric Unit and Symbol	Value	Conversion Factor
			NOTE: Exact conversions underlined. Others given to three significant figures.
LINEAR MEASUREMENT	metre (m)	base unit	yd × 0.9144 = m
			ft × 0.3048 = m
	micrometre (μm)	0.000 001 m	in × 25.4 × 10^3 = μm
	millimetre (mm)	0.001 m	in × 25.4 = mm
	kilometre (km)	1 000 m	mile × 1.61 = km
AREA	square metre (m^2)	SI unit	yd^2 × 0.836 = m^2
			ft^2 × 92.9 × 10^{-3} = m^2
	square millimetre (mm^2)	0.000 001 m^2	in^2 × 645.16 = mm^2
	hectare (ha)	10 000 m^2	acre × 0.405 = ha
	square kilometre (km^2)	1 000 000 m^2	sq mile × 2.59 = km^2
VOLUME	cubic metre (m^3)	SI unit	yd^3 × 0.765 = m^3
			ft^3 × 28.3 × 10^{-3} = m^3
	cubic millimetre (mm^3)	1 × 10^{-9} m^3	in^3 × 16.4 × 10^{-3} = mm^3
(Fluids only)	litre (l)	0.001 m^3	pt × 0.568 = l
			gal × 4.55 = l
	millilitre (ml)	1 × 10^{-6} m^3	pt × 568 = ml
	kilolitre (kl)	1 m^3	gal × 4.55 × 10^{-3} = kl
	megalitre (Ml)	1 × 10^3 m^3	gal × 4.55 × 10^{-6} = Ml
MASS	kilogram (kg)	base unit	lb × 0.454 = kg
	microgram (μg)	1 × 10^{-9} kg	oz × 28.3 × 10^6 = μg
	milligram (mg)	1 × 10^{-6} kg	oz × 28.3 × 10^3 = mg
	gram (g)	0.001 kg	oz × 28.3 = g
	tonne (t)	1 000 kg	ton (2240 lb) × 1.02 = t
PRESSURE	pascal (Pa)	SI unit	lbf/in^2 × 6.89 × 10^3 = Pa
	kilopascal (kPa)	1 000 Pa	lbf/in^2 × 6.89 = kPa
	megapascal (MPa)	1 000 000 Pa	lbf/in^2 × 6.89 × 10^{-3} = MPa
			$tonf/in^2$ × 15.4 = MPa
TIME	second (s)	base unit	
	minute (min)	60 s	
	hour (h)	60 min	
	day (d)	24 h	
TEMPERATURE	kelvin (K)	base unit	
	degrees Celsius (°C)	K – 273.15	$\frac{5}{9}$ (°F – 32) = °C
WORK, ENERGY QUANTITY OF HEAT	joule (J)	SI unit	Btu × 1.06 × 10^3 = J
	kilojoule (kJ)	1 000 J	Btu × 1.06 = kJ
	megajoule (MJ)	1 000 000 J	therm × 106 = MJ
POWER	watt (W)	SI unit	hp × 0.746 × 10^3 = W
	kilowatt (kW)	1 000 watts	hp × 0.746 = kW
	megawatt (MW)	1 000 000 watt	hp × 0.746 × 10^{-3} = MW

273

Source: National Waterwell & Drilling Association of Australia

CONVERSION FACTORS — Metric to Imperial

	Metric Unit and Symbol	Value	Conversion Factor
LINEAR MEASUREMENT	metre (m)	base unit	× 1.09 = yd
			× 3.28 = ft
	micrometre (µm)	1×10^{-6} m	× 3.94×10^{-5} = in
	millimetre (mm)	1×10^{-3} m	× 3.94×10^{-2} = in
	kilometre (km)	1 000 m	× 0.621 = mile
AREA	square metre (m^2)	SI unit	× 1.20 = yd^2
			× 10.8 = ft^2
	square millimetre (mm^2)	1×10^{-6} m^2	× 1.55×10^{-3} = in^2
	hectare (ha)	10×10^{3} m^2	× 2.47 = ac
	square kilometre (km^2)	1×10^{6} m^2	× 0.386 = sq mile
VOLUME	cubic metre (m^3)	SI unit	× 1.3 = yd^3
			× 35.3 = ft^3
	cubic millimetre (mm^3)	1×10^{-9} m^3	× 61.0×10^{-6} = in^3
(Fluids only)	litre (l)	1×10^{-3} m^3	× 1.76 = pt
			× 0.220 = gal
	millilitre (ml)	1×10^{-6} m^3	× 1.76×10^{-3} = pt
	kilolitre (kl)	1 m^3	× 220 = gal
	megalitre (Ml)	1×10^{3} m^3	× 220 000 = gal
MASS	kilogram (kg)	base unit	× 2.20 = lb
	microgram (µg)	1×10^{-9} kg	× 35.3×10^{-9} = oz
	milligram (mg)	1×10^{-6} kg	× 35.3×10^{-6} = oz
	gram (g)	1×10^{-3} kg	× 35.3×10^{-3} = oz
	tonne (t)	1×10^{3} kg	× 0.984 = ton (2240 lb)
FORCE	newton (N)	SI unit	× 0.225 = lbf
	kilonewton (kN)	1 000 N	× 0.225 = kip
	meganewton (MN)	1×10^{6} N	× 100 = tonf
PRESSURE	pascal (Pa)	SI unit	× 0.145×10^{-3} = lbf/in^2
	kilopascal (kPa)	1 000 Pa	× 0.145 = lbf/in^2
	megapascal (MPa)	1×10^{6} Pa	× 0.145×10^{3} = lbf/in^2
			× 64.8×10^{-3} = $tonf/in^2$
TIME	second (s)	base unit	
	minute (min)	60 s	
	hour (h)	60 min	
	day (d)	24 h	
TEMPERATURE	kelvin (K)	base unit	$\frac{9 \times {}^{o}C}{5} + 32 = {}^{o}F$
	degrees Celsius (°C)	K − 273.15	
WORK, ENERGY QUANTITY OF HEAT	joule (J)	SI unit	× 0.948×10^{-3} = Btu
	kilojoule (kJ)	1 000 J	× 0.948 = Btu
	megajoule (MJ)	1 000 000 J	× 9.48×10^{-3} = therm
	kilowatt hour (kW.h)	3.6 MJ	
POWER	watt (W)	SI unit	× 1.34×10^{-3} = hp
	kilowatt (kW)	1 000 watt	× 1.34 = hp
	megawatt (MW)	1 000 000 watt	× 1.34×10^{3} = hp

Source: National Waterwell & Drilling Association of Australia

Table 17 Conversion Tables – Length and Area

UNIT	EQUIVALENT							
	Centimeters	Inches	Feet	Yards	Meters	Rods	Kilometers	Miles
1 Centimeter =	ONE	.3937	.0328	.01093	.01	.00199	.00001	.00000621
1 Inch =	2.54	ONE	.08333	.0278	.02540	.00505	.0000254	.0000158
1 Foot =	30.48	12	ONE	.33333	.30480	.0606	.000305	.000189
1 Yard =	91.44	36	3	ONE	.91440	.18181	.000915	.000568
1 Meter =	100	39.37	3.2808	1.0936	ONE	.1988	.001	.000621
1 Rod =	502.9	198	16.5	5.5	5.0292	ONE	.00503	.00312
1 Kilometer =	100,000	39,370	3280.8	1093.6	1000	198.83	ONE	.62137
1 Mile =	160,935	63,360	5280	1760	1609.3	320	1.6093	ONE

LENGTH

UNIT	EQUIVALENT							
	Square Centimeters	Square Inches	Square Feet	Square Yards	Square Meters	Square Rods	Acres	Square Miles
1 Sq. Centimeter =	ONE	.155	.001076	.0001196	.0001	.000003953	—	—
1 Sq. Inch =	6.452	ONE	.00694	.0007716	.0006452	.00002551	—	—
1 Sq. Foot =	929	144	ONE	.1111	.0929	.003673	.00002296	—
1 Sq. Yard =	8361	1296	9	ONE	.8361	.03306	.0002066	—
1 Sq. Meter =	10,000	1550	10.76	1.196	ONE	.0395	.0002471	—
1 Sq. Rod =	252,908	39,204	272.25	30.25	25.29	ONE	.00625	.000009766
1 Acre =	40,465,284	6,272,640	43,560	4840	4047	160	ONE	.001563
1 Sq. Mile =	—	—	27,878,400	3,097,600	2,589,998	102,400	640	ONE

AREA

Source: National Waterwell & Drilling Association of Australia

Table 18 Conversion Tables – Velocity and Flow

UNIT	EQUIVALENT							
	Centimeters	Inches	Feet	Yards	Meters	Rods	Kilometers	Miles
1 Centimeter =	ONE	.3937	.0328	.01093	.01	.00199	.00001	.00000621
1 Inch =	2.54	ONE	.08333	.0278	.02540	.00505	.0000254	.0000158
1 Foot =	30.48	12	ONE	.33333	.30480	.0606	.000305	.000189
1 Yard =	91.44	36	3	ONE	.91440	.18181	.000915	.000568
1 Meter =	100	39.37	3.2808	1.0936	ONE	.1988	.001	.000621
1 Rod =	502.9	198	16.5	5.5	5.0292	ONE	.00503	.00312
1 Kilometer =	100,000	39,370	3280.8	1093.6	1000	198.83	ONE	.62137
1 Mile =	160,935	63,360	5280	1760	1609.3	320	1.6093	ONE

LENGTH

UNIT	EQUIVALENT							
	Square Centimeters	Square Inches	Square Feet	Square Yards	Square Meters	Square Rods	Acres	Square Miles
1 Sq. Centimeter =	ONE	.155	.001076	.0001196	.0001	.000003953	—	—
1 Sq. Inch =	6.452	ONE	.00694	.0007716	.0006452	.00002551	—	—
1 Sq. Foot =	929	144	ONE	.1111	.0929	.003673	.00002296	—
1 Sq. Yard =	8361	1296	9	ONE	.8361	.03306	.0002066	—
1 Sq. Meter =	10,000	1550	10.76	1.196	ONE	.0395	.0002471	—
1 Sq. Rod =	252,908	39,204	272.25	30.25	25.29	ONE	.00625	.000009766
1 Acre =	40,465,284	6,272,640	43,560	4840	4047	160	ONE	.001563
1 Sq. Mile =	—	—	27,878,400	3,097,600	2,589,998	102,400	640	ONE

AREA

Source: National Waterwell & Drilling Association of Australia

Table 19 Conversion Tables – Imperial Gallons to Litres

Basis: 1 gallon = 4.54609 **Imperial Gallons to Litres**

Imp. Gals.	0	1	2	3	4	5	6	7	8	9
0	-	4.546	9.092	13.638	18.184	22.731	27.277	31.823	36.369	40.915
10	45.461	50.007	54.553	59.099	63.645	68.191	72.737	77.284	81.830	86.376
20	90.922	95.468	100.014	104.560	109.106	113.652	118.198	122.744	127.291	131.837
30	136.383	140.929	145.475	150.021	154.567	159.113	163.659	168.205	172.751	177.298
40	181.844	186.390	190.936	195.482	200.028	204.574	209.120	213.666	218.212	222.758
50	227.305	231.851	236.397	240.943	245.489	250.035	254.581	259.127	263.673	268.219
60	272.765	277.311	281.858	286.404	290.950	295.496	300.042	304.588	309.134	313.680
70	318.226	322.772	327.318	331.865	336.411	340.957	345.503	350.049	354.595	359.141
80	363.687	368.233	372.779	377.325	381.872	386.418	390.964	395.510	400.056	404.602
90	409.148	413.694	418.240	422.786	427.332	431.879	436.425	440.971	445.517	450.063
	-	10	20	30	40	50	60	70	80	90
100	454.609	500.070	545.531	590.992	636.453	681.914	727.374	772.853	818.296	863.757
200	909.218	954.679	1000.140	1045.601	1091.062	1136.523	1181.983	1227.444	1272.905	1318.366
300	1363.827	1409.288	1454.749	1500.210	1545.671	1591.132	1636.592	1682.053	1727.514	1772.975
400	1818.436	1863.897	1909.358	1954.819	2000.280	2045.741	2091.201	2136.662	2182.123	2227.584
500	2273.045	2318.506	2363.967	2409.428	2454.889	2500.350	2545.810	2591.271	2636.732	2682.193
600	2727.654	2773.115	2818.576	2864.037	2909.498	2954.959	3000.419	3045.880	3091.341	3136.802
700	3182.263	3227.723	3273.185	3318.646	3364.107	3409.568	3455.028	3500.489	3545.950	3591.411
800	3636.872	3682.333	3727.793	3773.255	3818.716	3864.177	3909.637	3955.098	4000.559	4046.020
900	4091.481	4136.942	4182.403	4227.864	4273.325	4318.786	4364.246	4409.707	4455.168	4500.629
1000	4546.090									

Example 25 Litres = 5.499 gal. (5½ gal)
200 Litres = 43.994 gal. (44 gal)

Source: National Waterwell & Drilling Association of Australia

Table 20 Conversion Tables – Litres to Imperial Gallons

Basis: 1 litre = 0.219969 **Litres to Imperial Gallons**

	0	1	2	3	4	5	6	7	8	9
	GALLONS									
0		0.220	0.440	0.660	0.880	1.100	1.320	1.540	1.760	1.980
10	2.200	2.420	2.640	2.860	3.080	3.300	3.520	3.739	3.959	4.179
20	4.399	4.619	4.839	5.059	5.279	5.499	5.719	5.939	6.159	6.379
30	6.599	6.819	7.039	7.259	7.479	7.699	7.191	8.139	8.359	8.579
40	8.799	9.019	9.239	9.459	9.679	9.899	10.119	10.339	10.559	10.778
50	10.998	11.218	11.438	11.658	11.878	12.098	12.318	12.538	12.758	12.978
60	13.198	13.418	13.638	13.858	14.078	14.298	14.518	14.738	14.958	15.178
70	15.398	15.618	15.838	16.058	16.278	16.498	16.718	16.938	17.158	17.378
80	17.598	17.817	18.037	18.257	18.477	18.697	18.917	19.137	19.357	19.577
90	19.797	20.017	20.237	20.457	20.677	20.897	21.117	21.337	21.557	21.777
		10	20	30	40	50	60	70	80	90
100	21.997	24.197	26.396	28.596	30.796	32.995	35.195	37.395	39.594	41.794
200	43.994	46.193	48.393	50.593	52.793	54.992	57.192	59.392	61.591	63.791
300	65.991	68.190	70.390	72.590	74.789	76.989	79.189	81.388	83.588	85.788
400	87.989	90.187	92.387	94.587	96.786	98.986	101.186	103.385	105.585	107.785
500	109.985	112.184	114.384	116.584	118.783	120.983	123.183	125.382	127.582	129.782
600	131.981	134.181	136.381	138.580	140.780	142.980	145.180	147.379	149.579	151.779
700	153.978	156.178	158.378	160.577	162.777	164.977	167.176	169.376	171.576	173.776
800	175.975	178.175	180.375	182.574	184.774	186.974	189.173	191.373	193.573	195.772
900	197.972	200.172	202.371	204.571	206.771	208.971	211.170	213.370	215.570	217.769
1000	219.969									

Source: National Waterwell & Drilling Association of Australia

Table 21 Conversion Tables – Acre-Feet to 1,000 Cubit Meters

acre-feet	0	10	20	30	40	50	60	70	80	90
	1 000 cubic metres (megalitres)									
0	0.00	12.33	24.67	37.00	49.34	61.67	74.01	86.34	98.68	111.01
100	123.35	135.68	148.02	160.35	172.69	185.02	197.36	209.69	222.03	234.36
200	246.70	259.03	271.37	283.70	296.04	308.[illegible]7	320.71	333.04	345.37	357.71
300	370.04	382.38	394.71	407.05	419.38	431.72	444.05	456.39	468.72	481.06
400	493.39	505.73	518.06	530.40	542.73	555.07	567.40	579.74	592.07	604.41
500	616.74	629.08	641.41	653.75	666.08	678.42	690.75	703.08	715.42	727.75
600	740.09	752.42	764.76	777.09	789.43	801.76	814.10	826.43	838.77	851.10
700	863.44	875.77	888.11	900.44	912.78	925.11	937.45	949.78	962.12	974.45
800	986.79	999.12	1 011.46	1 023.79	1 036.12	1 048.46	1 060.79	1 073.13	1 085.46	1 097.80
900	1 110.13	1 122.47	1 134.80	1 147.14	1 159.47	1 171.81	1 184.14	1 196.48	1 208.81	1 221.15
1 000	1 233.48	1 245.82	1 258.15	1 270.49	1 282.82	1 295.16	1 307.49	1 319.83	1 332.16	1 344.50

BASIS: 1 acre = 4 840 sq yd
1 sq yd = 0.836 127 36 sq m
1 ft = 0.304 8 m
1 litre = 0.001 cubic metres
1 ac ft = 1.233 481 8[illegible] M2

ACRE-FEET TO 1 000 CUBIC METRES (OR MEGALITRES)

27

Source: National Waterwell & Drilling Association of Australia

Table 22 Conversion Tables – Cubic Yards to Cubic Meters

cubic yards	0	1	2	3	4	5	6	7	8	9
	cubic metres									
0	0.000 0	0.764 6	1.529 1	2.293 7	3.058 2	3.822 8	4.587 3	5.351 9	6.116 4	6.881 0
10	7.645 5	8.410 1	9.174 7	9.939 2	10.703 8	11.468 3	12.232 9	12.997 4	13.762 0	14.526 5
20	15.291 1	16.055 7	16.820 2	17.584 8	18.349 3	19.113 9	19.878 4	20.643 0	21.407 5	22.172 1
30	22.936 6	23.701 2	24.465 8	25.230 3	25.994 9	26.759 4	27.524 0	28.288 5	29.053 1	29.817 6
40	30.582 2	31.346 7	32.111 3	32.875 9	33.640 4	34.405 0	35.169 5	35.934 1	36.698 6	37.463 2
50	38.227 7	38.992 3	39.756 9	40.521 4	41.286 0	42.050 5	42.815 1	43.579 6	44.344 2	45.108 7
60	45.873 3	46.637 8	47.402 4	48.167 0	48.931 5	49.696 1	50.460 6	51.225 2	51.989 7	52.754 3
70	53.518 8	54.283 4	55.047 9	55.812 5	56.577 1	57.341 6	58.106 2	58.870 7	59.635 3	60.399 8
80	61.164 4	61.928 9	62.693 5	63.458 1	64.222 6	64.987 2	65.751 7	66.516 3	67.280 8	68.045 4
90	68.809 9	69.574 5	70.339 0	71.103 6	71.868 2	72.632 7	73.397 3	74.161 8	74.926 4	75.690 9
100	76.455 5	77.220 0	77.984 6	78.749 2	79.513 7	80.278 3	81.042 8	81.807 4	82.571 9	83.336 5

AUXILIARY TABLE

cubic yards	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
	cubic metres									
0	0.000 0	0.076 5	0.152 9	0.229 4	0.305 8	0.382 3	0.458 7	0.535 2	0.611 6	0.688 1

BASIS: 1 yd = 0.914 4 m

Source: National Waterwell & Drilling Association of Australia

Table 23 Conversion Tables – Imperial Gallons Per Minute to Litres Per Second

gallons/minute	0	1	2	3	4	5	6	7	8	9
	litres per second									
0	0.000 0	0.075 8	0.151 5	0.227 3	0.303 1	0.378 8	0.454 6	0.530 4	0.606 1	0.681 9
10	0.757 7	0.833 4	0.909 2	0.985 0	1.060 8	1.136 5	1.212 3	1.288 1	1.363 8	1.439 6
20	1.515 4	1.591 1	1.666 9	1.742 7	1.818 4	1.894 2	1.970 0	2.045 7	2.121 5	2.197 3
30	2.273 0	2.348 8	2.424 6	2.500 3	2.576 1	2.651 9	2.727 7	2.803 4	2.879 2	2.955 0
40	3.030 7	3.106 5	3.182 3	3.258 0	3.333 8	3.409 6	3.485 3	3.561 1	3.636 9	3.712 6
50	3.788 4	3.864 2	3.939 9	4.015 7	4.091 5	4.167 2	4.243 0	4.318 8	4.394 6	4.470 3
60	4.546 1	4.621 9	4.697 6	4.773 4	4.849 2	4.924 9	5.000 7	5.076 5	5.152 2	5.228 0
70	5.303 8	5.379 5	5.455 3	5.531 1	5.606 8	5.682 6	5.758 4	5.834 1	5.909 9	5.985 7
80	6.061 5	6.137 2	6.213 0	6.288 8	6.364 5	6.440 3	6.516 1	6.591 8	6.667 6	6.743 4
90	6.819 1	6.894 9	6.970 7	7.046 4	7.122 2	7.198 0	7.273 7	7.349 5	7.425 3	7.501 0
100	7.576 8	7.652 6	7.728 4	7.804 1	7.879 9	7.955 7	8.031 4	8.107 2	8.183 0	8.258 7

BASIS: 1 gallon = 4.546 09 litres

Source: National Waterwell & Drilling Association of Australia

Table 24 Conversion Tables – Pounds Per Square Inch to Kilo Pascals

psi	0	1	2	3	4	5	6	7	8	9
	kilopascals									
0	0.00	6.89	13.79	20.68	27.58	34.47	41.37	48.26	55.16	62.05
10	68.95	75.84	82.74	89.63	96.53	103.42	110.32	117.21	124.11	131.00
20	137.90	144.79	151.68	158.58	165.47	172.37	179.26	186.16	193.05	199.95
30	206.84	213.74	220.63	227.53	234.42	241.32	248.21	255.11	262.00	268.90
40	275.79	282.69	289.58	296.47	303.37	310.26	317.16	324.05	330.95	337.84
50	344.74	351.63	358.53	365.42	372.32	379.21	386.11	393.00	399.90	406.79
60	413.69	420.58	427.47	434.37	441.26	448.16	455.05	461.95	468.84	475.74
70	482.63	489.53	496.42	503.32	510.21	517.11	524.00	530.90	537.79	544.69
80	551.58	558.48	565.37	572.26	579.16	586.05	592.95	599.84	606.74	613.63
90	620.53	627.42	634.32	641.21	648.11	655.00	661.90	668.79	675.69	682.58
100	689.48	696.37	703.27	710.16	717.05	723.95	730.84	737.74	744.63	751.53
110	758.42	765.32	772.21	779.11	786.00	792.90	799.79	806.69	813.58	820.48
120	827.37	834.27	841.16	848.06	854.95	861.84	868.74	875.63	882.53	889.42
130	896.32	903.21	910.11	917.00	923.90	930.79	937.69	944.58	951.48	958.37
140	965.27	972.16	979.06	985.95	992.85	999.74	1 006.63	1 013.53	1 020.42	1 027.32
150	1 034.21	1 041.11	1 048.00	1 054.90	1 061.79	1 068.69	1 075.58	1 082.48	1 089.37	1 096.27
160	1 103.16	1 110.06	1 116.95	1 123.85	1 130.74	1 137.63	1 144.53	1 151.42	1 158.32	1 165.21
170	1 172.11	1 179.00	1 185.90	1 192.79	1 199.69	1 206.58	1 213.48	1 220.37	1 227.27	1 234.16
180	1 241.06	1 247.95	1 254.85	1 261.74	1 268.64	1 275.53	1 282.42	1 289.32	1 296.21	1 303.11
190	1 310.00	1 316.90	1 323.79	1 330.69	1 337.58	1 344.48	1 351.37	1 358.27	1 365.16	1 372.06
200	1 378.95	1 385.85	1 392.74	1 399.64	1 406.53	1 413.43	1 420.32	1 427.21	1 434.11	1 441.00

BASIS: 1 lbf = 0.453 592 37 kgf
1 kgf = 9.806 65 N
1 inch = 0.025 4 m
1 Pa = 1 N/m^2

Source: National Waterwell & Drilling Association of Australia

Table 25 Conversion Tables – Horsepower to Kilowatts

horsepower	0	10	20	30	40	50	60	70	80	90
	kilowatts									
0	0.00	7.46	14.91	22.37	29.83	37.28	44.74	52.20	59.66	67.11
100	74.57	82.03	89.48	96.94	104.40	111.85	119.31	126.77	134.23	141.68
200	149.14	156.60	164.05	171.51	178.97	186.42	193.88	201.34	208.80	216.25
300	223.71	231.17	238.62	246.08	253.54	260.99	268.45	275.91	283.37	290.82
400	298.28	305.74	313.19	320.65	328.11	335.56	343.02	350.48	357.94	365.39
500	372.85	380.31	387.76	395.22	402.68	410.13	417.59	425.05	432.51	439.96
600	447.42	454.88	462.33	469.79	477.25	484.70	492.16	499.62	507.08	514.53
700	521.99	529.45	536.90	544.36	551.82	559.27	566.73	574.19	581.65	589.10
800	596.56	604.02	611.47	618.93	626.39	633.84	641.30	648.76	656.22	663.67
900	671.13	678.59	686.04	693.50	700.96	708.41	715.87	723.33	730.79	738.24
1 000	745.70	753.16	760.61	768.07	775.53	782.98	790.44	797.90	805.36	812.81

BASIS: 1 hp = 550 ft-lbf/s
1 ft = 30.48 cm
1 lbf = 0.453 592 37 kgf
1 kgf = 980 665 dyn
1 W = 10 000 000 dyn cm/s

281

HORSEPOWER TO KILOWATTS

Source: National Waterwell & Drilling Association of Australia

2.7.2 ANNULAR VOLUME AND VELOCITY

The calculation of annular volume and annular velocity is an indispensable knowledge to all drillers for the proper drilling plan and control. The follows are an example of the calculation of annular volume and annular velocity.

1) Bore Volume

<u>12" Hole x 100 m</u>

Unit Volume

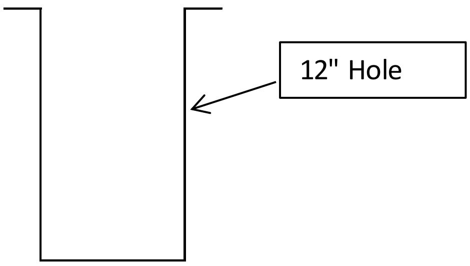
3.14 x (12 x 25.4)^2 /4,000

72.9 L/m

Total Volume

=72.93 L/m x 100 m

7293 L



2) Annular Volume

<u>12" Hole x 100 m</u>

<u>4-1/2" DP x 100 m</u>

Unit Volume

12" Hole

3.14 x (12 x 25.4)^2 /4,000

72.9 L/m

4-1/2" DP

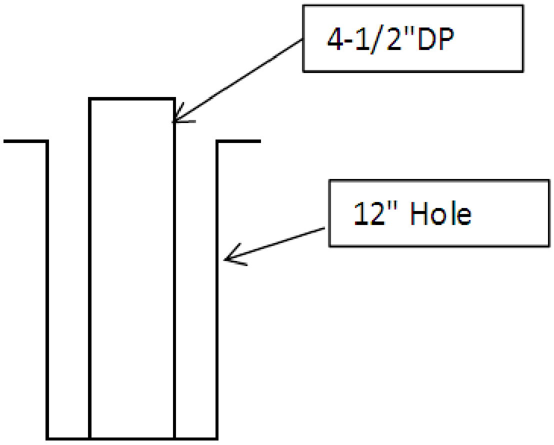
3.14 x (4.5 x 25.4)^2 /4,000

10.3 L/m

Annular Volume

72.9 L/m - 10.3 L/m

62.6 L/m



3) Annular Velocity

Discharge Rate

600 L/min

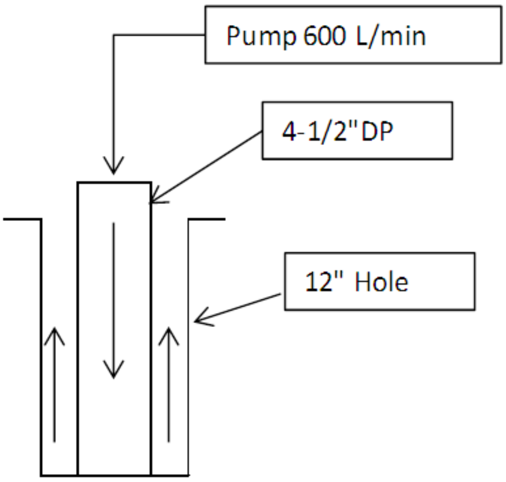
Annular Volume

62.6 L/m

Annular Velocity

(600 L/m) / (62.6 L/m)

= 9.6 m/min



2.8 WEIGHT OF DRILLING TOOLS (TA CODE 2-8)

The elements of the drill string is described in Section 2-4 Rig Accessory of this manual. This section explains how to express the drill string assembly and how to calculate the total weight of the drill string.

2.8.1 DRILL STRING ASSEMBLY

Prior to the decision of drill string assembly, necessary tools shall be listed up with their capacities before the determination of drill string assembly. Example of drill string assembly is shown in ***Table 26***, ***DP:*** Drill Pipe, DC: Drill Collar, ST: Stabilizer
Table 27 and ***Table 28***. These examples are for the mud drilling of 2stages. The 1st stage is drilling by 12-1/4" bit down to 30 m and the 2nd is drilling by 8-1/2" bit down to 100 m. At first, necessary drilling tools for 12-1/4" drilling and 8-1/2" drilling shall be listed up as shown in ***Table 26***. Then, the drill string assemblies are determined respectively for 12-1/4" drilling and 8-1/2" drilling as shown in ***DP:*** Drill Pipe, DC: Drill Collar, ST: Stabilizer
Table 27 and ***Table 28***.

Table 26 List of Necessary Tools for 12-1/4" and 8-1/2" Drilling

Tool	Connection		Unit Length (m)
	Top	Bottom	
4-1/2" DP	3-1/2" IF Box	3-1/2" IF Pin	6
6-1/4" ST	4" IF Box	4" IF Pin	1.2
6-1/4" DC	4" IF Box	4" IF Pin	6
8-1/4" ST	6-5/8" Reg Box	6-5/8" Reg Pin	1.2
8-1/4" DC	6-5/8" Reg Box	6-5/8" Reg Pin	6
8-1/2" Tri-Cone Bit	4-1/2" Reg Pin	-	0.6
12-1/4" Tri-Cone Bit	6-5/8" Reg Pin	-	0.8
Crossover Sub	3-1/2" IF Box	6-5/8" Reg Pin	0.6
Bit Sub	6-5/8" Reg Box	6-5/8" Reg Box	0.6

DP: Drill Pipe, DC: Drill Collar, ST: Stabilizer

Table 27 Drill String Assembly for 12-1/4" x 30 m Drilling

Tool	Connection		Unit Length (m)	Qty.	Length (m)
	Top	Bottom			
4-1/2" DP	3-1/2" IF Box	3-1/2" IF Pin	6	4	24
Crossover Sub	3-1/2" IF Box	6-5/8" Reg Pin	0.6	1	0.6
8-1/4" DC	6-5/8" Reg Box	6-5/8" Reg Pin	6	1	6
8-1/4" ST	6-5/8" Reg Box	6-5/8" Reg Pin	1.2	1	1.2
Sub	6-5/8" Reg Box	4-1/2"Reg Box	0.6	1	0.6
12-1/4" Tri-Cone Bit	6-5/8" Reg Pin	-	0.6	1	0.6
Total Length (m)					33

Table 28 Drill String Assembly for 8-1/2" x 100 m Drilling

Tool	Connection		Unit Length (m)	Qty.	Length (m)
	Top	Bottom			
4-1/2" DP	3-1/2" IF Box	3-1/2" IF Pin	6	14	84
Crossover Sub	3-1/2" IF Box	4"IF Box	0.6	1	0.6
6-1/4" DC	4" IF Box	4" IF Pin	6	3	18
6-1/4" ST	4" IF Box	4" IF Pin	1.2	1	1.2
Bit Sub	4" IF Box	6-5/8" Reg Box	0.6	1	0.6
12-1/4" Tri-Cone Bit	6-5/8" Reg Pin	-	0.6	1	0.6
Total Length (m)					105

2.8.2 WEIGHT CALCULATION

Total weight of the drill string assemblies are calculated for each. The weights of bits, subs, stabilizers can be included in those of driller pipes or drill collars, as they are not heavy comparing to the total weight.

Table 29 Weight Calculation of Drill String Assembly for 12-1/4” x 30 m Drilling

Tool	Unit Weight (kg/m)	Length (m)	Weight (kg)
4-1/2" DP	27	27	729
8-1/4" DC	241	6	1,446
Total		33	2,175

Table 30 Weight Calculation of Drill String Assembly for 8-1/2” x 100 m Drilling

Tool	Unit Weight (kg/m)	Length (m)	Weight (kg)
4-1/2" DP	27	84	2,268
6-1/4" DC	125	21	2,625
Total		105	4,893

As a result, total weight is 2.2 tons for 12-1/4” drilling and 4.9 tons for 8-1/2” drilling. Therefore, with the consideration of 10 % of the safety factor for the stucking, the lifting capacity of the drilling rig shall be not less than 5.4 tons. Furthermore, the total weight of casing pipes shall be considered as well.

2.9 ROTARY BIT ROTATION SPEED AND WEGHT ON BIT (TA CODE 2-9)

2.9.1 ROTATION SPEED OF BIT

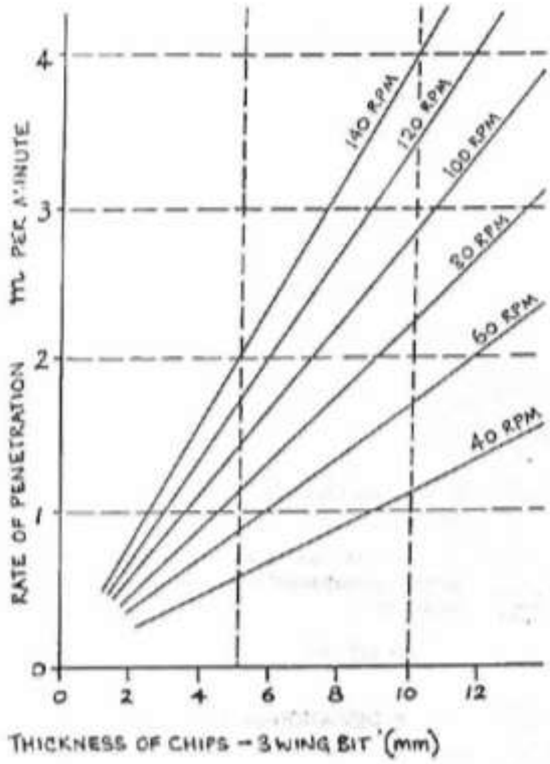
At the commencement of the hole, safe and smooth rotation and feed rates must be aimed for any consideration. When the hole is safely collared and drilling is proceeding, smooth operation continues to be the prime aim, but while maintaining smooth operation, work to achieve the desirable thrust loadings and rotational speed to give correct chip making.

The chip size produced by a rotary bit is controlled by four factors:

1. nature of the formation
2. the way that the bit makes the chip (crushing, cutting, tearing etc)
3. rotary speed
4. penetration rate

Large chips measn better samples and less energy required to penetrate. Larger chips also make chip clearing more difficult.:

1. the formation
2. the drill string
3. the interaction between these and the drilling rig



Source: Australian Drilling Industry Training Committee Ltd

Figure 17 Bit Penetration and Rotary Speed

The penetration rate improves as we increase thrust and rotation speed. But this holds true only while the bit operates correctly. If the bit is overloaded or runs too fast, the bearings break down, the gauge cutters wear rapidly and the chip clearing operation bogs down. For all bits, there is a maximum thrust and speed. For most bits, there is a minimum thrust to make them penetrate correctly.

Figure 17 shows the relationship between bit penetration and rotary speed. However, in DDCA, the range of 30 to 100 r.p.m is employed for the rotation speed of rotary bits.

2.9.2 WEIGHT ON BIT

The weight required on any rock roller bit for effective and Maximum Efficient Rate of Penetration (MERP) varies directly as the compressive strength of material being cut. This is a broad statement which is bascally true but within which there are many variations and exceptions. The heavy weights necessary to drill hard formations are required to give effective crushing force to the bit tooh and probably to keep the tool more or less flat running bottom.

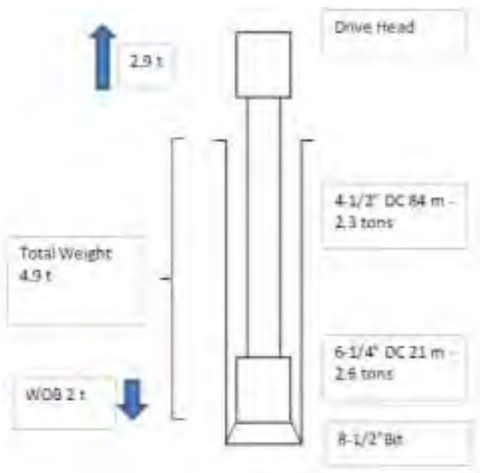


Figure 18 Example of the Calculation of WOB

The weight shall be loaded to to the bit when drilling the hard formations. In general, maximum weight on bit (WOB) is thought to be 1 to 1.5 tons per inch of bit diameter. If a bit is of 8 inches, maximum WOB is estimated to be eight to 12 tons. However, for the drilling of the level of 150 m boreholes, WOB is between the range of 1 to 3 tons. So as not to cause the damage of the drilling tools and the deviation of the hole, the WOB shall be within the weight of drill collar. During drilling, WOB shall be regulated by the lifting force by drive head.

Figure 18 shows an example of the calculation of the WOB for the drilling by 8-1/2" bit with 84 m of 4-1/2" DPs and 21 m of 6-1/4" DCs. The WOB is calculated as the following:

Maximum Weight on Bit (WOB)

2.6 x 0.8 = 2.08 ton

Total Weight of Drill String

4.9 ton

Target WOB 2 ton

Lifting Load by Drive Head

4.9 - 2 = 2.9 ton

The maximum WOB shall be not more than 80 % of the weitght of DCs (2.6 tons), with the consideration of the safety factor. Therefore, the target WOB was decided to be 2.0 tons. Total weight of the drill string is 4.9 ton. In order to regulate the WOB to 2.0 tons, the drill string shall be lifted up by the drive head. Then remaing weight of 2.9 tons are loaded on the bit as the WOB.

2.10 DTH BIT ROTATION SPEED AND WEGHT ON BIT (TA CODE 2-10)

2.10.1 ROTATION SPEED

To start drilling, turn on air rotary slowly. Then feed down slowly until the piston starts operating. Add just enough pulldown pressure to start breaking rock. Make sure the bit does not drift when it first strikes the formation because this can damage the bit buttons. Always check the operation of a DTH tool before running it into a hole. Try it out first on a solid piece of timber at the surface. As the tool approaches the bottom of the hole, proceed and start rotation before putting weight on the bit. The presence of water in the hole when drilling is resumed will not prevent tool operation. Lowering the tool into the hole with the air turned on will force the water out of the hole.

Proper rotation speed is important for long bit life and optimum penetration. The recommended speed ranges from 12 to 40 r.p.m. A slower rotation is used in hard, abrasive formations. A faster rotation is acceptable when drilling in soft, nonabrasive formations. Ideally, the bit should penetrate about 10 mm (3/8 in) per drill pipe revolution. “Rule of thumb” is penetration rate in metres-per-hour x 1.6 to obtain r.p.m about one-half of the penetration rate in feet-per-hour (Adjust up or down several r.p.m to match formation).

2.10.2 WEIGHT ON BIT

When the bit first cotacts the formation, apply minimal weight on the bit. After a few minutes, increase the thrust pressure to allow the tool to run smoothly. The correct optimum weight should be monitored and maintained throughout the drilling operation. As the hole gets deeper and drill pipe is added, the thrust pressure must be reduced to compensate for the added weight of the drill pipe. Hydraulic pressure required to keep the optimum weight on the bit varies from rig to rig.

Principally, whole totoal weight of the drill string shall be balanced by the drill head and WOB shall be less than one ton, so as not to cause the hole deviation. However, WOB and drilling speed shall be carefully regulated by the driller, so that the DTH can catch up the drilling down speed.

3 DRILLING CONTROL (TA CODE 4)

3.1 MUD CONTROL (A CODE 4-1)

The roll of mud circulation is as follows:

- Prevension from wall collapse
- Removal of drill cuttings from the hole
- Prevension from flow-in of groundwater
- Prevension form lost circulation
- Cleaning and cooling of bit
- Reducing the friction of bit rotation

Bentonite is the most general mud stabilizer. Other mud additives are CMC, polimers and dispersant. Viscosiity and density of the mud shall be well controlled by using the marsh funnel and mud balance. Funnel spped shall be approximately 30 seconds and specific gravity shall be not more than 1.2. If the mud is too strong, the cutting separation becomes non effective. Furthermore, it may cause the stucking of the drill string. The separation work from the mud canal is important.

Mud circulation system is composed of mud pump, suction pit, settlement pit and so on. Drillers are required to understand the functions of each component and proper operation of the mud circulation sysmte is important to implement the smooth drilling works. ***Figure 19*** shows the standard layout of drilling Figure 19equipment including the mud pits and canals.

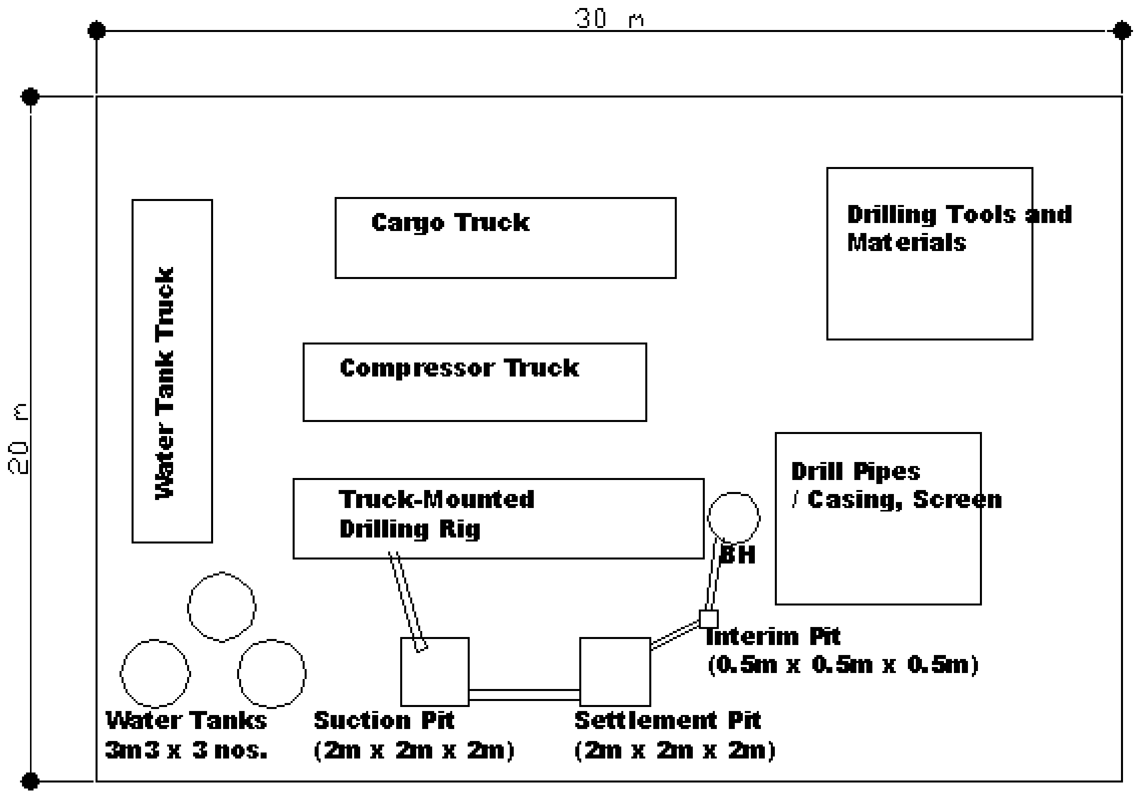


Figure 19 Standard Layout of Drilling Equipment on Site

3.2 MUD PUMP OPERATION (TA CODE 4-2)

The discharge rate of mud pump is important for the removal of the drill cuttings. Usual cares shall be taken on the worn out of the parts of the mud pump, because it decreases the discharge rate. In case that the discharge rate decreases during drilling, drill string shall be raised up to the depth up to the safe depth (in the casing) to check the mud pump.

The pump pressure shall be kept recorded as it is an important parameters to identify the borehole conditions. The variation of the pump pressure indicates the following conditions:

Increase of the pressure:

- Encountering clayey formations
- Mud visicosity and/or density is elevated
- Bore wall collapse
- Drill cuttings remains in the hole
- Bit is covered by the clay
- According to the increase of depth

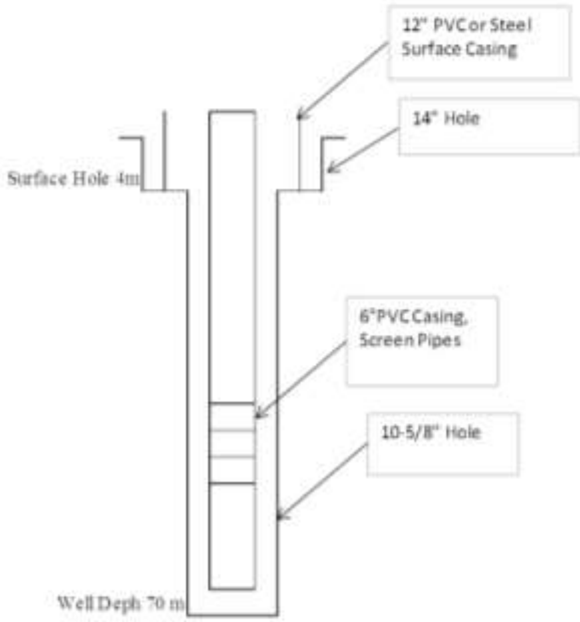
Decrease of the pressure:

- Breakdown of the mud pump
- Mud viscosity and/or density is decreased
- Lost circulation
- Encountering sandy formations

Please refer to Technical Item 2-4 for the further specifications and structure of the mud pump.

3.3 CASING FOR MUD DRILLING (TA CODE 4-3)

The boreholes in sedimentary formation are normally drilled by mud drilling methods in two stages, i.e. surface hole drilling and production hole drilling. Unlike DTH drilling, conductor casing is not installed unless collapsible and/or lost circulation formation exists which shall be protected by the conductor casing. ***Figure 20*** shows an example of the casing program for mud drilling borehole of which production casing and screen pipes are of 6".



The surface casing is required when:

- Surface water must be sealed off
- Unstable formations interfere with drilling, or
- Artesian flows are possible. in this case the surface casing must be cemented

The purpose of surface casing is to isolate freshwater zones so that they are not contaminated during drilling and completion. The surface casing is also necessary for the smooth work around the borehole during the drilling.

PVC casing and screen pipes are used for most of the boreholes in Tanzania. Please refer Technical Item 6-1 for the specifications of PVC casing and screens and Technical Item 6-3 for the installation procedures.

3.4 DRILLING OPERATION FOR MUD DRILLING (TA CODE 4-4)

Figure 20 shows the process of the drilling works by mud drilling method. It includes many processes and drillers are required to acquire lots of knowledge and techniques. Technical Item 1 to 15 covers all the process and drillers can refer to each material to conduct the works.

DDCA has the report forms for the record of the drilling works. Drillers shall keep proper records of their works using these forms. ***Figure 21*** shows an example of well completion form and ***Figure 22*** is another example of well section drawing.

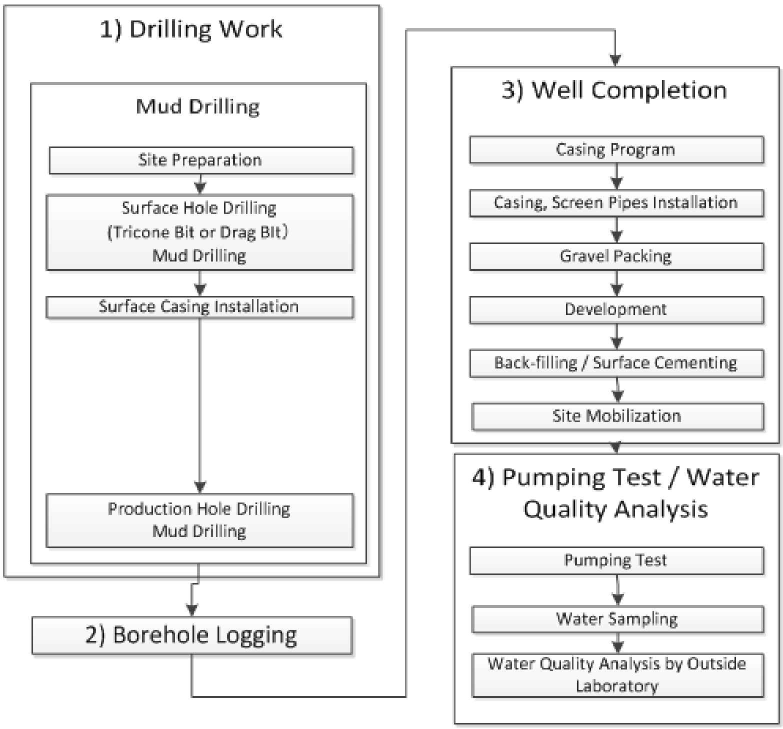


Figure 20 Work Flow of Mud Drilling

DRILLING AND DAM CONSTRUCTION AGENCY
WATER-WELL COMPLETION FORM

Borehole No: TBR 756/2008 **Drilled By (Rig No./Type):** 81
Locación/Área: MSIKITI WA IJUMAA **District:** TABORA TOWN **Region:** TABORA
Name of Applicant & Address: M/S. IGBAR
Date of Commencement: 02.12.2008 **Date of Completion:** 02.12.2008

1. STRATA:

From		To		General Description
m	cm	m	cm	
00	00	04	00	Sand top soil
04	00	06	00	Sandy clay
06	00	08	00	Fractured granite
08	00	12	00	Weathered granite
12	00	24	00	Granite
24	00	30	00	Fractured granite
30	00	34	00	Fractured and weathered granite
34	00	36	00	Granite
36	00	50	00	Fractured granite
50	00	56	00	Granite

2. WATER:
Struck at: 5,38,40 m
W.L. rose to: 02 m 57 cm
Yield tasted: 700 LPH
Water quality to taste: GOOD

3. **DIAMETER DRILLED AND DEPTH:**
8 inch Ø to 56 m 00 cm
..inch Ø to......m.......cm
..inch Ø to......m.......cm
Depth on completion: 53 m 96 cm

4. **CASING/SCREEN LEFT IN HOLE:**
Type: Dia: Length:
uPVC **Casing** 06 **inch** 36 **m** 56 **cm**
........**Casing**.......**inch**......**m**.......**cm**
uPVC **Screen** 06 **inch** 17 **m** 40 **cm**
........**Screen**.......**inch**......**m**.......**cm**
Casing above G.L: 00 m 50 cm
Top of Casing Secured: uPVC Cap
Bottom end of Casing protected with: uPVC Plug

5. **FINISH OF SECTION UNCASED:**
Hole uncased: 02 m 04 cm
Back-filled to: 53 m 96 cm
Filled with: Cuttings **Average size......**
Other Method: Sanitary seal to 5m

6. **GRAVEL SCREEN:**
Gravel Type: Quartz Gravel
Average Size: 2 – 4 mm
Inserted from:53m 96 **to** 05 **m** 00 **cm**

7. **DRILLING METHOD:**
Air Rotary to: 06 m 00 cm
Mud Rotary to:.......m.......cm
Air Hammer to: 56 m 00 cm
Cable-Tool to:........m........cm

MR. TITO MTANDA
Driller in charge signature:

Satisfied this Well has been completed in a manlike manner & drilling regulations have been complied with."

....

MANAGING DIRECTOR:

For: Managing Director
Drilling and Dam Construction Agency
P.O. Box [illegible]
DAR ES SALAAM

Figure 21 DDCA's Well Completion Form

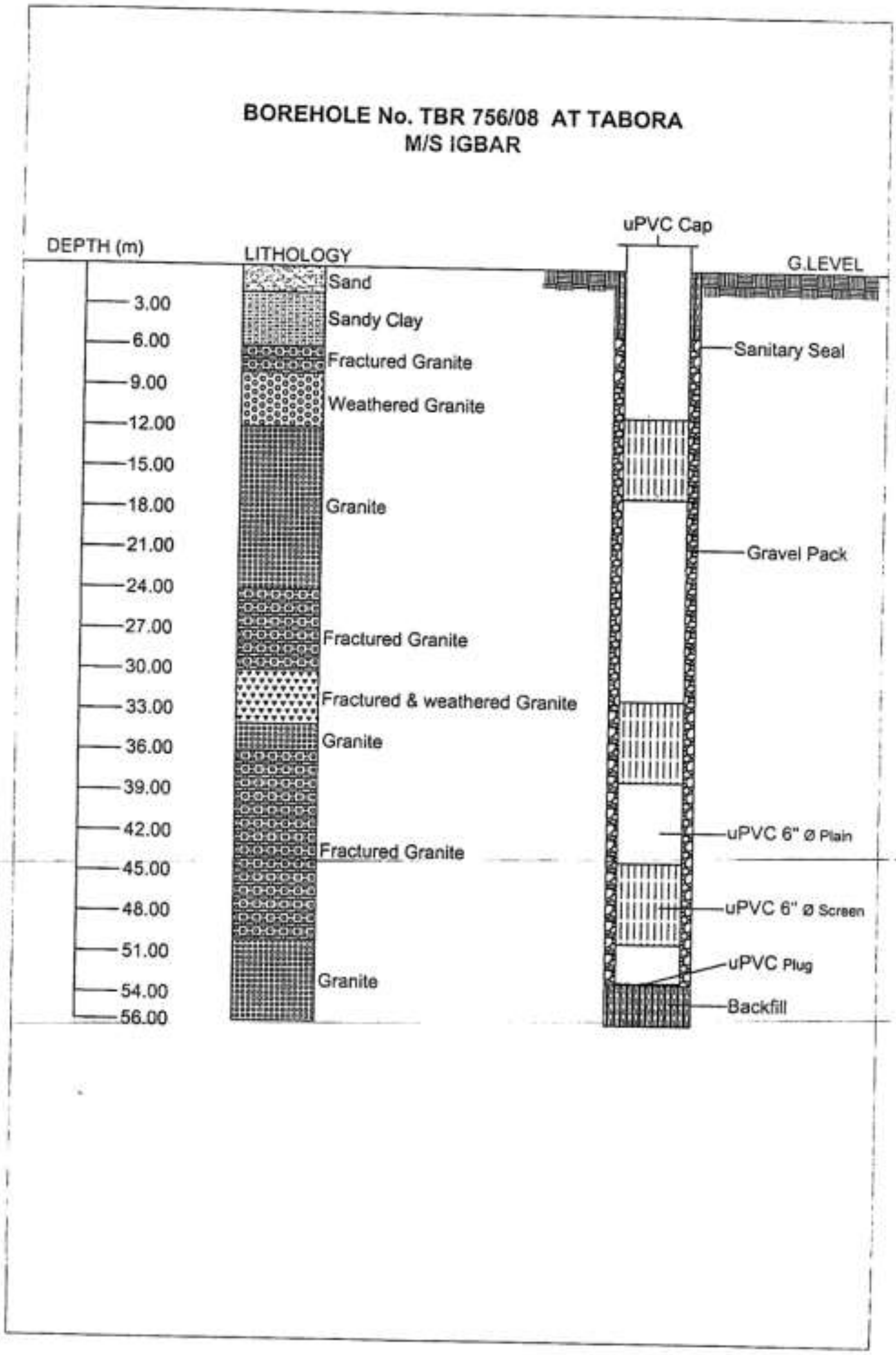


Figure 22 DDCA's Well Section Drawing Form

3.5 BIT CONTROL AND REPARING FOR MUD DRILLING (TA CODE 4-5)

Rotary bits shall be correctly controlled and the proper repair and/or replacement is required. The excessive use of bits over their lifetime brings about the following problems:

- Under gauge of the hole which causes the wearing of bit and/or tool stucking.
- By the wearing of bearings of roller bits, cones falls into the hole.
- Buttons or pieces of tooth fall into the hole.

For the drag bits, periodical repairing on their blades and gauges by welding is needed.

Drillers are required to conduct proper bit record and repairing/replacement using the log sheet as shown in ***Table 31*** .

Table 31 Example of Bit Log Sheet

BIT LOG SHEET					
Type:		Bit Size:		Part No.:	
Bit No.:					
Date of Issue:					
To Rig No.:					
Date of Return:			From Rig No.		
Date	Metrage Drilled w/Bit	Times Sharpened	Diameter or gauge after re-sharpened	Type of Formation Penetrated	Remark Service Record.

3.6 AIR CONTROL FOR DTH DRILLING (TA CODE 4-6)

It can be observed that drilling with Megadrills and Megabits do by far not reach the performance recommended by the manufacturer of the tools. Low penetration rate may result from problem of different nature of operation of Megadrills and bits such as:

- Air supply is not according to requirement resulting in not adequate air pressure in the Megadrill or air volume is not less than 1,200 m per minute or air pressure required for A 53-15 Megadrill not less than 9.0 to 10.3 bar.
- The drill bit is not sharpened properly
- The Megadrill is worn-out, clearance of piston and piston case sealing O- rings worn-out etc.
- Bits are very dully because of overrunning
- The necessary bit weight is not on the bit or there is too much load on the bit (for A 53-15 Megadrills 680 kg minimum weight and 1,600 kg maximum weight (is recommended).
- Rotation of bit is not according to the geological formation and to the expected penetration rate per revolution. Ideally the bit should penetrate 3/8"into the formation of the drill pipe. Generally acceptable revolution per minute are considered with 15rpm to 30rpm
- No use of water injection will create problems of “collaring” or bridging caused by scopage of small amounts of formation water into the hole. To be avoided by injecting 2 to 5 CPM of water into the air stream.
- The “back pressure” created by considerable formation water influx may reduce extremely the penetration rate. To overcome this problem form has to be used in quantities.

Drillers are required to understand the mechanism and function of the air-compressor and the DTH using the operation manual of the manufacturers. They have to consider the static water pressure, back-pressure, annular velocity necessary to remove the cuttings from the borehole and conduct proper operation of the air-compressor.

3.7 AIR COMPRESSOR OPERATION (TA CODE 4-7)

The specifications and structure of the air-compressor are described in Technical Item 2-4. The air-compressor is the major and important equipment for the DTH drilling. Therefore, the drillers are required to acquire the knowledge of the functions, maintenance and operation of the air-compressor. Please refer to other section of this manual related to the DTH drilling, for further comprehension of the operation of the air-compressor.

3.8 CASING FOR DTH DRILLING (TA CODE 4-8)

The boreholes in hard rock formation are normally drilled by DTH drilling methods in three stages, i.e. surface hole drilling, conductor hole drilling and production hole drilling. In general the shallow part in hard rock formation is unconsolidated overburden and is collapsible during air drilling. Therefore, down to 5 to 30 m, sometimes even to 60 m, this overburden shall be drilled by the mud drilling and the conductor casing shall be installed. ***Figure 23*** show an example of the casing program for DTH drilling borehole.

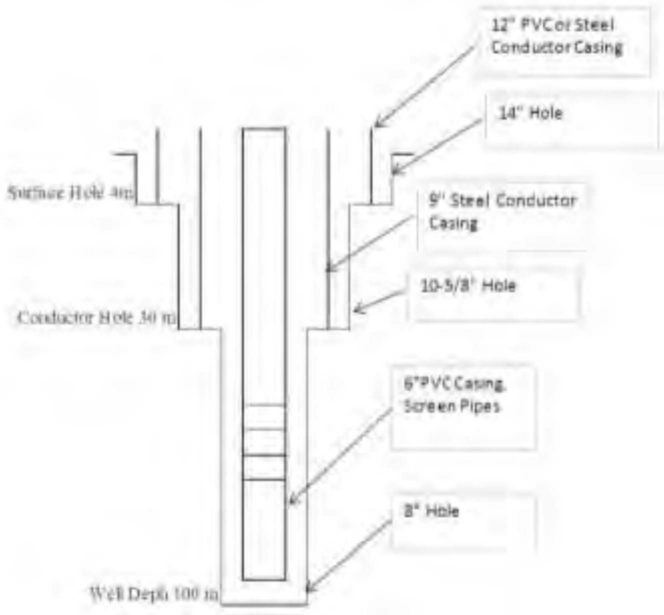


Figure 23 Example of the Casing Program for DTH Drilling Borehole

The surface casing is required when:

- Surface water must be sealed off
- Unstable formations interfere with drilling, or
- Artesian flows are possible. in this case the surface casing must be cemented

The purpose of surface casing is to isolate freshwater zones so that they are not contaminated during drilling and completion. The surface casing is also necessary for the smooth work around the borehole during the drilling.

PVC casing and screen pipes are used for most of the boreholes in Tanzania. Please refer Technical Item 6-1 for the specifications of PVC casing and screens and Technical Item 6-3 for the installation procedures.

The conductor casings are in general of steel and with flush joint. In many cases they are temporary and are to be removed after the completion of the drilling work. The preparation of the conductor casing with sufficient number on site is quite important to obtain the smooth progress of the drilling works by DTH. Please refer to Technical Item 2-5 for the specifications of steel casing pipes.

3.9 DRILLING OPERATION FOR DTH DRILLING (TA CODE 4-9)

Figure 24 shows the process of the drilling works by mud drilling method. It includes many processes and drillers are required to acquire lots of knowledge and techniques. Technical Item 1 to 15 covers all the process and drillers can refer to each material to conduct the works.

DDCA has the report forms for the record of the drilling works. Drillers shall keep proper records of their works using these forms. These forms are commonly used between mud drilling wells and DTH drilling wells. Please refer to Technical Item 4-4 for the examples of well completion forms.

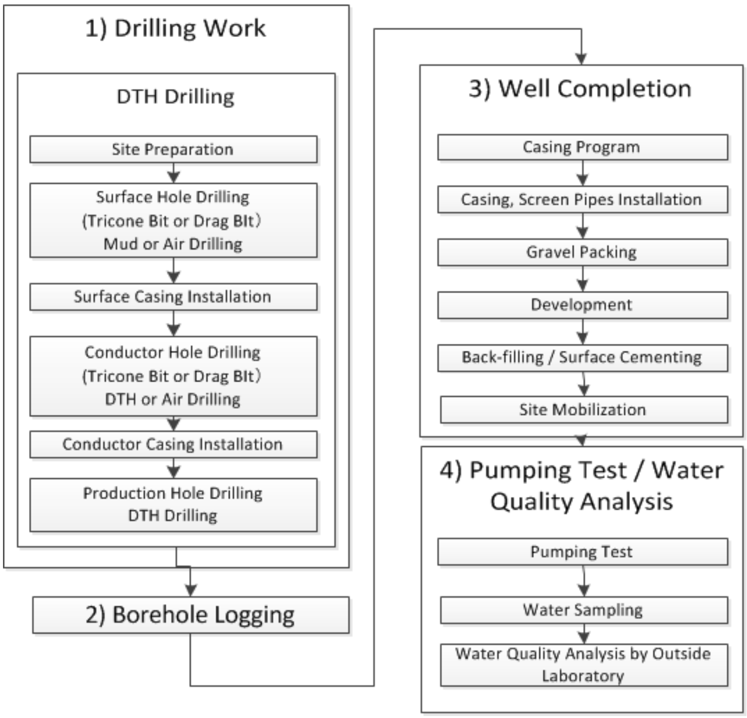


Figure 24 Work Flow of DTH Drilling

3.10 BIT CONTROL AND REPARING FOR DTH DRILLING (TA CODE 4-10)

DTH bits shall be correctly controlled and the proper repair and/or replacement is required. The excessive use of bits over their lifetime brings about the following problems:

- Under gauge of the hole which causes the wearing of bit and/or tool stucking.
- Buttons or pieces of tooth fall into the hole.
- Progress of drilling decreases when the buttons of bits are worn.

Periodical sharpening shall be conducted to keep the good drilling progress. Please refer to Technical Item 2-3 for the repairing of DTH Bit.

Together with Bit Log Sheet (Technical Item 3-5), DTH tool shall be controlled using the DTH log sheet as shown in

Table 32 Example of DTH Log Sheet

DTH LOG SHEET				
Model:				
No. of Tool				
Date of Issue:			To Rig No.:	
Date of Return:			From Rig No.:	
Date	Hours tool/Run	Metrage Drilled	Type of Formation Penetrated	Remarks, Cleaning Servicing Tool

4 BOREHOLE LOGGING (TA CODE 5)

4.1 BOEREHOLE LOGGING INSTRUMENTS (TA CODE 5-1)

4.1.1 GENERAL INFORMATION ABOUT BOREHOLE LOGGING

Many of the geophysical survey methods for groundwater exploration, which are carried out on the ground-surface, can also be used within a borehole in vertical direction.

- **Resistivity well logs – RES**

  Resistivity logging, usually called electric logging, provide a useful tool, and the information gained increases in general the effectiveness of the well design. A good log gives a detailed picture of the character and thickness of the various formations at the well site and an indication of the water quality by measuring the apparent resitivity of the subsurface material cross-sectioned in the borehole. Electric logging offers several important advantages, such as locating the top and bottom of each distinct layer, determining relative water quality, and differentiating fresh hard rock layers from fractured and weathered parts. A limiting factor in electric logging is that the method can only be done in boreholes that do not have casings and are filled with drilling fluid or water. The method is therefore best to be carried out in rotary mud circulation boreholes.

  Please note that in low-yield boreholes in hard rock formation, it is advised to carry out borehole logging the other morning after drilling was completed to allow the water level to rise for one night due to low recharge conditions.

- **Spontaneous Potential (SP) Logs**

  Self-potential or spontaneous potential logs are always run in conjunction with the electric logs. Spontaneous potentials are naturally occurring electrical potentials (voltages) that result from chemical and physical changes at the contact between different types of formation material. In a borehole, potentials also occur between the drilling fluid in the borehole and the fluid in the formation and also between the drilling fluid and the filter cake on the borehole wall.
  As in the case of drilling DTH in Swaziland, where fluid in the borehole is the same groundwater as in the formation, there cannot be a difference in the potential of both waters (fluids). In general SP logs make only sense in boreholes filled with drilling fluid (drilling mud).

  To measure SP at various depths, an electrode is lowered into an uncased borehole filled with drilling fluid as one electrical terminal. The terminal of the arrangement is connected as a ground terminal at the surface, which is often placed in the mud pit. The down-hole electrode is usually negative with respect to the surface electrode. Any current in the circuit, which results from electrochemical action between the drilling fluid and the formation or formation water, is conducted to the surface through the drilling fluid column. The milli-voltmeter connected between the electrodes, therefore, measures the drop (difference) in potential in the drilling fluid column between the down-hole electrode and the surface electrode.

  As the down-hole electrode is moved up and down in the borehole, the meter registers variations in spontaneous potentials of the different formations. A curve showing these potentials plotted against borehole depth provides what is called the SP log. Although the SP log may indicate the permeable zones, there is no definite relationship between the magnitude of the SP deflection and the permeability and porosity of the formation. Variations shown by the SP curve are interpreted along with variations in apparent resistivity shown by the resistivity curve. The two curves together constitute what is usually called the electric log.

  The SP log is plotted on the left-hand of the curve sheet, where it can be compared easily with the resistivity log on the right-hand side.

- **Natural Gamma Ray (GR) logs**

In gamma logging, measurements are made of naturally occurring radiation coming from the materials encountered in the borehole. The record of gamma radiation is used as a qualitative guide for correlation of formations and permeability of formations.

Gamma radiation is emitted from certain elements in geologic materials that are unstable and decay spontaneously into other more stable elements. Gamma rays are similar to X-rays in that having a great ability to penetrate other materials (for example even steel casings), but gamma rays have a shorter wave length.

Certain radioactive elements occur naturally in igneous rocks (granites, gabbros) and metamorphic rocks (slate, mica-schist, gneiss) and as depositional particles in sedimentary rocks. Clays and shale contain high concentration of radioactive isotopes, usually potassium. Sands and gravel on the other hand contain primarily silica, a stable substance, and therefore emit only very low levels of radiation.

So gamma ray curves of silica rich, light colored, acidic rocks, such as granites, gneiss and sandstones are showing deflections in the curve to the left.

Gamma ray logging has a fundamental advantage over electrical logging. It can be done either in cased wells or in open boreholes containing air, water, or drilling fluid. Therefore with gamma ray it is possible logging existing wells, where logs have been lost or were not carried out. The gamma probe is very simple, having a detecting element, which is measuring the pulses given off by the radioactive materials in the different formations. The radiation extensity is expressed as the average number of counts per second (cps).

The minerals normally found in sedimentary materials such as clay, silt, sand, or sandstones contain small amounts of radioactive potassium-40, and decay products of uranium and thorium. Potassium is an important constituent of clay minerals, mica, feldspar, and shale. Quartz sand contains no potassium or radioactive potassium-40. Quartz sand formations emit gamma-rays at extremely low levels. Normally the gamma logs show more cps at depths, corresponding to clay or shale layers and few cps at depths corresponding to sand or sandstone layers, if the sand is mostly consisting from quartz.

4.1.2 Operation of Borehole Logging

Components of the equipment of the Geologger 3030:

- Power winch 3895
- Geologger 3030 machine
- Combination Probe (GR, SP, RES)
- Sheave, sheave stand and supporting legs
- 2 Batteries 12 V
- 2 Surface electrodes
- Power supply cords
- Cable for Geologger 3030 to power winch
- Cable for Geologger 3030 to sheave

Connection of the equipment:

1. Join up the components of the probe (GR + SP/RES) then seal the joint with insulation tape
2. Connect slowly the winch connector to the probe turning slowly until there is a click sound, and then lock the link
3. Connect the battery to the power winch
4. Sheave stand is then put over the borehole and sometimes there might be a need for the sheave's stand additional / support legs in case, when the temporary casing is more than 30 cm above the ground
5. Then wind the cable from the winch, while the probe lies on the ground, to the sheave wheel and the direction of the wheel will be decided by the winding of the cable. The

winding of the cable should be in a cross manner and sometimes, just wind it straight. Then use the lock to prevent any slippage. Lock the probe cable with the lock knob from the wheel to avoid any slippage of the cable from the wheel and getting damaged

6. Connect the cables from power winch and sheave to connector panel of Geologger
7. Connect the earth electrodes to the connector panel and then to the ground with the B-near (black) the borehole- and the N-30m (red) maximum away from the borehole and they should be connected to wet ground.
8. After all the connection from the connector panel has been completed and the setting of the sheave then the probe is put inside the borehole. Then connect the cable from the Geologger to another battery.

Operation of the equipment:

Set the probe into the borehole and knowing the casing top above ground level, you will know exactly the top of the spring of the probe would set level with ground level.

Set the power switch "ON" and the menu will be displayed at the LCD display. As the menu items are displayed, they will respond to function keys shown to the left of the menu, F1 to F4.

First step

For the display and the setting of date and time, observe the following procedures:

- Choose date and time by pressing F1
- Setting the date by pressing the key (*) star. This enables you to set the date, "YY MM DD", by putting in the figures from the keyboard.
- Set the time by pressing the hash key (#). This enables you to set the time, " HH MM SS", by putting in the figures from the keyboard. Then enter.

Second step:

- Choose system by pressing F4
- System check by pressing F1

This enables the machine to check that everything is functioning well and if it is in order. It will let you know in case, which part of the system is not ok.

Note: If there is an error, for example with the floppy disk drive, it will tell you where the error is, and all you have to do, is to check, if the floppy disk is inside and then slightly press or move it sideways. Then cancel and restart system check.

Third step:

- Choose measure by pressing F3
- Measure by pressing F1

Depth input will appear, and then change depth to zero and then press enter. Sign change due to the direction of probe movement from sheave by pressing F1, if necessary – then press enter.

- Then set the gamma range, which is normally 0. 2K cps by pressing F3 – then press enter
- The ampere range is automatically set.
- Input sampling interval is normally every 10 cm, but can be change to other measuring interval.
- On the display will appear >>Reset data & start. Just press enter.
- After measuring press the enter key.
- Enter ID No. of the borehole. Then enter.

- Print out click play back on F2
- Input of ID No. This helps to know the file, in which the recorded data are stored on the floppy disk. This is entered with three figures e. g. M2-10-2, ID No. is 001 when measuring down and 002 when measuring up. With more reference to the recorded data, there is a sheet that needs to be filled for ID No. and borehole No.
- Depth scale selection is normally 1/500, but select by pressing F4.
- Selection of gamma scale can be selected from the keyboard from 1 to 9.
- Selection of resistivity scale can be selected from the keyboard from 1 to 9.
- Selection of Spontaneous Potential (SP) scale can be selected from keyboard from 1 to 5.

Please note for the scale selection of the different methods, it is important to observe constantly the measuring keyboard, while driving the probe down. Then you know the scale in which the measured values, ohmmeter for RES, mV for SP and cps for GR, are lying and subsequently you choose the appropriate scale for the print out process. The pictures of ***Figure 25*** shows the above procedures.

1.Measuring of the water level before Logging

2. Preparation of the Loging Equipment

3. Outlining the principles of the borehole-logging methods

4. Explaining the installation of sheave stand on top of the borehole

5. Arrangement of the logging equipment

6. Explanation of how to connect the cables to the equipment

7. Explaining the probes

8. How to insulate the probes

9. Connecting the probe to the winch

10. Inserting the probe into borehole

11. Explaining operation and measurementwith Geologger

12. Carrying out the borehole logging

13. Trainee personnel running the borehole-logging

14. Explanation of logging interpretation and casing plan

Source: JICA's Water Supply Project in Swaziland

Figure 25 Work Procedure of Borehole Logging (Geologer 3030)

4.2 INTERPRETATION OF BOREHOLE LOGGING RESULTS (TA CODE 5-2)

4.2.1 INTERPRETATION OF BOREHOLE LOGGING RESULTS

- **Interpretation of electric logs**

The electric log cannot be used to qualitatively identify the material encountered in the borehole, because the measured resitivity is a function of various different parameters, such as composition of the drilling mud or the fluid in the borehole, fluids in the formation, diameter of the borehole and the distance of the electrodes within the measuring probe. Depth related rock samples recovered during the drilling (drilling cuttings) are required for positive identification of specific geological formations. Dry formations are poor electrical conductors and show very high resistivities as well as fresh and dense igneous, metamorphic and volcanic rocks, such as granites, granodiorites, amphibolites, gneiss, dolerites, basalts and ryolites. Saturation of a formation reduces its resistivity. The reduction again is partly controlled by the porosity of the formation.

The type of material is only factor, which is influencing the resistivity. Water in the pore space is always mineralized differently due to the material of the formation and it's chemical composition. So various different factors are influencing the resistivity and experience is an important factor in the interpretation of electric logs. Knowledge of the general trends and the spectrum described above are also very important. In the hard rock formation of Swaziland high resistivities are usually indicating dense and dry hard rock types, whereas curves changing to lower resistivity values are indicating fractures and fissures and weathered formations, which can be filled with groundwater.

- **Interpretation of SP logs**

Interpreting SP logs is generally very difficult and it makes only sense to analyze logs which were carried out in an uncased borehole filled with drilling fluid and in a borehole having distinctive clay layers to provide a so called baseline (clay line). Please note here that SP logs published from oil-field works are completely different from SP logs run in water-wells. It is important to understand the differences between oil-well and water-well SP curves. In general groundwater associated with oil is salt water. The electrical conductivity of this water is extremely high in comparison with the conductivity of the water in the drilling fluid.

Groundwater suitable for drinking water purposes has low dissolved solids, on the other hand, and therefore has a much lower conductivity than oil-field brine. Its electrical conductivity may be about the same as, or even less than, the conductivity of water in the drilling fluid. Thus, the electrochemical reaction between the formation water and the drilling fluid is quite different, depending on whether the formation water is considerably more salty than the drilling fluid (oil-field condition), or whether the formation water has about the same salinity as the drilling fluid (water-well condition). When a permeable formation (aquifer) contains salt water and the drilling fluid is made with fresh water, the SP normally shows a relatively large deflection to the left in relation to the clay baseline. The SP deflection opposite the same formation containing fresh water, however, would be relatively small. Another way to describe the difference is to note that the formation with salt water shows a high negative potential in relation to clay layers, whereas the formation with fresh water shows only a slight negative potential. Some helpful observations in interpreting SP logs for formation with fresh water:

- It is often difficult to interpret a SP curve at shallow depth. SP deflections are more pronounced in moderately deeper to deeper wells because, as depth increases, the ground-water tends to become more highly mineralized.
- The first step in interpretation is to establish a clay baseline (shale baseline) on the log. If clay layers are not present, the SP log add little information to the interpretation. For many wells, the SP curve may be of little value, because variations in the curve may be insignificant.
-

- Note deflections to either the left (negative) side or the right (positive) side of the clay base-line. Formations having deflections to the left, generally indicate groundwater having higher chemical activity than formations having deflections to the right. These deflections indicate the positions and thickness of aquifers containing fresh water. Deflections in the SP curve may be insignificant unless the formation has at least a thickness of 1 – 1. 5 m.
- Conclusions drawn from the SP curve will generally correlate with data from the resistivity curve, although the SP curve will usually move in opposite direction.
- The clay baseline may shift gradually or abruptly at increasing depth for no apparent reason.
- SP curves should always be used in conjunction with resisitivity or other logs, because it may be particularly difficult to interpret the curves.

- **Interpretation of Gamma Ray (GR) logs**

In the hard rocks, we can say simply that silica rich, light colored, acidic rocks like granites, gneiss, contain less radioactive decaying minerals and showing less cps, than rocks with less silica content, but high in micas, dark colored, basic rocks, like diorites, gabbros, amphibolites, shales contain more radioactive decaying minerals, showing more cps.

A problem of interpretation is related to the borehole diameter. As we know, gamma ray can only be detected around the borehole wall into the formation with a distance of about 0. 3 m. Where caving clay or shales are encountered and a wash-out occurs, the gamma ray log will indicate low cps opposite of the enlarged section of the borehole. Thus the log will appear to indicate a sand- or granite formation. Borehole samples, the driller's log, and a caliper log can be used to minimize this difficulty in interpretation.

4.2.3 Determination of Screen Position

After having successfully carried out the borehole-logging operation, the casing plan has to be established. As described earlier, in certain low-yielding wells it might be suitable to carry out the logging the other day, allowing the low recharging water table to rise to the static level. The following information is necessary to establish a sound casing plan:

- Situation of the static water level after completion of drilling
- Depth of various or single water strikes
- Description of the drill cutting samples
- Penetration rate records
- Measurements of water quantities at various depths
- Information about the stability of the borehole wall
- Drillers general observation of fracture zones and water strikes

Generally, high yielding water wells with distinctive, groundwater producing fractures zones need only a limited quantity of screen length opposite of the fractures. Low yielding wells however, or wells with a certain number of micro fractures need a longer screen length to exploit groundwater as much as possible from every fracture present. In order to achieve a hydraulically good connection between the well and the aquifer(s), it is good practice to install one screen section only, for better inflow conditions of the groundwater into the well.

For a more safe installation of the well assembly into the well, it is common practice to drill some 1-3% deeper than the depth, at which it is intended to place the bottom cap of the casings. The following pipe-lengths are available to install within the project:

- Plain casing length of 5.72 m
- Plain casing length of 2.81 m

- Plain casing length of 0.93 m
- Plain screen length of 2.81 m

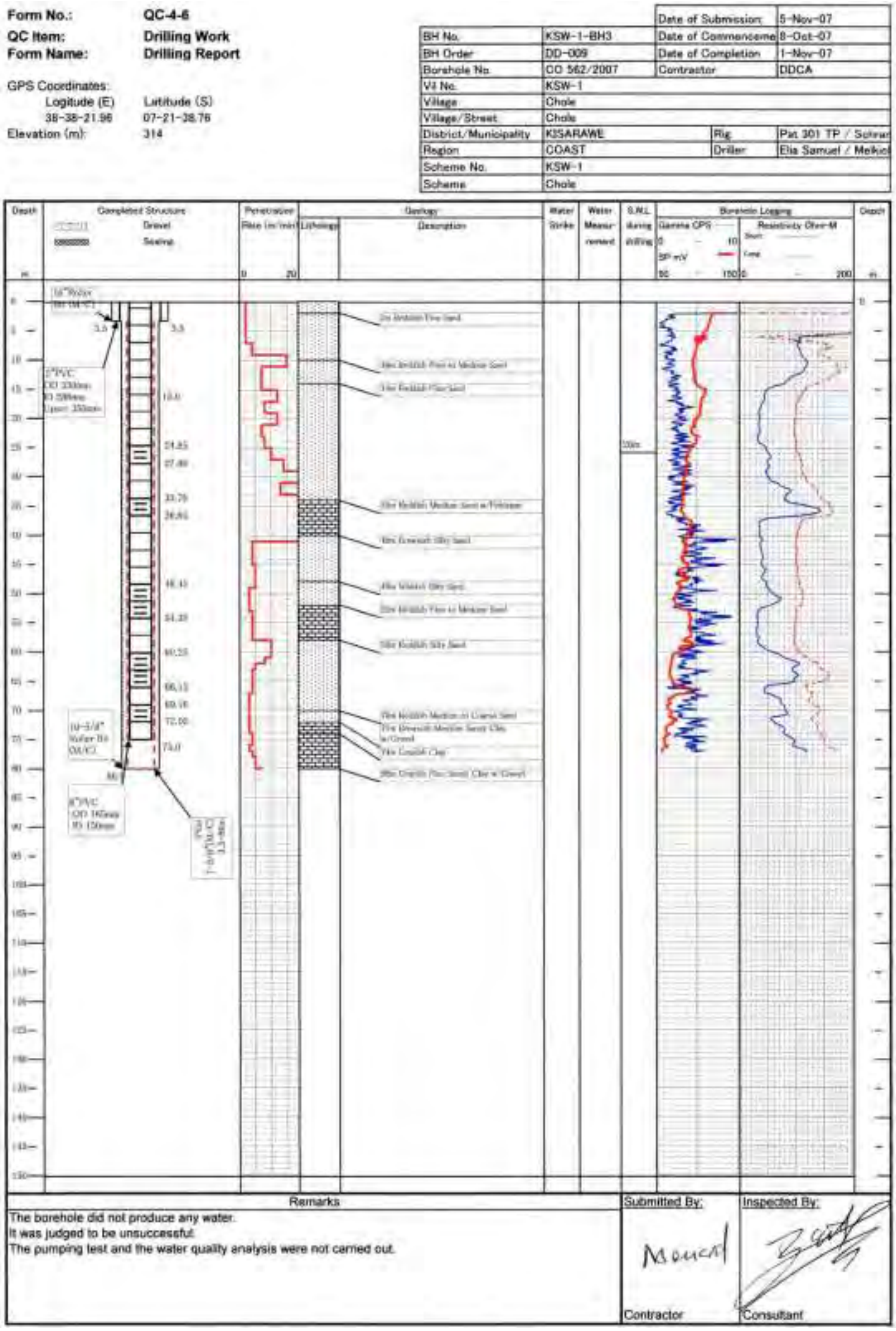
The depth calculation of the casings and screens to be installed into the borehole should start from the bottom to the top of the borehole, indicating as well the portion of casings, which is going to stand over the ground surface. Knowing from the records the height of the drilling table of the drilling rig above ground surface, it is possible to indicate exactly the casing depth.

Screens need to be placed opposite of groundwater bearing zones (aquifers) and not shallower than the first water strike, which was reported during drilling. The project is not allowing the installation of screens at a shallower depth than 20 m below ground surface.

Generally on top of the bottom cap (lowest part of the well) a so called sedimentation pipe or sump pipe has to be installed, being a plain casing pipe with 2.81 m length.

Centralizers have to be installed around casing and screens in the depth where gravel pack is intended to be placed, in order to keep the pipes centrically in the borehole and allowing the gravel pack to be placed evenly around the screen pipes.

Figure 26 shows the example of logging results and casing program for a borehole in sedimentary formation in Kisarawe region. ***Figure 27*** shows the one for a borehole in hard rock formation in Bagamoyo region. Principally, resistivity shows the high value at the position of the aquifer in sedimentary formation. On the contrary the resistivity of the aquifer in hard rock formation becomes higher than the formation with lower water contents.



Form No.: QC-4-6
QC Item: Drilling Work
Form Name: Drilling Report

GPS Coordinates:
Logitude (E) 38-38-21.96 Latitude (S) 07-21-38.76
Elevation (m): 314

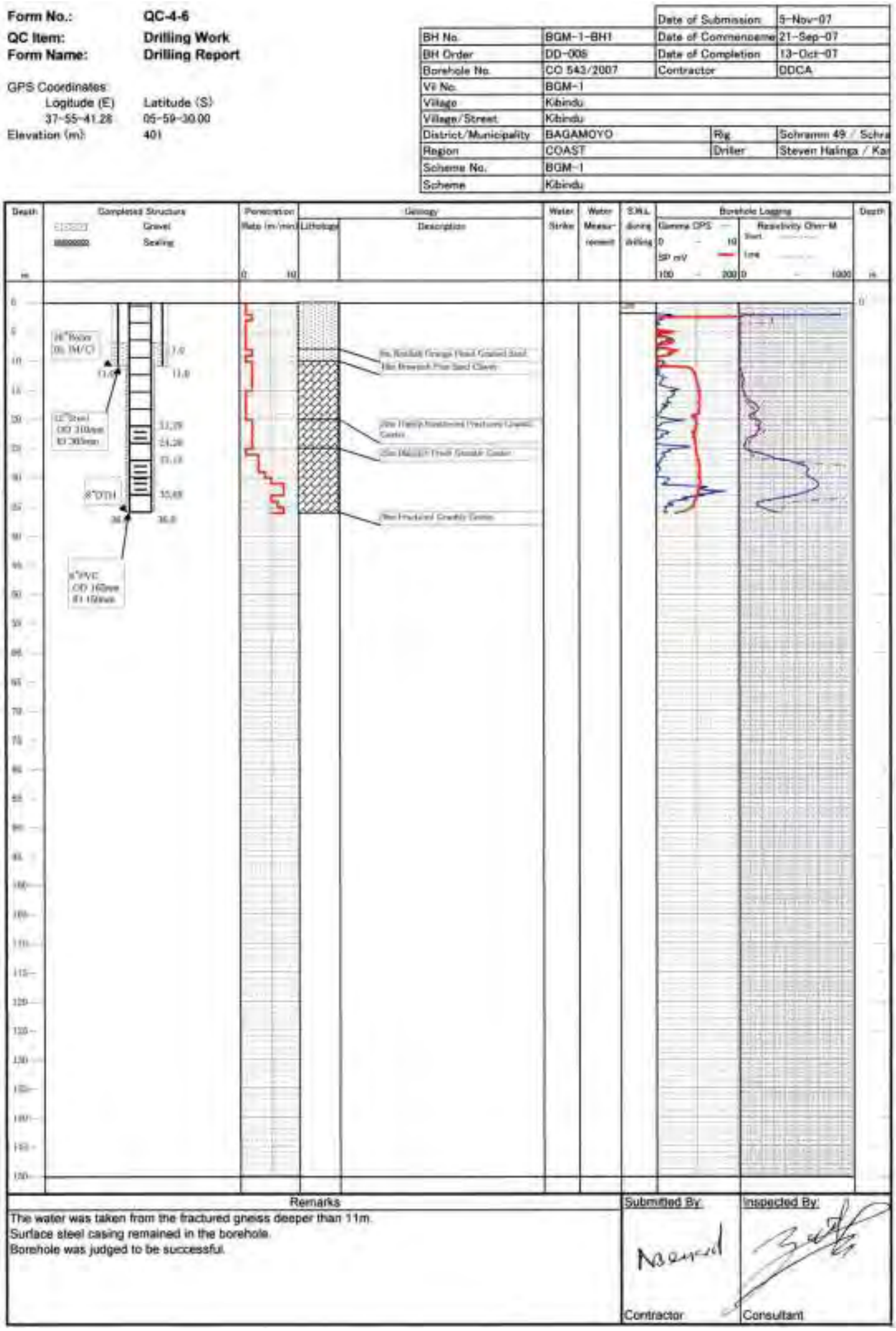
		Date of Submission	5-Nov-07
BH No.	KSW-1-BH3	Date of Commenceme	8-Oct-07
BH Order	DD-009	Date of Completion	1-Nov-07
Borehole No.	CO 562/2007	Contractor	DDCA
Vil No.	KSW-1		
Village	Chole		
Village/Street	Chole		
District/Municipality	KISARAWE	Rig	Pat 301 TP / Schrar
Region	COAST	Driller	Elia Samuel / Melkio
Scheme No.	KSW-1		
Scheme	Chole		

Depth | Completed Structure | Penetration Rate (m/min) | Geology: Lithology, Description | Water Strike | Water Measurement | S.W.L. during drilling | Borehole Logging: Gamma CPS, SP mV, Resistivity Ohm-M | Depth

Remarks
The borehole did not produce any water.
It was judged to be unsuccessful.
The pumping test and the water quality analysis were not carried out.

Submitted By: Contractor
Inspected By: Consultant

Figure 26 Example of Logging Result and Casing Program (Sedimentary Formation)



Form No.: QC-4-6
QC Item: Drilling Work
Form Name: Drilling Report

GPS Coordinates
Logitude (E) 37-55-41.28
Latitude (S) 05-59-30.00
Elevation (m): 401

		Date of Submission	5-Nov-07
BH No.	BGM-1-BH1	Date of Commenceme	21-Sep-07
BH Order	DD-006	Date of Completion	13-Oct-07
Borehole No.	CO 543/2007	Contractor	DDCA
Vil No.	BGM-1		
Village	Kibindu		
Village/Street	Kibindu		
District/Municipality	BAGAMOYO	Rig	Schramm 49 / Schra
Region	COAST	Driller	Steven Halinga / Ka
Scheme No.	BGM-1		
Scheme	Kibindu		

Remarks
The water was taken from the fractured gneiss deeper than 11m.
Surface steel casing remained in the borehole.
Borehole was judged to be successful.

Submitted By: Contractor
Inspected By: Consultant

Figure 27 Example of Logging Result and Casing Program (Hard Rock Formation)

5 GRAVEL PACKING (TA CODE 7)

5.1 DETERMINATION OF GRAVEL SIZE (TA CODE 7-1)

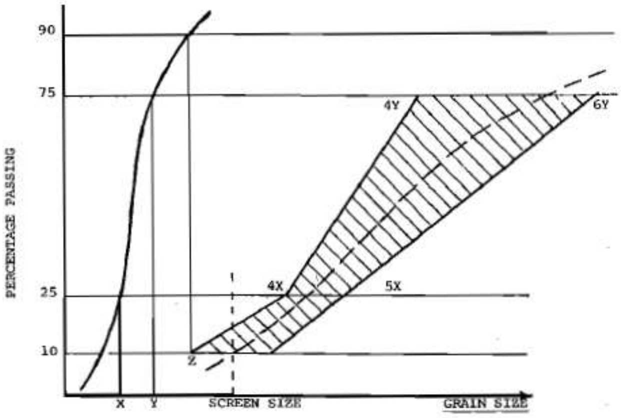
Various parameters shall be considered for the design of gravel pack such as aquifer characteristics,screen size, discharge rate, hole diameter and so on. The size of the gravel shall be principally less than the size of the slot of the screen. The velocity shall be considered upon the decision of the hole diameter so as not to cause the sand production.

The steps necessary to design a gravel pack are as follows (Refer to ***Figure 28***):

1. Read off the 25 % and 75 % grain size values of the percentage of material passing and multiply them by 4 and 5, and 4 and 6 respectively. Plot these results on the graph.
2. Draw connecting lines through 4X and 4Y and 5X and 6Y.
3. Transfer the position of the 90 % passing to the 10 % passing position for the same graph size. This point then becomes Z.
4. Complete the line 4Y – 4X –Z.

   An envelop has now been defined (shaded area). The gravel pack analyses should fall within this envelop (except at its extreme ends). Search around for suitable rounded gravel which will fall within this envelop or can easily be adjusted (by addition or subtraction of sand or gravel) into the envelop, e.g. broken curve – natural gravels of the ideal type are difficult or time consuming to find, hence the envelop.

   Select a screen size to pass 10 % of gravel pack and round up to nearest 0.1 mm (100 micron).



Source: National Waterwell & Drilling Association of Australia

Figure 28 Example of Gravel Pack Design

To sieve analyse a sand sample (Refer to ***Figure 29***):

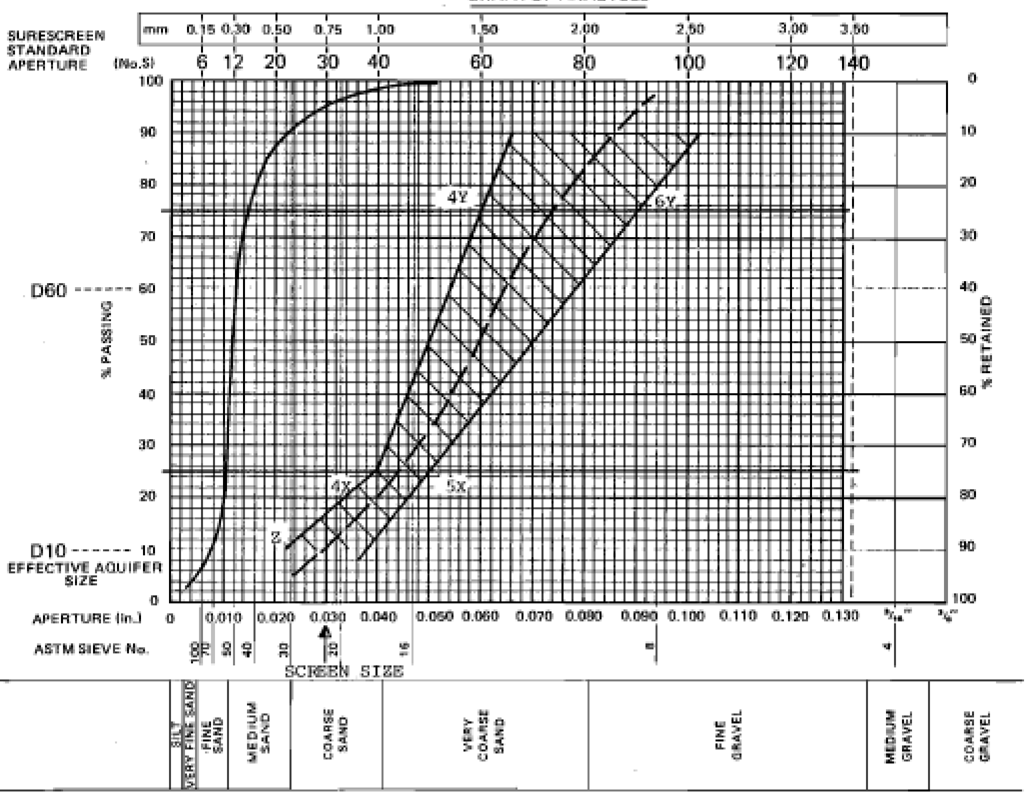
1. Select a sand sample and thoroughly dry it (a clean BBQ plate is ideal for drying). Extreme heat should be avoided since it may cause breakage of the grains. The sample quantity can be any amount, but about 0.8 to 1.0 kg is convenient.
2. Weight the sample.
3. Arrange sand sieves according to aperture, largest opening at the top, smallest at the bottom, and place pan on bottom. Pour in sand sample and shake sieves.
4. Weigh the quantity trapped on each size (largest to smallest) and the bottom pan.
5. Add the individual quantitie and compare the figure with the original smaple weight. If less than 5 % difference) proceed with calculation. If greater than 5 %, look for and correct the mistake, or start again.
6. Complete cumulative percentage retained as per Sieve Analysis sheet.
7. Plot sieve size versuscumulative percentage passing on Sieve Analysis sheet.

SIEVE ANALYSIS

TOTAL SAMPLE WEIGHT (gms)				
ASTM SIEVE No.	APERTURE		CUMULATIVE	
	in.	mm	WT. RETAINED (gms)	% RETAINED
3/8"	0.375	9.53		
4	0.187	4.76		
8	0.094	2.38		
16	0.047	1.19	9	1
20	0.033	0.84	35	4
30	0.023	0.60	78	9
40	0.016	0.42	183	21
50	0.012	0.30	409	47
70	0.008	0.21	765	88
100	0.006	0.15	810	93
TRAY			870	100

SUGGESTED SCREEN SLOT 0.60mm
% RETAINED 90% of pack material

GRAPH OF ANALYSES



Source: National Waterwell & Drilling Association of Australia

Figure 29 Example of Sieve Analysis Sheet

5.2 CALCULATION OF GRAVEL VOLUME (TA CODE 7-2)

Drillers are required to acquire the calculation method of the volume of gravel including the safety factor to be considered according to the conditions of each borehole. The miscalculation of the gravel volume will bring about the interruption of the drilling work. Furthermore, insufficient volumeof the gravel can be the cause of the turbidity of the pumped water after the delivery to the client.

This section gives an example of the gravel calculation for a borehole design shown in ***Figure 30***. The borehole was drilled down to 100 m and casing was planned to be installed down to 90 m. The top of screen is 40 m and the gravel is to be packed up to 30 m from the ground level. The volume of the gravel is calculated as described below:

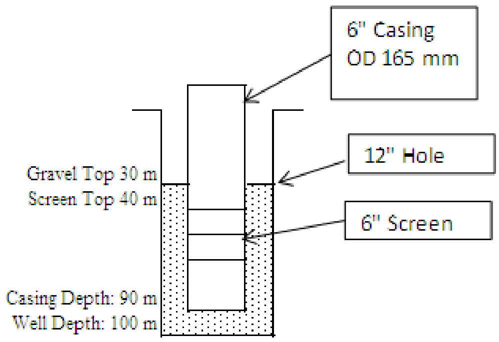


Figure 30 Example of the Gravel Calculation

1) Bore Volme

12" Hole

3.14 x (12 x 25.4)^2 /4,000

72.9 L/m

6" PVC Casing OD 165 mm

3.14 x 165^2/4,000

21.4 L/m

2) Annular Volume

Between 12" Hole and 6" PVC Casing

72.9 L/m - 21.4 L/m

51.5 L/m

3) Gravel Volume at the Bottom Uncased

72.9 L/m x (100 m - 90 m) x 1.2 (Safety Factor)

874.8 L

4) Gravel Volume In Annulus between 12" Hole and 6" PVC Casing

51.5 L/m x (90 m - 30 m) x 1.2 (Safety Factor)

3,708 L

5) Total Gravel Volume

874.8 L + 3,708 L

4,583 L

The gravel is to be packed in two parts of the borehole, i.e. the uncased bottom from 90 m to 100 m and the annular space between 12” hole and 6” PVC casing. With the consideration of the enlargement of the drilled hole according to the geological conditions, safety factor of 1.2 is taken. The total gravel volume is calculated as 4,583 L.

5.3 GRAVEL PACKING (TA CODE 7-3)

5.3.1 GRAVEL PACKING PROCEDURES

When the well assembly is successfully installed into the borehole and the assembly is still hanging in the hole, the annular space between casing and screens and the borehole wall has to be filled with filter gravel. The filter gravel is also called gravel pack or formation stabilizer. The gravel is normally well graded in relation to the grain size of the aquifer material and is to filter the entering groundwater and holding back fine material from the formation to enter the well. For borehole drilled into rock formation, a gravel pack with a grain-size of 3-5 or 3-6 should be installed.

Figure 31 Installation of Gravel Pack

The volume of the gravel to be poured into the well has to calculate accurately. The gravel pack shall be installed at least 10 m above the depth of the highest screen. The drilling diameter of 8 ½" equals a volume of 36.59 l/m. The volume of the PVC pipe with a diameter of 165 mm equals 21.37 l/m has to be deducted from the volume of the drilling diameter. The volume of the annular space comes then to 15.22 l/m. One sack of filter gravel has a volume of about 30 l. With one bag of filter gravel almost 2 m of annular space between pipes and borehole wall can be filled.

It is always good practice to have some 20 % more gravel on site than calculated, because some parts of the formation could have washed out fractures or has been caved out by the drilling process.

Figure 32 Measurement of Gravel Top

The installation of the gravel has to be done slowly and in careful manner to allow the gravel to pour into the borehole with a most even flow rate (See ***Figure 31***). This is to avoid bridge building of the gravel pack, which can have serious results, when not noticed and corrected. Should a gravel bridge being developed, then pump with some pressure clear water into the well pipes, which will enter through the screen openings into the annular space and will lift up the gravel bridge and allow it to settle down.

Figure 33 Installation of clay pellets

During the pouring of gravel mea sure the gravel level from time to time to avoid overfilling and bridging.

After the installed level of the gravel pack has been confirmed by measuring (See ***Figure 32***) and after allowing for certain additional time to have been settled fully, a clay sealing is installed on top of the gravel pack (See ***Figure 33***).

There are commercial clay (bentonite) pellets available, which are poured into the annular space the same way as the gravel has been installed. When the clay pellets are coming into contact with water, they are expanding their volume (of up to 45%) and therefore sealing off the annular space completely. The sink velocity of clay pellets is about 25-30 m/min.

A clay layer in the annular space of about 3 m should be sealing off the aquifer formation against any kind of surface water, which could contaminate the fresh water of the aquifer.

As described earlier, also the installation of the clay sealing has to be done slowly and carefully to avoid bridging of the material.

6 WELL DEVELOPMENT (TA CODE 8)

6.1 WELL CLEANING AFTER DRILLING (TA CODE 8-1)

After the well-construction has been completed and the surface cementation could be hardened for more than 24 hours, the water well should be developed.

The well was dug into the ground and while the water well was completed, the surroundings of the well became certainly disturbed by the drilling process. Well development is the operation to re-generate the previous free-flow situation of the groundwater, in spite the fact that well pipes and artificial filter gravel has been installed into the ground. The development and pumping test team shall be equipped with the following equipment:

- An air-compressor with 8 bar pressure and 125 l/s air-volume
- Air injection pipe, which for 4” to 6” wells is usually a PE hose with a diameter of 40 mm to 50 mm and a length of 100 m with connection subs to the air-lift tool and to the compressor
- Airlift-tool, which is generally a metal pipe with diameter of 40 mm as well, and is Closed at the bottom end and having about 40 holes of diameter 4 mm around the length of the circumference of this pipe
- water level indicators with a length of 150 m
- 1 metal bucket with a content of 20 l for measurements of water discharge rates
- 1 outflow pipe of 1 m length with yield adjustment valve
- 1 Pick Up truck for transportation of personnel and material

There are various well development procedures carried out due to special requirements, special hydro-geological situation, well diameter and depth of the wells. For the rather shallow and slim wells drilled with depths of 100 m and 6” PVC well assembly installation with 8 ½” drilling diameter in hard rock formation only, a direct airlift procedure without the use of special conductor pipes, will be sufficient(***Figure 34***). The fine material can be removed from the fractures or contact zones (aquifers) and from the gravel pack. The development normally takes duration of 4-8 hours, which can be prolonged until the well will be free of sand. Compressed air to develop wells is widely used in unconsolidated, loose, sedimentary formation, as well as in hard rock formation.

Figure 34 Development by Single-Tube Air-Lifting

In air surging (or flushing) the air is injected into the well directly through a single air injection pipe (the well pipes are then quasi conductor pipes) to lift the water to the surface. When the water reaches the top of the casing on the ground, the air supply is shut off, allowing the aerated water column to fall. Air lift pumping (continuous airlifting) is used to pump the well periodically to remove fine material from the screen, gravel pack and from the borehole.

Air development should begin by determining that the groundwater can flow freely into the screen. Application of too much air volume into the borehole, when the screen and formation are still clogged by fine material can result in a collapsed screen. So in the beginning of air development the initial pumping rate has to be minimized and the air-injection pipe should be placed at a rather shallow submergence. Once the uninhibited flow of groundwater into the screen has been established, the injection pipe can be lowered close to the bottom of the well. Before blowing any water out of the well with a sudden large injection of air, the airlift should be operated at a reduced rate.

Airlifting from the well has to continue until the water is virtually free of sand. Normally the entire length of the screens has to be developed. The air-injection pipe is raised through the screen length by certain intervals. From time to time and at least at the end of the development the injection pipe has to be lowered again to the bottom of the well to blow out the last fine material which has been accumulated in the sump (sedimentation) pipe on top of the bottom cap.

Patience, intelligent observation, and the right tools are requested to develop a well correctly. Well development is not expensive, considering the often remarkable results that can be obtained in improving yields and eliminating sand- and fine material pumping. Similarly, aquifer development is often overlooked an effective way to increase yields substantially.

For the other various methods of the development, please refer to Section 13-2.

6.2 SINGLE TUBE METHOD AIR LIFTING (TA CODE 8-2)

There are two major measures for air-lifting, i.e. single tube method and double tube method. As shown in ***Figure 35***, single-tube method is very simple and does not require very complicated equipment. However this methods transmits its hydraulic force directly to the casing, screen pipes. And sometimes, it damages the pipes, especially when the well depth is deep and water level is shallow. When it is applied. Installation depth of the air nozzle shall be gradually increased to decrease the shock upon the commencement of the air-lift pumping.

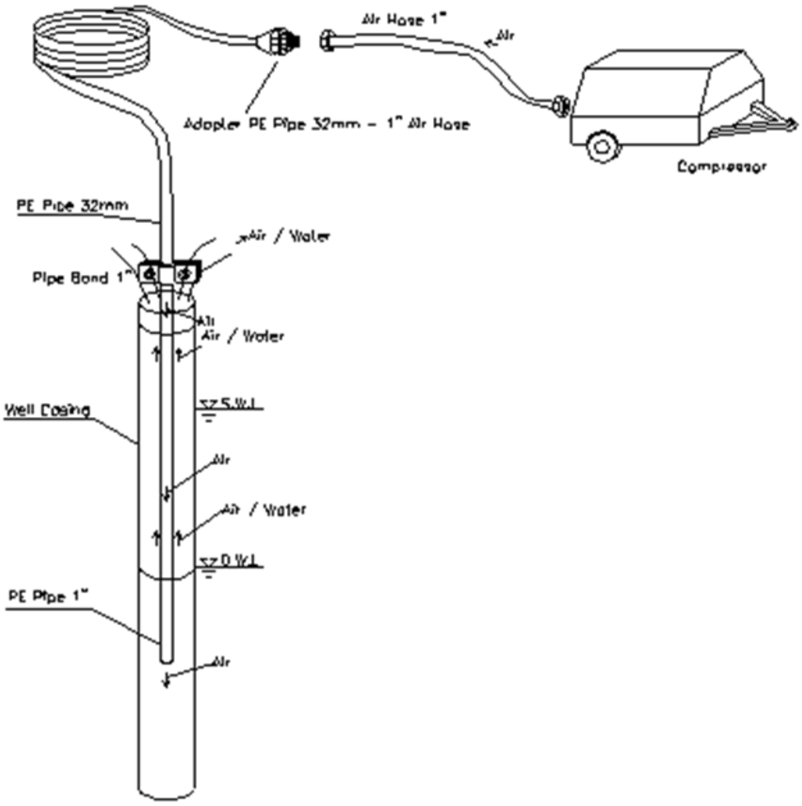


Figure 35 Single Tube Air-Lifting Method

6.3 DOUBLE-TUBE METHOD AIR LIFTING (TA CODE 8-3)

The double-tube method requires more complexed equipment compairing to the single-tube method (See ***Figure 36***). However, there are several advantage for this mehod as follows:

- The shock upon the commencement is less than the one of the single tube method. As the air going up between the outer educator pipe and the inner air pipe.
- It is possible to measure the discharge rate and the dynamic water level if the proper air-lift manihold is used.

The disadvantage is that the crane truck is necessary to handle the pipes, as steel pipes are needed. The selection between the single-tube method and the double-tube method is examined according to the well design and geological conditions.

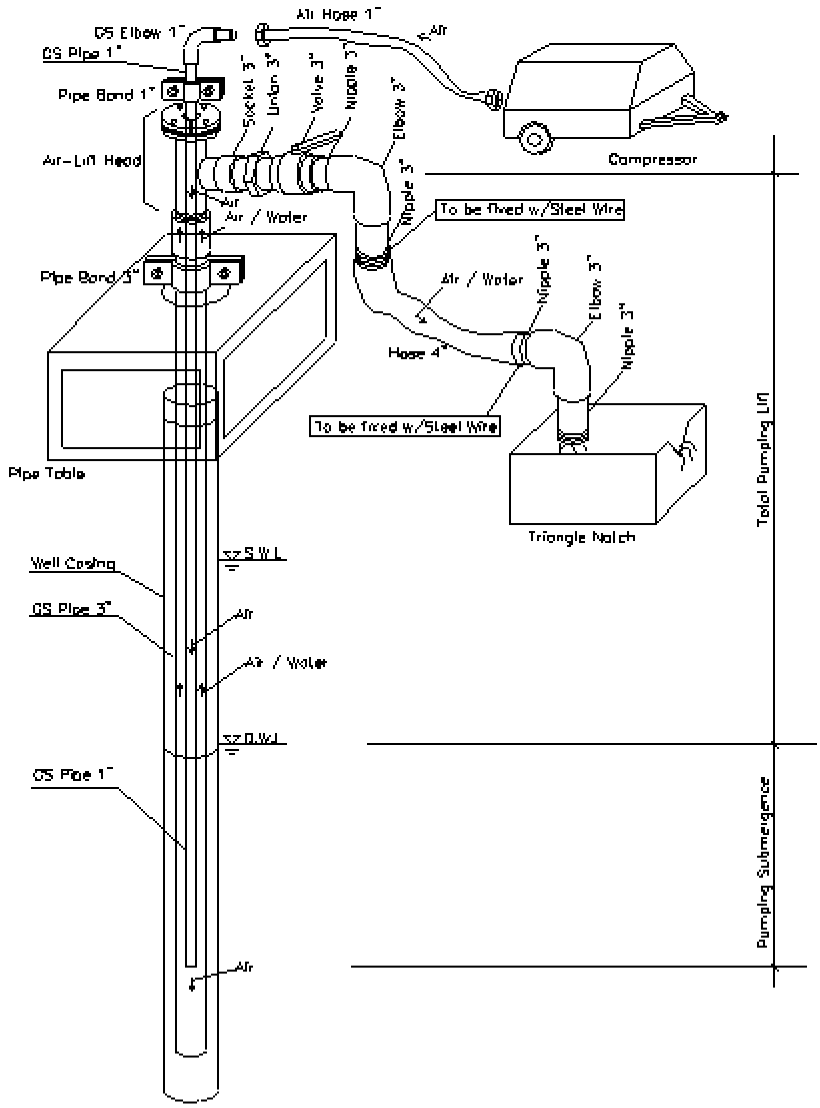


Figure 36 Double-Tube Air-Lifting Method

7 BACK-FILLING&SURFACE CEMENTING (TA CODE 9)

7.1 BACK-FILLING (TA CODE 9-1)

After having confirmed the top of the clay sealing by measurement, the annular space on top of the clay sealing has to be backfilled with drill cuttings up to a depth of 5 to 10 m below ground surface as required by the specification. It is not allowed to backfill using organic material. Also this backfilling has to be carried out slowly and carefully.

Water Resources Division (WRD) of Ministy of Water prepared the government specifications and regulations applicable to water well drilling and installation. The work specification of back filling is shown in this document. The document is distributed to all government agancies and private drilling companies which have registered to the drilling permit. The application of this document is necessary for DDCA to duly follow it. The full document is shown in ***Figure 37***.

TO: ALL GOVERNMENT AGENCIES, PRIVATE WATER WELL DRILLING COMPANIES, CONTRACTORS AND NON-GOVERNMENTAL ORGANIZATIONS

GOVERNMENT SPECIFICATIONS AND REGULATIONS APPLICABLE TO WATER WELL DRILLING AND INSTALLATION IN TANZANIA MAINLAND

1. All water well drilling operations in the country are to be undertaken by registered companies, contractors and NGOs with a water well drilling permit and certified drillers.
2. A Water Well Drilling Permit will be issued to a registered company, contractor, executive agency or NGO upon satisfying the following requirements:
   (i) Making application letter listing equipments, drill rigs and accessories as well as CVS of personnel should be attached.
   (ii) Physical inspection of the listed items and scrutinizing of personnel by Officers from the Ministry of water, Water Resources Division.
   (iii) Certification of drillers.
   Upon satisfying the Ministry requirements, a water well drilling permit will be issued.

   The Drilling Water Well Permit is of six months or one (1) year duration and is renewable upon continuing to meet the above requirements and showing satisfactory performance in the past year.
3. Any registered company, public executive agency or NGO with Ministry Water Well Drilling permit before embarking on water well drilling will make an application and be issued with Borehole Identification Number (s) for new water wells to be drilled.
4. No drilling activity in the country is to be undertaken without a Hydrogeological and Geophysical survey, the Technical Report of which must be submitted to the Basin Water Officer of the respective Basin and a copy to the Ministry of Water, Water Resources Division.
5. Upon submission of the said Hydrogeological and Geophysical Technical report, a Water Well Drilling Clearance Permit will be issued by the Basin Water Officer to the prospective client. No client will be allowed to have a water well drilled in his/her property without such a permit.. A clearance permit will be given within seven days after submission of the Technical report.
6. Each new water well must be assigned an identification number and its geographical position given in UTM co-ordinates where possible, previously given to the recommended borehole site, and should not under any circumstances be changed by the driller.
7. On completion of the water well, the drilling technology to drill the well, changes in diameter, depths to each water strike, as well as the static water level from the ground surface must all be indicated in the completion forms.

Figure 37 Government Specifications and Regulations Applicable to Water Well Drilling and Installation Method (1/3)

8. If the upper section of a well is in unstable rock formation, temporary or permanent cementing/casing must be installed for all exploration or production wells respectively. A proper sanitary seal (or intermediate seals) must be placed to preserve, conserve and protect groundwater resources (its quality) and reservoir pressure potential. This should as well effectively prevent contaminated water to enter and mix with aquifer waters.
9. All boreholes should be well cased and screened to bottom of the borehole and plugged properly. No open boreholes will be allowed/ permitted.
10. In order to ensure that no interference occurs between a new well and existing wells or water body in the vicinity, the distance apart should be at least 300m for unconfined aquifers and 100m for confined aquifers.
11. While drilling, a site Hydrogeologist should properly collect drilling cuttings which will be a representative of depth intervals of 2.0m. Where there is change in rock composition (in between the said interval), this be noted in driller's report. Drill cuttings are kept in sample boxes at the drilling site for lithological logging. However, a small portion (250 gm) of each sample be placed in sample bag, properly labeled and sent to the respective Basin Office for storage and future use. However a water well completion Report detailing the well lithology should be prepared and a copy sent to Hydrogeology Section.
12. If any borehole geophysics is undertaken, all relevant details of the exercise be recorded and a report sent to the Basin Water Officer for further action and again a copy sent to the Water Resources Division.
13. All casings and screens to be installed in a production water well have to be properly chosen to prevent chemical and/or galvanic corrosion and thus guarantee structural integrity of the well, long life and good quality of water.
14. The selection of gravel pack material, with pear size grains and rounded shape has to be installed into the angular space of the drilled well after having been washed and sieved. The material used has to ensure that well efficiency is not lower than internationally accepted Standards. The thickness of gravel pack installed shall likewise satisfy the same conditions.
15. Internationally accepted methods of well cleaning, development to clear and silt free state of water and step- draw down pumping test followed by a constant rate pumping test of at least 24 hours depending on the yield of the borehole shall be followed. Evaluation of pumping test results shall determine safe production limits and aquifer parameters, though actual abstraction of water shall not exceed levels set by the granted water right for the well. All records should be filled in a Completion form and sent to:-
    (a) Water Resources Division
    (b) Basin Water officer
    (c) Well owner

    Note:

    (i) This information would later be required when well rehabilitation, maintenance or Servicing works are due in years of its utility.
16. Any newly drilled borehole that is not to be put immediately into operation should be securely capped to protect it from vandalism or damage.
17. A water well shall be commissioned and put to its intended use after a step- draw down pumping test followed by a constant rate pumping test of at least 24 hours duration depending on the yield of the water well and immediately followed by a recovery test until initial SWL has been attained and thorough physical, chemical and bacteriological analysis of the water by the Central Water Laboratory or a recognized and qualified laboratory.
18. No groundwater abstraction shall commence until the well owner has been issued with a Water Permit by respective Basin Water Office
19. Water well disinfection must be undertaken after well installations and pumping test has been completed to ensure that the water will be safe for human consumption where internationally accepted standards shall apply as well.
20. Any abandoned drilled water well must be properly and perfectly back filled to protect and conserve ground water resources as well as to eliminate any hazards to human beings and

Figure 37 Government Specifications and Regulations Applicable to Water Well Drilling and Installation Method **(2/3)**

animals.

21. Once a water well has been completed, a Completion Form (copy of which could be obtained from Water Resource Division or Basin Water Officer) must be filled in. To certify correctness of information, adherence to professional's ethics and good workmanship; it should be signed by the responsible Driller and countersigned by the Basin Water Officer or his representative. The Driller or Company shall then produce sufficient number of copies and distribute to the Well Owner, Water Resources Division and respective Basin Water Officer.

Remarks: Finally, let it be known that groundwater resources are the Nation's Property. They must be conserved and well protected if safe and sustainable water supply in sufficient quantities and acceptable quality is to be guaranteed for present and future generations. To safeguard its waters therefore, the Government will not hesitate to take stern actions against person, institution or company which pollutes, over pumps a water well or leaves an abandoned water hole not properly back-filled. It is the responsibility of any water well drilling company or driller to fully understand National and International Standards applicable in water well drilling and installation practice which are safe to human, livestock, ecology and the environment.

The Ministry of Water has in this respect, through the enacted relevant laws and regulations, the capacity and duty to monitor, supervise, inspect, regulate and control the water well drilling activities by both Government and non-government water well drilling companies in TANZANIA MAINLAND.

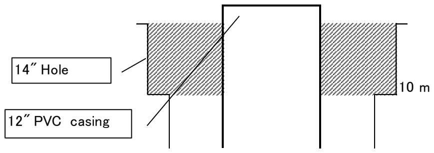
Figure 37 Government Specifications and Regulations Applicable to Water Well Drilling and Installation Method (3/3)

7.2 SURFACE CEMENTING (TA CODE 9-2)

On the backfilling material, cement slurry has to be installed. The slurry consists only of Portland cement and water. With a consistency of 25 l of water per one bag of 50 kg of cement the specific gravity of the slurry will be 1.8. Allow the cement slurry to harden for at least 24 hours before development works can be carried out in the borehole. ***Table 33*** shows example of cement mixing calculation, while ***Table 33*** shows work procedure of surface cementing.

Table 33 Example of Cement Mixing Calculation

1. Basic calculation of cement slurry



a. Cement type : Portland
SG 3.3
b. Specific gravity of slurry SG 1.8
c. Water ratio 568.2 L/ton CMT

Formula 1.8 = (1000+x) / (1000/3.3 +x)

d. Yeild of slurry / ton cement
: 1000/ 3.3 + 568.2 = 871.23 L/ton CMT

e. Yeild of slurry / 50 kg cement
: 50/ 3.3 + 28.41 = 43.562 L/50 kg CMT

2. Volume of Tools

Item	Outside	
	OD(mm)	(L/m)
14"hole	355.6	99.26
12 PVC casing	225	39.74
Annular volume	130.6	59.52

3. Slurry volume

a. Between 14" hole- 12" casing
59.52 L/m x (0 m〜 10 m) 10 m x 1.2 =
Total 714.24 L
÷ 43.56 L
= **16.4 bags of 50 kg cement**
Water 714.24 L / 28.41 L 50 kg cement
= 25.14044 L

1. Mixing of cement slurry

2. Slurry poured into the borehole

3. Fixing clamp on pulled out temporary casings

4. Removal of temporary casing from he well

5. Well casing equipped with temporary well cap

Source: JICA's Water Supply Project in Swaziland

Figure 38 Work Procedure of Surface Cementing

8 PUMPING TEST (TA CODE 14)

8.1 PURPOSE AND METHODS OF PUMPING TEST (TA CODE 14-1)

8.1.1 PURPOSE OF PUMPING TEST

The capacity of well shall be measured by the pumping test. The pumping test is carried out by installing electric submersible pump in a well.

The pumping test shall include the following components:

- Preliminary pumping test
- Step drawdown test
- Constant discharge rate test
- Recovery test

The purposes and methodology of each test are described below:

8.1.2 PRELIMINARY PUMPING TEST

Preliminary Pumping Test is carried out to grasp the rough estimation of well yield. It is conducted generally for the period of 2 to 4 hours by varying the discharge rate. From the results of the preliminary pumping test, the schedule of the step draw down test is planned.

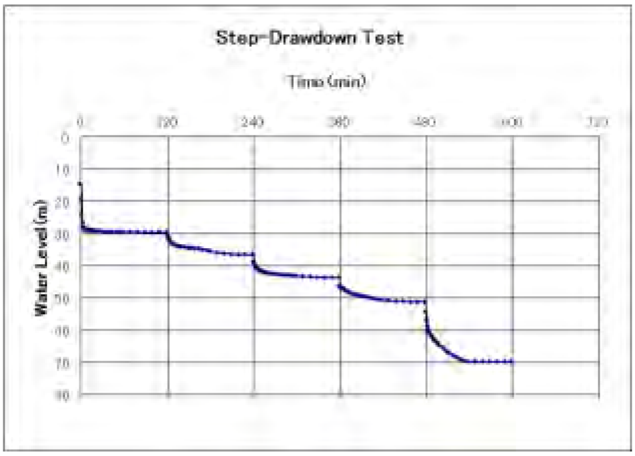


Figure 39 Example of Results of Step Drawdown Tests (t-dwl curve)

8.1.3 STEP DRAWDOWN PUMPING TEST

In Tanzania, the step drawdown test with three (3) to five (5) steps of two (2) hours is conducted. ***Figure 39*** shows an examples of t-dwl (time-dynamic water level) curve of the step drawdown test.

From the results of step drawdown test, the well loss can be calculated approximately by the following quotation:

$Swl=CQ^2$

Swl: well loss (m)

C: well loss constant, (h^2/m^5)

Q: discharge rate (m^3/h)

Well loss constant C indicates the resistance of well structure against water flow from the aquifer. If the screen or neighbouring aquifer is clogged, C will show the elevation.

Drillers can detect the clogging of screen by comparing current C and the past one, if they can obtained the past step drawdown test data.

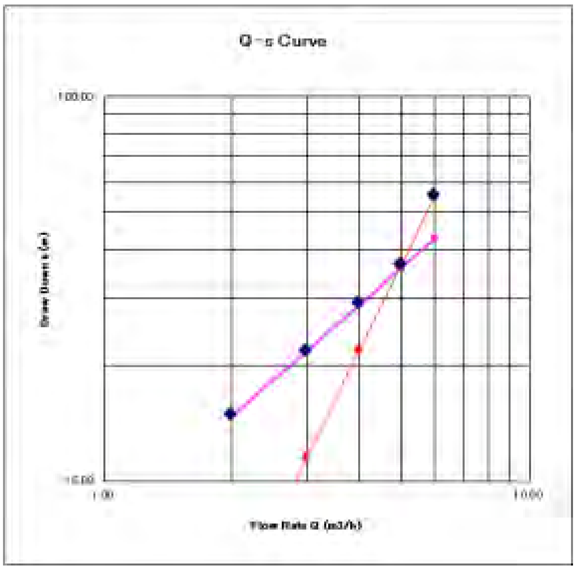


Figure 40 Example of Results of Step Drawdown Tests (Q-s curve)

Figure 40 shows the plotting of discharge rate and drawdown on Log-Log paper (Q-s curve). From this chart, the maximu discharge rate can be estimated. Because of transition from laminar flow to turbulent flow depending on the flow velocity, drawdown suddenly increases from certain value. This discharge rate of the transition is often used as maximum discharge rate. The excessive pumping over this maximum discharge rate may be the cause of the lowering of water level of a well.

The results of the step drawdown test is used for the decision of the discharge rate of the constant discharge rate test.

8.1.4 CONSTANT RATE PUMPING TEST

Figure 41 shows the example result of constant discharge rate test and the following recovery test.

The constant discharge rate test is often omitted for the purpose of well investigation. The major purpose of this test is, to verify if a well shows the same capacity as the analysed discharge rate from step drawdown test for longer pumping period.

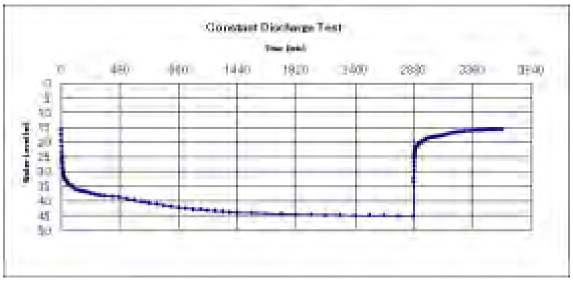


Figure 41 Example of Results of Step Drawdown Tests and Recovery Test (t-s curve)

In general, 24 to 48 hours pumping for piped water schemes and 8 to 12 hours for handpump well is applied for constant discharge rate. However, more pumping time may be applied for wells of large-scale water supply schemes.

The hydraulic coefficients such as transmissivity, storage coefficients etc., can be analyzed from the results from the constant discharge rate test and recovery test.

It is preferable to conduct constant discharge rate test even if it is for the well investigation.

8.1.5 RECOVERY TEST

The recovery test is continuously conducted immediately after the termination of the constant discharge rate test. ***Figure 41*** shows the examples of the plotting of time and dynamic water level (t-dwl curve) of a recovery test together with a constant discharge rate test. This test is to know how fast the dynamic water level is recovered to static water level. The recovered water level is an important factor to formulate the daily pump operation plan and also important to detect the deterioration of well.

8.2 PUMPING TEST EQUIPMENT (TA CODE 14-2)

Figure 42 shows the standard setting of pumping test equipment. Major equipment necessary to conduct the pumping test is described below:

8.2.1 SUBMERSIBLE PUMP

Sumbmersible pump is the most important components of pumping test equipment. Various types and capacities of pumps are manufactured by many manufacturers. A pump consists of pump parts of multi-stage impellers and casings and submersible motors. The sumbmersible motor is of three phases power of 200 or 400 V or single phase of 200 V. They are classified by diameters of casings which they are to be applied. Each pump has a range of the total head and discharge rate. The pump is connected to the generator on the ground by submersible cables. Two-cores single cable is used for single phase pump. Three-cores single cable and three-cores double cables are respectively used for the starting methods of direct start and star-delta start for three phases pumps.

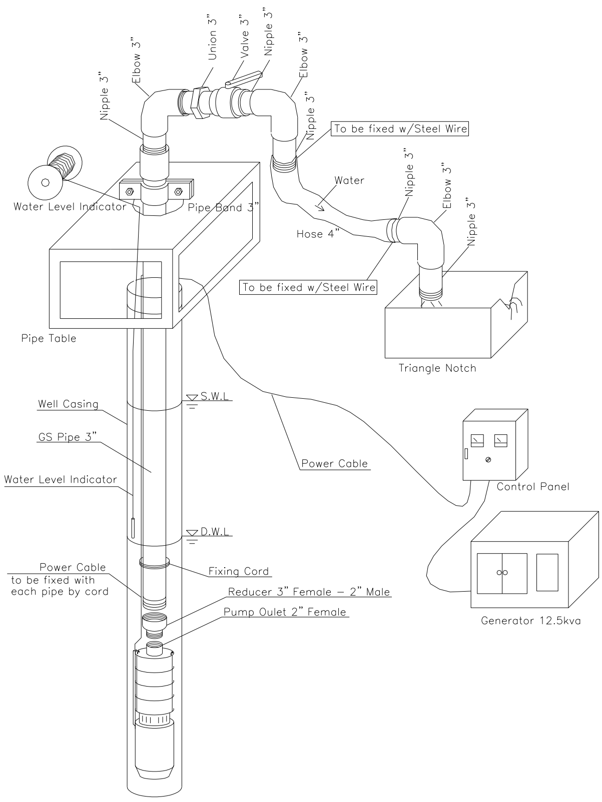


Figure 42 Standard Setting of Pumping Test Instruments

8.2.2 CONTROL PANEL

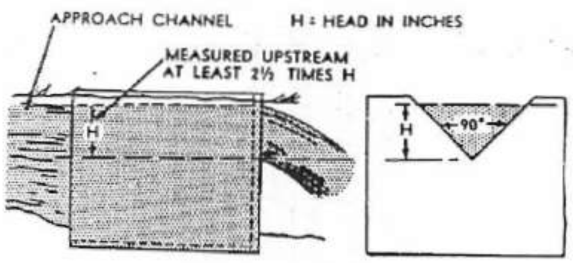
The control panel is an important instrument to control the pump. It is connected between the pump and the generator. It consists of the electrical circuit for on/off operation, safety cut/off for the over/under voltage and current, operation control by water level, pressure etc. The knowledge and skills of the operation and maintenance of the control panel is important for the drillers in charge of pumping test.

8.2.3 RISER PIPE

Riser pipes are threaded or franged pipes which conducts water from the pump to the ground or to the water tank. In general galvanized steel 1-1/2" to 6" pipes are used. For the permanent setting purpose, stainless riser pipes are used, too, as they are anticorrosive.

8.2.4 PUMP HEAD MANIHOLD

The pump head manihold consists of small pipes, elbows, reducers, valves, pressure gauges, air-release valve etc. This is important component to conduct proper control of the discharge rate for the test measurement.



Source: Australian Drilling Industry Training Committee Ltd

Figure 43 Structure of Notch Tank

8.2.5 NOTCH TANK

The discharge rate shall be correctly measured. For large discharge rate, the notch tank is used. The discharge rate is calculated from the measured height of overflow from the weir(***Figure 43***). ***Table 34*** shows the conversion table from the measured height to the discharge rate.

Table 34 Conversion Table of Discharge Rate for 90 Deg. Notch Tank

Headabove Apex mm	L/sec	m³ day	gal/h	Headabove Apex mm	L/sec	m³ day	gal/h
000	00000	00000	00000	155	12.93	1117	10243
010	0.016	1.44	13	160	14.23	1229	11272
015	0.030	2.88	26	165	15.37	1328	12170
020	0.082	7.20	66	170	16.67	1431	13121
025	0.133	11.52	106	175	17.80	1538	14097
030	0.217	18.72	172	180	19.20	1650	15127
035	0.317	27.36	251	185	20.47	1768	16209
040	0.450	38.88	356	190	21.87	1889	17318
045	0.600	51.84	475	195	23.33	2016	18480
050	0.783	67.68	620	200	24.86	2148	19694
055	0.983	84.96	779	205	26.43	2284	20935
060	1.233	106.6	977	210	28.08	2426	22242
065	1.483	128.2	1175	215	29.77	2572	23572
070	1.800	155.5	1426	220	31.55	2726	24987
075	2.133	184.3	1689	225	33.38	2884	26439
080	2.216	217.4	1993	230	35.27	3047	27931
085	2.933	253.4	2323	235	37.22	3216	29426
090	3.367	290.9	2666	240	39.22	3388	31060
095	3.867	334.1	3062	245	41.30	3568	32710
100	4.383	378.7	3472	250	43.43	3752	34399
105	4.950	427.7	3920	255	45.20	3905	35798
110	5.583	482.4	4422	260	47.92	4140	37950
115	6.233	538.6	4937	265	50.25	4342	39798
120	6.933	599.0	5491	270	52.67	4550	41712
125	7.683	663.8	6085	275	55.11	4762	43652
130	8.467	731.5	6706	280	57.67	4982	45672
135	9.300	803.5	7366	285	60.27	5207	47731
140	10.18	879.8	8065	290	62.95	5438	49856
145	11.13	961.9	8818	295	65.70	5676	52034
150	12.17	1047	9596	300	68.52	5920	54265

A bucket is used for the measurement of small discharge rate. In this case, the usual confirmation of the volume of the bucket with the standard is important, so as not to prevent from the wrong measurement.

8.2.6 Water Level Indicator

The water level indicator consists of electric sensor which detect the water level by transmission of current through the water. The sensor is connected to the alarming device with buzzar or light by the two-cores cable with the depth measure. In order to conduct a smooth measurement, 1" PVC pipes are installed with the riser pipes to ensure the path of the sensor down to the water level.

8.3 SELECTION OF SUBMERSIBLE PUMP (TA CODE 14-3)

8.3.1 PUMP SPECIFICATIONS

Drillers in charge of the pumping test shall be acquired the proper knowledge of the submersible pump for the selection of the suitable for each test. Principally, pump shall be selected according to the discharge rate and the total head. ***Table 35*** shows the specifications of the series of submersible pump of SP17 manufacture by GRUNDFOS. "17" of "SP17-10" means it is designed for pumping of 17 m^3/h of discharge rate. "10" is the number of stages of impeller. More number of stages produces hiegher pressure and needs more power. An option of ppower supply can be selected from voltages of 230 V or 400 V and from single phase or three phases. Diameter of the pump is important as well. The selected pump shall be of the diameter which can be smoothly installed into the casing pipes of the well, with the consideration of power cables.

8.3.2 PUMP CAPACITY CURVE AND SELECTION OF SUBMESIBLE PUMP

Figure 44 shows an example of the calculation of total head. In this example, the pump transmits the water of 10 m3/h up to the water tank of which the difference of the elevation down to the dynamic water level of the well is 82.5 m. In order to decide the total head of the submersible pump, head loss through the riser pipe and transmission pipe shall be calculated. The head loss of each diameter of the pipe can be calculated by using the pressure loss nomogram (See ***Figure 45***) According to the nomogram, unit head loss for each diameter of the pipes for 10 m^3/h are obtained as follows:

2" GS:	0.0350 m/m
2-1/2" GS:	0.0182 m/m
3" GS	0.0048 m/m

If 50 m of 2"GS is used, the head loss is calculated as 0.0350 m/m x 50 m = 1.75 m. For the type B in the example, 2" riser pipes and 3" transmission pipes are used. In this case the total head loss is calculated to be 6.89 m. The difference of the elevation between the dynamic water level and the tank is 82.5 m. Therefore the necessary pump head is calculated as 6.89 m + 82. 50 m = 89.39 m. Consequently the submersible pump with the discharge rate not less than 10 m^3/h and the total head not less than 89.39 m shall be selected.

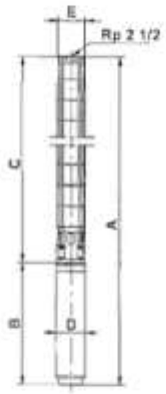
Figure 46 shows the pump capacity curve of SP17 series submersible pumps. The suitable pump can be selected by using the pump capacity curve according to the discharge rate and the total head. From these examinations, the submersible pump SP17-9 was selected.

Table 35 Specifications of Submersible Pump SP17 (Grundfos)

Technical data

Submersible pumps
SP 17

Dimensions and weights



SP 17-43 to SP 17-60 are mounted in sleeve for R 3 connection.

Pump type	Motor Type	Motor Power [kW]	C	B 1x230V	B 3x230V 3x400V	A 1x230V	A 3x230V 3x400V	D	E*	E**	Net weight [kg] 1x230V	Net weight [kg] 3x230V 3x400V
SP 17-1	MS 402	0.55	314	291	241	605	555	95	131		13	11
SP 17-1 N (R)	MS 4000 R	0.75	314		398		713	95	131			17
SP 17-1 N (R)	MS 4000 R	2.2	314	573		887		95	131		26	
SP 17-2	MS 402	1.1	374	346	306	720	680	95	131		17	15
SP 17-2 N (R)	MS 4000 R	1.1	374		413		787	95	131			20
SP 17-2 N (R)	MS 4000 R	2.2	374	573		947		95	131		27	
SP 17-3	MS 402	2.2	435		346		781	95	131			19
SP 17-3 N (R)	MS 4000 R	2.2	435	573	453	1008	888	95	131		28	23
SP 17-4	MS 402	2.2	495		346		841	95	131			20
SP 17-4	MS 4000	2.2	495	573	453	1068	948	95	131		29	24
SP 17-5	MS 4000	3.0	556		494		1050	95	131			26
SP 17-6	MS 4000	4.0	616		574		1190	95	131			31
SP 17-7	MS 4000	4.0	677		574		1251	95	131			33
SP 17-8	MS 4000	5.5	737		674		1411	95	131			39
SP 17-9	MS 4000	5.5	798		674		1472	95	131			40
SP 17-10	MS 4000	5.5	858		674		1532	95	131			41
SP 17-11	MS 4000	7.5	919		773		1692	95	131			47
SP 17-12	MS 4000	7.5	979		773		1752	95	131			49
SP 17-13	MS 4000	7.5	1040		773		1813	95	131			50
SP 17-8	MS6	5.5	753		535		1288	143	142	142		50
SP 17-9	MS6	5.5	814		535		1349	143	142	142		51
SP 17-10	MS6	5.5	874		535		1409	143	142	142		53
SP 17-11	MS6	7.5	935		565		1500	143	142	142		55
SP 17-12	MS6	7.5	995		565		1560	143	142	142		56
SP 17-13	MS6	7.5	1056		565		1621	143	142	142		57
SP 17-14	MS6	9.2	1116		590		1706	143	142	142		64
SP 17-15	MS6	9.2	1177		590		1767	143	142	142		65
SP 17-16	MS6	9.2	1237		590		1827	143	142	142		66
SP 17-17	MS6	9.2	1298		590		1888	143	142	142		67
SP 17-18	MS6	11	1358		683		2041	143	142	142		72
SP 17-19	MS6	11	1419		683		2102	143	142	142		73
SP 17-20	MS6	11	1479		683		2162	143	142	142		74
SP 17-21	MS6	13	1540		708		2248	143	142	142		78
SP 17-22	MS6	13	1600		708		2308	143	142	142		79
SP 17-23	MS6	13	1661		708		2369	143	142	142		81
SP 17-24	MS6	13	1721		708		2429	143	142	142		82
SP 17-25	MS6	15	1782		738		2520	143	142	142		87
SP 17-26	MS6	15	1842		738		2580	143	142	142		88
SP 17-27	MS6	15	1903		738		2641	143	142	142		89
SP 17-28	MS6	18.5	1963		783		2746	143	142	142		96
SP 17-29	MS6	18.5	2024		783		2807	143	142	142		97
SP 17-30	MS6	18.5	2084		783		2867	143	142	142		99
SP 17-31	MS6	18.5	2145		783		2928	143	142	142		100
SP 17-32	MS6	18.5	2205		783		2988	143	142	142		101
SP 17-33	MS6	18.5	2266		783		3049	143	142	142		102
SP 17-34	MS6	22	2326		838		3164	143	142	142		106
SP 17-35	MS6	22	2387		838		3225	143	142	142		111
SP 17-36	MS6	22	2447		838		3285	143	142	142		112
SP 17-37	MS6	22	2508		838		3346	143	142	142		113
SP 17-38	MS6	22	2568		838		3406	143	142	142		114
SP 17-39	MS6	22	2629		838		3467	143	142	142		115
SP 17-40	MS6	22	2689		838		3527	143	142	142		117
SP 17-43	MS6	26	3118		903		4021	143	175	181		164
SP 17-45	MS6	26	3239		903		4142	143	175	181		167
SP 17-48	MS6	26	3420		903		4323	143	175	181		172
SP 17-51	MS6	30	3602		968		4570	143	175	181		185
SP 17-53	MS6	30	3723		968		4691	143	175	181		189
SP 17-55	MMS 6000	37	3844		1425		5269	144	175	181		239
SP 17-58	MMS 6000	37	4025		1425		5450	144	175	181		244
SP 17-60	MMS 6000	37	4146		1425		5571	144	175	181		248

* Maximum diameter of pump with one motor cable.

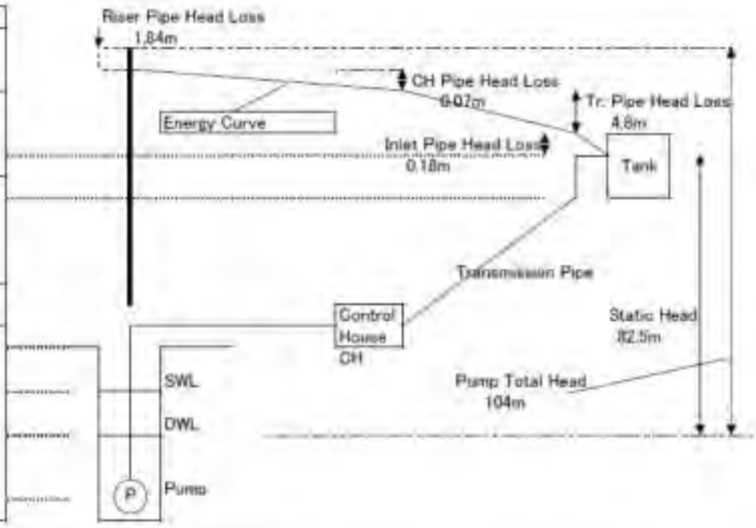
** Maximum diameter of pump with two motor cables.

The pump types above are also available in R and N-versions, see page 5 for further details. Dimensions as above.

Other types of connection are possible by means of connecting pieces, see page 87.

GRUNDFOS

Elevation	Pipe Length
T. Head m (from Well GL)	
	Inlet Pipe (Tank GL to Inlet) 10 m
Inlet 40 m (from Well GL)	
Tank GL 30 m (from Well GL)	Transmission Pipe (Control House to Tank GL) 1000 m
Control House 0 m	Well – Control House 10 m
Well 0 m	Riser Pipe 52.5 m
SWL -14.64 m	
DWL -42.5 m	
Pump -52.5 m	



Head Loss Calculation

Type A		
Riser Pipe		
	Pipe Type	2"GS
	Pipe Dia.	52.48 mm
	Velocity	1.28 m/sec
	Hydro. Grad.	0.035 m/m
	Pipe Length	52.5 m
	Head Loss	1.84 m
Control House Pipe		
	Pipe Type	2"GS
	Pipe Dia.	52.48 mm
	Velocity	1.28 m/sec
	Hydro. Grad.	0.035 m/m
	Pipe Length	10 m
	Head Loss	0.35 m
Transmission Pipe		
	Pipe Type	2"GS
	Pipe Dia.	52.48 mm
	Velocity	1.28 m/sec
	Hydro. Grad.	0.035 m/m
	Pipe Length	1000 m
	Head Loss	35 m
Inlet Pipe		
	Pipe Type	2-1/2"GS
	Pipe Dia.	62.68 m
	Velocity	0.9 m/sec
	Hydro. Grad.	0.0182 m/m
	Pipe Length	10 m
	Head Loss	0.18 m

Total Head Loss	37.37 m
Elevation between Tank and DWL	82.5 m
Necessary Pump Head	119.87 m

Type B		
Riser Pipe		
	Pipe Type	2"GS
	Pipe Dia.	52.48 mm
	Velocity	1.28 m/sec
	Hydro. Grad.	0.035 m/m
	Pipe Length	52.5 m
	Head Loss	1.84 m
Control House Pipe		
	Pipe Type	2"GS
	Pipe Dia.	52.48 mm
	Velocity	1.28 m/sec
	Hydro. Grad.	0.0065 m/m
	Pipe Length	10 m
	Head Loss	0.07 m
Transmission Pipe		
	Pipe Type	3"GS
	Pipe Dia.	52.48 mm
	Velocity	0.58 m/sec
	Hydro. Grad.	0.0048 m/m
	Pipe Length	1000 m
	Head Loss	4.8 m
Inlet Pipe		
	Pipe Type	2-1/2"GS
	Pipe Dia.	62.66 m
	Velocity	0.9 m/sec
	Hydro. Grad.	0.0182 m/m
	Pipe Length	10 m
	Head Loss	0.18 m

Total Head Loss	6.89 m
Elevation between Tank and DWL	82.5 m
Necessary Pump Head	89.39 m

Velocity of Transmission Pipe shall be less than 0.6m/s

Total Head Loss shall be less than 20 m

Then,

Suitable Type is Type-B

Residual Head shall be not less than 5m

Provisional Pump Selection	
Pump Model	SP-17-10
Total Head	104 m
Necessary He	89.39 m
Residual Head	14.61 m
Closing Head	112 m
Power	5.5 kw

Figure 44 Example of Calculation of Pump Total Head (Discharge Rate 10 m^3/h)

Pressure Loss Nomogram

Miscellaneous

Pressure Loss for Hot Galvanized Steel Pipes without Deposits

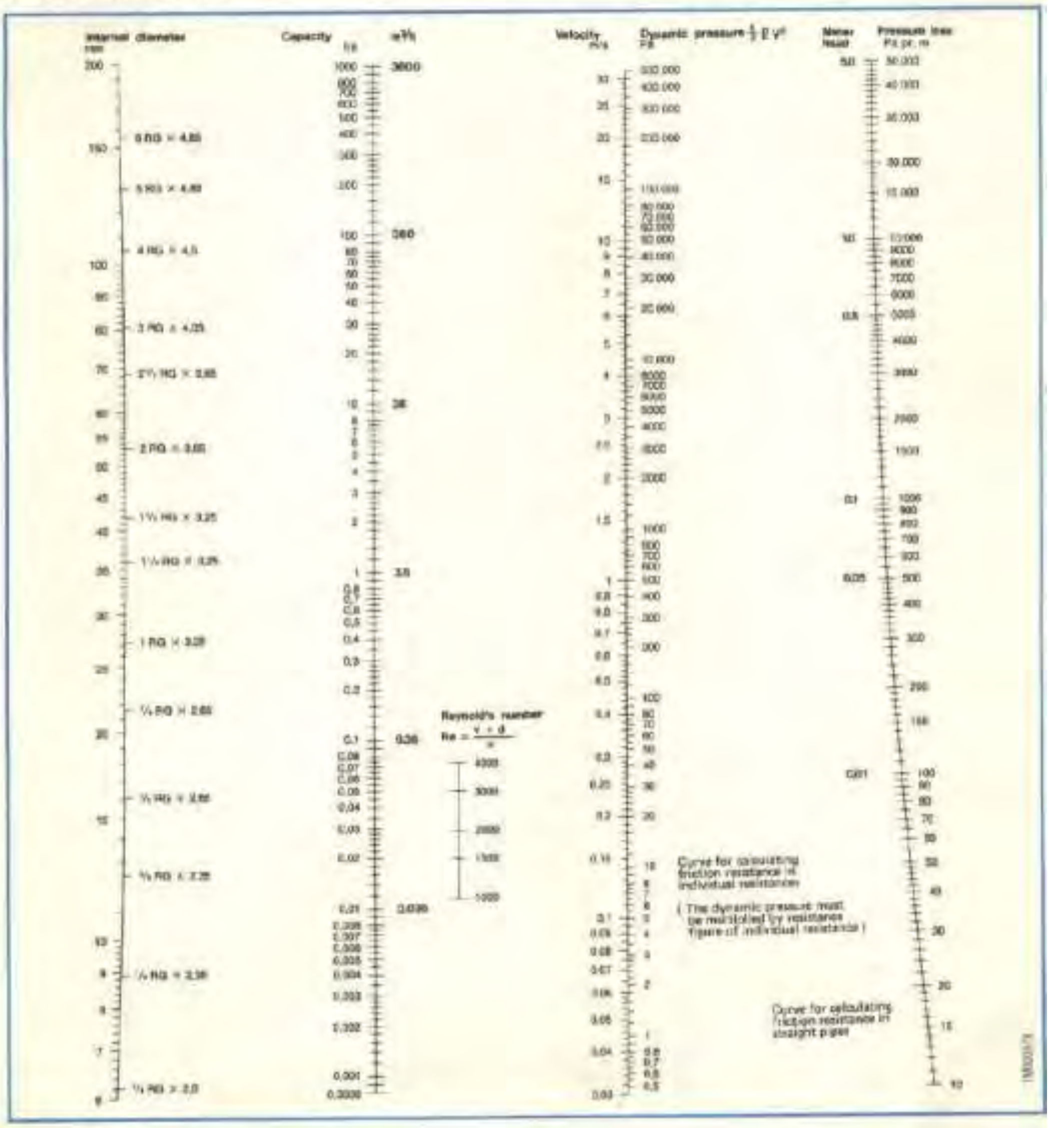
Water Temperature: 10°C

Application
Pipes for domestic water where no deposits are expected.

Temperature range
The nomogram is valid for water at 10°C. At 0°C the pressure loss error will be no more than +10% and at 55°C no more than −25%.

Basis
Colebrook's formula at a water temperature t=10°C and an absolute roughness k=0.15×10⁻³ m.

Diameters
On the right hand side of the diameter scale, the internal diameter of medium thick threaded pipes, steel 00, according to DS 540, 3rd edition, are stated.
According to this standard these diameters are indicated with the thread that can be cut in the pipe, plus the wall thickness in mm.



GRUNDFOS

Figure 45 Pressure Loss Nomogram for Galvanized Steel Pipe

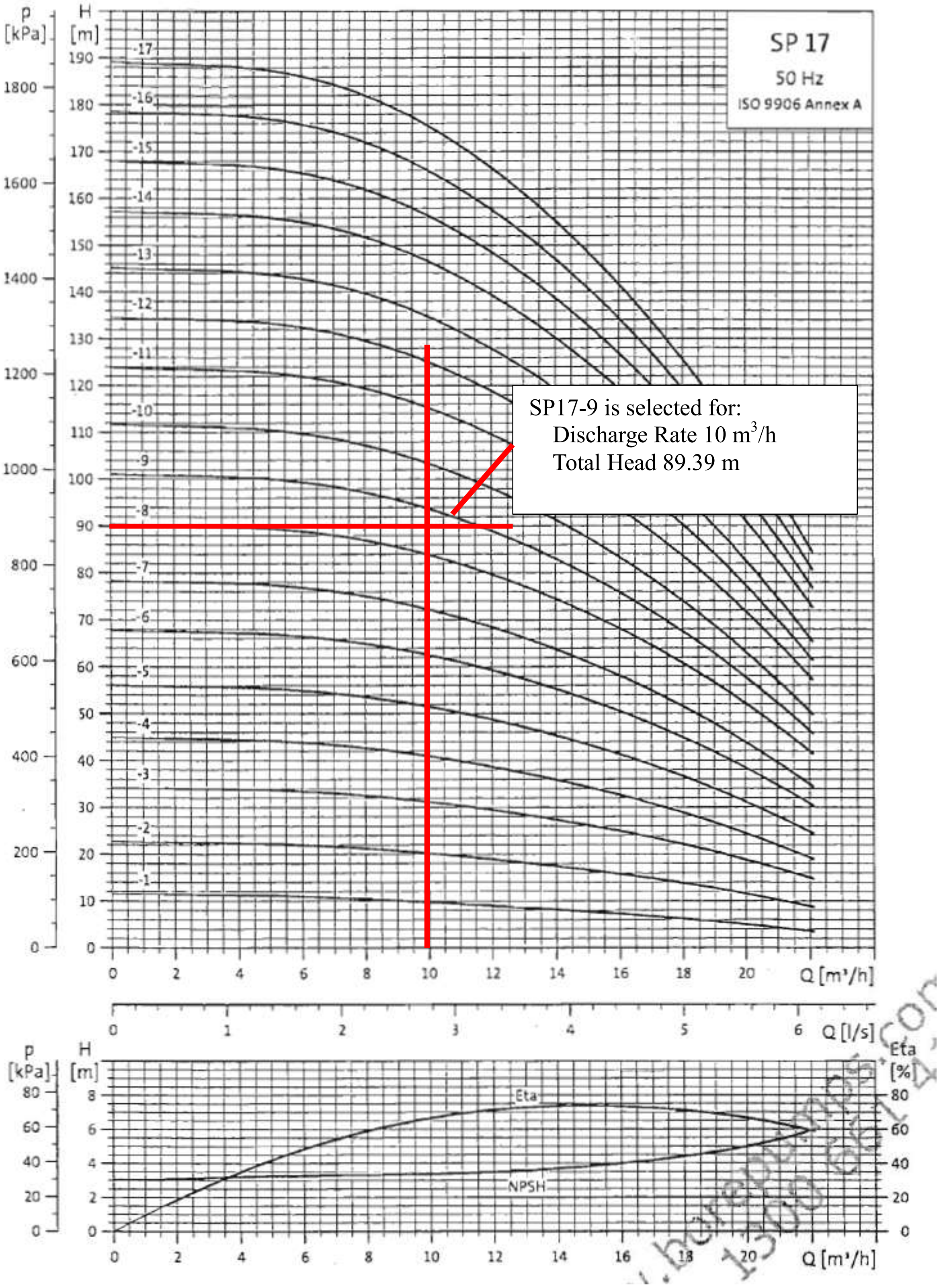


Figure 46 Pump Capacity Curve of SP17 Serieis (GRUNDFOS)

8.4 INTERPRETATION OF TEST RESULTS (TA CODE 14-4)

8.4.1 RECORD OF PUMPING TEST

DDCA normally conducts the constant discharge rate pumping test and the recovery test after the completion of the drilling works. The step drawdown tests are conducted when the client specially requests. ***Figure 48*** is the DDCA's record form for the constant discharge rate test and ***Figure 49*** is the one for the recovery test. A challenge related to the pumping test records of DDCA is that the summary of the pumping test including the preliminary pumping test, step drawdown pumping test, constant discharge rate pumping test and recovery test is not included in the record forms. This series of test shall be summarized as the example shown in ***Figure 47***.

Summary of Pumping Test

Borehole No.: CO 596/2008
Done By: DDCA

1. Contents:		
Preliminary Test	Yes	(Yes/No)
Step Drawdown Test	5	(numbers of steps)
Constant Discharge Rate Test	Yes	(Yes/No)
Recovery Test	Yes	(Yes/No)

2. Preliminary Test	
Date From	28-Oct-08
Date To	29-Oct-08
Duration (min)	360
Static Water Level (m)	11.21
Q (m3/h)	40.62
Q (L/min)	677
D.W.L (m)	15.28
s (m)	4.07

3. Step-Drawdown Test						
Date:	29-Oct-08		Date To	29-Oct-08		
Static Water Level (m):			6.98			
Step	Duration (min)	Q (m3/h)	Q (L/min)	D.W.L. (m)	s (m)	Q/s (m3/h/m)
1	120	10.09	168.17	11.68	4.70	2.15
2	120	20.63	343.83	14.94	7.96	2.59
3	120	29.33	488.83	15.70	8.72	3.36
4	120	40.62	677	16.58	9.60	4.23
5	120	49.50	825	17.52	10.54	4.70

4. Constant-Drawdonw Test	
Date From	30-Oct-08
Date To	01-Nov-08
Static Water Level (m)	8.85
Duration (min)	2880
Q (m3/h)	49.50
Q (L/min)	825
D.W.L (m)	21.40
Q/s (m3/h/m)	3.94
s (m)	12.55
Recovered D.W.L. After 1hr(m)	12.70

Figure 47 Example of Form of Summary of Pumping Test

CONSTANT PUMPING TEST

Conducted for: 05:00 **Hours Done by:** DDCA
S.W.L at: 02 **meters** 57 **cm** **Yield:** 700 LPH **Drawdown** 45 **meters** 62 **cm**
Outflow measured with Tank Capacity of: 22 **liters.**

PUMP TEST METHOD

Air lift size..............................**inches; Placed at depth of**..............**meters.**
Pump Cylinder size......................**inches; Placed at depth of**..............**meters.**
Submersible pump size:..................**Placed at depth of:** 50 **meters** 00 cm

WATER LEVEL DRAWDOWN (B.G.L.)

Date	Time		DWL		Yield LPH	Date	Time		DWL		Yield LPH	Remarks (Water Appearance, Test interrupted. Etc.
	hrs	min	m	cm			hrs	min	m	cm		
04.12.2008		00	02	57	-----			300	48	19		
		01	04	30	700							
		02	04	47	700							
		03	04	63	700							
		04	04	89	700							
		05	05	13	700							
		06	05	26	700							
		07	05	53	700							
		08	05	68	700							
		09	06	05	700							
		10	06	32	700							
		12	07	06	700							
		14	07	97	700							
		16	08	93	700							
		18	09	58	700							
		20	09	55	700							
		25	11	80	700							
		30	13	48	700							
		35	15	56	700							
		40	16	95	700							
		50	17	81	700							
		60	19	50	700							
		75	21	38	700							
		90	25	18	700							
		105	27	28	700							
		120	29	73	700							
		135	37	12	700							
		150	40	16	700							
		165	43	93	700							
		195	45	21	700							
		210	46	94	700							
		225	46	61	700							
		240	48	17	700							
		270	48	18	700							

Figure 48 DDCA's Record Form of Constant Discharge Rate Test

CONSTANT WATER LEVEL RECOVERY (B.G.L.)

Date	Time		Water level rose to:		Date	Time		Water level rose to:		Additional Notes
	hrs	min	m	cm		hrs	min	m	cm	
		00	48	19			300	37	24	
		01	48	08			330	37	02	
		02	47	75			360	36	16	
		03	47	48			390	35	03	
		04	47	19			420	32	17	
		05	46	65			450	26	14	
		06	46	18			480	18	13	
		07	45	90			540	16	72	
		08	45	60			600	10	17	
		09	43	98			660	07	94	
		10	43	52			720	06	41	
		12	43	38			780	05	03	
		14	43	27			840	04	71	
		16	43	18			900	04	12	
		18	43	07			960	04	01	
		20	42	88			1020	03	81	
		25	42	67			1080	03	66	
		30	42	44			1140	03	51	
		35	42	30			1200	03	50	
		40	42	21			1260	03	50	
		50	42	10						
		60	41	89						
		75	41	67						
		90	41	48						
		105	41	20						
		120	40	98						
		135	40	55						
		150	40	22						
		165	39	75						
		195	38	60						
		210	38	19						
		225	38	01						
		240	37	90						
		270	37	80						

REMARKS:

Figure 49 DDCA's Record Form of Recovery Test

8.4.2 INTERPRETATION OF PUMPING TEST RESULTS

There are various interpretation methos of pumping test. They are categorized in two major methods of non-equilibrium method and equilibrium method. The equilibrium methods are used to calculate the hydraulic coefficients of aquifer such as transmissivity, storage coefficient etc. These methods are based on Theis' formula. The non-equilibrium methods are used to calculate the well capacities and efficiency by calculating the parameters such as well loss and aquifer loss coefficient, specific capacity.

This section describes the simplified non-equilibrium method to determine the recommended discharge rate of the well to decide the pump capacity and position. This is one of practical interpretation methods for drillers. An example of the pumping test data and intrpreptation are given in ***Figure 50*** to ***Figure 53***. The data of well is as follows:

Completion Date		14-Oct-08
Well No.		CO 596/2008
Borehole No.		MKR-2-BH2
Pumping Test No.		PT-025
Village		Mwandege
Region		COAST
Contractor		DDCA
Static Water Level (m)		1.3
Blown Yield (m3/h)		4.2
Screen Position (m-m)		55.35-61.10, 69.68-72.54
Casing Depth (m)		76
Date of Step Drawdown Test	From	17-Oct-08
	To	18-Oct-08
Date of Constant Discharge Rate Test	From	19-Oct-08
	To	20-Oct-08

From the results of the step drawdown test, discharge rate, dynamic water level, drawdown and s/Q are summarized and Q-s curve is plotted as shown in ***Figure 52***. Then the recommended discharge rate is determined from the Q-s curve as to be 4.25 m^3/h with the consideration of safety factor of 0.85. Accordingly, dynamic water level is estimated to be 45.70 m. The pump setting depth can be determined from this dynamic water level and several meters for seasonal fluctuation. All the pumping test results, interpretation and pump setting plan are summarized as shown in ***Figure 53***.

1st Step				2nd Step				3rd Ster				4th Step				5th Step			
Time Since Pump Started (min)	Time of Each Step	Dynamic Water Level (m)	Discharge Rate Q (m3/h)	Time Since Pump Started (min)	Time of Each Step	Dynamic Water Level (m)	Discharge Rate Q (m3/h)	Time Since Pump Started (min)	Time of Each Step	Dynamic Water Level (m)	Discharge Rate Q (m3/h)	Time Since Pump Started (min)	Time of Each Step	Dynamic Water Level (m)	Discharge Rate Q (m3/h)	Time Since Pump Started (min)	Time of Each Step	Dynamic Water Level (m)	Discharge Rate Q (m3/h)
0	0	14.64																	
1	1	19.53	2	121	1	30.7	3	241	1	38.65	4	361	1	46.22	5	481	1	54.37	6
2	2	24.42		122	2	30.99		242	2	39.22		362	2	46.6		482	2	56.49	
3	3	26.61		123	3	31.37		243	3	39.75		363	3	46.72		483	3	58.55	
4	4	28.22		124	4	31.85		244	4	40.14		364	4	46.81		484	4	59.58	
5	5	28.47		125	5	32.35		245	5	40.5		365	5	46.95		485	5	60.06	
6	6	28.55		126	6	32.64		246	6	40.76		366	6	47.1		486	6	60.46	
7	7	28.61		127	7	32.85		247	7	41.02		367	7	47.23		487	7	60.84	
8	8	28.69		128	8	33.08		248	8	41.11		368	8	47.4		488	8	61.18	
9	9	28.75		129	9	33.25		249	9	41.3		369	9	47.51		489	9	61.52	
10	10	28.8		130	10	33.37		250	10	41.42		370	10	47.65		490	10	61.82	
12	12	28.88		132	12	33.58		252	12	41.62		372	12	47.93		492	12	62.38	
14	14	28.93		134	14	33.7		254	14	41.79		374	14	48.2		494	14	62.92	
16	16	29		136	16	33.82		256	16	41.89		376	16	48.45		496	16	63.42	
18	18	29.07		138	18	33.94		258	18	42.05		378	18	48.6		498	18	63.93	
20	20	29.12		140	20	33.98		260	20	42.2		380	20	48.73		500	20	64.43	
25	25	29.21		145	25	34.15		265	25	42.33		385	25	48.99		505	25	65.37	
30	30	29.27		150	30	34.35		270	30	42.44		390	30	49.24		510	30	66.27	
35	35	29.35		155	35	34.44		275	35	42.55		395	35	49.47		515	35	67.08	
40	40	29.4		160	40	34.57		280	40	42.67		400	40	49.7		520	40	67.78	
45	45	29.43		165	45	34.64		285	45	42.8		405	45	49.91		525	45	68.43	
50	50	29.44		170	50	34.8		290	50	42.9		410	50	50.1		530	50	68.98	
55	55	29.44		175	55	34.99		295	55	42.99		415	55	50.36		535	55	69.4	
60	60	29.45		180	60	35.47		300	60	43.07		420	60	50.51		540	60	69.68	
70	70	29.45		190	70	35.84		310	70	43.23		430	70	50.77		550	70	69.72	
80	80	29.47		200	80	36.09		320	80	43.4		440	80	50.99		560	80	69.75	
90	90	29.48		210	90	36.28		330	90	43.51		450	90	51.1		570	90	69.77	
100	100	29.48		220	100	36.4		340	100	43.6		460	100	51.14		580	100	69.78	
110	110	29.48		230	110	36.46		350	110	43.62		470	110	51.18		590	110	69.78	
120	120	29.48		240	120	36.46		360	120	43.62		480	120	51.18		600	120	69.78	

Figure 50　Example of Results of Step Drawdown Test

Constant Discharge Rate Test									Recovery Test					
Time Since Pump Started (min)	Dynamic Water Level (m)	Discharge Rate Q (m3/h)	Time Since Pump Started (min)	Dynamic Water Level (m)	Discharge Rate Q (m3/h)	Time Since Pump Started (min)	Dynamic Water Level (m)	Discharge Rate Q (m3/h)	Time Since Pump Started (min)	Time Since Pump stopped (min)	Dynamic Water Level (m)	Time Since Pump Started (min)	Time Since Pump stopped (min)	Dynamic Water Level (m)
0	15.72								2880	0	45.13			
1	17.68	5	100	35.46	5	1200	43.28	5	2881	1	33.61	2980	100	19.15
2	19.7		110	35.88		1260	43.48		2882	2	32.12	2990	110	19.03
3	21.44		120	36.1		1320	43.64		2883	3	29.95	3000	120	18.72
4	23.43		140	36.41		1380	43.89		2884	4	28.1	3020	140	18.52
5	24.53		160	36.7		1440	44		2885	5	26.83	3040	160	18.34
6	25.43		180	36.84		1560	44.21		2886	6	25.62	3060	180	18.18
7	26.24		200	36.95		1680	44.39		2887	7	24.88	3080	200	18.07
8	26.85		220	37.26		1800	44.5		2888	8	24.27	3100	220	17.95
9	27.23		240	37.45		1920	44.68		2889	9	23.75	3120	240	17.78
10	27.57		270	37.7		2040	44.85		2890	10	23.33	3150	270	17.42
12	28.67		300	38.04		2160	44.93		2892	12	22.86	3180	300	17.09
14	29.18		330	38.2		2280	44.99		2894	14	22.53	3210	330	16.82
16	30.29		360	38.32		2400	45.05		2896	16	22.28	3240	360	16.57
18	31.12		420	38.53		2520	45.1		2898	18	22.1	3270	390	16.57
20	31.6		480	38.75		2640	45.12		2900	20	21.88	3300	420	16.35
25	32.21		540	39.35		2760	45.13		2905	25	21.64	3330	450	16.35
30	32.7		600	39.95		2880	45.13		2910	30	21.24	3360	480	16.16
35	32.91		660	40.45					2915	35	21.01	3390	510	16.16
40	33.17		720	40.81					2920	40	20.95	3420	540	16.02
45	33.44		780	41.21					2925	45	20.7	3450	570	16.02
50	33.75		840	41.59					2930	50	20.51	3480	600	15.93
55	34.13		900	41.95					2935	55	20.38	3510	630	15.93
60	34.33		960	42.3					2940	60	20.23	3540	660	15.87
70	34.65		1020	42.56					2950	70	20.03	3570	690	15.87
80	34.91		1080	42.81					2960	80	19.72	3600	720	15.82
90	35.24		1140	43.06					2970	90	19.53	3660	780	15.82

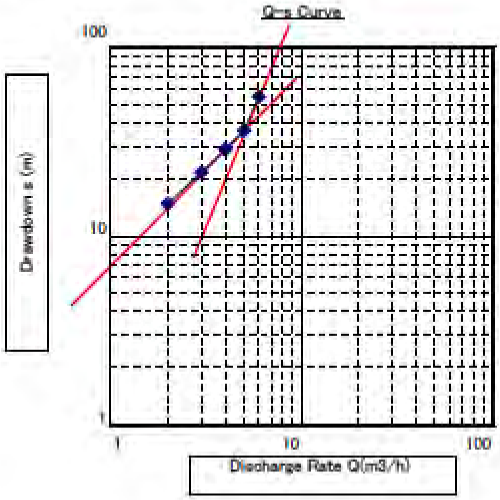
Figure 51　DDCA's Record Form of Recovery Test

Form No.: PT-002
Form Name: Analysis of Step Drawdown Test

Date: 17-Oct-08 ~ 18-Oct-08

Static Water Level (m) :	14.64

Step	Duration (min)	Q (m3/h)	D.W.L (m)	s (m)	Q/s (m3/h/m)	s/Q (m/(m3/h))
1	120	2.00	29.48	14.84	0.13	7.42
2	120	3.00	36.46	21.82	0.14	7.27
3	120	4.00	43.62	28.98	0.14	7.25
4	120	5.00	51.18	36.54	0.14	7.31
5	120	6.00	69.78	55.14	0.11	9.19

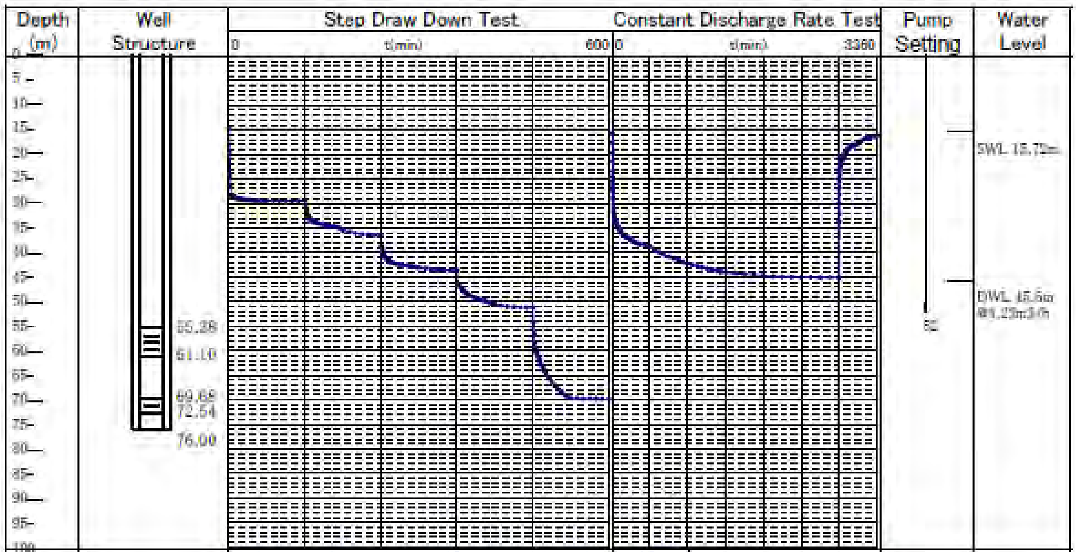


Analysed Max. Discharge Rate (m3/h)	5 (1)
@ s (m)	36.54 (2)
@D.W.L (m)	51.18 (3)
Safety Factor	0.85 (4)
Recommended Discharge Rate (m3/h)	
(1) x (4)	4.25 (5)
@ s (m) (2) x (4)	31.06 (6)
@D.W.L (m (6) + SWL	45.70 (7)

Figure 52 Example of Interpretation of Step Drawdown Test

Form No.: PT-001
Form Name: Pumping Test Results

Well Information			
Completion Date	14-Oct-08	Static Water Level (m)	1.3
Well No.	CO 596/2008	Blown Yield (m3/h)	4.2
Borehole No.	MKR-2-BH2	Screen Position (m-m)	55.35-61.10, 69.68-72.54
Pumping Test No	PT-025		
Village	Mwandege		
Region	COAST		
Contractor	DDCA	Casing Depth (m)	76



14.64					15.72	SWL (m)	
29.48	36.46	43.62	51.18	69.78	45.13	DWL (m)	Operational Discharge Rate
2.00	3.00	4.00	5.00	6.00	5.00	Discharge Rate (m3/h)	4.23 m3/h 71 L/min
14.84	21.82	28.98	36.54	55.14	29.41	s (m)	
0.13	0.14	0.14	0.14	0.11	0.17	Q/s (m3/h/m)	
7.42	7.27	7.25	7.31	9.19	5.88	s/Q (m/(m3/h))	

Figure 53 Summary Report of Pumping Test Result and Pump Installation Plan

9 WATER QUALITY (TA CODE 15)

9.1 PURPOSE OF WATER QUALITY ANALYSIS (TA CODE 15-1)

9.1.1 IMPORTANCE OFSAFE WATER QUALITY

Access to safe drinking-water is important for health, basic human right and development at national, regional and local levels. In some areas, it has been found that investments in water supply can support a net economic benefit such as reductions in adverse health effects and health-care costs outweigh the costs of undertaking the interventions. It has also shown that the improvement of access to safe water confers benefits to the poor in particular, whether in rural or urban areas, and can be an effective part of poverty alleviation strategies.

According to above aspects, water quality analysis is required to be confirmed not only at drilling but also at rehabilitation.

9.1.2 WATER QUALITY PARAMETERS

Table 36 and lists suggesting water parameter to be analised in Tanzania, pollution sources and effects respectively. Categories of the tableare based on Tanzania Temporary Standards (TBS, 1974).

Table 36 Water Quality Parameters and each Pollition Sources and Effects

No.	Name of Constituent	Symbol	Pollution Source (Indicators)	Effects
Toxic				
1	Lead	Pb	Rust of lead pipes	Health effects
2	Arsenic	As	Geological condition	Health effects
3	Selenium	Se	Geological condition	Health effects
4	Chromium	Cr	Geological condition or effluents from industries	Health effects
5	Cyanide	Cn	Effluents from industries	Health effects
6	Cadmium	Cd	Effluents from industries	Health effects
7	Barium	Ba	Geological condition	Health effects
8	Mercury	Hg	Effluents from industries	Health effects
9	Silver	Ag	Geological condition	Not specified
Affecting Human Health				
1	Fluoride	F	Geological condition	Tooth decay and fluorosis
2	Nitrate	NO_3	Fertilizers, sewage, faeces or decaying organic matters	Cause of hemoglobinemia (blue babies) and support algae growth
3	Nitrite	NO_2	(Fertilizers, sewage, faeces or decaying organic matters)	Cause of hemoglobinemia (blue babies) and support algae growth
Organoleptic				
1	Color		Metals or organic matters	Appearance
2	Turbidity		Soil particles	Appearance
3	Taste		Geological condition, seawater, effluents from industries or algae growth	Taste
4	Odor		Sewage, effluents from industries or algae growth	Odour
Salinity and Hardness				
5	pH		Sewage, effluents from industries or algae growth	Attack metals (e. g. pipe rust)
6	Total Filterable Residue		Minerals from geological condition and dissolved matters	Taste and appearance
7	Total Hardness	$CaCO_3$	Geological condition	Taste and soap consuming
8	Calcium	Ca	Geological condition	Not specified
9	Magnesium	Mg	Geological condition	Not specified
10	Magnesium + Sodium sulphate	$Mg\text{-}Na_2$	Sewage, effluents from industries or seawater	Na: taste

No.	Name of Constituent	Symbol	Pollution Source (Indicators)	Effects
11	Sulphate	SO_4	Geological condition or effluents from industries	Taste and smell
12	Chloride	Cl	Sewage, effluents from industries, seawater or geological condition	Not specified
Less-toxic Metals				
13	Iron	Fe	Effluents from industries and mining / Pipe or pump rusting	Taste and appearance
14	Manganese	Mn	Geological condition	Taste and appearance
15	Copper	Cu	Rust of copper pipes	Taste
16	Zinc	Zn	Geological condition or pipes	Taste and appearance
Organic Pollution of Natural Origin				
17	BODs(5 days)	O_2	Organic matters	Cause of water born diseases and decaying water
18	PV (Oxygen abs. $KMnO_4$)	O_2	Organic matters	Cause of water born diseases and decaying water
19	Ammonium	NH_3	Faeces	Cause of water born diseases and disinfectant consuming
20	Total Nitrogen Exclusive Nitrate		Sewage or effluents from industries	Algae growth
Organic Pollution Introduced Artificially				
21	Surfactants ABS (Alkyl Benxyl Sulphonates)		Organic matters	Odour
22	Organic matter as carbon in chloroform extract)		Organic matters	Cause of water borne diseases
23	Phenolic substances as phenol		Effluents from industries	Health effects
Bacteriological				
1	Coliform count per 100ml at 37℃		Sewage	Cause of water borne diseases
2	E. coli count per 100ml at 44℃		Faeces	Cause of water borne diseases

Source: Guideline for Drinking-water quality (WHO, 2004) and Tanzania temporary standards (TBS, 1974)

9.2 ITEM OF WATER QUALITY ANALYIS (TA CODE 15-2)

9.2.1 GUIDELINE/STANDARD OF WATER QUALITY

There are two types of guideline for drinking-watre in Tanzania; Guideline for Drinking-water Quality (WHO, 2004) and Tanzania temporary standards (TTS) (TBS, 1974). WHO guideline is for urban water suppies and large water supplies, and TTS is for domestic water supplies and small rural water supplries. Therefore, is is necessary to instruct which guideline/standard is adopt for water at drilled boreholes to customers and laboratories.

9.2.2 PARAMETERS OF WATER QUALITY ANALYSIS

Table 37 lists WHO guideline and TTS values, and drinking water quality should be less than the valuses in both Tables.

Table 37 Values of WHO Guideline and TTS

No.	Name of Constituent	Symbol	Units	WHO guideline	TTS
Toxic					
1	Lead	Pb	mg/l	0. 01	0. 01
2	Arsenic	As	mg/l	0. 01	0. 05
3	Selenium	Se	mg/l	0. 01	0. 05
4	Chromium	Cr	mg/l	0. 05	0. 05
5	Cyanide	Cn	mg/l	0. 07	0. 20
6	Cadmium	Cd	mg/l	0. 003	0. 05
7	Barium	Ba	mg/l	0. 7	1. 00
8	Mercury	Hg	mg/l	0. 001	0. 001
9	Silver	Ag	mg/l	Not mentioned	Not mentioned
Affecting Human Health					
1	Fluoride	F	mg/l	1. 5	1. 5 - 4. 0
2	Nitrate	NO_3	mg/l	50	10 – 75
3	Nitrite	NO_2	mg/l	3	Not mentioned
Organoleptic					
1	Color		mg/l	15 TCU	15 - 50
2	Turbidity		mg/l	5 NTU	5 - 25
3	Taste		-	Not objectionable	Not objectionable
4	Odor		-	Not objectionable	Not objectionable
Salinity and Hardness					
5	pH			6. 5-8. 5/9. 5	6. 5 – 9. 2
6	Total Filterable Residue		mg/l	1500	2000
7	Total Hardness	$CaCO_3$	mg/l	Not mentioned	600
8	Calcium	Ca	mg/l	200	Not mentioned
9	Magnesium	Mg	mg/l	150	Not mentioned
10	Magnesium + Sodium sulphate	Mg-Na_2	mg/l	-	Not mentioned
11	Sulphate	SO_4	mg/l	400	600
12	Chloride	Cl	mg/l	600	800
Less-toxic Metals					
13	Iron	Fe	mg/l	1	1
14	Manganese	Mn	mg/l	0. 4	1. 5
15	Copper	Cu	mg/l	2	3. 0
16	Zinc	Zn	mg/l	15	15
Organic Pollution of Natural Origin					
17	BODs(5 days)	O_2	mg/l	6. 0	6. 0
18	PV (Oxygen abs. $KMnO_4$)	O_2	mg/l	10	20
19	Ammonium	NH_3	mg/l	0. 5	Not mentioned
20	Total Nitrogen Exclusive Nitrate		mg/l	0. 1	1
Organic Pollution Introduced Artificially					
21	Surfactants ABS (Alkyl Benxyl Sulphonates)		mg/l	1	2
22	Organic matter as carbon in		mg/l	0. 2	0. 5

No.	Name of Constituent	Symbol	Units	WHO guideline		TTS
	chloroform extract)					
23	Phenolic substances as phenol		mg/l	0. 001		0. 002
Bactriological						
1	Coliform count per 100ml at 37℃	-	-	Acceptable	Allowable	1-3
				-	1-3	
2	E. coli count per 100ml at 44℃	-	-	Nil		Nil

Source: Guideline for Drinking-water quality (WHO, 2004) and Tanzania temporary standards (TBS, 1974)

9.2.3 TIMING OF WATER ANALYSIS

Water is analysed after pumping tests (after water become likely clean) and rehabilitations. Moreover, regular water analysis is needed for both rural water supply and urban water supply in order to ensure safe drinking-water in boreholes. Therefore, DDCA should advise to customers to analyse water regularly. ***Table 38*** and ***Table 39*** respectively show frequency of sampling for rural water supply and urban water supply.

Table 38 Frequency of Sampling for Rural Water Supply

Type of Source/Population served	Up to 1,000	Up to 2,000	Up to 5,000
Borehole deeper than 8m	6 months	4 months	3 months

Source: National Environmental Standards Compendium (TBS, 2003)

Table 39 Frequency of Sampling for Urban Water Supply

Population served	Max interval between successive samples	Minimum number of samples to be taken from whole distribution
Less than 20,000	1 month	1 sample / 5,000 people / month
20,000 – 50,000	2 weeks	
50,000 – 100,000	4 days	
More than 100,000	1 day	1 sample / 10,000 people / month

Source: Design Manual for Water Supply and Wastewater Disposal (MoWI, 2009)

9.2.4 SAMPLING AND TRANSPORTATION METHODS

Sampling is a very important process in order to get the true value of water quality. Therefore, following processes are required for sampling.

- To clean the working
- To wash hands
- To avoid dust and draughts in the working area
- To use clean and dry containers washed by proper methods
  - those rinced by distilled water for general parameters
  - those sterilized by ethanol etc. for bacteriological parameters
  - those washed by solution of hydrochloric acid and rinced by distilled water for heavy metals
- To rinse containers three times by water sample if they are wet by a different water sample
- To sterilize an intake of a tap or a pump by ethanol or fire in order to sterilize and to prevent biological contamination
- To avoid touching any part of the container dishes and sampler
- To keep samples cold

– To transfer samples within 24 hours to a laboratory

9.2.5 OTHER NOTIFICATION

The followings are also important for water analysis implemented at sites.

– To adequately calibulate equipment before analysis such as pH meter and conductivity mether

– To turn off equipment if they are not utilized for a while.

Drilling and Dam Construction Agency (DDCA)
Japan International Cooperation Agency (JICA)

DDCAP

Technical Manual for Tool Fishing and Well Rehabilitation for Technical Support Plan for the Drillers in DDCA

Version 1

January 2013

Groundwater Development and Management Capacity Development (DDCAP) Project

Contents

Tables

Figures

1 INTRODUCTION

The baseline survey on DDCA's drilling organization was conducted in the course of the Project, for the purpose to reveal the current status of drilling works and the technical level of drillers in DDCA. The results of the baseline survey were compiled in the Technical Support Plan for the Drillers in DDCA (hereinafter referred to as "TSP") which was formulated in January 2013. This plan identified 15 technical areas which cover the drilling works of DDCA including eight technical areas necessary to be enhanced and two new technical areas to be needed, as shown in ***Table 1***.

Table 1 Identified Technical Areas Covering Drilling Works of DDCA

No.	Technical Area	All Areas	Areas to be Enhanced	New Areas to be Needed
1	Site Mobilization	✔		
2	Drilling Tools and Equipment	✔	✔	
3	Drilling Drawbacks	✔		
4	Drilling Control	✔	✔	
5	Borehole Logging	✔	✔	
6	Casing Program / Installation	✔		
7	Gravel Packing	✔	✔	
8	Well Development	✔	✔	
9	Back-Filling & Surface Cementing	✔	✔	
10	Site Demobilization	✔		
11	Well Investigation	✔		
12	Tool Fishing	✔		✔
13	Well Rehabilitatation	✔		✔
14	Pumping Test	✔	✔	
15	Water Quality Analysis	✔	✔	

This Technical Manual for Tool Fishing and Well Rehabilitation was prepared according the TSP and covers two new technical areas to be needed. This manual is expected to be utilized by the senior drillrs in DDCA in order to acquire the necessary technical knowledge and the proper work procedures. Furthermore, it forms a part of materials for the teaching guidance which is used for the technical instruction to both private drillers and DDCA's drillers. In the TSP, the technical areas were further divided into details namely technical items. Technical areas and items are the important basic units for the activities of technical training and guidance in the Project, in the respects of the manual formulation, training plan, technical evaluation and so on. They are commonly used between three major training related documents i.e. the Teaching Guidance, the Manual for Drilling Works and the Manual for Well Rehabilitation and Tool Fishing, as shown in ***Table 2***.

Table 2 Technical Area / Item Covered by Teaching Guidance and Manuals

TA Code	Technical Area / Item	Teaching Guidance	Manual for Drilling Works	Manual for Well Rehabilitation and Tool Fishing
1	**Site Mobilization**	✔		
1-1	Site Preparation and Drilling Machine Setting-Out	✔		
2	**Drilling Tools and Equipment**	✔	✔	
2-1	Selection of drilling bit and drilling method	✔	✔	
2-2	Rotary Bits	✔	✔	
2-3	DTH and DTH Bit	✔	✔	
2-4	Rig Accessory	✔	✔	
2-5	Casing Tools	✔	✔	
2-6	Drilling Equipment	✔	✔	
2-7	Drilling Calculation	✔	✔	
2-8	Weight of drilling tools	✔	✔	
2-9	Rotary bit rotation speed and weight on bit	✔	✔	
2-10	DTH Bit rotation speed and weight on bit	✔	✔	

TA Code	Technical Area / Item	Teaching Guidance	Manual for Drilling Works	Manual for Well Rehabilitation and Tool Fishing
3	**Drilling Drawbacks**	✔		
3-1	Countermeasures against lost circulation during mud drilling	✔		
3-2	Countermeasures against lost circulation during DTH drilling	✔		
3-3	Countermeasures against bore wall collapse during mud drilling	✔		
3-4	Countermeasures against bore wall collapse during DTH drilling	✔		
3-5	Countermeasures against jamming of drilling tools	✔		
4	**Drilling Control**	✔	✔	
4-1	Mud control	✔	✔	
4-2	Mud Pump Operation	✔	✔	
4-3	Casing for mud drilling	✔	✔	
4-4	Drilling operation for mud drilling	✔	✔	
4-5	Bit control and repairing for mud drilling	✔	✔	
4-6	Air control for DTH drilling	✔	✔	
4-7	Air compressor operation	✔	✔	
4-8	Casing for DTH drilling	✔	✔	
4-9	Drilling operation for DTH drilling	✔	✔	
4-10	Bit control and repairing for DTH drilling	✔	✔	
5	**Borehole Logging**	✔	✔	
5-1	Borehole logging instruments	✔	✔	
5-2	Interpretation of borehole logging results	✔	✔	
6	**Casing Program / Installation**	✔		
6-1	PVC casing, screen pipe	✔		
6-2	Casing Program	✔		
6-3	Role of centralizer	✔		
6-4	Casing, screen pipe installation	✔		
7	**Gravel Packing**	✔	✔	
7-1	Determination of gravel size	✔	✔	
7-2	Calculation of gravel volume	✔	✔	
7-3	Gravel packing	✔	✔	
8	**Well Development**	✔	✔	
8-1	Well cleaning after drilling	✔	✔	
8-2	Single-tube method air-lifting	✔	✔	
8-3	Double-tube method air-lifting	✔	✔	
9	**Back-Filling & Surface Cementing**	✔	✔	
9-1	Back-filling	✔	✔	
9-2	Surface cementing	✔	✔	
10	**Site Demobilization**	✔		
10-1	Precautions upon site demobilization	✔		
11	**Well Investigation**	✔		
11-1	Necessary information of well rehabilitation plan	✔		
11-2	Well rehibilitation plan	✔		
12	**Tool Fishing**	✔		✔
12-1	Tool fishing plan	✔		✔
12-2	Fishing tools	✔		✔
13	**Well Rehabilitatation**	✔		✔
13-1	Phenomenan and causes of well deterioration	✔		✔
13-2	Methods of well rehabilitation	✔		✔
13-3	Usage of well camera	✔		✔
14	**Pumping Test**	✔	✔	
14-1	Purpose and methods of Pumping Test	✔	✔	
14-2	Pumping test equipment	✔	✔	
14-3	Selection of Submersible Pump	✔	✔	
14-4	Interpretation of test results	✔	✔	
15	**Water Quality Analysis**	✔	✔	
15-1	Purpose of Water quality analysis	✔	✔	
15-2	Item of water quality analysis	✔	✔	

12 TOOL FISHING (TA CODE 12)

12.1 TOOL FISHING PLAN (TA CODE 12-1)

For wells with fallen tools and/or materials which disturb the proper installation of alternative pump, such obstacles in a well shall be at first removed from a well by "Tool Fishing".

Prior to the formulation of tool fishing plan, the following preliminary investigation shall be conducted:

12.1.1 DATA COLLECTION

- Collection of well and water supply scheme.
- Detailed specifications of fallen materials such as diameters, lengths, shape, materials.
- If the fallen material is a pump, specifications of auxially tools such as riser pipes and cables shall be obtained too.
- The remaining parts of fallen materials are also the important information source. In case the riser pipe of the pump is cut at certain point on the riser pipe, the length of the fallen pump and riser pipes in the well can be calculated by measuring the remaining parts of the riser main. Furthermore, the observation of the cut point is important to estimate the shape of the top of the fallen riser pipe.
- Well structure information such as depth, diameter, length, materials and whether or not production hole is cased.

With the integral analysis of the above information, the proper tool fishing plan shall be prepared.

12.1.2 DOWN-HOLE INVESTIGATION

After the maximum efforts to collect the data, the condition of the top of the fallen materials shall be investigated by following measures:

- Confirm reachable depth by water level sensor
- Confirm reachable depth by pipes or rods
- Run into the hole, investigating device such as plate with nails
- Run into the hole, well camera

From the collected data and the results of the above down-hole investigation, the illustration of the down-hole situation of the fallen material shall be drawn up as shown in ***Figure 1*** and suitable tool fishing plan shall be prepared.

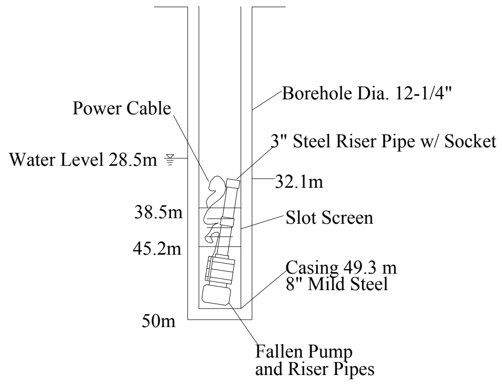


Figure 1 Analysed Image of Fallen Material

12.1.3 WELL CLEANING

If a well is not cased, collapsed bore wall may be sedimented above and/or around fallen materials. Prior to tool fishing works, such sedimentation shall be removed by the following measures:

(1) Removal of sedimentation above fallen material

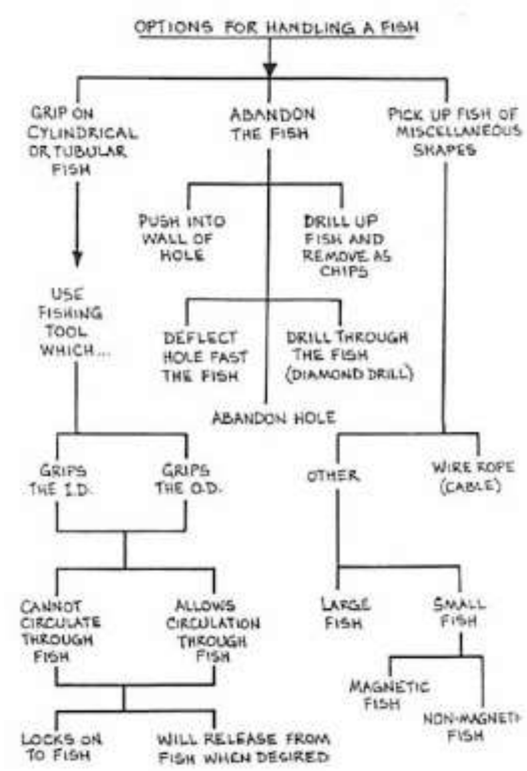
Air-lifting, bailing, reaming with rotary bit etc are used.

(2) Removal of sedimentation around fallen material

Sedimentation shall be reamed by casing pipes. If the fallen material leans one side of the hole, it must be straightened up using spud.

12.1.3 FISHING PLAN

Based on the results of the data collection and the down-hole investigation, the fishing plan shall be planned. This plan shall include the necessary equipment, tools, materials, consumables, work procedures, staff organizations and so on. Proper fishing art and tools shall be selected as well. ***Figure 2*** shows the decision tree of fishing tools.



Source: Australian Driling Industry Trining Committee

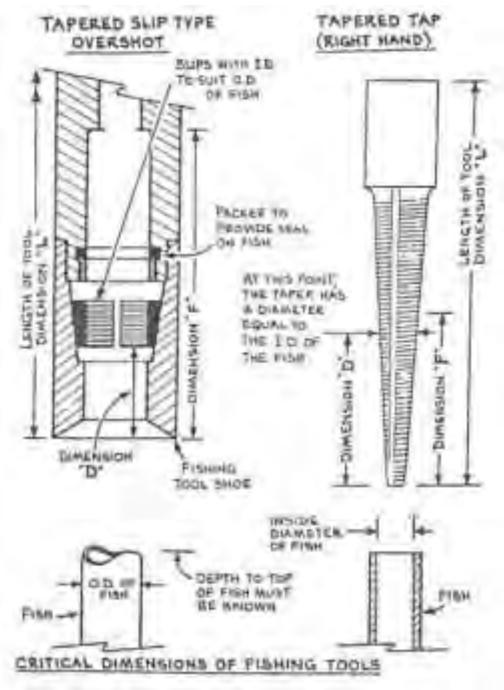
Figure 2 Decision Tree of Fishing Tool Selection

12.2 Fishing Tools (TA CODE 12-2)

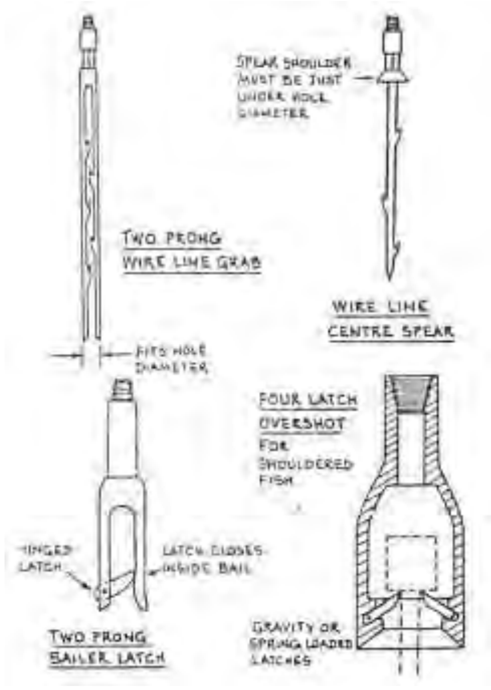
There are many types of fishing tools as shown in ***Figure 3*** and ***Figure 4***. These tools are selected depending on the purpose of each stage of tool fishing works.

Each fishing tool is manufacture for certain range of dimension of fallen materials. It is not possible to keep stock of fishing tools for all types and dimensions of fallen materials.

Therefore, the skills for manufacturing "order-made" fishing tools to be fit to the target fallen material and down-hole conditions is important, too.



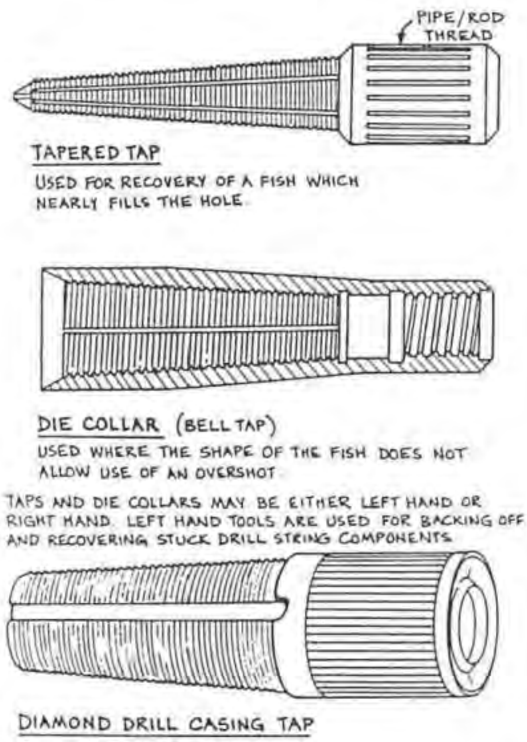
Engaging the Fish



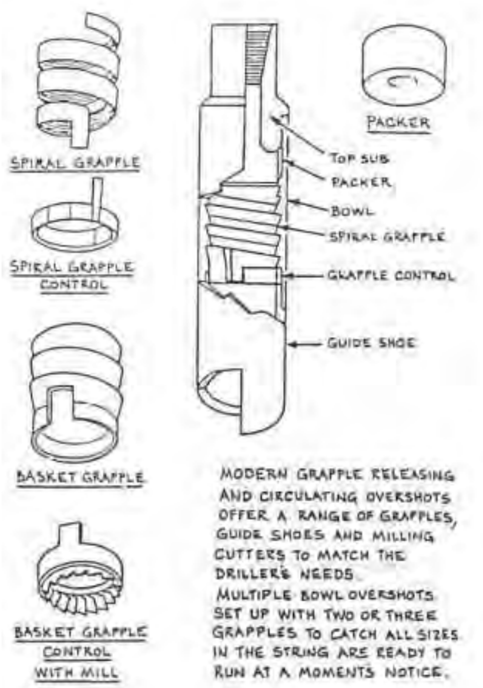
Hooks and Latching Tools

Source: Australian Driling Industry Trining Committee

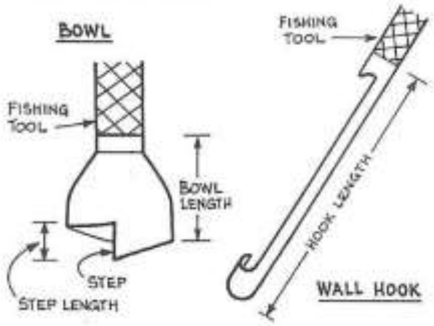
Figure 3 Fishing Tools (1/2)



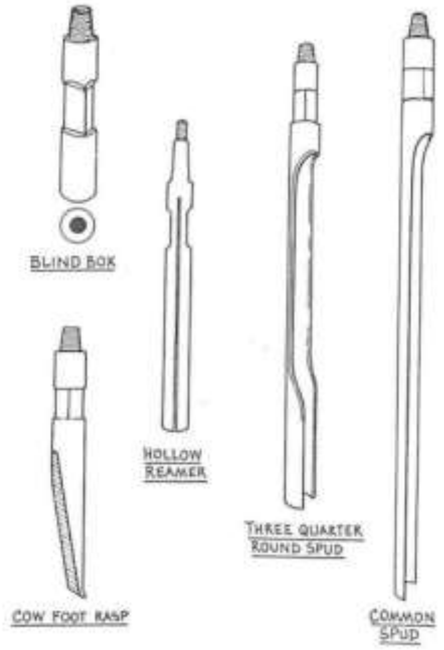
Taps and Die Collar



Grapple Overshot



Tools for Catching



Tools to Straighten the Fish

Source: Australian Driling Industry Trining Committee

Figure 4 Fishing Tools (2/2)

13 WELL REHABILITATION (TA CODE 13)

13.1 PHENOMENAN AND CAUSES OF WELL DETERIORATION (TA CODE 13-1)

13.1.1 WELL FAILURE BY INCRUSTATION

Chemical and biological incrustations are major causes of well failure. Water quality chiefly determines the occurrence of incrustation. The surface characteristics of the screen itself may also play a part in regulating the rate at which incrustation occurs. If the screen is constructed of rough-surface metal, for example, incrustants may build up at a faster rate. The kind and amount of dissolved minerals and gases in natural waters determine their tendency to deposit mineral matter as incrustation.

Groundwater normally moves slowly and remains in contact with the minerals of the aquifer material for hundreds or thousands of years in a quasi-chemical equilibrium with its environment. Any change in the physical or chemical conditions (such as pumping a well) upsets the equilibrium and may cause precipitation of relatively insoluble materials.

The incrustation often forms a hard, brittle, cement- like deposit similar to the scale found in water pipes. It may also be soft, paste-like sludge or gelatinous material, depending on conditions.

The major forms of incrustation include:

- Precipitation of calcium and magnesium carbonates or their sulfates.
- Precipitation of iron and manganese compounds, primarily their hydroxides or hydrated oxides.
- Slime-producing iron bacteria or other slime-forming organisms (biofouling).

(1) Causes of Carbonate Incrustation:

Chemical incrustation usually results from the precipitation of carbonates, mainly of calcium, from groundwater in the proximity of the well screen. Other substances, such as aluminium silicates and iron compounds, may also be entrapped in the scale-like carbonates that cement sand grains together around the screen. The deposits fill the voids, and the flow of water into the well is reduced proportionately.

The explanation is that calcium carbonate can be carried in solution in proportion to the amount of dissolved carbon dioxide in the groundwater. The ability of water to hold carbon dioxide in solution varies with pressure – the higher the pressure, the higher the concentration of carbon dioxide.

When water is pumped from a well in an unconfined aquifer the hydrostatic pressure in the deeper portions of the aquifer is decreased with greatest change being at the well.

Because of the reduction in pressure, some carbon dioxide is released from the water. When this occurs, the water is unable to carry its full load of dissolved calcium carbonate and part of this material is precipitated onto the well screen and in the formation material adjacent to the well screen.

Pumping a well in a confined aquifer produces a similar pressure reduction and resulting precipitation.

Formation of calcium carbonate precipitate from calcium bicarbonate is the classic example:

$$Ca(HCO_3)_2 \quad \rightarrow\text{-}\Delta P\rightarrow \quad CaCO_3\downarrow + CO_2\uparrow + H_2O$$

where ΔP is a change in pressure.

Solubility of calcium bicarbonate is 1300 mg/l while the solubility of calcium carbonate is 13 mg/l. Carbon dioxide (CO_2) escapes when the head, or pressure, is reduced.

Magnesium bicarbonate changes to magnesium carbonate in the same manner when the carbon dioxide is released, but magnesium carbonate incrustation occurs only in special instances because it is still soluble at concentrations over 5000 mg/l (Kemmer, 1979). Precipitation occurs, therefore, only when the carbonate concentration exceeds this level.

(2) Causes of Iron and Manganese Incrustation:

Many rocks throughout the world contain iron and manganese, and are the source of iron and manganese ions found in groundwater if the pH is about 5 or less.

Velocity- induced pressure changes due to pumping can disturb the chemical equilibrium of the groundwater and result in the deposition of insoluble iron and manganese hydroxides. These hydroxides are gel-like and may occupy relatively large volumes. Over time, they harden into scale deposits.

Dissolved iron is affected by pressure reduction as follows:

$$Fe(HCO_3)_2 \quad \rightarrow\text{-}\Delta P\rightarrow \quad Fe(OH)_2\downarrow \quad + \quad 2CO_2\uparrow$$

The solubility of ferrous hydroxide (on the right side of the equation) is less than 20 mg/l. If oxygen is introduced by aeration during pumping, additional precipitation of ferric hydroxide occurs:

$$4Fe(OH)_2 \; + \; 2H_2O \; + \; O_2 \quad \rightarrow \quad 4Fe(OH)_3\downarrow$$

The solubility of ferric hydroxide is less than 0.01 mg/l.

Soluble manganese becomes insoluble in the same way as iron:

$$2Mn(HCO_3)_2 \; + \; O_2 \; + \; 2H_2O \;\rightarrow\; 2Mn(OH)_4\downarrow \; + \; 4CO_2\uparrow$$

Further oxidation of the hydroxides of iron and manganese, or an increase in pH, causes the formation of hydrated oxides containing these ions. Ferrous iron in solution, for example, can react with oxygen to form ferric oxide:

$$2Fe^{+2} + 4HCO_3^{-} + H_2O + 1/2O_2 \quad = \quad Fe_2O_3 + 4CO_2 + 3H_2O$$

The ferric oxide is a reddish brown deposit similar to rust, whereas the hydrated ferrous oxide is a black sludge.

The insoluble manganese oxide is also black or dark brown.

Iron and manganese deposits are often found associated with calcium and magnesium carbonate scale.

In the cone of depression around a well in an unconfined aquifer, air enters the voids and oxidizes iron in the films of water adhering to individual sand grains. If pumping is started and stopped intermittently, a coating of iron oxide can build up, thereby gradually reducing the void space in this part of the formation. This action reduces the formation's storage capacity in the vicinity of the well, and the cone of depression enlarges more rapidly than it would otherwise.

(3) Well Failure Caused by Iron Bacteria:

Iron bacteria occur widely in wells open to the atmosphere when sufficient iron and/or manganese are present in the groundwater in conjunction with dissolved organic material, bicarbonate, or carbon dioxide.

The principal forms of iron bacteria plug wells by enzymatically catalyzing the oxidation of iron (and manganese), using the energy to promote the growth of threadlike slimes, and accumulating large amounts of ferric hydroxide in the slime.

In this process, the bacteria obtain their energy by oxidizing ferrous ions to ferric ions, which are then precipitated as hydrated ferric hydroxide on or in their mucilaginous sheaths. Precipitation of the iron and the rapid growth of the bacteria create a voluminous material that quickly plugs the screen pores of the sediment surrounding the well bore.

Sometimes the explosive growth rates of iron bacteria can render a well virtually useless within a matter of months.

Many other forms of iron bacteria induce the precipitation of iron through nonenzymatic means. Found almost everywhere in both water and soil, these bacteria promote precipitation of iron by:

- Raising the pH of the water through metabolic and photosynthetic processes.
- Changing the redox potential of the water by algal photosynthesis. In this process, oxygen given off by plants increases the redox potential, thereby causing the precipitation of iron.
- Liberating chelated iron by inducing a breakdown in the bond between iron and oxalate, citrate, humic acids, or tannins.

Many forms of enzymatic bacteria that could grow in water wells prefer water with the following general physical and chemical characteristics:

- Has an iron content of 1 to 25 mg/l and contains only traces of organic matter.
- Low in oxygen, typically in the 0.1 to 1.0 mg/l range.
- Usually fresh.
- Contains over 20 mg/l carbon dioxide.
- Has a redox potential in the range of 200 to 300 millivolts (mv).
- Has a pH in the range of 6 to 7.6.
- Has a temperature from 40 to 60^0F (4.4 to 15.6^0C).

There are, however, other forms of iron bacteria that can grow in waters having extremely low pH (2 to 6) and much higher temperatures [60 to 185^0F (15.6 to 85^0C)]

A second classification of iron bacteria is the one based on the physical form of the organisms. There are three general forms:

- The capsulated coccoid form which consists of numerous short rods surrounded by a mucoid capsule. The deposit surrounding the capsule is hydrous ferric oxide, a rust-brown precipitate.
- The stalked iron-fixing bacteria composed of twisted bands resembling a ribbon or chain with a bean-shaped bacterial cell at the end of the twisted stalk.
- The filamentous group that take different shapes and structures.

Under each form are numerous genera and species.

If the presence of iron bacteria is suspected in a well, samples of the organism can be obtained by a filtering device attached to the discharge of the pump for one week. The water passing through the filter during this period leaves a dark brown precipitate on the porcelain cover which can be examined for iron bacteria by a qualified laboratory.

Another method of sample collection is to examine the material scraped from valves or pump discharge lines from suspected wells, pump shaft seals, water closets, or small steel objects suspended temporarily in the well.

However, unless a microscope of at least 1000X is available, it is best to send the samples to a laboratory or firm familiar with iron bacteria identification.

(4) Prevention and Treatment of Incrustation Problems:

So far, means of preventing the incrustation of well screens has not been found. One unique method does exist, however, that is designed to reduce the amount of iron incrusting materials reaching the well screen. This method, called the Vyredox System, uses a series of injection wells located in a circle around the production well. Oxygenated water is injected into the wells to oxidize iron in solution and promote the growth of iron bacteria so that little iron reaches the production well.

For most wells where incrusting material cannot be removed before reaching the well, several actions can be taken to delay incrustation and make it a less serious problem:

- The well screen should be designed to have the maximum possible inlet area to reduce the flow velocity to a minimum through the screen openings.
- The well should be developed thoroughly.
- The pumping rate may be reduced and the pumping period increased, thereby decreasing entrance velocities.
- The pumping load may be divided among a larger number of smaller diameter wells instead of obtaining all of the supply from only one or a few larger diameter wells.
- A more frequent maintenance or cleaning procedure – by qualified water well contractor- should be undertaken wherever local experience shows considerable difficulty from incrustation.

In localities where incrustation is prevalent, samples of the incrusting material and water should be analyzed. The proportions of the various materials shown by the analyses should indicate the kind of treatment and the type of chemicals that would be most successful in recovering well yield.

13.1.2 WELL FAILURE FROM CORROSION:

Metals are generally extracted from ores of stable mineral compounds that are in physical and chemical harmony with their natural environment. In the elemental state most metals are not inherently stable.

In the environment, elemental metals naturally revert back into more stable mineral compounds.

This completely natural process is called corrosion. It changes the physical and chemical properties of metals, frequently destroys the usefulness of of fabricated metallic articles or structures, and may, over time, reduce or destroy metal products.

Corrosion can severely limit the useful life of water wells in four ways:

- Enlargement of screen slots or development of holes in the casing, followed by sand pumping.
- Reduction in strength, followed by failure of well screen or casing.
- Deposition of corrosion products, thereby blocking screen-slot openings and reducing yield.
- Inflow of low-quality water caused by corrosion of the casing.

(1) Chemical and Electrochemical Corrosion:

Corrosion results from chemical and electrochemical processes. Chemical corrosion occurs when a particular constituent is present in water in sufficient concentration to cause rapid removal of material over broad areas. Commonly these constituents are carbon dioxide, oxygen, hydrogen sulfide, hydrochloric acid, chloride, and sulfuric acid.

Chemical corrosion can cause severe damage in wells, regardless of the amount of total dissolved solids. The number of wells affected by chemical corrosion is, however, small compared to those affected by electrochemical corrosion.

In electrochemical corrosion, flow of an electric current facilitates the corrosive attack on a metal. Two conditions are necessary:

- A difference of an electrical potential on metal surfaces.
- Water containing enough dissolved solids to be a conductive fluid (electrolyte).

A potential (electrical) difference may develop between two different kinds of metals, or between nearby but separate areas on the surface of the same metal.

Difference in potential on the same steel pipe, for example, can occur:

- At heat affected areas around welded joints.
- At heated areas around torch-cut slots.
- At work-hardened areas around machine-cut slots.
- At cut surfaces of exposed threads at pipe joints.
- At breaks in surface coatings such as paint and mill scale.

In the above cases both a cathode and an anode develop, and metal is removed from the anode.

Bimetallic corrosion results when two different metals are in contact and immersed in an electrolyte. A galvanic cell is created an corrosion occurs. A well screen made of two different metals, such as low-carbon steel and stainless steel, will be damaged because the mild-steel portion is corroded by the galvanic action.

When electrochemical corrosion takes place, corrosion products may be deposited at the cathode. These deposits are usually voluminous. If iron or steel is corroded, the corrosion products are iron combined with other elements and are normally ferric hydroxide or ferric oxide.

Deposition of corrosion products that results in blocked screen-slot openings and reduced well yields is evidence of electrochemical corrosion.

13.2 METHODS OF WELL REHABILITATION (TA CODE 13-2)

13.2.1 GENERAL

The major purposes of well rehabilitation are:

(1) To revive the well yield by cleaning the clogged screen and neighbouring aquifer

(2) To remove the sedimentation of sand at the bottom of a well

(3) To repair the damaged screen and/or casing which produce sand and/or clay into the pumped water

For above (1), mechanical methods such as air-lifting, bailing, brushing, swabbing etc., and chemical methods using acid are used.

For (2) air-lifting or bailing is used.

The countermeasures for (3) need more complex and expensive process. Double-casing methods are commonly used if the diameter of internal casing to be installed is sufficiently enough to install the pump. Principles of the above methods are described below.

13.2.2 MECHANICAL CLEANING

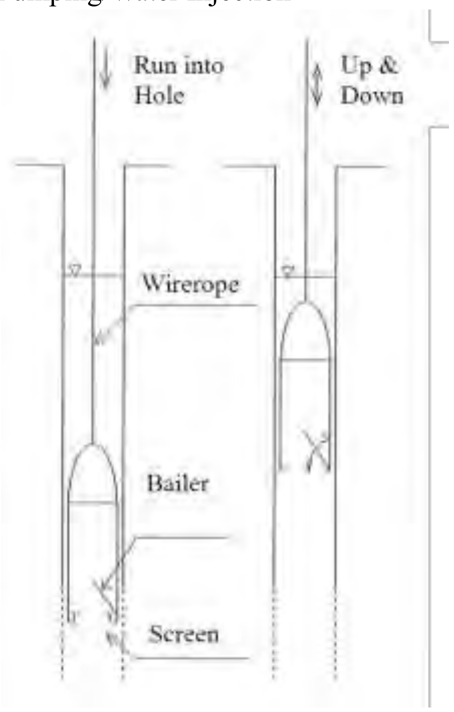
Mechanical cleaning is the method of removing scale, sand, silt which clogs the screen and neighbouring aquifer by hydraulic force and/or direct physical contact of cleaning devises. The following methods are generaly used (See ***Figure 5*** and ***Figure 6***).

(1) Bailing

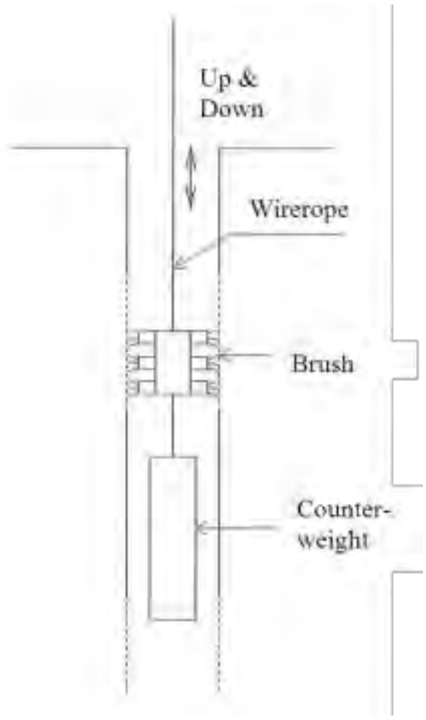
(2) Brushing

(3) Jetting

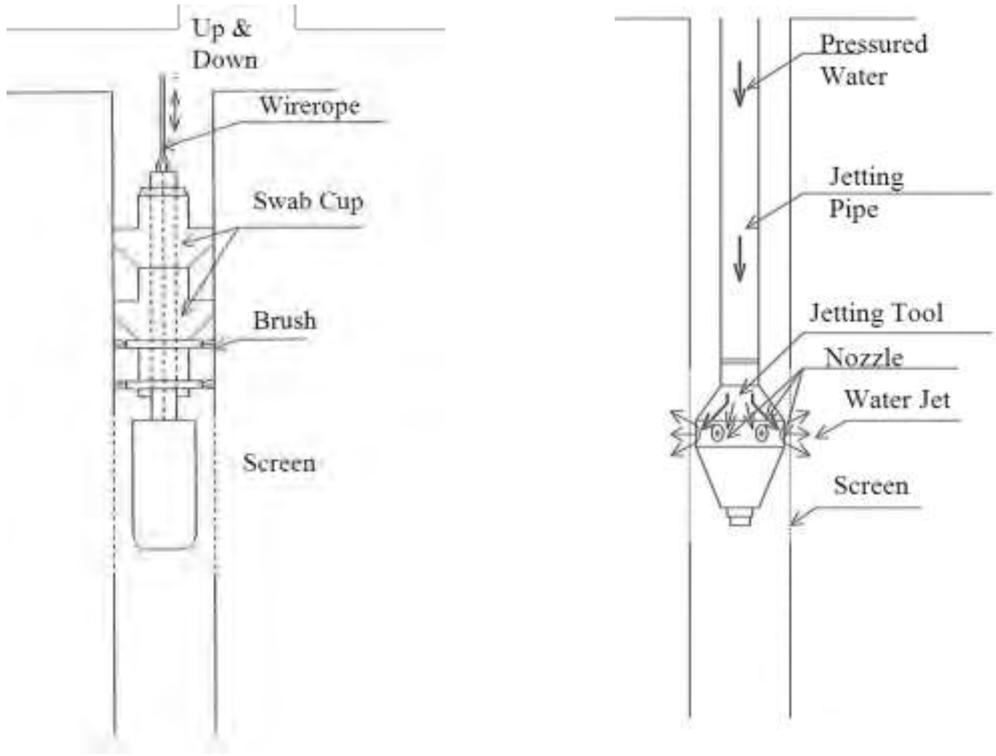
(4) Pumping/Water Injection



Bailing

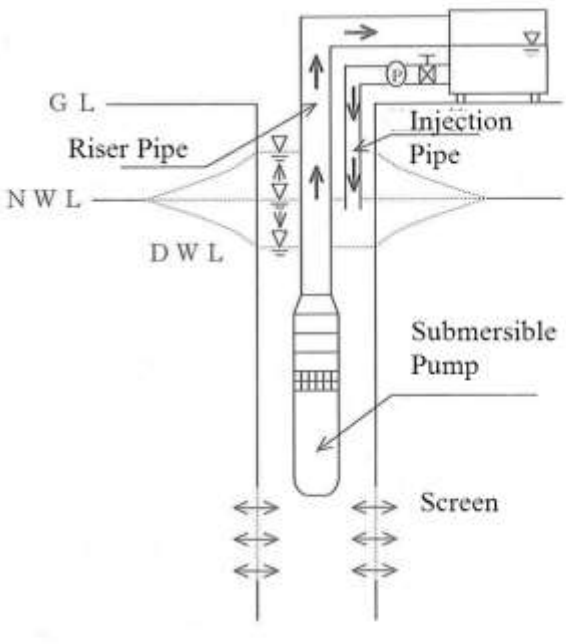


Swabbing



Source: National Water Well Association of Japan

Figure 5　Mechanical Cleaning (1/2)



Pumping/Water Injection

Source: National Water Well Association of Japan

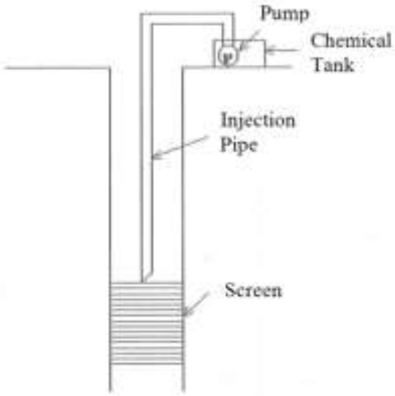
Figure 6　Mechanical Cleaning (2/2)

13.2.3 CHEMICAL CLEANING

Mechanical methods are effective for the cleaning of the scales on the suface of screen and casing. However, the effects often do not reach to the inside of the neighbouring aquifer. In this case, chemical method is used together with mechanical method.

Various types of chemical agent for the well rehabilitation are available for the purposes of the decomposition of scale, disinfection of iron bacteria etc.

The instruments of chemical injection are shown in ***Figure 7***.



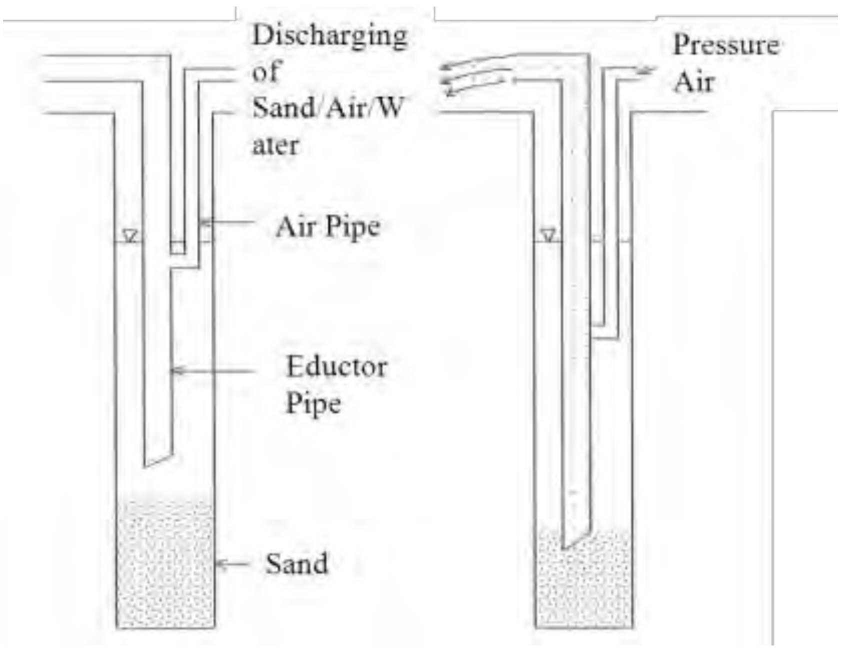
Source National Water Well Association of Japan

Figure 7 Installation of Chemical Cleaning

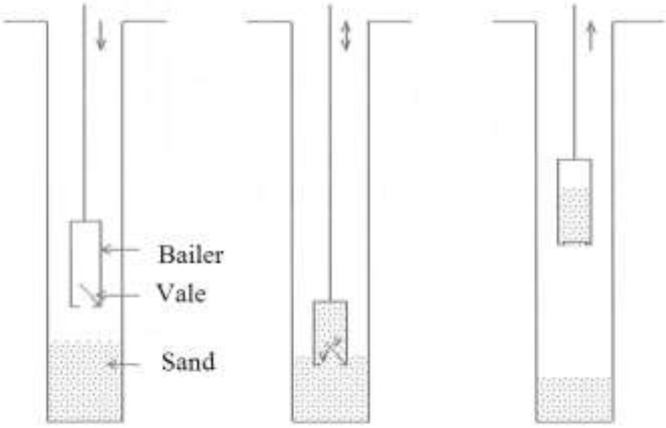
13.2.4 SEDIMENTATION REMOVAL

The pumped water contains certain amount of sand. The sand is deposited at the bottom of well during the pumping operation. This sand deposit may cause the elvation of sand content in the pumped water and/or decrease of water yield due the clogging of screen.

The deposited of sand shall be periodically removed by the measures of air-lifting and/or bailing (See ***Figure 8***)



Air-Lifting Method



Bailing Method

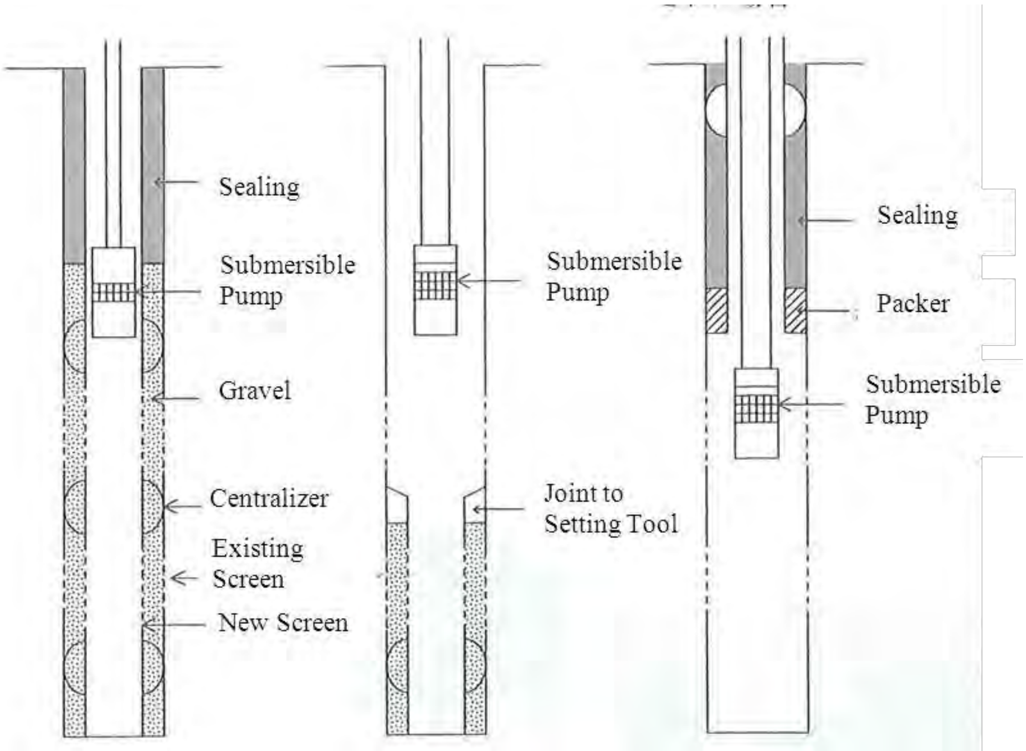
Source National Water Well Association of Japan

Figure 8 Sedimentation Removal Method

13.2.5 DOUBLE-CASING METHOD

Especially for steel casing and screen, the holes on casing and screen occur by corrosion. These holes will be expanded gradually. One of the popular counter-measure to repair the holes on casing and screen is double-casing method.

Smaller casing and screen are installed inside the existing casing and screen as shown in ***Figure 9***.



Source National Water Well Association of Japan

Figure 9 Double-Casing Method

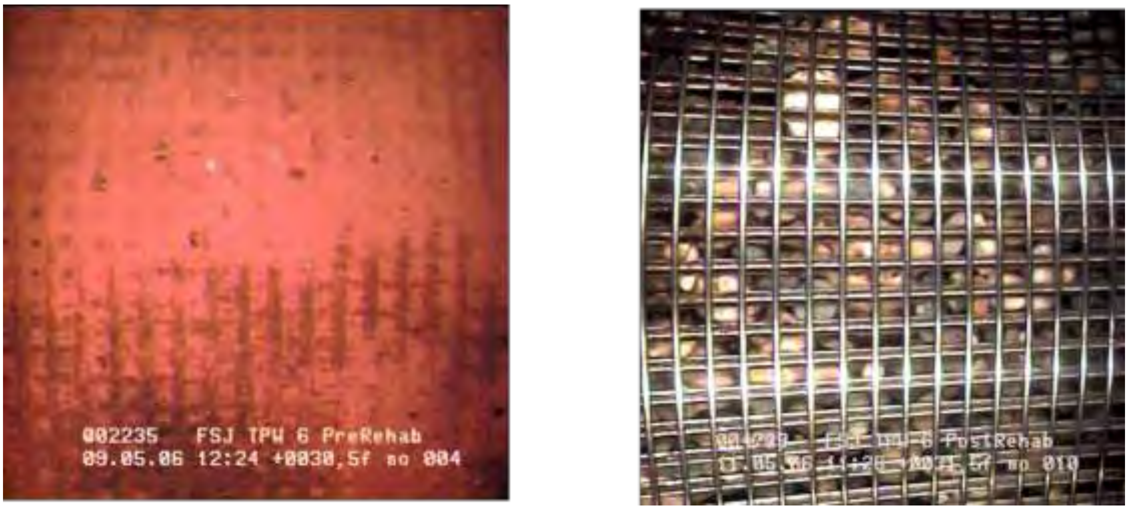
13.3 USAGE OF WELL CAMERA (TA CODE 13-3)

Well camera is very useful tool which can obtain the following information:

– Condition of the casing and screen in a well
– Screen position, casing diameter, casing materials

Figure 8 clearly shows the difference of the conditions of the screen before and after the well rehabilitation, by well camera.

- DDCA is now procuring one (1) set of well camera for the purposes of the well investigation.



Source: Golder Associates Ltd – Kamloops (2006)

Figure 10 Well Screen Before and after treatment of Incrustation

dtcode_lst

DT-0010 RegionName | DT-0020 DistrictName | DT-0030 WardName | DT-0040 VillageStreetName | DT-0050 SubVillageName | DT-0100 BoreholeNo | DT-0110 Zone | DT-0120 Coordiante | DT-0130 CoordianteY | DT-0200 SurveyRef | DT-0190 DateOfCompletion | DT-0360 DiametrDrilled | DT-0370 DepthDrilled | DT-0300 StructAtDepthTo | DT-0330 Yield

Project ID	井戸位置情報																	
ID	国番号	国名	州	県	郡	村	集落	プロジェクト内番号	登録井戸番号	緯度	経度	地表高度	UTM のゾーン	UTM X	UTM Y	座標取得	緯度経度の精度	地図
	Location																	
ID	Country No.	Country	Region	District	Division	Village	Community or Site Name	Borehole No. in This Project	Registered Boreholen No.	Latitude	Longitude	Altitude	UTM Zone	UTM X	UTM Y	Coordinate Collected Point	Accuracy	Map
			NULL			NULL	Buhungukira NYAHANGHA											
1			Tabora	Tabora	NULL	NULL	Malongwe		05/31									
2			Tabora	Tabora	NULL	NULL	Malongwe		8/31									
3			Shinyanga	Shinyanga	NULL	NULL	Huru Huru		9/31									
4			Shinyanga	Shinyanga	NULL	NULL	Shinyanga		11/34									
5			Shinyanga	Shinyanga	NULL	NULL	)ld Shinyanga		10C/31									
6			Morogoro	Morogoro	NULL	NULL	Ngerengere		1/31									
7			Manyoni	Manyoni	NULL	NULL	a Station, Makutupora		2/31									
8			Manyoni	Manyoni	NULL	NULL	lakutupora Station		3/31									

Project ID	井戸合否	不合格理由	水質基準合否	注釈	新規掘削/リハビリテーション	物理探査			掘削年月日	仕上げ孔				掘進率情報	水が出た深度情報	エアリフト揚水量
ID						データの有無	探査データイメージ	探査番号		ビットタイプ	井戸掘削径	掘削流体	掘削深度			
ID	Positive or Negative Borehole	Reason for Negative	Positive or Negative quality	Remarks	New Construction / Rehabilitation	Geophysical Survey			Drilling							
						Present/Absent	Survey Data	Survey No.	Drilling Date	Bit Type	Drilling Diameter	Drilling Liquid	Drilling Depth	Drilling Rate	Water Strike Depth or Mud Water Lost Depth	Water Yield by Air Lifting
									dd/mmm/yyyy		″ (inch)					m3/h
1									1931/10/10							0.02
2									29/09/1931							0.7
3									11/Oct/1931							0.6
4									18/12/1931							0.8
5									12/Dec/1931							
6									04/Nov/1931							1.5
7									13/03/1931							1.9
8									06/Feb/1931							1.9

DT-0380 CasingType | DT-0390 CasingDiameter | DT-0350 DepthOnCompletion | DT-0420 ScreenPositionFrom | DT-0430 ScreenPositionTo | DT-0540 Length

井戸諸元																							
揚水基準合否	ケーシング																			柱状図	孔内検層		
	挿入の有無	材質	サイズ	挿入深度	Top Screen		2nd Screen		3rd Screen		4th Screen		5th Screen		6th Screen		7th Screen		総スクリーン長		検層図有無	検層項目1	検層項目2
					Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom					
Well Information																							
	Casing																			Geological Column	Logging		
Acceptable Yield or not	Installation	Material	Diameter Size	Installed Depth	Top Screen		2nd Screen		3rd Screen		4th Screen		5th Screen		6th Screen		7th Screen		Toltal Screen Length		Logging data	Item 1	Item 2
					Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom					
Pass/Fail	Installed/Not installed		″ (inch)	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m				
				128																			
				444.5	31.0									32.0									
				300.0	13.0									16.0									
				211.0	29.0									32.0									
				80.0																			
				240.0																			
				158.5																			
				300.0																			

DT-0320 WLRoseTo | DT-0851 DateFrom | DT-0853 Step Discharge Rate | DT-0854 Step Pumping Time | DT-0855 Step DWL

						揚水試験																				
		孔内水位測定			柱状図画像	揚水試験開始日	段階揚水試験																			
検層項目3	検層項目4	水位測定基準	測定基準高	自然水位			1段階			2段階			3段階			4段階			5段階			6段階			7段階	
							揚水量	揚水時間	動水位	揚水量	揚水時間	動水位	揚水量	揚水時間	動水位	揚水量	揚水時間	動水位	揚水量	揚水時間	動水位	揚水量	揚水時間	動水位	揚水量	揚水時間
						Pumping Test																				
		Water Level Mesurement			Column Image	Test Starting Date	Step Draw Down Test																			
Item 3	Item 4	Measuring Level	Height from Ground Leve	Natural Water Level			1st Step			2nd Step			3rd Step			4th Step			5th Step			6th Step			7th Step	
							Discharging Rate	Pumping Time	Dinamic Water Level	Discharging Rate	Pumping Time	Dinamic Water Level	Discharging Rate	Pumping Time	Dinamic Water Level	Discharging Rate	Pumping Time	Dinamic Water Level	Discharging Rate	Pumping Time	Dinamic Water Level	Discharging Rate	Pumping Time	Dinamic Water Level	Discharging Rate	Pumping Time
			m	m			m3/h	hh:mm	m	m3/h	hh:mm	m	m3/h	hh:mm	m	m3/h	hh:mm	m	m3/h	hh:mm	m	m3/h	hh:mm	m	m3/h	hh:mm
				39																						
				50.60																						
				65.50																						
				23.80																						
				8.80																						
				28.20																						
				54.90																						

		DT-1300 Const Discharge Rate	DT-1310 Const Pumping Time	DT-1320 Const DWL		DT-1330 Recovery Measuri	DT-1340 Recovery WL rose to																			DT-1680 Colour		DT-1670 Turbidity		DT-0340 Taste	DT-2260 Reporting(	DT-1700 PH		DT-1720 Conductivi
														設置ポンプ				施設																
	連続揚水試験					回復試験		揚水試験結果解析				グラフイメージ	イメージリン	タイプ	モデル	ポンプスペック（径等）	設置深度	プラットフォーム	井戸利用目的	井戸所有者	写真画像	分析の有無	色度		色度		濁度		臭気	味	温度	pH	酸化還元電位	電気伝導度
動水位	試験開始水位	揚水量	揚水時間	動水位	比湧出量	計測時間	回復水位	透水量係数	透水係数	透水量係数	透水係数												UCV		mgPt/l		UNT						ORP	
																							符号	値	符号	値	符号	値	値	値	値	値	値	値
														Pump				Facility																
	Constant Rate Test					Recovery Test		Pumping Test Analysis				Analyzed Data	Pump Test Image	Type	Model	Specification	Installed Depth	Platform	Constructional Purpose	Holder	Image	Data Present or not	Color		Color mgPt/l		Turbidity		Odor	Taste	Temperature	pH	Oxidation-reduction	Conductivity
Dinamic Water Level	Starting Water Level	Discharging Rate	Pumping Time	Draw Down Level	Specific Capacity	Measured Time	Recovered Water Level	Transmissivity	Permeability	Transmissivity	Permeability												Sign	Value	Sign	Value	Sign	Value	Value	Value	Value	Value	ORP Value	Value
m	m	m3/h	hh:mm	m	m3/D/m	hh:mm	m	m2/sec	cm/sec	m2/sec	cm/sec													UCV		mg/l		UNT			℃		mV	mS/m
																															NULL		38 grains per ga	
																															NULL		35 grains per ga	
																															NULL		72 grains per ga	
																															NULL		180 grains per ga	
																															NULL			No water
																															NULL		63 grains per gal	
																															NULL		1770 grains per g	
																															NULL		1770 grains per g	

DT-1730 DT-1790 DT-1960 DT-1990 DT-2030 DT-1920 DT-1980 DT-1990 DT-2000 DT-1850 DT-1940 DT-1830 DT-1840 DT-1860

tyAt25C/Sali TotalDissolvedSolid Hardness(asCaCo3) AmonicalNitroge Iron Fluoride Manganese NitrateNitrogen TotalPhosphorus Orthophosphate Sodium Zinc Calcium Magnesium Potassium

水質試験																																		
蒸発残留物		全硬度		アルミニウム		アンモニウム		鉄		フッ素		マンガン		硝酸塩		亜硝酸塩		溶存酸素		リン		リン酸塩		ナトリウム		亜鉛		カルシウム		マグネシウム		カリウム		重炭酸
TDS				Al		NH3		Fe		F		Mn		NO3		NO2		DO		P		PO_4^{3-}		Na		Zn		Ca		Mg		K		HCO3
符号	値	符号	値	符号	値	符号	値	符号	値	符号	値	符号	値	符号	値	符号	値	符号	値	符号	値	符号	値	符号	値	符号	値	符号	値	符号	値	符号	値	符号
Water Quality Analysis																																		
Total Dissolved Solid		Total Hardness		Alminium		Ammonium		Iron		Fluoride		Manganese		Nitrate		Nitrit	Nitrite	Disolved Oxygen		Phosphorus		Phosphate		Sodium		Zinc		Calcium		Magnesium		Potassium		Bicarbon
TDS		TH		Al		NH3		Fe		F		Mn		NO3		NO2		DO		P		PO_4^{3-}		Na		Zn		Ca		Mg		K		HCO3
Sign	Value	Sign	Value	Sign	Value	Sign	Value	Sign	Value	Sign	Value	Sign	Value	Sign	Value	Sign	Value	Sign	Value	Sign	Value	Sign	Value	Sign	Value	Sign	Value	Sign	Value	Sign	Value	Sign	Value	Sign
	mg/L				mg/L		mg/L		mg/L		mg/L		mg/L		mg/L		mg/L		mg/L		mg/L		mg/L		mg/L		mg/L		mg/L		mg/L		mg/L	
llon																																		
llon																																		
llon																																		
allon																																		
llons																																		
allons																																		
allons																																		

DT-1800 Carbonate | DT-2010 Sulphate | DT-1760 Alcalinity(asCaCo3) | DT-1910 Lead | DT-1930 Mercury | DT-1870 Cadmium | DT-1890 Copper | DT-1880 Chromium | DT-2060 OthersTotalColiform

塩	炭酸塩		塩化物		硫酸塩		アルカリ度		TAC	鉛		パラジウム		水銀		セレン		砒素		ホウ素		カドミウム		銅		クロム		六価クロム		一般細菌		大腸菌		糞便性大腸菌		プロジェクト情報										
-	CO3-		Cl-		SO_4^{2-}					Pb		Pd		Hg		Se		As		B		Cd		Cu		Cr		Cr6+								プロジェクト名	コンサルタント名	施工業者	完了報告書提出年	施工開始年月	施工終了年月	掘削本数	成功掘削数	不成功掘削	揚水量基準不合格数	水質基準不合格数
値	符号	値	符号	値	符号	値	符号	値	値	符号	値	符号	値	符号	値	符号	値	符号	値	符号	値	符号	値	符号	値	符号	値	符号	値	符号	値	符号	値	符号	値											
ates	Carbonate		Chloride		Sulfate		Alcalinite		TAC	Lead		Palladium		Mercury		Selenium		Arsenic		Boron		Cadmium		Copper		Chromium		Sexivalent Chromium		General Bacteria		Total Coliform		Facal Coliform, E-Coli		Project Information										
-	CO3-		Cl-		SO_4^{2-}					Pb		Pd		Hg		Se		As		B		Cd		Cu		Cr		Cr6+								Project Name	Consultant	Contractor	Year Submitted Report	Construction Works Started	Construction Works Finished	Drilled Boreholes	Positive Boreholes	Negative Boreholes	Q'ty of Negative Yield	Q'ty of Negative quality
Value	Sign	Value	Sign	Value	Sign	Value	Sign	Value	Value	Sign	Value	Sign	Value	Sign	Value	Sign	Value	Sign	Value	Sign	Value	Sign	Value	Sign	Value	Sign	Value	Sign	Value	Sign	Value	Sign	Value	Sign	Value											
mg/L		mg/L		mg/L		mg/L		mg/L	Dgree Fransais		mg/L		mg/L		mg/L		mg/L		mg/L		mg/L		mg/L		mg/L		mg/L		mg/L		/100ml		/100ml		/100ml				Year(yyyy)	mmm/yyyy	mmm/yyyy	pcs	pcs	pcs	pcs	pcs

不合格理由不明数	成功率	リハビリ本数	注釈	和文概要リンク	英文概要リンク
Q'ty of Boreholes the reason for	Success Rate	Q'ty of Rehabilitation	Remarks	Project Summary (Jp)	Project Summary (English)
pcs	%	pcs			

LOCAIDES GENERAL SUPPLY LIMITED

P.O. Box 33333, Dar es Salaam. Survey, Kinondoni
Tel:2700096 Fax: 2700096
email: locaides@gmail.com,berthаricky@yahoo.com

GROUNDWATER DEVELOPMENT AND MANAGEMENT

CAPACITY DEVELOPMENT PROJECT

DDCAP

OUTPUT (2) LIST OF NUMBER OF DRILLED BOREHOLES PER YEAR

SEPTEMBER 2013

LOCAIDES GENERAL SUPPLY LIMITED

Output (2) List of Number of Drilled Boreholes per Year

Table 1table shows number of drilled borehole per year. Total number of drilled borehole up to 2011/2013 is 12,932.

Table 1 Number of drilled boreholes per year

Financial Year	Borehole Drilled	Financial Year	Borehole Drilled	Financial Year	Borehole Drilled	Financial Year	Borehole Drilled	Financial Year	Borehole Drilled
19301931	13	1950-1951	41	1970-1971	144	1990-1991	151	2010-2011	244
1931-1932	10	1951-1952	38	1971-1972	272	1991-1992	186	2011-2013	269
1932-1933	15	1952-1953	47	1972-1973	286	1992-1993	152		
1933-1934	16	1953-1954	54	1973-1974	314	1993-1994	139		
1934-1935	12	1954-1955	62	1974-1975	291	1994-1995	212		
1935-1936	11	1955-1956	45	1975-1976	284	1995-1996	73		
1936-1937	38	1956-1957	44	1976-1977	253	1996-1997	335		
1937-1938	14	1957-1958	29	1977-1978	193	1997-1998	352		
1938-1939	10	1958-1959	34	1978-1979	156	1998-1999	505		
1939-1940	4	1959-1960	41	1979-1980	150	1999-2000	583		
1940-1941	5	1960-1961	40	1980-1981	282	2000-2001	404		
1941-1942	6	1961-1962	41	1981-1982	110	2001-2002	390		
1942-1943	13	1962-1963	21	1982-1983	98	2002-2003	422		
1943-1944	5	1963-1964	36	1983-1984	133	2003-2004	516		
1944-1945	13	1964-1965	41	1984-1985	240	2004-2005	485		
1945-1946	13	1965-1966	29	1985-1986	96	2005-2006	466		
1946-1947	18	1966-1967	52	1986-1987	193	2006-2007	467		

Output (2) List of Number of Drilled Boreholes per Year

Financial Year	Borehole Drilled	Financial Year	Borehole Drilled	Financial Year	Borehole Drilled	Financial Year	Borehole Drilled	Financial Year	Borehole Drilled
1947-1948	16	1967-1968	93	1987-1988	158	2007-2008	493		
1948-1949	30	1968-1969	106	1988-1989	204	2008-2009	443		
1949-1950	35	1969-1970	125	1989-1990	180	2009-2010	292		

Total 12,932

(Data source: DDCA)

LOCAIDES GENERAL SUPPLY LIMITED

P.O. Box 33333, Dar es Salaam. Survey, Kinondoni
Tel:2700096 Fax: 2700096
email: locaides@gmail.com,berth690aricky@yahoo.com

GROUNDWATER DEVELOPMENT AND MANAGEMENT

CAPACITY DEVELOPMENT PROJECT

DDCAP

OUTPUT (4) REQUIREMENT COMPLETED

OCTOBER 2012

LOCAIDES GENERAL SUPPLY LIMITED

Table of Contents

Figures

1. CURRENT STATUS OF DATA MANAGEMENT OF DDCA

DDCA started drilling works since 1931 when it was the former Drilling Department of MoW and continues drilling works after the transition to DDCA in 1997. Total number of boreholes drilled by DDCA is approximately 10,000. Paper-based borehole completion reports are principally stored in registry room of DDCA. However, most of the borehole completion reports of former Drilling Department are stored in Water Resources Department (WRD) of MoW and in the DDCA Office in Dodoma.

Currently, the completion report is submitted to Basin Water Office and client after approval of DDCA headquarters. The report submitted is stored in DDCA branch office in Dodoma. The staffs who analyze the data go to refer to the stored reports. The flow of preparing the report is shown in **Figure 1**.

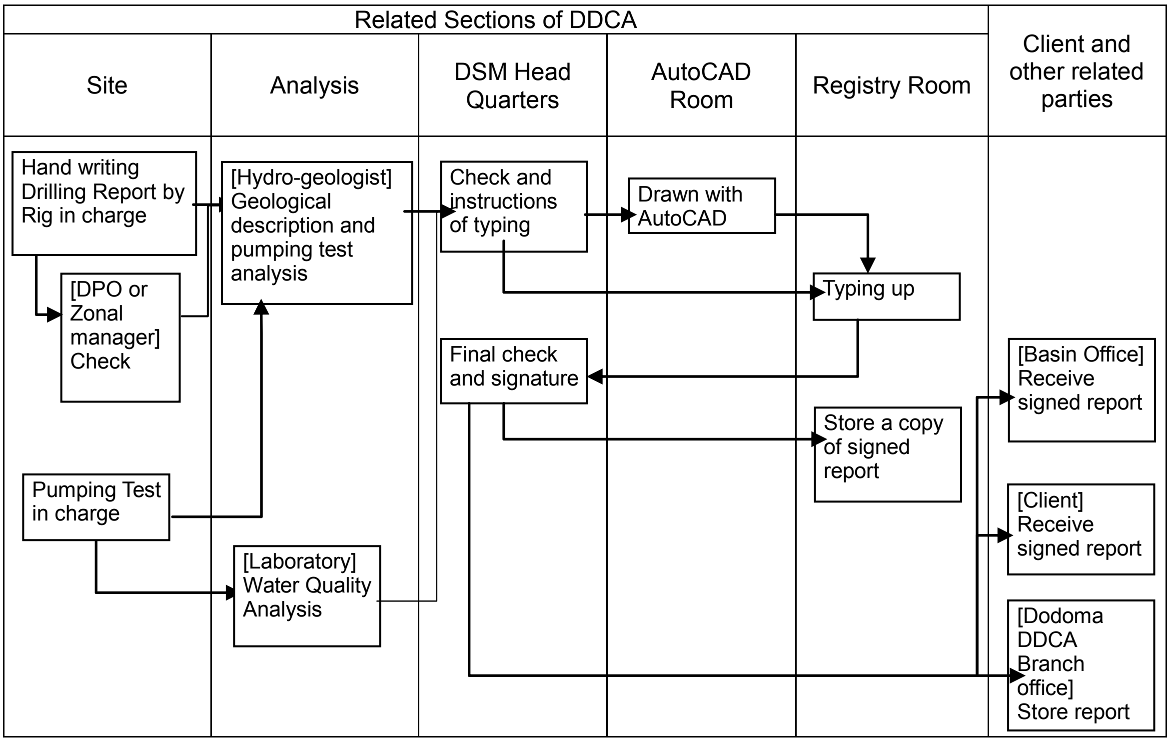


Figure 1: Flow of current organization of report

2. EXISTING WELL COMPLETION REPORT

The well completion reports include two types of forms one is the old forms which had been used 1931 to 1946,the other one is the existing form currently used(form 1).The forms include on drilling work, pumping test, water quality analysis. They consistof the following seven types of forms:

1) cover page, 2) drilling record, 3) well section drawing, 4) step pumping test result, 5) constant rate pumping test result, 6) recovery test result, and 7) water quality analysis result.Among the above, the form 2) and 3) are prepared by the drilling teams.

They are prepared in hand writing by each Rig in Charge and sent to the main office in Dar es Salaam through the Zonal Manager or Drilling Project Officer (DPO). After the examination of the Head of Drilling Section, the form 2) is typed up in the registry room and the form 3) is prepared with Auto-CAD in the drawing room. The forms 4) to 6) are prepared by the pumping test teams. They are filled in hand writing and checked up by the Drilling Manager, then typed up with MS-Word in the registry room. The typed up reports of the drilling work and the pumping test are examined by the Drilling Manager. After that they will be approved by CEO, to submit to the clients together with the form 7) to be prepared in the laboratory and the form 1) cover page as well.

The set of the well completion report are shown in the Appendices 1-1 to 1-6. The old form is shown in Appendix 1-2, while the form 1 is shown in Appendix 1-3.

3. INTRODUCTION OF NEW DATABASE SYSTEM

The purpose of the database is to provide the well data which facilitate the private company to make a proper drilling plan when they start the drilling work in the areas where they do not have experiences.

Currently, the existing well completion reports are stored in the DDCA's headquarters in Dar es Salaam, DDCA branch office in Dodoma and Water Resource Department (WRD) of MoW in Dodoma. The work of the Contractor includes the data entry of those reports into the database.After the data entry of all existing well completion reports, DDCA staffs shall continue the entry of the new coming data. The database shall be constructed according to the following principles so that DDCA can update the database periodically.

✓ The Software shall be MS-Excel as a versatile and popular one. This enables the DDCA staffs to continue the update and maintenance of the database by themselves.

- ✓ Too much additional tasks for the updating of new database by DDCA shall be avoided. Therefore, the change from the existing report making system shall be as less as possible. Necessary consideration shall be taken such as the utilization of the typed-up data of handwriting report in existing report as inputs to new database.
- ✓ Many data items in the database can be commonly used with the "Well Database in African Countries (WDAF)" of JICA. The database shall be equipped with a function for the easy transferring of data to the "African Countries Well Database" at the same time, shall be added to the database.

4. REVISION OF FORMS

The form 2) was examined and revised upon the commencement of the database construction.Hereafter, the existing form is called as "Form 1" (refer to the Appendix 1-2) and the revised form is called as "Form 2" (refer to the Appendix 2). The purpose of the revision was to add more information related to well location, well structure and drilling work record. However, it was considered not to make the staffs spare much time for entering those additional data. So the existing form has been utilized and only minimal items were added.

The Form 1 consists of the following items:

1) general description of the stratum, 2) record of water strike, 3) drilled diameter and depth, 4) record of casing screen, 5) record of backfilling, 6) record of gravel, 7) record of drilled method and any other general description.

The column added in the Form 2 is as below.

(1) General information

The column for entering either borehole newly drilled or rehabilitated was added.

The column for entering GPS coordination was added. The coordination system of GPS was defined as Arc 1960 UTM.

The column for entering ward, village /street and sub-village were added.

The column for entering the survey reference number of the geophysical survey was added.

(2) Description of the stratum

The column for entering the water strike was added.

(3) Record of water strike

The column for entering water yield at each water strike depth was added. This information is important to identify which aquifer was the major one.

The columns for entering the major aquifer and recovered water level were added.

(4) Drilled diameter and depth

No addition

(5) Record of casing and screen

The column for entering the position of screen was added.

The columns for screen diameter and depth were added in order to record the telescopic type casing and screen.

The column for entering the diameter and depth of conductor casing and surface casing were added.

The column for entering the hole uncased was moved to this section from the section 5 Finish of Section Uncased of Form 1.

(6) Finish of Section Uncased and Gravel Screen

5) Finish of Section Uncased and 6) Gravel Screen in Form 1 were combined to be 5) Clearance Fill Up. The columns for entering Sealing Above Gravel Up To, Back Filling Up To and Sanitary Sealing were added.

(7) Drilling Method

The format was changed so that the data on depth and drilling method shall be filled.

The form of drilling work record revised as the above (Form 2) is shown in Appendix 2.

5. DATA SHARING WITH JICA'S WELL DATABASE

Many attributes in WDAF are same as or can be converted from those in WID.

The Appendices 3-1 to 3-4 show the list of the data items of WDAF. The attributes which can be used for WDAF are shown with filled color (yellow: can be used directly, green: can be converted by calculation).

Not all attributes of WID can be used in WDAF since the specifications of drilling works of DDCA differ from those of the groundwater development projects of JICA. However, the information related to well structure, pumping test and water quality analysis are almost common between above two. So it is useful to produce the data sheet in WDAF's format from the data which are entered in WID.

Regarding the implementation of the database, placing all attributes in a data sheet in MS-Excel will make the data entry works complicated.

The order of the entry sheet of WID is almost same as that of the entry to the well completion report. Therefore, efficient way for the data entry is to place only the attributes for input in data sheet in this order. In the same context, another datasheet in a WDAF's format shall be set in same excel book as WID's data sheet and the data of WDAF's shall be automatically referred from WID's data sheet by measures of by direct reference or calculation.

6. CHANGE OF DATABASE SOFTWARE TO MS-EXCEL

6.1 Database Structure in MS-Excel

As mentioned in Section 1.2, the well completion report except for the well section drawing and the result of water quality analysis are typed up in the registry in the DDCA's headquarters. By using these data for the well completion forms as the input for WID, too much increase of tasks on data entry clerks for the updating WID can be avoided and sustainable operation of WID can be ensured.

For the pumping test result, only representative data of each pumping test shall be entered to the WID. Detailed records of draw down etc. shall be entered and saved in the datasheet to be prepared separately from WID's self. Currently, the pumping test results are entered to the forms in MS-Word. By changing these forms into MS-Excel, the data could be easily utilized for making charts and interpretation of hydraulic constant, in case it is necessary.

WID shall be constructed in MS-Excel in order to allow DDCA staffs easily maintain it by themselves. Technical support to improve the skills in MS-Excel of DDCA's staff shall be provided by the Contractor and JICA Expert Team, since there are currently no staffsthat have enough skills for the operation and maintenance of the WID.

6.2 Information Retrieval from WID

The borehole data in the WID is helpful for private drilling companies to formulate their drilling plan and to determine the drilling method. However, if DDCA is equipped with the capacity to provide them with filtered and/or analysed data according to the needs of the private companies, the technical support from DDCA will be more effective.

The area-wise analyse will be special useful for the private companies. The maximum, minimum and average value of well depth, well structure and well yield by area will contribute to the accuracy improvement of the drilling plan and to the prevention of risk to start the drilling work in inexperienced area.

The existing well completion reports of DDCA include the data of only regions and districts as the information of well locations but do not have that of wards, villages and GPS coordinates. DDCA decided to start to record such important data by using the revised drilling record form which contains the column for entering those data. It means that the new well data will include this information. On the other hand, DDCA has a plan to start to collect the GPS coordinates of existing wells and add them to the WID. The WID is expected to provide more useful information with improved quality by the above updating.

Apart from the area-wise analysis, the analysis by different parameters such as year or drilling method is one of the major advantages of database. In order to achieve this, DDCA's staffs need to acquire the skill of data analysis by MS-Excel.

Appendices

Appendix 1-1 Existing Well Completion Report Form Cover Page (Sample)

M/S. IGBAR MSIKITI WA IJUMAA
TABORA TOWN – TABORA REGION

DRILLING AND DAM CONSTRUCTION AGENCY

BOREHOLE COMPLETION REPORT
TBR/BH.756/2008

DRILLED BY:
DRILLING AND DAM CONSTRUCTION AGENCY
UBUNGO – UDSM ROAD
P.O.BOX, 55658
TEL No. 2410299,2410384
DAR ES SALAAM

December,2008

Appendix 1-2 Existing Well Completion Report Form Drilling Work Record (Old form) (Sample)

BOREHOLE NO. 27/50. DRILL FOREMAN: D.N. Crawfo

Plant:	Ruston Bucyrus No. 6
Hirer:	Native Treasury.
Place:	Gombero.
District:	Tanga.
Agreement dated:	-
Date Commenced:	27th October 1950.
Date Completed:	30th November 1950.
Total Cost:	Nett. shs.2004.23 O'heads.2976.77 Cap.4981.00
Distance travelled from previous borehole:	-
Formation pierced:	Sandy clay slatey shales Karroo?
Diameter:	8" to 127'. 6½" from 127' to 200'.
Total Depth:	200'.
Water Struck at:	72'.
Static level of water:	14'.
Tested yield:	3600.g.p.h.
Salinity:	391 g.p.g.
Casing left in borehole:	55' of 8"
Footage in hard rock:	-
" " soft " :	-
Hours erecting:	5
Hours drilling:	96
Hours pumping:	24
Hours engine running:	115
Hours delay:	-
Hours due to hirer:	-
SStores consumed:	Diesoline 218 gals. Engine oil 14 gals. C.oil 1 gal. Grease 4 lbs. Goal 5 cwts.

Remarks:

DRILLING AND DAM CONSTRUCTION AGENCY
WATER-WELL COMPLETION FORM

Borehole No: TBR 756/2008 **Drilled By (Rig No./Type):** 81
Locación/Área: MSIKITI WA IJUMAA **District:** TABORA TOWN **Region:** TABORA
Name of Applicant & Address: M/S. IGBAR
Date of Commencement: 02.12.2008 **Date of Completion:** 02.12.2008

1. STRATA:

From m	From cm	To m	To cm	General Description
00	00	04	00	Sand top soil
04	00	06	00	Sandy clay
06	00	08	00	Fractured granite
08	00	12	00	Weathered granite
12	00	24	00	Granite
24	00	30	00	Fractured granite
30	00	34	00	Fractured and weathered granite
34	00	36	00	Granite
36	00	50	00	Fractured granite
50	00	56	00	Granite

2. WATER:
Struck at: 5,38,40 m
W.L. rose to: 02 m 57 cm
Yield tasted: 700 LPH
Water quality to taste: GOOD

3. DIAMETER DRILLED AND DEPTH:
8 inch Ø to 56 m 00 cm
...inch Ø to......m.......cm
...inch Ø to......m.......cm
Depth on completion: 53 m 96 cm

4. CASING/SCREEN LEFT IN HOLE:
Type: Dia: Length:
uPVC **Casing** 06 **inch** 36 **m** 56 **cm**
.........**Casing**.......**inch**......**m**.......**cm**
uPVC **Screen** 06 **inch** 17 **m** 40 **cm**
.........**Screen**.......**inch**......**m**.......**cm**
Casing above G.L: 00 m 50 cm
Top of Casing Secured: uPVC Cap
Bottom end of Casing protected with: uPVC Plug

5. FINISH OF SECTION UNCASED:
Hole uncased: 02 m 04 cm
Back-filled to: 53 m 96 cm
Filled with: Cuttings **Average size**.......
Other Method: Sanitary seal to 5m

6. GRAVEL SCREEN:
Gravel Type: Quartz **Gravel**
Average Size: 2 – 4 mm
Inserted from:53m 96 **to** 05 **m** 00 **cm**

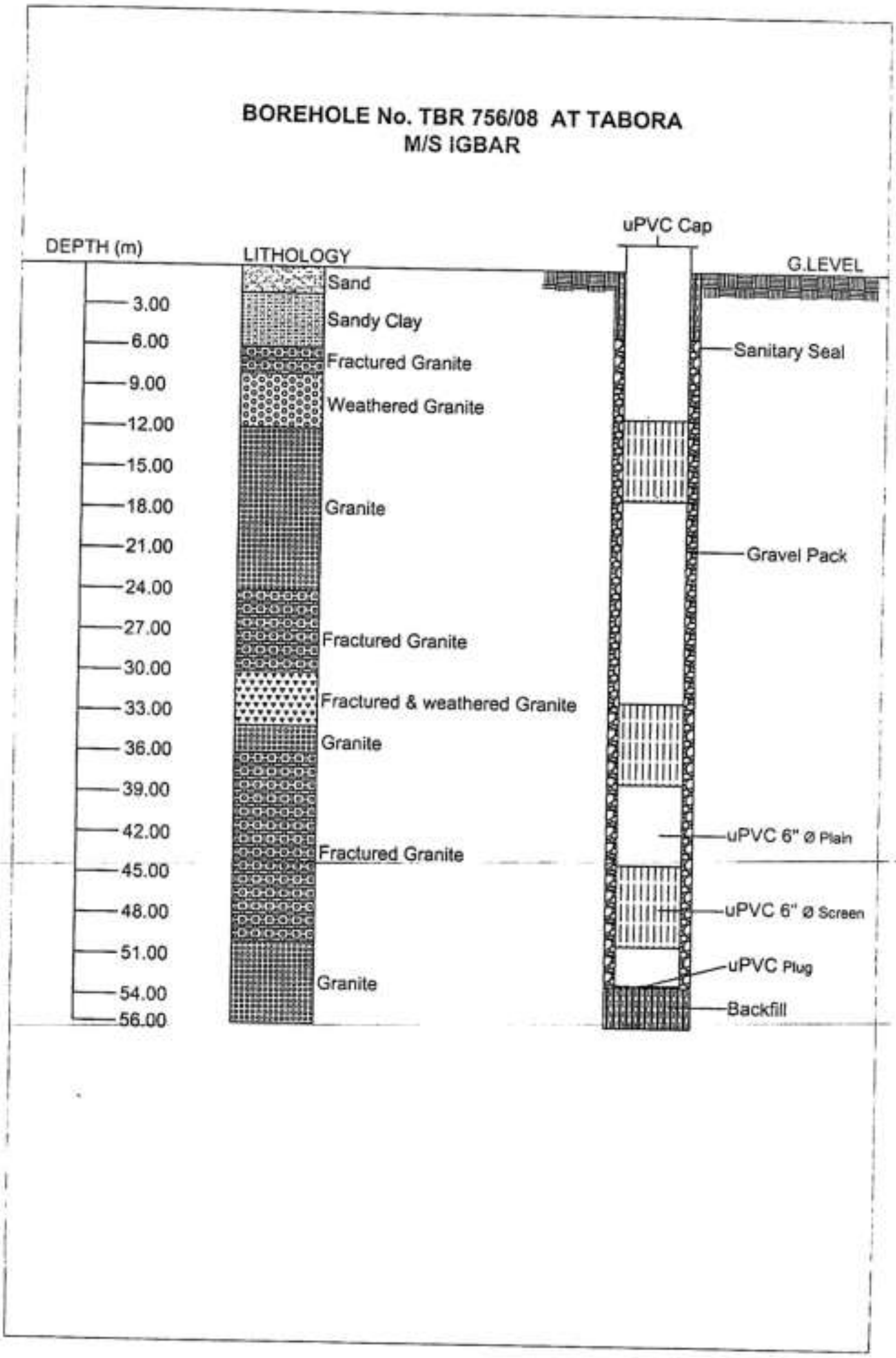
7. DRILLING METHOD:
Air Rotary to: 06 **m** 00 **cm**
Mud Rotary to:.......**m**.......**cm**
Air Hammer to: 56 **m** 00 **cm**
Cable-Tool to:........**m**........**cm**

MR. TITO MTANDA
Driller in charge signature:

Satisfied this Well has been completed in a manlike manner & drilling regulations have been complied with."

....
MANAGING DIRECTOR:
For: Managing Director
Drilling and Dam Construction Agency
P.O. Box 35038
DAR ES SALAAM

Appendix 1-4 Existing Well Completion Report Form Borehole Section Drawing (Sample)



CONSTANT PUMPING TEST

Conducted for: 05:00 **Hours Done by:** DDCA
S.W.L at: 02 **meters** 57 **cm** **Yield:** 700 LPH **Drawdown** 45 **meters** 62 **cm**
Outflow measured with Tank Capacity of: 22 **liters.**

PUMP TEST METHOD

Air lift size...**inches; Placed at depth of**................**meters.**
Pump Cylinder size............................**inches; Placed at depth of**...............**meters.**
Submersible pump size:...................**Placed at depth of:** 50 **meters** 00 **cm**

WATER LEVEL DRAWDOWN (B.G.L.)

Date	Time		DWL		Yield LPH	Date	Time		DWL		Yield LPH	Remarks (Wate Appearance, Tes interrupted. Etc.
	hrs	min	m	cm			hrs	min	m	cm		
04.12.2008		00	02	57	-----			300	48	19		
		01	04	30	700							
		02	04	47	700							
		03	04	63	700							
		04	04	89	700							
		05	05	13	700							
		06	05	26	700							
		07	05	53	700							
		08	05	68	700							
		09	06	05	700							
		10	06	32	700							
		12	07	06	700							
		14	07	97	700							
		16	08	93	700							
		18	09	58	700							
		20	09	55	700							
		25	11	80	700							
		30	13	48	700							
		35	15	56	700							
		40	16	95	700							
		50	17	81	700							
		60	19	50	700							
		75	21	38	700							
		90	25	18	700							
		105	27	28	700							
		120	29	73	700							
		135	37	12	700							
		150	40	16	700							
		165	43	93	700							
		195	45	21	700							
		210	46	94	700							
		225	46	61	700							
		240	48	17	700							
		270	48	18	700							

2

Appendix 1-6 Existing Well Completion Report Form Recovery Test Result (Sample)

CONSTANT WATER LEVEL RECOVERY (B.G.L.)

Date	Time		Water level rose to:		Date	Time		Water level rose to:		Additional Notes
	hrs	min	m	cm		hrs	min	m	cm	
		00	48	19			300	37	24	
		01	48	08			330	37	02	
		02	47	75			360	36	16	
		03	47	48			390	35	03	
		04	47	19			420	32	17	
		05	46	65			450	26	14	
		06	46	18			480	18	13	
		07	45	90			540	16	72	
		08	45	60			600	10	17	
		09	43	98			660	07	94	
		10	43	52			720	06	41	
		12	43	38			780	05	03	
		14	43	27			840	04	71	
		16	43	18			900	04	12	
		18	43	07			960	04	01	
		20	42	88			1020	03	81	
		25	42	67			1080	03	66	
		30	42	44			1140	03	51	
		35	42	30			1200	03	50	
		40	42	21			1260	03	50	
		50	42	10						
		60	41	89						
		75	41	67						
		90	41	48						
		105	41	20						
		120	40	98						
		135	40	55						
		150	40	22						
		165	39	75						
		195	38	60						
		210	38	19						
		225	38	01						
		240	37	90						
		270	37	80						

REMARKS:

Appendix 1-7 Existing Well Completion Report Form Water Quality Analysis Result (Sample)

KARMEL CONTRACTORS AND SUPPLIERS LIMITED

Dealers Consultation services on water quality testing geophysical survey, drilling, pump testing well construction.

P. O. Box 70901, Mob. 255 0755 638396, Email: vkazinja@yahoo.com

Water Quality Report

Date: **22/12/2008**

Analysis requested by (Client) M/s. MD – DDCA

Ref............... Date received at the Laboratory 18/12/2008

Water sources: **B/Hole No: 756/08** Location: **TABORA TOWN** Purpose: **Domestic use**

Physical & Chemical Parameters	Concentration	Unit	Tanzanian National Standard	Remarks
Turbidity	0.1	NTU	30	Good
pH	7.4		6.5 – 9.2	Good
Colour	NIL	MgPt/L	50	Good
Electrical Conductivity	131	μS/cm	2000	Good
Total Dissolved Solids	72.05	Mg/l	500 – 1500	Good
Odour	NIL	TON	n.m	
Taste	NO		No Offensive	Not Objectionable
Phenolphalein Alkalinity	NIL	$MgCaCo_3/L$	n.m	
Total Alkalinity	86.2	$MgCaCo_3/L$	n.m	
Carbonate Hardness	86.2	$MgCaCo_3/L$	n.m	
Non Carbonate Hardness	NIL	$MgCaCo_3/L$	n.m	
Total Hardness	25	$MgCaCo_3/L$	600	Good
Calcium	NIL	Mg/l	250	Good
Magnesium	6.08	Mg/l	200	Good
Manganese	NIL	Mg/l	0.5	Good
Zinc	NIL	Mg/l	15.0	Good
Iron	NIL	Mg/l	1.0	Good
Chloride	17.7	Mg/l	800	Good
Sulphate	NIL	Mg/l	600	Good
Nitrate	0.01	Mg/l	100	Good
Sodium	2	Mg/l	n.m	
Potassium	NIL	Mg/l	n.m	
Orthophosphate	NIL	Mg/l	n.m	
Fluoride	NIL	Mg/l	8.0	Good
MICROBIOLOGICAL ASPECTS				
BACTERIOLOGICAL PARAMETERS	**Count/100mL**	**Count/100 mL**		
Total Coliform	ND		NIL	ND
Faecal Coliform	ND		NIL	ND
Faecal Strepotococci	ND		NIL	ND
Chroline Residual	ND		0.3 – 0.5	ND

n.m = Not Mentioned, **NA** = Not Applicable **ND** = Not Determined

RECOMMENDATION: According to Tanzania National standards for water quality the water is physically and chemically suitable for the above mentioned purpose. Regular monitoring is recommended.

Signature........................

Initials: **A. KAZINJA.**

Position: **HEAD OF WATER LABORATORY.**

KARMEL CONTRACTORS & SUPPLIERS LTD. P. O. BOX 70901 DAR-ES-SALAAM

DRILLING AND DAM CONSTRUCTION AGENCY
WATER-WELL COMPLETION FORM

Work scope(1-New borehole construction, 2-Rehabilitation, 3-Other ( )
Borehole No: Drilled By (Rig No./ Type):
Location / Area: Sub-village: Village/Street:
Ward: District: Region:
Coordinate (Arc 1960 UTM) : Zone ______ x ________________ Y__________________
Name of Applicant & Address:
Date of Commencement: Date of Completion:
Survey Ref. No.: VES No.: DDCA Borehole No.

1. STRATA

From m	To m	General Description	Water Strike

2. WATER:
Strike depth & each yield:
____ - ____ m ____ LPH, ____ - ____ m ____ LPH
____ - ____ m ____ LPH, ____ - ____ m ____ LPH
____ - ____ m ____ LPH, ____ - ____ m ____ LPH
Main aquifer: ____________
Final yield ________ LPH
Water level ________ m
Water quality:

3. DIAMETER DRILLED AND DEPTH:
φ____ inch(=______ mm) to ______ m
φ____ inch(=______ mm) to ______ m
φ____ inch(=______ mm) to ______ m
Depth on completion ______ m

4. CASING / SCREEN LEFT IN HOLE:
Type Dia. Total Length Thickness
____ Casing ____ inch(=____ mm) ____ m ____ mm
____ Casing ____ inch(=____ mm) ____ m ____ mm
____ Screen ____ inch(=____ mm) ____ m ____ mm
____ Screen ____ inch(=____ mm) ____ m ____ mm
Screen position:
____ - ____ m, ____ - ____ m, ____ - ____ m,
____ - ____ m, ____ - ____ m, ____ - ____ m,
Diameter and position
Φ____ inch (=______ mm) ____ - ____ m
Φ____ inch (=______ mm) ____ - ____ m
Top plug ______ Above GL ______ m
Bottom plug ______
Conductor casing: dia. ____ mm, GL to ____ m
Surface casing: dia. ____, GL to ____ m
Hole uncased up to: ________ m

5. CLEALANCE FILL UP:
Bottom back filling up to ________ m
Material ________ size ________ mm
Gravel filling up to: ________ m
Material ________ size ________ mm
Sealing above gravel up to: ________ m
Material ________
Back filling up to: ________ m
Material ________
Sanitary sealing: from ____ m to ____ m
Material ________

6. Drilling Method:
from ____ m to ____ m: ____________
from ____ m to ____ m: ____________
from ____ m to ____ m: ____________
from ____ m to ____ m: ____________

Driller in charge ______________ signature ______________

Satisfied this Well has been completed in a manlike manner & drilling regulations have been complied with."

____

CHIEF EXECTIVE OFFICER:

Appendix 3-1 African Countries Well Database Data Item(Well Location and Specification)

Group	Category	Data Item of African Countries Well Database	Method Extracted from DDCA database	Remarks
Well Location	Well Location	Country No.	For Tanzania	Country Code of Tanzania
		Country	For Tanzania	Tanzania
		Region	Direct Reference	Added in Revised Form
		District	Direct Reference	
		Division	Direct Reference	Added in revised form
		Village	Direct Reference	Added in revised form
		Community or Site Name	Direct Reference	
		Borehole No. in This Project	No data	
		Registered Boreholen No.	Direct Reference	
		Latitude	No data	
		Longitude	No data	
		Altitude	No data	
		UTM Zone	Direct Reference	Added in revised form
		UTM X	Direct Reference	Added in revised form(Arc1960)
		UTM Y	Direct Reference	Added in revised form(Arc1960)
		Coordinate Collected Point	No data	
		Accuracy	No data	
		Map	No data	
Well Specificatio	Well Specifications	Positive or Negative Borehole	No data	Can be calculated by setting criteria for success
		Reason for Negative	No data	Can be calculated by setting criteria for success
		Positive or Negative quality	No data	Can be calculated by setting criteria for potable water quality standard
		Remarks	No data	
		New Construction / Rehabilitation	Direct Reference	Added in revised form
	Geophysical Survey	Present/Absent	No data	
		Survey Data	No data	
		Survey No.	Direct Reference	Added in revised form
	Drilling Date	Drilling Date	Direct Reference	Date of completion of drilling
	Drilling Diameter	Bit Type	Calculation	Calculated from drilling diameter
		Drilling Diameter	Calculation	Calculated from drilling diameter
		Drilling Liquid	Calculation	Calculated from drilling diameter
		Drilling Depth	Direct Reference	
	Drilling Information	Drilling Rate	No data	
		Water Strike Depth or Mud Water Lost Depth	Direct Reference	
		Water Yield by Air Lifting	Direct Reference	Confirmed water yield
		Acceptable Yield or not	No data	
	Casing	Installation	Calculation	Calculated from whether or not casing data exists
		Material	Direct Reference	
		Diameter Size	Direct Reference	
		Installed Depth	Direct Reference	
		Top Screen Top	Direct Reference	
		Top Screen Bottom	Direct Reference	
		2nd Screen Top	Direct Reference	
		2nd Screen Bottom	Direct Reference	
		3rd Screen Top	Direct Reference	
		3rd Screen Bottom	Direct Reference	
		4th Screen Top	Direct Reference	
		4th Screen Bottom	Direct Reference	
		5th Screen Top	Direct Reference	
		5th Screen Bottom	Direct Reference	
		6th Screen Top	Direct Reference	
		6th Screen Bottom	Direct Reference	
		7th Screen Top	Direct Reference	
		7th Screen Bottom	Direct Reference	
		Toltal Screen Length	Direct Reference	
	Lithological Log	Geological Column	Direct Reference	
	Borehole Logging	Logging data	No data	
		Item 1	No data	
		Item 2	No data	
		Item 3	No data	
		Item 4	No data	
	Water Level	Measuring Level	No data	
		Height from Ground Leve	No data	
		Natural Water Level	Direct Reference	
	Image of Lithogical	Column Image	Direct Reference	

: Data directly to be used in African Countries Well Database

: Data to be extracted from African Countries Well Database by Calculation

Appendix 3-2 African Countries Well Database Data Item(Pumping Test, Pump Installation and Facility)

Group	Category	Data Item of African Countries Well Database	Method Extracted from DDCA database	Remarks
Pumping Test	Pumping Test Date	Test Starting Date	Direct Reference	
	Step Drawdown Test	1st Step Discharging Rate	Direct Reference	
		1st Step Pumping Time	Direct Reference	
		1st Step Dinamic Water Level	Direct Reference	
		2nd Step Discharging Rate	Direct Reference	
		2nd Step Pumping Time	Direct Reference	
		2nd Step Dinamic Water Level	Direct Reference	
		3rd Step Discharging Rate	Direct Reference	
		3rd Step Pumping Time	Direct Reference	
		3rd Step Dinamic Water Level	Direct Reference	
		4th Step Discharging Rate	Direct Reference	
		4th Step Pumping Time	Direct Reference	
		4th Step Dinamic Water Level	Direct Reference	
		5th Step Discharging Rate	Direct Reference	
		5th Step Pumping Time	Direct Reference	
		5th Step Dinamic Water Level	Direct Reference	
		6th Step Discharging Rate	Direct Reference	
		6th Step Pumping Time	Direct Reference	
		6th Step Dinamic Water Level	Direct Reference	
		7th Step Discharging Rate	Direct Reference	
		7th Step Pumping Time	Direct Reference	
		7th Step Dinamic Water Level	Direct Reference	
	Constant Dicharge Ra	Starting Water Level	Direct Reference	
		Discharging Rate	Direct Reference	
		Pumping Time	Direct Reference	
		Draw Down Level	Direct Reference	
		Specific Capacity	Calculation	
	Recovery Test	Measured Time	Direct Reference	
		Recovered Water Level	Direct Reference	
	Pumping Test Interpr	Transmissivity	No data	
		Permeability	No data	
		Transmissivity	No data	
		Permeability	No data	
	Image of Pumping Tes	Analyzed Data	No data	
		Pump Test Image	No data	
Water Supply Pump	Pump for Water Suppl	Type	No data	
		Model	No data	
		Specification	No data	
		Installed Depth	No data	
Superstructure	Superstructure	Platform	No data	
		Constructional Purpose	No data	
		Holder	No data	
		Image	No data	

: Data directly to be used in African Countries Well Database
: Data to be extracted from African Countries Well Database by Calculation

Appendix 3-3 African Countries Well Database Data Item (Water Quality Analysis)

Group	Category	Data Item of African Countries Well Database	Method Extracted from DDCA database	Remarks
Water Quality Ana	Water Quality Analys	Data Present or not	Calculation	Calculated from whether or not data exists
		Color	No data	
		Color	No data	
		Color mgPt/l	No data	
		Color mgPt/l	Direct Reference	
		Turbidity	No data	
		Turbidity	Direct Reference	
		Odor	No data	
		Taste	Direct Reference	
		Temperature	No data	
		pH	Direct Reference	
		Oxidation-reduction Potential ORP	No data	
		Conductivity	Direct Reference	
		Total Dissolved Solid TDS	No data	
		Total Dissolved Solid TDS	Direct Reference	
		Total Hardness TH	No data	
		Total Hardness TH	Direct Reference	
		Alminium Al	No data	
		Alminium Al	No data	
		Ammonium NH3	No data	
		Ammonium NH3	Direct Reference	
		Iron Fe	No data	
		Iron Fe	Direct Reference	
		Fluoride F	No data	
		Fluoride F	Direct Reference	
		Manganese Mn	No data	
		Manganese Mn	Direct Reference	
		Nitrate NO3	No data	
		Nitrate NO3	Direct Reference	
		Nitrit NO2	No data	
		Nitrite	Direct Reference	
		Disolved Oxygen DO	No data	
		Disolved Oxygen DO	No data	
		Phosphorus P	No data	
		Phosphorus P	Direct Reference	
		Phosphate PO43-	No data	
		Phosphate PO43-	No data	
		Sodium Na	No data	
		Sodium Na	Direct Reference	
		Zinc Zn	No data	
		Zinc Zn	Direct Reference	
		Calcium Ca	No data	
		Calcium Ca	Direct Reference	
		Magnesium Mg	No data	
		Magnesium Mg	Direct Reference	
		Potassium K	No data	
		Potassium K	Direct Reference	
		Bicarbonates HCO3-	No data	
		Bicarbonates HCO3-	No data	
		Carbonate CO3-	No data	
		Carbonate CO3-	Direct Reference	
		Chloride Cl-	No data	
		Chloride Cl-	Direct Reference	
		Sulfate SO42-	No data	
		Sulfate SO42-	Direct Reference	
		Alcalinite	No data	
		Alcalinite	Direct Reference	
		TAC	No data	
		Lead Pb	No data	
		Lead Pb	Direct Reference	
		Palladium Pd	No data	
		Palladium Pd	No data	
		Mercury Hg	No data	
		Mercury Hg	Direct Reference	
		Selenium Se	No data	
		Selenium Se	No data	
		Arsenic As	No data	
		Arsenic As	No data	
		Boron B	No data	
		Boron B	No data	
		Cadmium Cd	No data	
		Cadmium Cd	Direct Reference	
		Copper Cu	No data	
		Copper Cu	Direct Reference	
		Chromium Cr	No data	
		Chromium Cr	Direct Reference	
		Sexivalent Chromium Cr6+	No data	
		Sexivalent Chromium Cr6+	No data	
		General Bacteria	No data	
		General Bacteria	No data	
		Total Coliform	No data	
		Total Coliform	Direct Reference	
		Facal Coliform, E-Coli	No data	
		Facal Coliform, E-Coli	Direct Reference	

: Data directly to be used in African Countries Well Database
: Data to be extracted from African Countries Well Database by Calculation

Appendix 3-4 African Countries Well Database Data Item (Project Information)

Group	Category	Data Item of African Countries Well Database	Method Extracted from DDCA database	Remarks
	Project Information	Project Name	No data	
		Consultant	No data	
		Contractor	No data	
		Year Submitted Report	No data	
		Construction Works Started	No data	
		Construction Works Finished	No data	
		Drilled Boreholes	No data	
		Positive Boreholes	No data	
		Negative Boreholes	No data	
		Q'ty of Negative Yield	No data	
		Q'ty of Negative quality	No data	
		Q'ty of Boreholes the reason for rejection is not knowable	No data	
		Success Rate	No data	
		Q'ty of Rehabilitation	No data	
		Remarks	No data	
		Project Summary (Jp)	No data	
		Project Summary (English)	No data	

LOCAIDES GENERAL SUPPLY LIMITED

P.O. Box 33333, Dar es Salaam. Survey, Kinondoni
Tel:2700096 Fax: 2700096
email: locaides@gmail.com,bertharicky@yahoo.com

GROUNDWATER DEVELOPMENT AND MANAGEMENT

CAPACITY DEVELOPMENT PROJECT

DDCAP

OUTPUT (5) SYSTEM ANALYSIS AND DESIGN COMPLETED

OCTOBER 2012

LOCAIDES GENERAL SUPPLY LIMITED

Table of Contents

Tables

Figures

1. ATTRIBUTES TO BE STORED IN DATABASE

As much as possible, all the data shall be able to be entered in only one datasheet of MS-Excel, from left to right according to the same order of the data in well completion report.

The attributes in the data sheet are lined up as a queue from left to right on the top of the sheet. The data shall be entered to the one row under those attributes as the data to one well. This structure is same as WDAF.

The following E-R diagram shows the attributes to be stored in the database.

Figure 1: Attributes to be Stored in Database

2. DESCRIPTION OF ATTRIBUTES TO BE STORED IN DATABASE

Table 1: Shows the description of each attribute to be stored in the database.

Table 1: Description of Attribute

No.	Data item	Description	Types of data	Remarks
1	Region	Locality information. Region of the drilling point.	text	Unique to a well
2	District	Locality information. District of the drilling point.	text	Unique to a well
3	Ward	Locality information. Ward of the drilling point.	text	Unique to a well
4	Village/Street	Locality information. Village/Street of the drilling point.	text	Unique to a well
5	Sub Village	Locality information. Sub Village of the drilling point	text	Unique to a well
6	Location / Area	Locality information. Name of the belonging facility/house/area etc.	text	Unique to a well
7	Work Scope	New borehole construction, rehabilitation or any other scope	text	Unique to a well
8	Drilled by (Rig No.)	Rig No. of the drilling rig which drilled the borehole	Number	Unique to a well
9	Drilled by (Rig Type)	Rig type of the drilling rig which drilled the borehole	text	Unique to a well
10	Borehole No.	Officially registered number with the water office	Number	Unique to a well
11	UTM Zone	Locality information. UTM zone of the drilling point	Text	Unique to a well
12	Coordinate (X)	Locality information. UTM (X) of the drilling point	Number	Unique to a well
13	Coordinate (Y)	Locality information. UTM (Y) of the drilling point	Number	Unique to a well
14	Elevation	Locality information. Elevation of the drilling point	Number	Unique to a well
15	Applicant id	Client id registered in DDCA	Number	Unique to a well

No.	Data item	Description	Types of data	Remarks
16	Applicant Name	Client Name	Text	Unique to a well
17	Applicant Address	Client Address	Text	Unique to a well
18	Date of Commencement	Date of commencement of the drilling work	Date	Unique to a well
19	Date of Completion	Date of completion of the drilling work	Date	Unique to a well
20	Survey Ref. No.	Ref. No of survey which is for the drilling point	Number	Unique to a well
21	Drawing	Number of drawing belonging to this report	Number	Unique to a well
22	Name of Driller in charge	Name of driller in charge who drilled the borehole	Text	Unique to a well
23	Remarks	Any remarks regarding drilling works	Text	Unique to a well
24	Signature	Signature	Signature	Unique to a well
25	Strata from	Top depth of distribution range of an each lithological description	Number	Many to each well
26	Strata to	Bottom depth of distribution range of an each lithological description	Number	Many to each well
27	General Description	Lithological description of cuttings	Text	Many to each well
28	Water Strike	The zone where the water came from	Number	Many to each well
29	Strike at Depth from	Starting depth of the zone where the water increased	Number	Many to each well
30	Strike at Depth to	Ending depth of the zone where the water increased	Number	Many to each well
31	Yield	Measured water yield at the end of the zone the water increased	Number	Many to each well
32	Water Level Rose to	Water level at the end of drilling work	Number	Unique to a well
33	Yield Tested	Yield at the end of development	Number	Unique to a well
34	Water Quality to Taste	Taste of water	Text	Unique to a well
35	Depth on Completion	Total drilling depth	Number	Unique to a well

No.	Data item	Description	Types of data	Remarks
36	Diameter Drilled	Diameter and drilled borehole	Number	Many to each well
37	Depth Drilled	Drilling depth of each diameter	Number	Many to each well
38	Casing Type	PVC, steel, FRP etc.	Text	Many to each well
39	Casing Diameter	Diameter of the installed casing	Number	Many to each well
40	Casing Length	Length of the installed casing	Number	Many to each well
41	Casing Thickness	Thickness of the installed casing	Number	Many to each well
42	Screen Position from	Top depth of each screen position	Number	Many to each well
43	Screen Position to	Bottom depth of each screen position	Number	Many to each well
44	Casing above GL	Remnant of the casing standing above ground level	Number	Unique to a well
45	Top of Casing Secured/Top Plug	Material or type of top plug	Text	Unique to a well
46	Bottom End of Casing Protected with Bottom plug	Material or type of bottom plug	Text	Unique to a well
47	Hole Uncased up to	Top depth of zone without permanent casing	Number	Unique to a well
48	Backfilled to	Top depth of bottom back filling	Number	Unique to a well
49	Filled with	Material for backfilling	Text	Unique to a well
50	Average Size	Average size of the material of backfilling	Number	Unique to a well
51	Other Method		Text	Unique to a well
52	Length	Length of the installed casing	Number	Unique to a well
53	Conductor Casing Diameter	Diameter of the conductor casing	Number	Unique to a well

No.	Data item	Description	Types of data	Remarks
54	Conductor Casing GL to	Installation depth of the conductor casing	Number	Unique to a well
55	Surface Casing GL to	Installation depth of the surface casing	Number	Unique to a well
57	Diameter from	Top depth of gravel zone	Number	Unique to a well
58	Diameter to	Bottom depth of gravel zone	Number	Many to each well
59	Gravel Type	Gravel type	Text	Many to each well
60	Sealing Position	Top depth of sealing position above gravel	Number	Unique to a well
61	Sealing Material	Material of sealing above gravel	Text	Unique to a well
62	Average Size	Average size of the gravel	Number	Unique to a well
63	Inserted from	Top depth of the gravel position	Number	Unique to a well
64	Inserted to	Bottom depth the gravel position	Number	Unique to a well
65	No. of Cubic Meter Inserted	Volume of gravel	Number	Unique to a well
66	Bottom Backfilling up to	Top depth of bottom backfilling below permanent casing	Number	Unique to a well
67	Bottom Backfilling up Material	Material of bottom backfilling	Text	Unique to a well
68	Bottom Backfilling up Material Size	Material size of bottom backfilling	Number	Unique to a well
69	Gravel Filling up to	Top depth of gravel packing	Number	Unique to a well
70	Gravel Filling up Material	Material of gravel	Text	Unique to a well
71	Gravel Filling up Material Size	Size of gravel	Number	Unique to a well
72	Sealing above Gravel up	Top depth of sealing position above gravel	Number	Unique to a well

No.	Data item	Description	Types of data	Remarks
	to			
73	Sealing above Gravel up Material	Material of sealing above gravel	Text	Unique to a well
74	Backfilling up to	Top depth of backfilling above sealing	Number	Unique to a well
75	Backfilling up Material	Material of backfilling above sealing	Text	Unique to a well
76	Backfilling up Material Size	Size of material of backfilling above sealing	Number	Unique to a well
77	Sanitary Sealing from	Bottom depth of sanitary sealing (it should be "backfilling up to")	Number	Unique to a well
78	Sanitary Sealing to	Top of sanitary sealing (normally it is GL)	Number	Unique to a well
79	Sanitary Sealing Material	Material for sanitary sealing	Text	Unique to a well
80	Method Name	Drilling method	Text	Many to each well
81	From	Started depth of the drilling method	Number	Many to each well
82	To	ended depth of the drilling method	Number	Many to each well
83	Date from	Commencement date of pumping test	Date	Unique to a well
84	Step SWL	Static water level at the beginning of step drawdown test	Number	Unique to a well
85	Step Discharge Rate	Discharge rate of the step drawdown test	Number	Many to each well
86	Step Pumping Time	Pumping time of the step	Number	Many to each well
87	Step DWL	Drawdown water level of the step	Number	Many to each well
88	Constant SWL	Static water level at the beginning of constant test	Number	Unique to a well
89	Constant Discharge Rate	Discharge rate of the constant test	Number	Unique to a well
90	Constant Pumping Time	Pumping time of the constant discharge test	Number	Unique to a well
91	Constant DWL	Drawdown of the constant test	Number	Unique to a well

No.	Data item	Description	Types of data	Remarks
92	Recovery Measuring Time	Duration of recovery measuring	Number	Unique to a well
93	Recovery WL rose to	Water level at the end of the recovery test	Number	Unique to a well
94	Conducted for	Purpose of the pumping test	Text	Unique to a well
95	Conducted by	Operator of the pumping test	Text	Unique to a well
96	SWL at	Static water level at the beginning of the pumping test	Number	Unique to a well
97	Draw down	Drawdown of the pumping test	Number	Unique to a well
98	Yield	Yield of the pumping test	Number	Unique to a well
99	Type of Pumping Test	Type of pumping test like preliminary, step drawdown, constant rate, or recovery.	Text	Unique to a well
100	No. of Steps	Number of steps. Constant rate test and recovery is one step.	Number	Unique to a well
101	Out Flow Measurement with Tank Capacity of	The volume of the equipment to measure the discharging.	Number	Unique to a well
102	Airlift Size	Airlift pipe size	Number	Unique to a well
103	ALSP laced at depth of	The length of the airlift pipe	Number	
104	Pump Cylinder Size	Pump cylinder size	Number	Unique to a well
105	PCS Placed at Depth of	Pump cylinder setting depth	Number	Unique to a well
106	Equipment	Equipment	Text	Unique to a well
107	Pump Model	Pump model	Text	Unique to a well
108	EPM Placed at Depth of	Pump setting depth	Number	Many to each well
109	Date	Started date of pumping test	Date	Many to each well
110	Time Hour	Measured time; hour	Number	Many to each well

No.	Data item	Description	Types of data	Remarks
111	Time Minute	Measured time; minute	Number	Many to each well
112	Meter	Measured value: meter	Number	Many to each well
113	Centimeter	Measured value: centimeter	Number	Many to each well
114	Yield LPH	Discharging	Number	Many to each well
115	Discharge Measured Using	Equipment to measure discharging	Text	Many to each well
116	Remarks	Remarks regarding the pumping test	Text	Many to each well
117	Date	Starting date of recovery test	Date	Many to each well
118	Time Hour	Measured time; hour	Number	Many to each well
119	Time Minutes	Measured time; minute	Number	Many to each well
120	Time Difference	Total duration from the beginning of constant test	Number	Many to each well
121	WL Raised to	Recovered water level	Number	Many to each well
122	Additional Notes	Additional notes	Text	Many to each well
123	Remarks	Remarks regarding the pumping test	Text	Many to each well
124	Turbidity	One of parameter of water quality	Number	Unique to a well
125	Color	One of parameter of water quality	Text	Unique to a well
126	Settable Matter	One of parameter of water quality	Text	Unique to a well
127	PH	One of parameter of water quality	Number	Unique to a well
128	Taste	One of parameter of water quality	Text	Unique to a well
129	Conductivity at 25C/Salinity	One of parameter of water quality	Text	Unique to a well
130	Total Dissolved Solid	One of parameter of water quality	Number	Unique to a well

No.	Data item	Description	Types of data	Remarks
131	Total Non filterable Residual at 105C	One of parameter of water quality	Number	Unique to a well
132	Total Volatile and Fixed Residual at 550C	One of parameter of water quality	Number	Unique to a well
133	Alkalinity (as CaCo3)	One of parameter of water quality	Number	Unique to a well
134	Phenolphthalein	One of parameter of water quality	Number	Unique to a well
135	Total Alkalinity	One of parameter of water quality	Number	Unique to a well
136	Hardness (as CaCo3)	One of parameter of water quality	Number	Unique to a well
137	Carbonate	One of parameter of water quality	Number	Unique to a well
138	Non Carbonate	One of parameter of water quality	Number	Unique to a well
139	Total Hardness	One of parameter of water quality	Number	Unique to a well
140	Calcium	One of parameter of water quality	Number	Unique to a well
141	Magnesium	One of parameter of water quality	Number	Unique to a well
142	Sodium	One of parameter of water quality	Number	Unique to a well
143	Potassium	One of parameter of water quality	Number	Unique to a well
144	Cadmium	One of parameter of water quality	Number	Unique to a well
145	Chromium	One of parameter of water quality	Number	Unique to a well
146	Copper	One of parameter of water quality	Number	Unique to a well
147	Iron	One of parameter of water quality	Number	Unique to a well
148	Lead	One of parameter of water quality	Number	Unique to a well
149	Manganese	One of parameter of water quality	Number	Unique to a well
150	Mercury	One of parameter of water quality	Number	Unique to a well

No.	Data item	Description	Types of data	Remarks
151	Zinc	One of parameter of water quality	Number	Unique to a well
152	Total Nitrogen	One of parameter of water quality	Number	Unique to a well
153	Ammonical Nitrogen	One of parameter of water quality	Number	Unique to a well
154	Organic Nitrogen	One of parameter of water quality	Number	Unique to a well
155	Nitrate Nitrogen	One of parameter of water quality	Number	Unique to a well
156	Total Phosphorus	One of parameter of water quality	Number	Unique to a well
157	Orthophosphate	One of parameter of water quality	Number	Unique to a well
158	Sulphate	One of parameter of water quality	Number	Unique to a well
159	Chloride	One of parameter of water quality	Number	Unique to a well
160	Fluoride	One of parameter of water quality	Number	Unique to a well
161	Others Total Coliform	One of parameter of water quality	Number	Unique to a well
162	Faecal Strep otococci	One of parameter of water quality	Number	Unique to a well
163	AsmgKMnO/L	One of parameter of water quality	Number	Unique to a well
164	BOD(5Days)	One of parameter of water quality	Number	Unique to a well
165	Chlorine Residual	One of parameter of water quality	Number	Unique to a well
166	Remarks	Remarks regarding water quality analysis	Text	Unique to a well
167	Note	Note	Text	Unique to a well
168	Reporting Officer Name	Name of the laboratory which analysed water quality	Text	Unique to a well
169	Signature	Person who signed	Signature	Unique to a well
170	Position	Position of the signer	Text	Unique to a well
171	Ref No.	Reference number of the analysis	Number	Unique to a well

No.	Data item	Description	Types of data	Remarks
172	Telephone	Telephone number of the laboratory	Number	Unique to a well
173	Telegram	Telegram of the laboratory	Number	Unique to a well
174	Email	E-mail address of the laboratory	E-mail address	Unique to a well
175	Fax No.	Fax number of the laboratory	Number	Unique to a well
176	Analysis Requested by	Person or organization who requested the analysis. It may be DDCA	Text	Unique to a well
177	Dated	Analysis date	Date	Unique to a well
178	Date Received At Laboratory	Date that the laboratory received the water sample	Date	Unique to a well
179	Date Collected For Analysis	Date that the water sample was collected at site	Date	Unique to a well
180	Time Collected For Analysis	Time that the water sample was collected at site	Date	Unique to a well
181	Temperature	Temperature	Number	Unique to a well
182	Purpose of Sampling	Purpose of sampling	Text	Unique to a well
183	Preservative Added/Type of Treatment to Water before Sampling	Preservatives for the water sample before analysis if added	Text	Unique to a well

3. CONTENTS OF REPEATING GROUP AND MAXIMUM NUMBER OF DATA

The attributes without filled color in the Appendix 4 are repeating groups to a well or a pumping test (hereafter called as “repeating group”). Therefore, it is necessary to secure the necessary numbers of columns which allows the maximum possible numbers of data in data sheet in MS-Excel.

The contents of the repeating group and the maximum number of the data are described below.

In case the data exceeds to the maximum number of the data, the necessary number of the column in data sheet in MS-Excel shall be added.

(1) Strata

The record of strata includes the following attributes;

- Strata From: the depth of each starting stratum
- Strata To: the depth of each ending stratum
- Description of strata: description on each stratum
- Water Strike: whether or not there was water strike at each stratum

The division of the strata at each well is of two to three at minimum and more than 10 at most. Accordingly, 20 numbers of the data would be enough for the record of strata.

Principally, all data shall be included in one data sheet. However, as the strata record has many data, they shall be entered in separated data sheet. This makes the work of data entry easier.

(2) Water Strike

The record of water strike includes the following attributes;

- Depth of Water Strike From: the starting depth of the water strike
- Depth of Water Strike To: the ending depth of the water strike
- Yield: Measured yield

The maximum number of the data shall be six since the supposed numbers of water strike are zero to six.

(3) Drilled diameter/depth

The drilled diameter/depth includes the following attributes;

- Drilled Diameter: the diameter drilled in each drilling stage
- Drilled Depth: the depth drilled in each drilling stage

The number of the data item is equal to the number of drilling stage. Since DDCA has 1 to 3 drilling stages, the maximum number shall be three.

(4) Casing screen

The casing screen includes the following attributes. There are three data types i.e. Specification on the casing, screen position and casing diameter/depth. The contents and the maximum number of the each data are described as below.

1) Specification of casing

- Casing Type: material of the casing such as PVC, steel or stainless steel
- Casing Diameter: nominal diameter of the casing
- Casing Length: the total length of the installed casing

These attributes are for the production casing and screen. Normally, one type of the productive casing screen is installed from top to bottom. However, for the large diameter well, sometimes telescopic-type structure is used which are composed of large diameter pump housing and other smaller casing and screen. In this case, the number of the data becomes two.

Accordingly, the maximum number of the data shall be two.

2) Screen position

- Screen Positioned From: the top depth of each screen
- Screen Positioned To: the bottom depth of each screen

Normally, the screen is divided into one part to five. The maximum numbers of the data in the WDAC were seven. Therefore, the same numbers i.e. 7 is used for the WID.

3) Casing diameter/depth

- Diameter From: the top depths of shallow part and deep part of production casing
- Diameter To: the bottom depths of shallow part and deep part of production casing and screen

These attributes are for the record of the depth of pump housing, in case that telescopic-type production casing and screen are used.

The number of the data is one, for normal straight-type casing screen and two for telescopic-type casing and screen.

Accordingly, the maximum number of the data shall be two.

(5) Drilling method

The drilling method includes the following attributes;

- Method: To be selected from four types, i.e. mud rotary, air rotary, air percussion (DTH) and cable tools
- From: the depth of starting each method
- To: the depth of ending each method

Normally, multiple drilling methods are used by DDCA for a borehole, depending on the type of drilling equipment and/or geological condition. Normally, as much as two methods are used for a borehole while the all the four methods are used in some cases.

Accordingly, the maximum number of the data shall be four.

(6) Step pumping test

The step pumping test includes the following attributes;

- Step pumping test yield: final yield of each step
- Step pumping test pumping time: pumping time of each step
- Step pumping test dynamic water level: final dynamic level of each step

Normally, the numbers of step are four to five for DDCA. In WDAF, the maximum numbers of step was seven. Therefore, the same number, 7, shall be applied in this database.

4. DATABASE DESIGN

Based on the above analysis, ER Diagram was designed (*Figure 2*). This design is used to construct data entry system for existing borehole reports. After completion of data entry, the entered data will be exported to excel format. The main components of excel database are borehole data, pumping test data and water quality data.

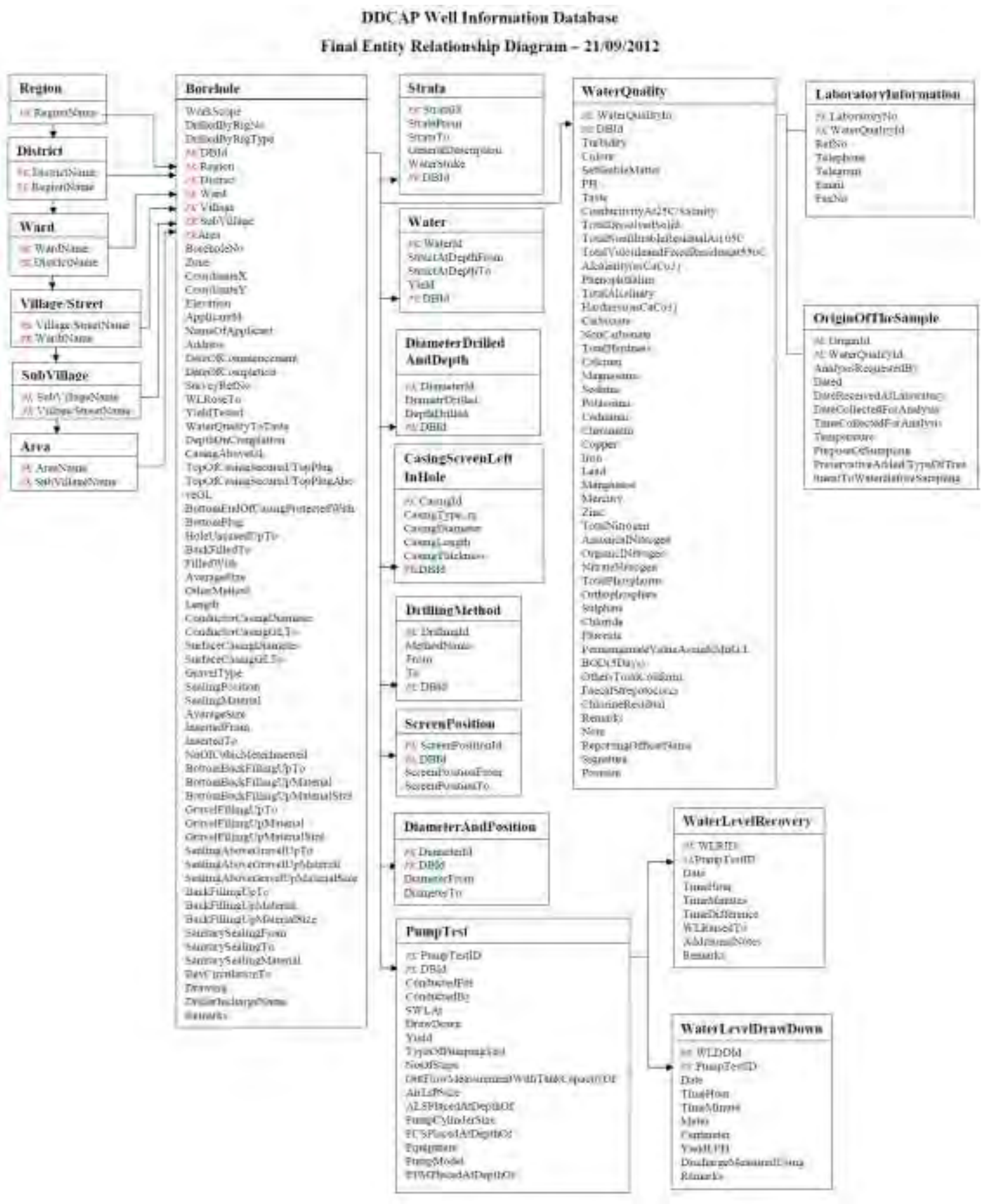


Figure 2: ER Diagram of database

5: DATA ENTRY AND DATABASE MAINTENANCE

ORGANIZATION

The WID will be updated by the new data entry from the drilling work record form and pumping test record form which are filled by handwriting on site and water quality analysis report which are prepared in the laboratory.

The rolls of concerned staffs with the preparation of the well completion report, the update and maintenance of the WID are described below.

(1) Rig in charge

Each rig in charge of the drilling team fills in the drilling record form by handwriting on drilling site and submits it to the Zonal Managers or DPOs.

(2) Zonal Managers and DPOs

The Zonal Managers or DPOs receive the drilling record form submitted from the Rig in charge and forward it to the Head of Drilling Section of DDCA's Headquarters.

(3) Pumping test in charge

Pumping test in charge fills in the form by handwriting on site and submits it to the Drilling Manager of DDCA's headquarters.

(4) Hydrogeologist in Survey Section of the Technical Support Division in DDCA's headquarters

Hydrogeologist analyzes the drill cuttings on site or in DDCA's headquarters and prepares a casing programme. These results are supposed to inform the Rig in charge.

He is responsible for the control of the survey reference numbers and informs the Rig in charge of it.

He browses the WID for the purpose to check the record of strata and casing program and to interpret the survey result.

(5) Water quality analysis laboratory

The water samples which are collected in the end of the pumping test will be sent to the water quality analysis laboratory to conduct the analysis.

The water quality analysis laboratory will prepare the water quality analysis report and submit it to the Head of Drilling Section.

(6) Head of Drilling Section of the DDCA's Headquarters

The Head of Drilling Section examines the well completion report form submitted from each staff in charge.

After the examination, he gives the instruction to the data entry clerk of the registry room to finalize the drilling record form and pumping test record form by data entry in WID and to finalize the well section drawing to the drawing room by Auto-CAD.

He compiles the final version of the well completion report and submits it to the CEO for his approval. After that, he submits it to the client.

He is responsible for the supervision of the entire process of preparation of the well completion report, the update and the information retrieval from the WID for providing data to the private drilling companies.

(7) Drawing room in the DDCA's Headquarters

The well section drawings are prepared with Auto-CAD based on the handwritten drilling work record form and well section drawing form after the examination of the Head of Drilling Section.

(8) Registry Room in the DDCA's Headquarters

After the examination by the Head of the Drilling Section, the handwritten drilling work record form and the pumping test form are handed to the data entry clerk of the registry room for finalization. The finalized forms are submitted to the Head of Drilling Section.

(9) Computer room

The computer room is mainly in charge of the calculation related to the account issues. This room is not directly related to the data entry to the WID. However, the server computer is installed in this room and the staffs in this room shall be of the network administrator.

(10) Data entry room

The data entry room is in charge of the management of the information related to the contracts of drilling works such as contract prices, payment, clients and contract specifications.

Though this room is not directly related to the data entry to the WID, this room browses the WID for the purpose of comparing the contents of the contract and work results such as specifications, resulted amount etc.

The rolls of the concerned staffs described above and the flow of well completion report preparation are shown in **Figure 3**.

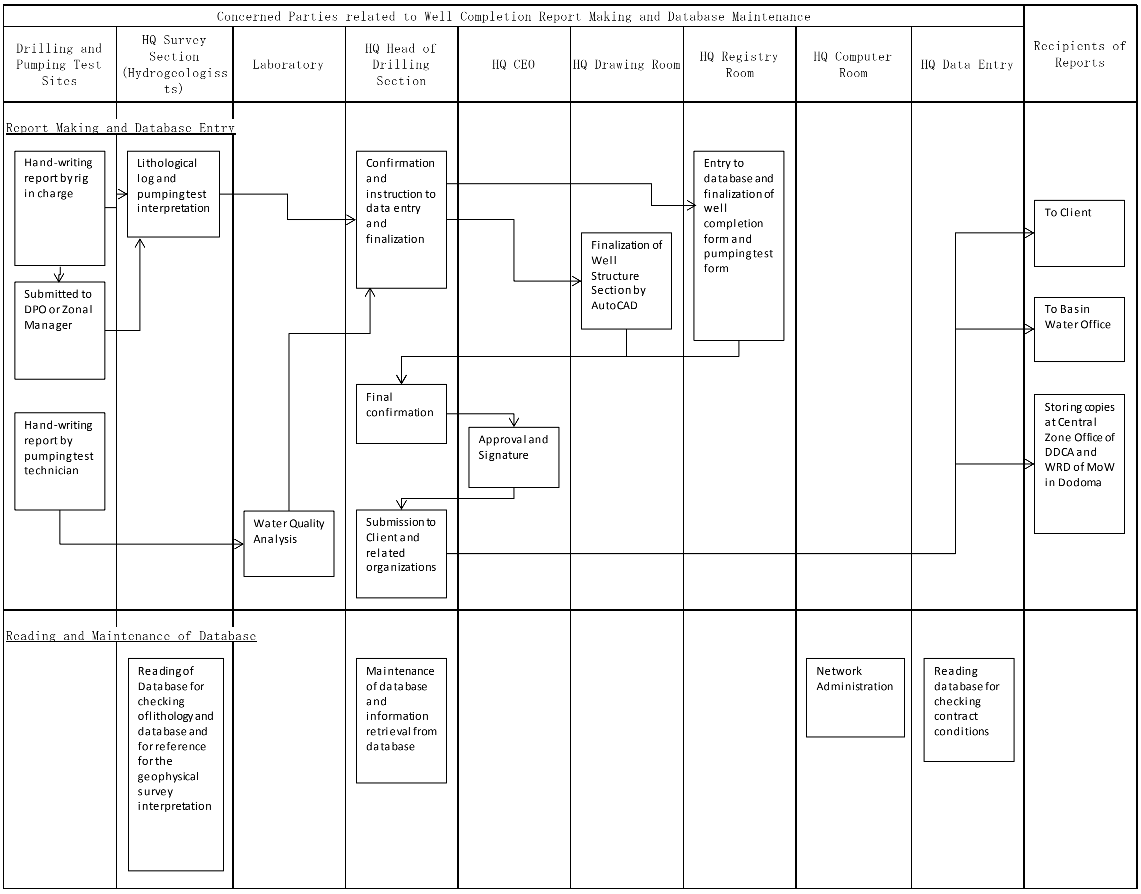


Figure 3: Roles of Concerned Staffs and Flow of Well Completion Report Preparation

Among the staffs in charge shown in the above, the staffs directly related to the update and maintenance of the WID are the Head of Drilling Sectionand the staffs in the registry room. The Head of Drilling Section is responsible for supervision of the data entry, maintenance and data analysis while the staffs in the registry room are responsible for the data entry of the hand written well completion report.

The Drilling Manager has an experience of making a simple borehole inventory with MS-Excel. Even so he is required to improve the necessary skills for database maintenance and data analysis such as making tables, creating formulas and using the aggregate function.

The staffs in the registry room have simple skills to input values in forms in MS-Word since they have experiences of the data entry of well completion report to forms in MS-Word. However, they do not have any knowledge and skills of MS-Excel. Therefore, they need to acquire the skills of MS-Excel for the data entry in WID.

The technical support from the Contractor and JICA Expert Team in order for DDCA's staff to acquire the above skills is described in Section 3.

6: COMPUTER NETWORKING SYSTEM

Three computers will be procured by the Project for the construction of WID. One computer is used as a server computer while two are used as the client computers. Each computer is connected by wireless LAN. Total 3 sets of computers are procured in this project. The specifications of those computers are almost same. One computer is for server and the others are for clients.

The location to be installed and the usage of each computer are described below.

(1) Server computer

Server computer is installed into the computer room. The staffs in this room shall be the network administrator. The WID itself is saved in this server. The backup is done periodically for both server and client computers.

(2) Client computer

One Client computer is installed in the registry room. Update, maintenance and information retrieval are done in this computer. The staffs in the registry and the Head of Drilling Section use this computer.

Another Client computer is installed in the Survey Section of Technical Support Department. Hydrogeologists mainly use it for checking the record of strata and casing program, and for interpreting the survey result.

DDCA is planning to procure one client computer for browsing the WID to compare the contract conditions and work results. It will be installed in the data entry room as the Client Computer No.3. **Figure 4**shows the networking of these four computers.

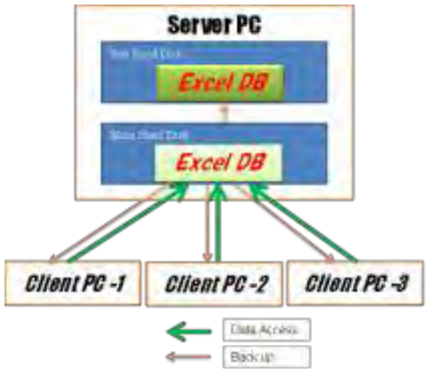


Figure 4: Computer Network

7. TECHNICAL SUPPORT FOR UPDATE AND MAINTENACE OF DATABASE

The following technical support for DDCA to acquire the necessary skills on WID is for the smooth implementation of the preparation of well completion report forms, update, maintenance and information retrieval of the WID.

(1) Preparation of the guideline on how to enter the drilling record form

With the support by JICA Expert, DDCA will prepare this guideline. The guideline facilitates each drilling team to fill up the revised drilling record form.

(2) Preparation of the operation manual of WID

The operation manual of the WID will be prepared by the Contractor.

The manual shall include the database structure, description of the attributes, folder structure, data entry operation, modification of attributes, backup, setting and change of password and information retrieval etc.

(3) Guidance of the data entry

The Contractor will give guidance on the data entry with using the operation manual for the staffs in the registry room.

(4) Guidance of the database maintenance and information retrieval

The Contractor will give guidance on the database maintenance and information retrieval with using the operation manual for the Head of Drilling Section together with the Assistant Database Manager of WID to be appointed.

Appendices

Appendix 1: DDCA Well Database Entry Sheet Index Label List (Draft)

Appendix 1: DDCA Well Database Entry Sheet Index Label List (Draft)

	1-1 WellLocation																							
	RegionName	DistrictName	FarmName	VillageOrFarmName	SubVillageName	LocationAreaName	WorkScope	DrilledByRight	DrilledByWellType	BoreholeNo	Zone	CoordinateX	CoordinateY	Elevation	ApplicantId	NameOfApplicant	Address	DateOfCommencement	DateOfCompletion	SurveyRefNo	Drawing	DrillerInChargeName	Remarks	Signature

No. of Maximum Data	1-2 Strata																							
20	StrataFrom	StrataTo	GeneralDescription	WaterStrike	StrataFrom2	StrataTo2	GeneralDescription2	WaterStrike2	StrataFrom3	StrataTo3	GeneralDescription3	WaterStrike3	StrataFrom4	StrataTo4	GeneralDescription4	WaterStrike4	StrataFrom5	StrataTo5	GeneralDescription5	WaterStrike5	StrataFrom6	StrataTo6	GeneralDescription6	WaterStrike6

No. of Maximum Data	1-3 Water Strike																							
8	StructAtDepthFrom	StructAtDepthTo	Yield	StructAtDepthFrom2	StructAtDepthTo2	Yield2	StructAtDepthFrom3	StructAtDepthTo3	Yield3	StructAtDepthFrom4	StructAtDepthTo4	Yield4	StructAtDepthFrom5	StructAtDepthTo5	Yield5	StructAtDepthFrom6	StructAtDepthTo6	Yield6	StructAtDepthFrom7	StructAtDepthTo7	Yield7	StructAtDepthFrom8	StructAtDepthTo8	Yield8

1-3 Water Strike			
WLRoseTo	YieldTested	WaterQualityToTaste	DepthOnCompletion

No. of Maximum Data	1-4 Diameter Drilled And Depth					
3	DiameterDrilled	DepthDrilled	DiameterDrilled2	DiameterDrilled2	DiameterDrilled3	DiameterDrilled3

No. of Maximum Data	1-5 Casing Screen							
2	CasingType	CasingDiameter	CasingLength	CasingThickness	CasingType2	CasingDiameter2	CasingLength2	CasingThickness2

No. of Maximum Data	1-5 Casing Screen (Screen Position)													
7	ScreenPositionFrom	ScreenPositionTo	ScreenPositionFrom2	ScreenPositionTo2	ScreenPositionFrom3	ScreenPositionTo3	ScreenPositionFrom4	ScreenPositionTo4	ScreenPositionFrom5	ScreenPositionTo5	ScreenPositionFrom6	ScreenPositionTo6	ScreenPositionFrom7	ScreenPositionTo7

1-5 Casing Screen														
CasingAboveGL	TopOfCasingSecured/TopPlug	TopOfCasingSecured/TopPlugAboveGL	BottomEndOfCasingProtectedWith	BottomPlug	HoleUncasedUpTo	BackFilledTo	FilledWith	AverageSize	OtherMethod	Length	ConductorCasingDiameter	ConductorCasingGLTo	SurfaceCasingDiameter	SurfaceCasingGLTo

No. of Maximum Data	1-5 Casing Screen (Diameter / Depth)			
2	DiameterFrom	DiameterTo	DiameterFrom2	DiameterTo2

1-6 DrillingMethod																					
GravelType	SealingPosition	SealingMaterial	AverageSize	InsertedFrom	InsertedTo	NoOfCubicMeterInserted	BottomBackFillingUpTo	BottomBackFillingMaterial	BottomBackFillingMaterialSize	GravelFillingUpTo	GravelFillingUpMaterial	GravelFillingUpMaterialSize	SealingAboveGravelUpTo	SealingAboveGravelUpMaterial	SealingAboveGravelUpMaterialSize	BackFillingUpTo	BackFillingUpMaterial	BackFillingUpMaterialSize	SanitarySealingFrom	SanitarySealingTo	SanitarySealingMaterial

No. of Maximum Data	1-7 Drilling Method											
4	MethodName	From	To	MethodName2	From2	To2	MethodName3	From23	To23	MethodName234	From234	To234

2-1 Pumping Test General Information										
DateFrom	Step SWL	Step Discharge Rate	Step Pumping Time	Step DWL	Const SWL	Const Discharge Rate	Const Pumping Time	Const DWL	Recovery Measuring Time	Recovery WL rose to

No. of Maximum Data	2-1 Pumping Test General Information																				
20	Step Discharge Rate	Step Pumping Time	Step DWL	Step Discharge Rate2	Step Pumping Time2	Step DWL2	Step Discharge Rate3	Step Pumping Time3	Step DWL3	Step Discharge Rate4	Step Pumping Time4	Step DWL4	Step Discharge Rate5	Step Pumping Time5	Step DWL5	Step Discharge Rate6	Step Pumping Time6	Step DWL6	Step Discharge Rate7	Step Pumping Time7	Step DWL7

2-1 Pumping Test General Information					
Const SWL	Const Discharge Rate	Const Pumping Time	Const DWL	Recovery Measuring Time	Recovery WL rose to

3-1 Water Quality																							
EC DS/m	Turbidity	Colour	SettleableMatter	PH	Taste	ConductivityAt25C/Salinity	TotalDissolvedSolid	TotalNonFiltrableResidualAt105C	TotalVolatileandFixedResidualat550C	Alkalinity(asCaCO3)	Phenolphthalein	TotalAlkalinity	Hardness(asCaCO3)	Carbonate	NonCarbonate	TotalHardness	Calcium	Magnesium	Sodium	Potassium	Cadmium	Chromium	Copper

3-1 Water Quality																							
Iron	Lead	Manganese	Mercury	Zinc	TotalNitrogen	AmmonicalNitrogen	OrganicNitrogen	NitrateNitrogen	TotalPhosphorus	Orthophosphate	Sulphate	Chloride	Fluoride	PermanganateValueAsmgMnO/L	BOD(5Days)	OthersTotalColiform	FaecalStreptococci	ChlorineResidual	Remarks	Note	ReportingOfficerName	Signature	Position

3-2 Laboratory Information					3-3 Origin Of The Sample							
RefNo	Telephone	Telegram	Email	FaxNo	AnalysisRequestedBy	Dated	DateReceivedAtLaboratory	DateCollectedForAnalysis	TimeCollectedForAnalysis	Temperature	PurposeOfSampling	PreservativeAdded/TypeOfTreatmentToWaterBeforeSampling

(white box): Item unique to a well (blue box): Item many to each pumping test

LOCAIDES GENERAL SUPPLY LIMITED

P.O. Box 33333, Dar es Salaam. Survey, Kinondoni
Tel:2700096 Fax: 2700096
email: locaides@gmail.com,bertharicky@yahoo.com

GROUNDWATER DEVELOPMENT AND MANAGEMENT

CAPACITY DEVELOPMENT PROJECT

DDCAP

OUTPUT (7)
OPERATION MANUAL FOR A DATABASE OF WELLS DRILLED BY DDCA

FEBRUARY 2013

LOCAIDES GENERAL SUPPLY LIMITED

Index

Table of Contents

Tables

Figures

1. INTRODUCTION

The DDCA Well Database was established as a part of DDCAP project. The database is assumed to be provided to any private drilling company on demand.

This Operation Manual has been prepared to explain how to use the application of DDCA database. The database has 9997 borehole data and several functions. Users can add new borehole data and use them, like report making, data search, data counting and summarizing. The database made by using Microsoft Excel. User can modify the report form and make new extraction form.

2. DATABASE COMPOSITION

The root folder is "DDCA Well Database" which consists of database main unit and scan data (see *Figure 1*). The database main unit is made up of 5 books of Microsoft Excel which are "010 Well Database.xlsm", "020 Water Well Completion Form for Print.xls", "030 Pumping Test Form for Print.xlsm", "040 Pumping Test Existing Data.xlsm" and "050 Water Quality for Print.xlsm". *Table 1* shows the components of the database main unit.

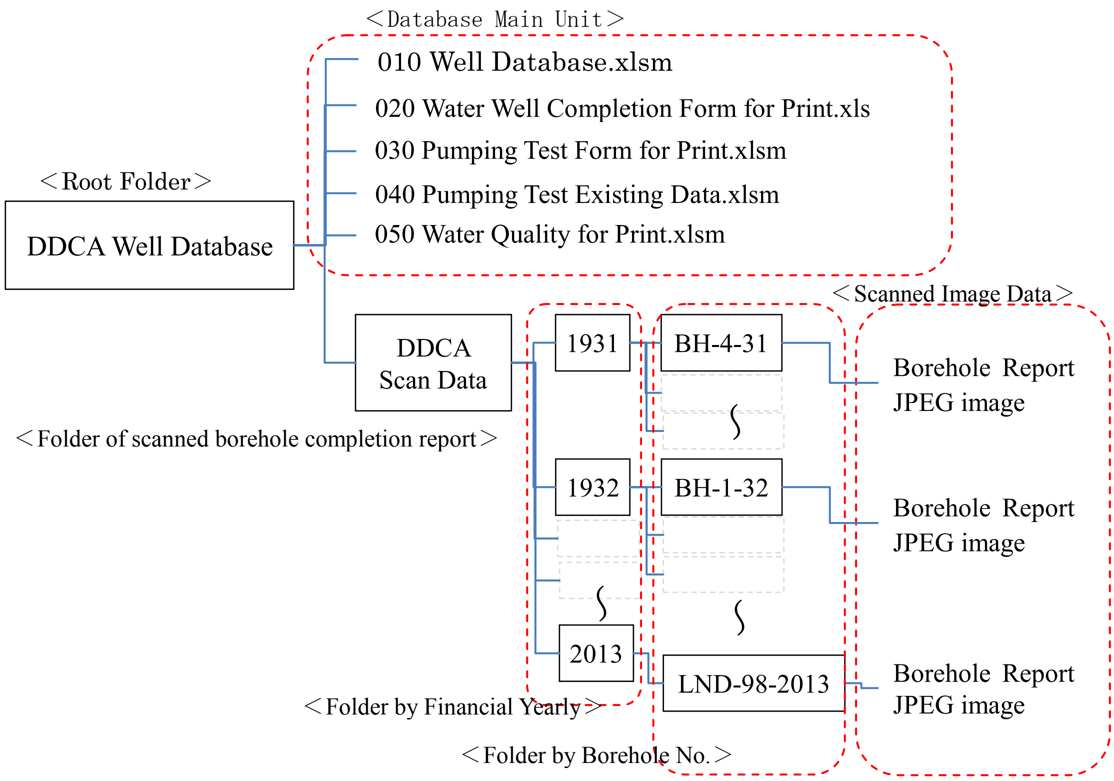


Figure 1 Folder and file composition of DDCA Well Database

Table 1 Components of the database main unit

Book Name		
	Sheet Name	Sheet Contents
010 Well Database.xlsm		
	DataEntryForm2	Data entry form for borehole completion report
	PumpingTestSummaryEntryForm	Data entry form for pumping test summary
	WaterQualityEntryForm	Data entry form for Water quality analysis
	DDCADB main	Data storage of this database
	ExportData	Control form of data exporting function. User can export stored data to other database form (see xxx)
	Welldata_africa	"Well database in African Country" form of JICA
	Catalogue	Form of Water Resource Management Office in Dodoma
	WamiRuvuDB	Form of WamiRuvu Basin Water Office
	rat	Table of data attribute. Attribute name displayed in this database is linked to the table. Revision of the table demands a lot of attention because it affects to all books and sheets in this database
	Unit	Unit list which are used in DDCADB main sheet. Revision of this sheet affect DDCADB main sheet. Revision of the unit list demands a lot of attention because it affects to data storage
	EntrySheetProtect	This sheet has a command button to unprotect and protect sheets
020 Water Well Completion Form for Print.xls		
	OLD	Well completion report form which had been used from the 1930s to the 1950s
	FORM1	Well completion report form in use at the year 2013.
	FORM2	Revised well completion report form
030 Pumping Test Form for Print.xlsm		
	ConstantDD	Report form of constant discharge rate test
	ConstantRecovery	Report form of water level recovery test
040 Pumping Test Existing Data.xlsm		
	pumptest	Data ID of pumping test etc., necessary data for data correction and display
	waterleveldrawdown	Store of constant discharge test data
	waterlevelrecovery	Store of water level recovery test data
050 Water Quality for Print.xlsm		
	WaterQuality	Report form for water quality data

3. DATA ENTRY

For entering the data into the database, double click to open "010 Well Database.xlsm". The book has a main data storing sheet "DDCADB_main". All data will be entered into this sheet.

The well data submitted by Rig in Charge to the registry will be entered into the "DDCADB_main" sheet. The attributes in the sheet are ranged based on the order of items in the completion report form. The borehole No. should be entered first at the left side column. From the next column, the other data will be entered.

Step-1 Open the Data Entry sheet

Step-2 Enter the borehole number into the left end column under the attributes row.

Step-3 Start entering the data from the left column next to borehole No. horizontally.

Step-4 Cross check the data entered

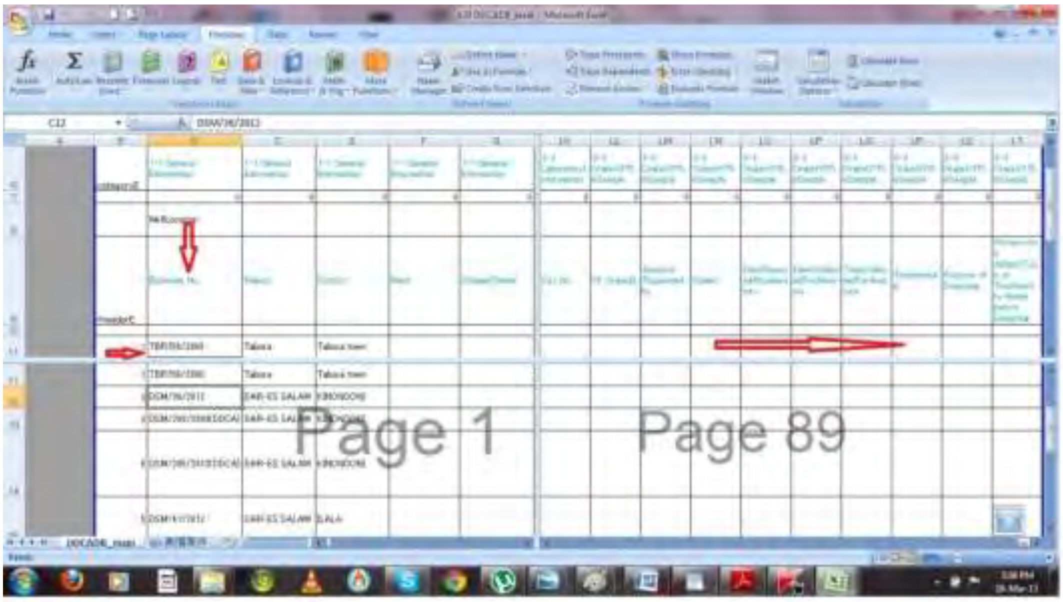


Figure 2: Data entry sheet

4. DATA SEARCH

Data are stored in the sheet of "DDCDB_main" of "010 Well Database.xlsm" book. User can search a target borehole data by using several search methods of EXCEL. User can select any method as its convenience. In this manual, two methods are introduced as followings.

(1) Use "Find"

Step-1 Open "DDCADB_main" and select arbitrary a column.

Step-2 Select Home Tab and select function as following.

[Home Tab] >> [Find and Select] >> [Find]

Step-3 Search box will open. Enter the words into the text box

Step-4 Click the search button. If the word is exists it will be fund.

(2) Use "Filter"

Step-1 Open “DDCADB_main” and Unprotect the sheet as following.

[Review Tab] >> [Unprotect sheet] >> Enter a password “ddcadb” >> Click OK or tap Enter Key

Step-2 Select the row 10 and use filter function as following.

[Data Tab] >> [Filter]

Then an inverted triangle is shown in each cell of the row 10. The inverted triangle is a pull down menu for filtering.

Step-3 Click pull down menu of necessary attribute column and select necessary data. For example, if a user wants borehole data of the financial year of 1995, click pull down menu of “Year BH” column and select only 1995 (selected all in default). Click “OK”. Only the borehole data of year 1995 are shown.

Step-4 For reset filter function. Click “Filter” of Data Tab.

Step-5 For protecting sheet again. Open “Sheet Protect” and click a command button of “Unprotected”. The comment “Unprotected” changes to “Sheets are protected” and a message box “Sheets are protected” is shown. Click “OK” of the message box and sheet protection is completed properly.

5. REPORT MAKING

(1) Borehole Completion Report

Open “010 Well Database.xlsm” and “020 Water Well Completion Form for Print.xls”. “020 Water Well Completion Form for Print.xls” includes 3 types of report forms which are “Old “ form sheet, “Form1” sheet and “Form2” sheet. User can choose as the need.

The Figure 3 shows a part of well completion report form. The borehole No. is entered into the top of the sheet. The data stored in “DDCADB_main” sheet will be shown up in the form by referring to the borehole No.

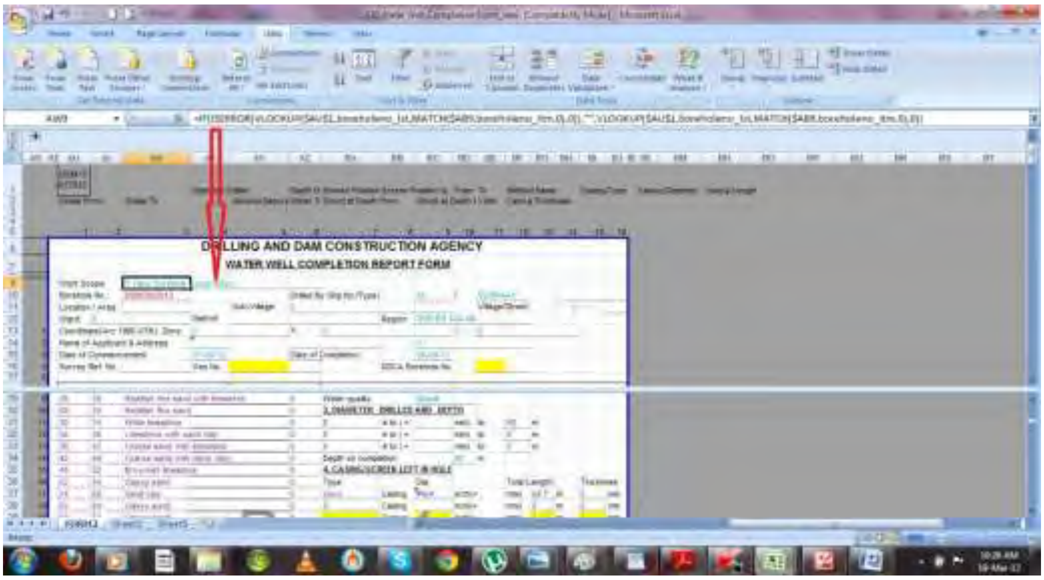


Figure 3: Well Completion Report Form

Step-1 Open “010 Well Database.xlsm” and “020 Water Well Completion Form for Print.xls”.

Step-2 Choose a sheet from Old, Form1 and Form2 which are in the book of “020 Water Well Completion Form for Print.xls”.

Step-3 Copy borehole No. of the target borehole from “DDCADB_main” and paste to the top of the form of each sheet.

Step-4 The data which had been entered into the “DDCADB_main” are shown by referring (LOOKUP function).

Step-5 Print out the form

- If the data are not shown proper, check each formula, borehole No., rat No. and “DDCADB_main” original data. For correction of the formula, refer to ***9*** in this manual.

(2) Pumping Test Report

Step-1 Open “010 Well Database.xlsm”, “030 Pumping Test Form for Print.xlsm” and “040 Pumping Test Existing Data.xlsm”.

Step-2 Choose a sheet from ConstantDD and ConstantRecovery.

Step-3 Copy borehole No. of the target borehole from “DDCADB_main” and paste to the top of the form of the chosen sheet.

Step-4 The data which had been entered into the “DDCADB_main” and the “040 PumpingTestExistingData.xlsm” are shown by referring. (Lookup Function)

Step-5 Print out the form

- If the data are not shown proper, check each formula, borehole No., and original data of related files. For correction of the formula, refer to ***9*** in this manual.

(3) Water Quality Analysis Report

Step-1 Open “010 Well Database.xlsm” and “050 Water Quality for Print.xlsm”

Step-2 Copy borehole NO. of the target borehole from “DDCADB_main” and paste to the top of the water quality analysis form

Step-3 The data which a had been entered into the “DDCADB_main” are shown by referring function (Lookup Function).

Step-4 Print out the form

- If the data are not shown proper, check each formula, borehole No., and original data of related files. For correction of the formula, refer to ***9*** in this manual.

6. DATA COUNTING AND SUMMARISING

7. SHEET PROTECTION

In order to avoid modify “010 Well Database.xlsm” by mistake, the sheets and book are protected by password. Modification and data correction are restricted by this protection. ***Table 2*** shows the detail of the protection. The protection consists of Sheet protection and Book protection.

There are two methods to unprotect and re-protect.

(1) Method-1: Use Excel Tab

1) Sheet protection

Step-1 Open “DDCADB_main” sheet

Step-2 [Review Tab] >> [Unprotect Sheet] >> Enter password “ddcadb” and click OK to unprotect sheet

Step-3 After editing,

[Review Tab] >> [Protect Sheet] >> Enter password “ddcadb” and click OK to re-protect *Don’t change check boxes

*Unprotect and re-protect should be done for each sheet. If any sheet is unprotected, export function is disabled.

2) Book protection

Step-1 Open “DDCADB_main” sheet

Step-2 [Review Tab] >> [Protect Workbook] >> Click “Protect Structure and Windows” >> Enter password “ddcadbbook” and click OK to unprotect this book

Step-3 After editing,

[Review Tab] >> [Protect Workbook] >> Enter password “ddcadbbook” to re-protect book.

* Don’t change check box.

(2) Method-2: Use Macro Command button <u>only for Sheet protection</u>

Step-1 Open “Sheet protection” sheet

Step-2 Click a command button named “Protected”.

Step-3 A message box “Unprotect?” appears. Click OK to unprotect.

Step-4 After editing, click the command button to re-protect. If any sheet is not protected, export function does not work.

Table 2 Detail of sheet and book protection

Protecting Target	Sheet protection	Book protection
Protecting contents	Restricting editing Data Entry Interface, Data Storage (DDCADB_main) and Attribute sheet (rat). The cells of the interfaces and command buttons are enabled. For correction of registered data and revision of interfaces, this protection should be disabled.	Restricting changing Sheet composition (move, add, delete sheet). For changing sheet composition, this protection should be disabled.
Password	ddcadb	ddcadbbook
Restricted functions while unprotected	Interfaces for data entry and data export function do not work.	

8. Data Export

The storing data in DDCADB_main can be exported to the other database form. This database is mounted an export function for three types of other database forms. Those forms are “Well database of Africa”, Dodoma water resource office form and WamiRuvu basin office form.

Export function is build up with VBA Macro. The process of exporting is as following.

Step-1 Open "ExportData" sheet.

Step-2 Click a command button to open a control panel for export.

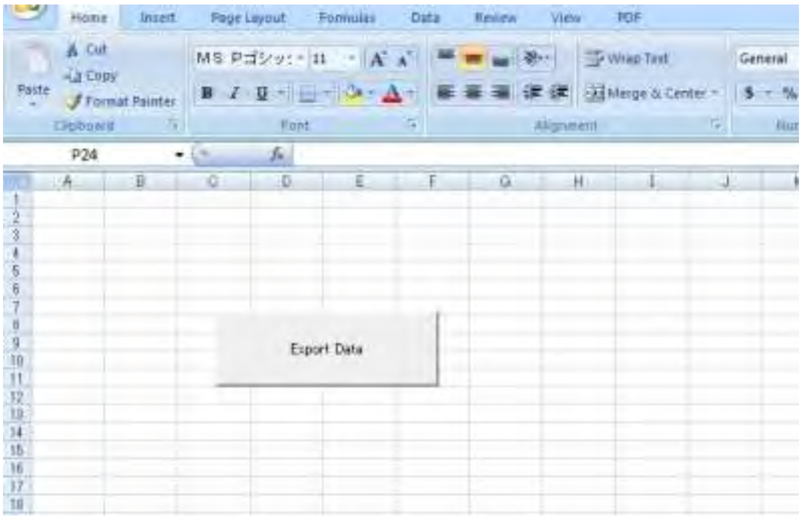


Figure 4: Command button of Export Data at "ExportData" sheet

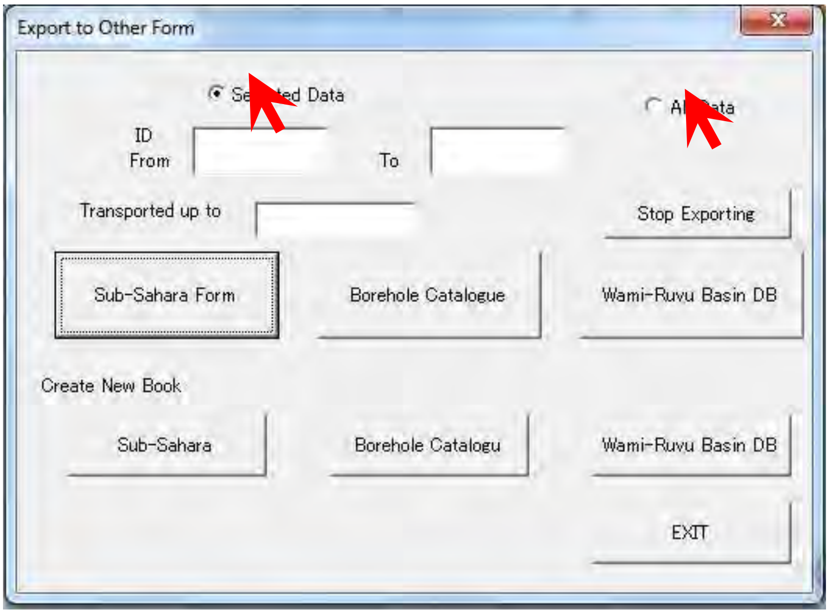


Figure 5: Control panel for export

Step-3 Select "Selected Data" or "All Data" as need. "Selected Data" is for partial exporting. "All Data" is for exporting all data at once. In the case of "Selected Data", enter range of ID, like "from _____ to_____".

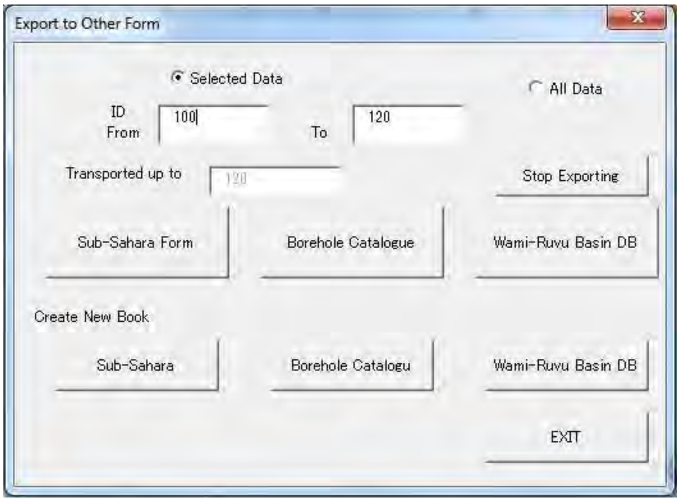


Figure 6: Enter specific range of Database ID

Step-4 Click "Sub-Sahara Form" for JICA form, "Borehole Catalogue" for Dodoma water resource office or "Wami-Ruvu Basin DB" for WamiRuvu basin office. If user wants to abort exporting, click a command button of "Stop Exporting".

Step-5 Upon the completion, a message box appears. Click OK.

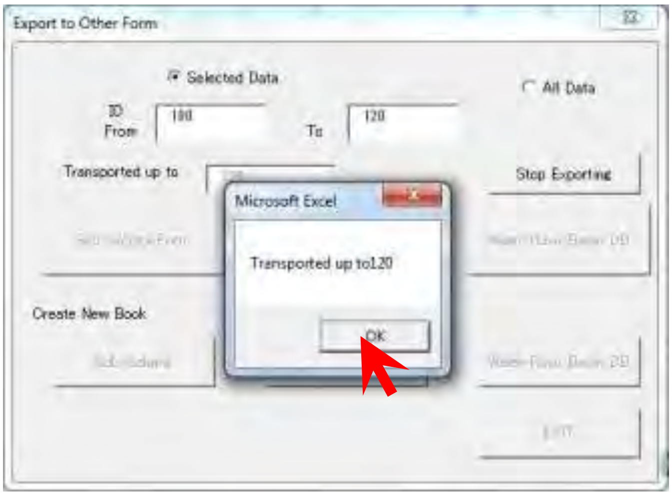
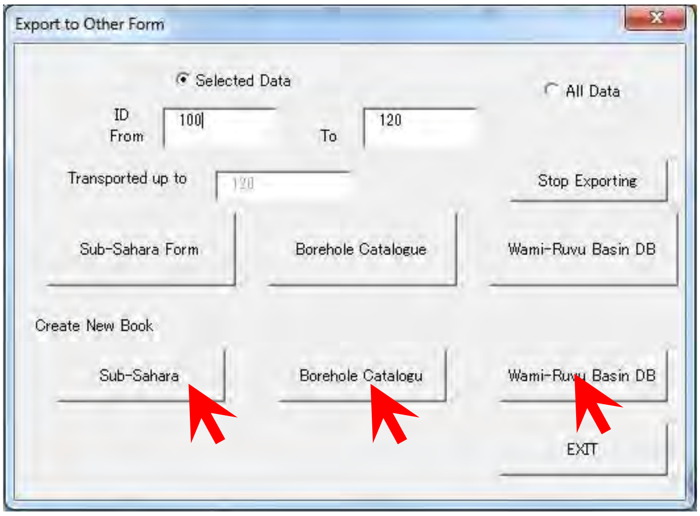


Figure 7: Completion of data exporting

Step-6 If user wants to create new book of exported data, click a command button below "Create New Book" as needed.



Step-7 After completion, click "EXIT" to close the control panel.

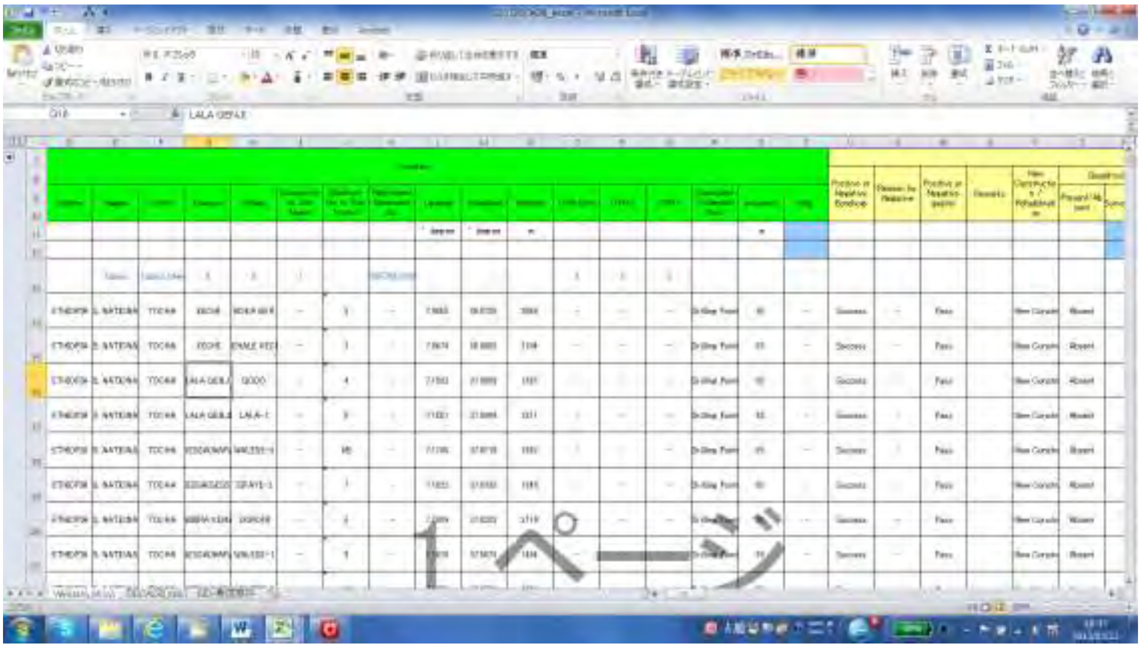


Figure 8: Exported data for Well Database in African Countries (WDAF)

9. MODIFICATION OF REPORT FORM AND EXTRACTION FORM

(1) Basic MS-Excel Function used in a Database of Wells Drilled by DDCA

Some useful MS-Excel functions are applied in the database. LOOKUP function is mainly used for making the well completion report. LOOKUPfunction isto referto the information filled in othercolumn, sheet or book. Once the formula is set, there is no need to retype up. The other functions such as MATCH, ISERROR and IF functions are also used in the database. As the introductory step to handle the database, this Section describes the MS-Excel functions to be mastered, which are needed for data entry.

1) LOOKUP (VLOOKUP: Vertical LOOKUP) Function

- Purpose

Refer to data from other sell, sheet and book.

- Formula

=Vlookup(*lookup_value*,*table array*,*Col_index_number*, *Approximate match*)

- How to set VLOOKUP formula in the column

1 Put equal then write "vlookup"

2 Put open brackets

3 Click the lookup value and put comma

4 Select and put the range of table in which the data to be referred is included, then put comma

5 Put number of column in which the data to be referred is located, then put comma

6 Select Zero, then put close brackets

7 Press enter

- Example

Table 3: LOOKUP function

Column

$B$2:$E$2→Nauli_itm

Row →

	A	B	C	D	E
1	$B$3:$E$6 →	Nauli_lst			
2		Region	DSM	Arusha	Mwanza
3		Morogoro	5000	30000	65000
4		Mbeya	40000	80000	100000
5		Tanga	60000	35000	55000
6		Kagera	70000	45000	50000

: Naming of table by using "Name Manager"as instructed in *1 Box

Tanga-DSM **=vlookup($B$5, nauli_lst, 2, 0)**

=60000

Morogoro–Mwanza **=vlookup($B$3, nauli_lst, 4, 0)**

=65000

Kagera-Arusha **=vlookup($B$6, nauli_lst, 3, 0)**

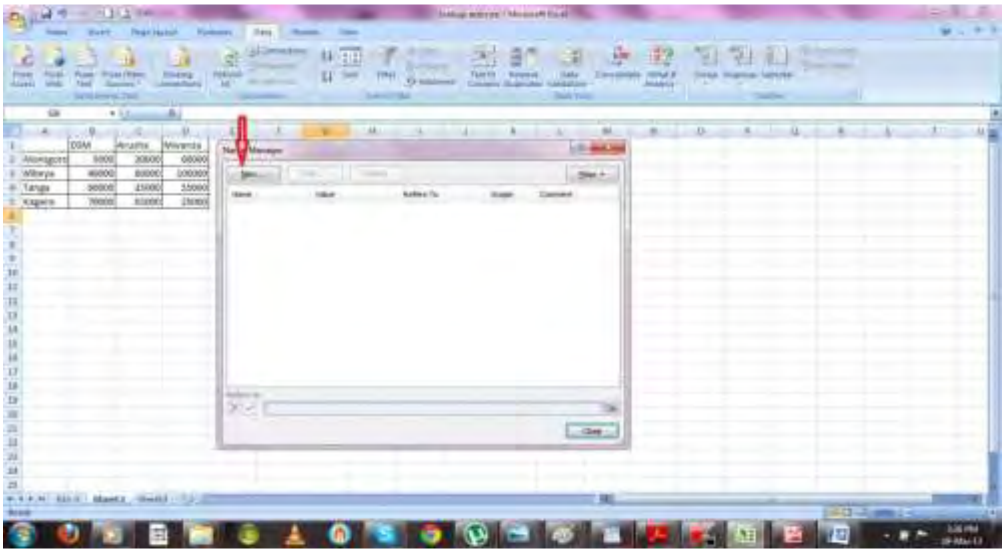
=45000

***1 Name Manager**

1 With pressing “ALT”, press “I”, “N”, “D”

2 Name manager box will be appeared

3 Click “New” to name



4 Write the name “ nauli_lst” as example table shows

5 Select the range “$B$3:$E$6” to refer

6 Refer to selected nauli list or nauli item then press ok

7 Close name manager box

Note: $ means fixedrow or column. There are three types of $ usage, which is either $B$3 (absolute), $B3 (relative column) or B$3 (relative row). $ Position is changed with pressing “F4”.

2) MATCH Function

- Purpose

To find the No. of column which the data locates

- Formula

=match(*value*,*table array*,*approximate match*)

- How to set MATCH formula in the column

1 Put equal then write “match”

2 Open brackets

3 Click the value from the data celland put comma

4 Select and put the range of table in which the data to be referred is included, then put comma

5 Select approximate match 0 (complete), then put close brackets

6 Press enter

- Example

Table 4: MATCH function

	Column 1	Column 2	Column 3	Column 4	Column 5
	A	B	C	D	E
1	Nauli_lst				
2		Region	DSM	Arusha	Mwanza
3		Morogoro	5000	30000	65000
4		Mbeya	40000	80000	100000
5		Tanga	60000	35000	55000
6		Kagera	70000	45000	25000

DSM **=match(C2, nauli_lst, 0)**

=3

Arusha **=match(D2, nauli_lst, 0)**

=4

Mwanza **=match(E2, nauli_lst, 0)**

=5

3) Combination of VLOOKUP&MATCH Function

- Formula

=volookup(*looup_value,table array, match(value, table_array, approximate match*)

- How to set VLOOKUP&MATCH formula in the column

1 Put equal then write "vlookup"

2 Open brackets

3 Click the lookup value and put comma

4 Select and put the range of table in which the data to be referred is included, then put comma

5 As "Col_index_number"put MATCH formulain which the data to be referred is located, then put comma

6 Select Zero, then put close brackets

7 Press enter

- Example

Table 5: Combination of VLOOKUP and MATCH function

	A	B	C	D	E
1	Nauli_lst				
2		Region	DSM	Arusha	Mwanza
3		Morogoro	5000	30000	65000
4		Mbeya	40000	80000	100000
5		Tanga	60000	35000	55000
6		Kagera	70000	45000	25000

Tanga-DSM **=vlookup($B$5, nauli_lst, match(C$2, nauli_itm, 0), 0)**

=60000

Morogoro–Mwanza **=vlookup($B$3, nauli_lst, match(E$2, nauli_itm, 0), 0)**

=65000

Kagera-Arusha **=vlookup($B$6, nauli_lst, match(D$2, nauli_itm, 0), 0)**

=45000

5) IF Function

- Purpose

To return the deduced value as defined in case of TRUE and FALSE

- Formula

=if(*value,TRUE,FALSE*)

- How to set IF formula in the column

Table 6: IF function 1

	A	B	C	D	E
1	Score_lst				
2		Name	Math	Average	Pass/Fail
3		Ali	90	50	
4		Juma	45	30	
5		Michel	30	45	
6		Maria	90	50	
7		Godfrey	10	20	

Ali	**=if(C3>D3,"pass","fail")**
	=Pass
Juma	**=if(C4>D4,"pass","fail")**
	=Pass
Michel	**=if(C5>D5,"pass","fail")**
	=Fail
Maria	**=if(C6>D6,"pass","fail")**
	=Pass
Godfrey	**=if(C7>D7,"pass","fail")**
	=Fail

Table 7: IF function 2

	A	B	C	D	E
1	Score_lst				
2		Name	Math	Average	Pass/Fail
3		Ali	90	50	Pass
4		Juma	45	30	Pass
5		Michel	30	45	Fail
6		Maria	90	50	Pass
7		Godfrey	10	20	Fail

6) ISERROR Function

- Purpose

To check the error such as #NULL!, #DIV/0, #VALUE!, #REF!, #NAME?, #NUM!, #N/A, #GETTING_DATA and return TRUE or FALSE.

- Formula

=iserror(*value*)

- How to set ISERROR formula in the column

The formula to refer to the transport fee Mwanza-Mbeya is as follows;

=VLOOKUP($A4,nauli_lst,MATCH(E$2,nauli_itm,0),0)

Table 8: ISERROR function 1

	A	B	C	D	E
1	Nauli_lst				
2		Region	DSM	Arusha	Mwanza
3		Morogoro	5000	30000	65000
4		Mbeya	40000	80000	#DIV/0
5		Tanga	60000	35000	55000
6		Kagera	70000	45000	25000

In case the error is happened for the cell of E4, the following formula makes the error show as defined by IF function.

Mwanza-Mbeya

"To show blank"

=IF(ISERROR(VLOOKUP($A3,nauli_lst,MATCH(D$3,nauli_itm,0),0)),"",VLOOKUP($A3,nauli_lst, MATCH(D$3,nauli_itm,0),0)

Table 9: ISERROR function 2

	A	B	C	D	E
1	Nauli_lst				
2		Region	DSM	Arusha	Mwanza
3		Morogoro	5000	30000	65000
4		Mbeya	40000	80000	
5		Tanga	60000	35000	55000
6		Kagera	70000	45000	25000

5.2 How to Start the DDCADB

As the programme of the database is MS-EXCEL software, ensure that the programme is installed into your computer.To start the database the user should double click the icon of file.

The application of database consists of the following 4 files.

1. DDCADB
2. DDCA Repository
3. Water Well Completion Form
4. Constant PumpTest Form

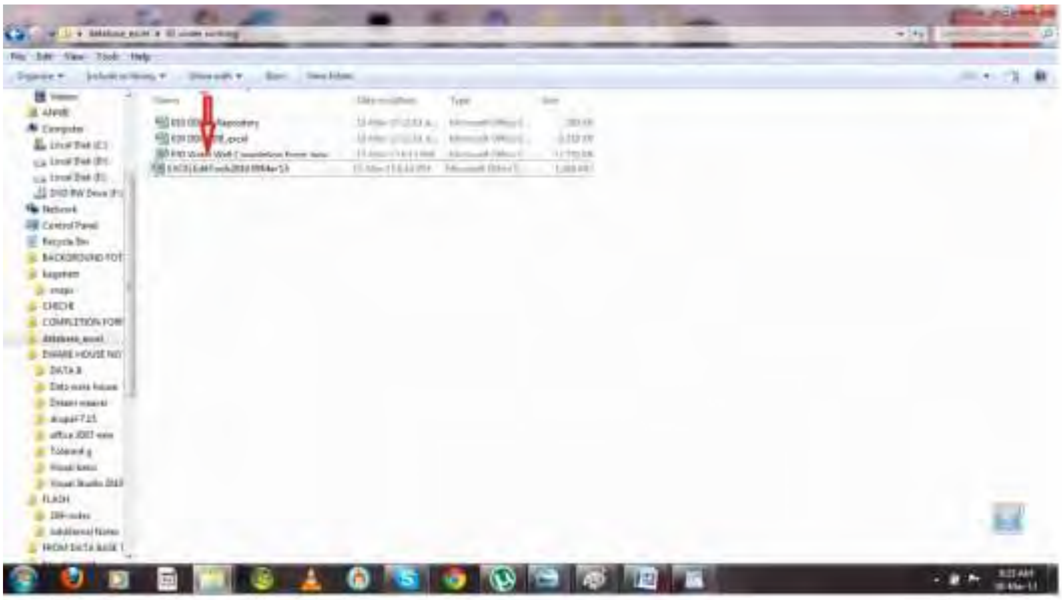


Figure 9: Composition of database files

5.4 How to Make Report

Principally, the Water Well Completion Report is prepared by referring to the data entry sheet with LOOKUP function. When the data entry is completed, the report is ready for print out and submission. It means that the form will not be saved but printed out. There are three types ofwater well completionform which are Old Form, Form1 and Form2 includingthe general information on drilled place, person in charge and drilled borehole information such as drilled diameter, depth and yield etc. For another form such as pumping test is filled by typing up. The data on pumping test entered into the data sheet is referred by the form of pumping test.

5.4.2 Form of Pumping Test

There are four records of water level drawdown and water recovery for both constant pumping test and step pumping test. The following window shows the form of constant water recovery pumping test.

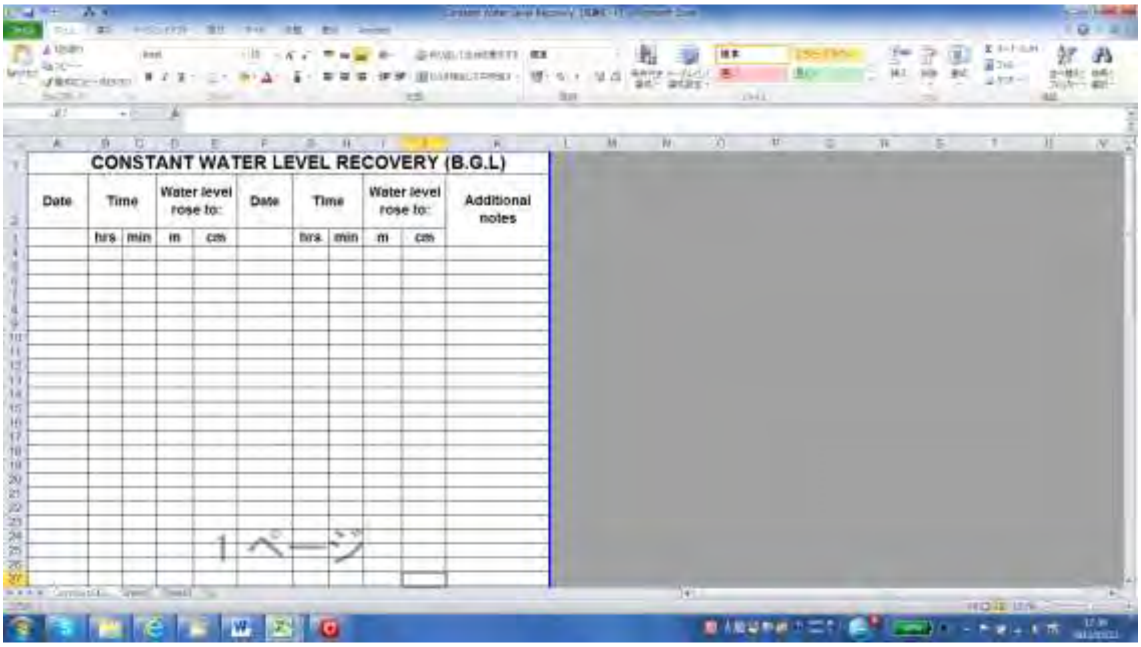


Figure 10: Pumping Test Form

5.5 Database Repository

Database repository is prepared for storing the attributes.In case new attribute addition is added, the new attribute will be stored into the repository first and then reflected to the data entry sheet. The attributes stored into the repository are sorted bygroup and category. Each attribute, group and category has data No. with the item codeas below.

- ✓ GROUP→GR
- ✓ CATEGORY→CT
- ✓ ATTRIBUTE→AT
- ✓ ATTRIBUTE→RAT

There are three types of sheet of "GR", "CT" and "AT". The followings describe details of each sheet.

GRlist sheet

GR list sheet shows the groups with GR No. As the following window shows, there are three groups. In case new group is added, make sure to re-range and rename the table.

1. Drilling

2. Pumping Test

3. Water Quality

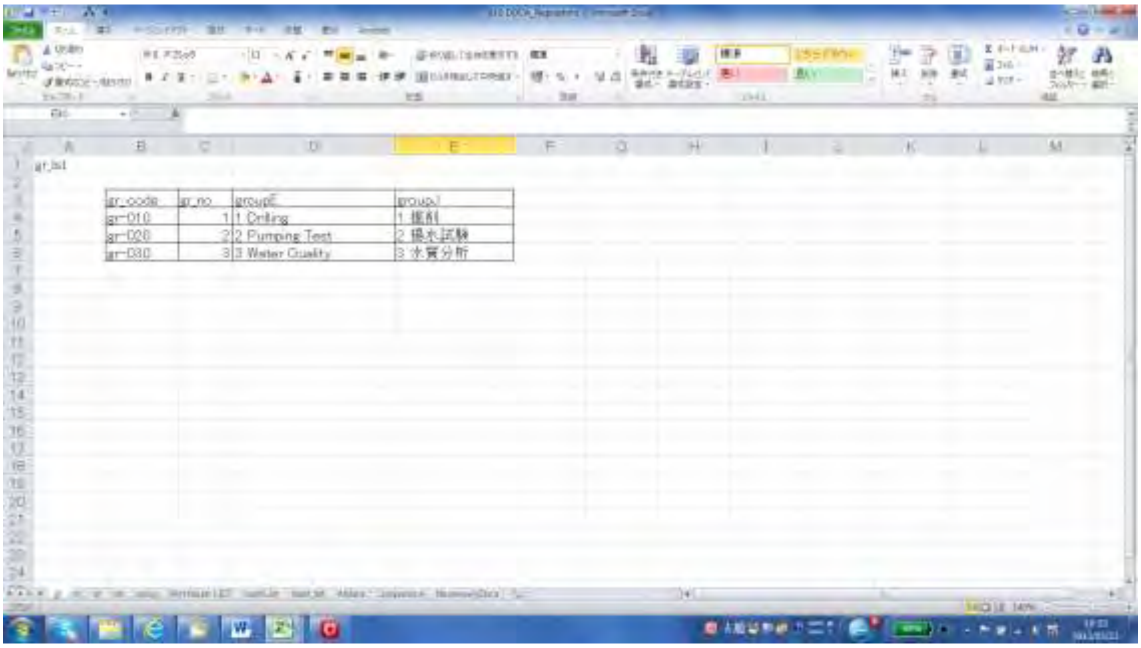


Figure 11: Group List (GR list)

CT list sheet

CT list sheet shows the categories under the group. Each category has coded the CT No. and refers to the group in the GR list sheet with using the LOOKUP function (the cells with blue color). In case that new category is added, make sure to expand the range of list (re-range and rename). There are 14 categories as the following window shows.

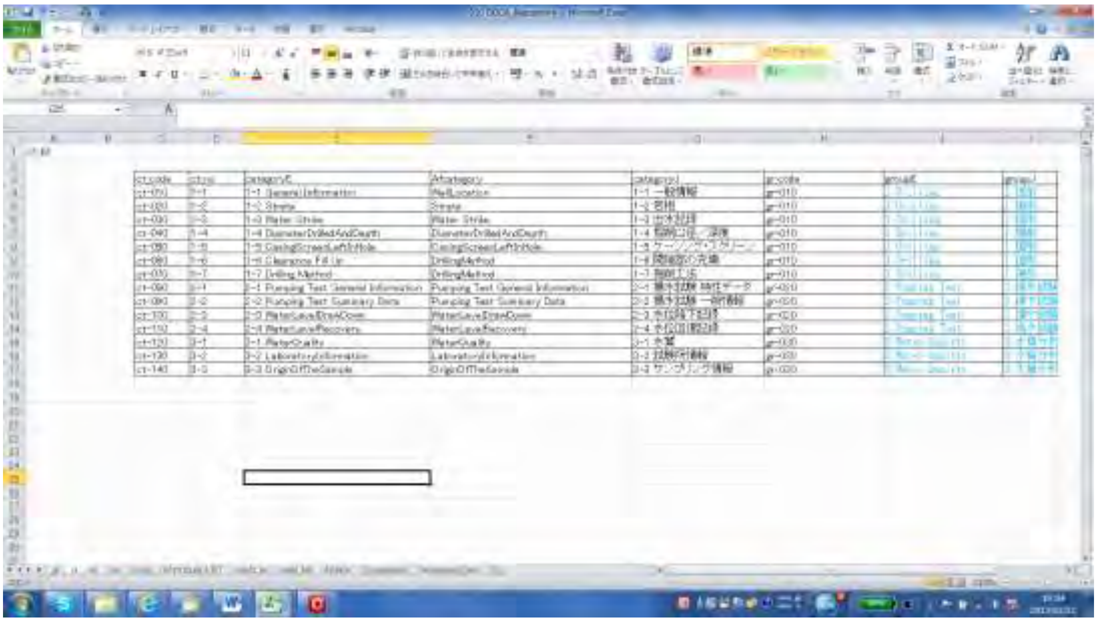


Figure 7: Category List (CT list)

AT list sheet

AT list sheet shows the attributes which is under each category and group. Each category has coded the AT No. and refers to the group in the CT list sheet with using the LOOKUP function (the cells with blue color). In case that new category is added, make sure to expand the range of list (re-range and rename). There are 190 attributes as the following window shows.

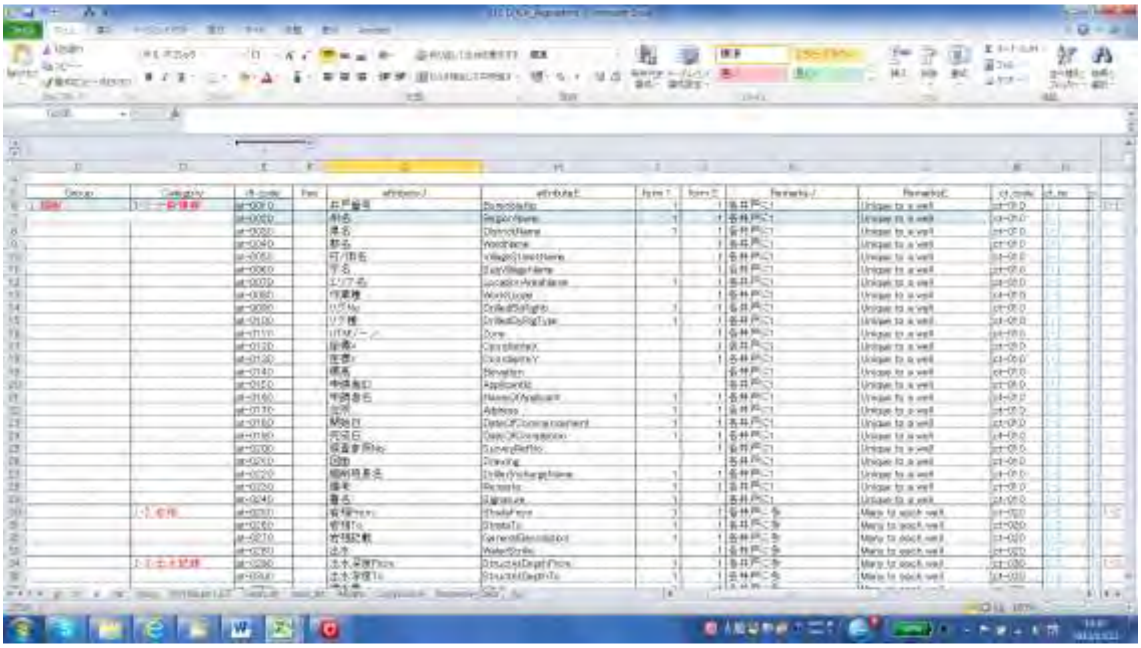


Figure 12: Attribute List (AT list)

RAT list sheet

RAT list sheet shows the all attributes unfolding the repeating items. Each data has been coded the RAT No. The group, category and attribute before unfolding the repeating items are also shown by referring to the AT list with using the LOOKUP function. Make sure to re-range and rename the list after addition of the new attribute. RAT No. is stored into the top row in the data entry sheet so as to store the attributes into the data entry sheet from RAT list sheet in the repository by referring to the RAT No.

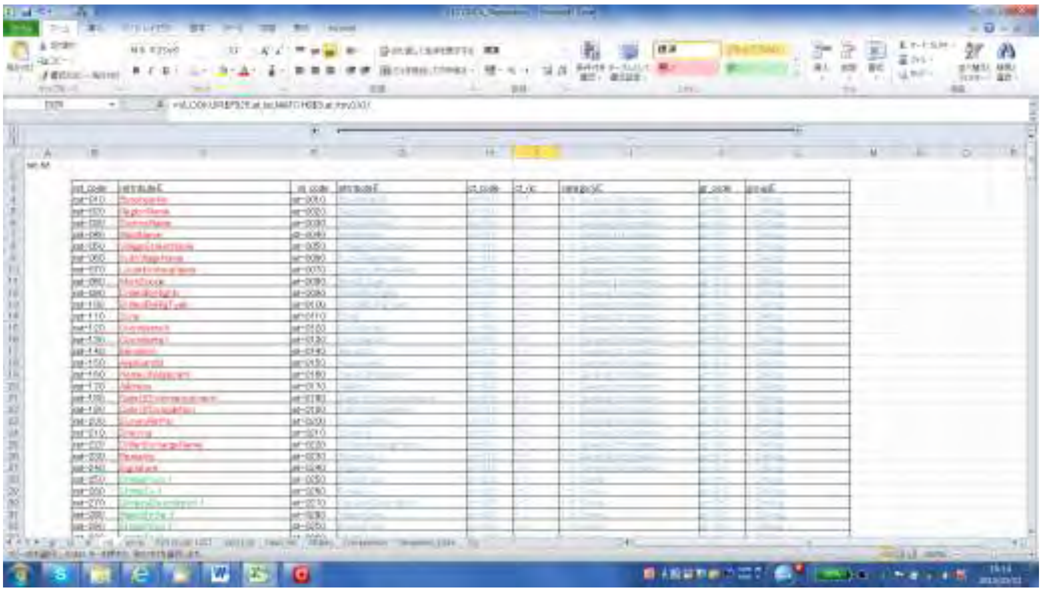


Figure 13: Attribute List (RAT list)

- **Steps for addition of new attributeto repository and data entry sheet**
  1. In AT list sheet, insert the row where the new attribute will be stored.
  2. Code new AT No and enter the new attribute.
  3. The VLOOKUP formula is set into the category column.
  4. Shift to the RAT list sheet and insert the row where the new attribute will be stored.
  5. Enter the new RAT No.
  6. The VLOOKUP formulas of group and category for new RAT items are set.
  7. The formula for the RAT item is set as set in the cells up and down cells.
  8. In case the new attribute is repeating items, the formula is set like that of green color. In case of not repeating items, the formula is set as that of red color.
  9. Shift to the data entry sheet and insert the column in which the new attribute is stored.
  10. Set the formula of VLOOKUPso as to quote the attribute from the repository into the data entry sheet.

LOCAIDES GENERAL SUPPLY LIMITED

P.O. Box 33333, Dar es Salaam. Survey, Kinondoni
Tel:2700096 Fax: 2700096
email: locaides@gmail.com,berthakicky@yahoo.com

GROUNDWATER DEVELOPMENT AND MANAGEMENT

CAPACITY DEVELOPMENT PROJECT

DDCAP

OUTPUT (8)
COMPLETION REPORT OF PHASE 1 DATABASE DESIGN AND CONSTRUCTION

APRIL 2013

LOCAIDES GENERAL SUPPLY LIMITED

Table of Contents

Figure

1. DATABASE DESIGN

(1) Review of existing report

Recent borehole reports are stored in the Dar es Salaam DDCA office. Old reports are stored in the Dodoma DDCA office and Dodoma water resource office. After the reports stored in the Dodoma DDCA office are brought to Dar es Salaam, LOCAIDES reviewed existing reports. Important features are observed through the review of existing borehole reports.

For example, the well completion Report includes two types of form. The one is the old form which had been used from 1931 to 1946 and the other one is existing form current used form one. The units of length and discharging rate have several description such as feet, meter for length, gal/h, m3/h, L/h, L/sec for discharging rate.

The information of the number of drilled boreholes per year was supplied by DDCA.

The review of existing report was completed in September, 2012. The result of the review was reported by the weekly report and "Output (2) List of number of drilled boreholes per year".

(2) Collection of Electrical data of village coordinates.

The village coordinates are submitted as a GIS data. The collection of electrical data of village coordinates was completed in September, 2012.

(3) Hardware and software installation

The equipment for data base will be procured by the client. LOCAIDES will setup the system and install the database up to the direction of the client.

(4) Equipment preparation

LOCAIDES has prepared necessary equipment and system to construct the database and enter the borehole data. The equipment includes several computer, printer, scanner, photocopy machine, MS-Office.

(5) Requirement analysis of the client

LOCAIDES, the client and DDCA had meeting frequently and discussed the requirement for the database. The client explained details of the borehole reports and their requirement. Mainly the requirement consists of the attributes to be stored for form one and two, Major components of the system,DDCA organization and management data entry, form one data entry, form two data entry.

The client requirement includes some database function such as exporting to other database form, data entry interface and output form. The data attributes of the other database form requested by the client were compiled. The requirement analysis of the client was completed in September, 2012. The result of the requirement analysis of the client was reported as "Output (4) Requirement completed" and submitted already.

(6) System Analysis and System Design

The necessary data to be stored in the database and the data for database management such as Id number and the relationship between entities were analyzed. The E.R.Diagram of the database for data entry was established. The system analysis was completed in September, 2012.

The database system had been designed based on the system analysis after the discussion among LOCAIDES, the client and DDCA. System design had been completed in October, 2012, and data entry was started. The result of system design was reported in October, 2012.

2. SYSTEM CONSTRUCTION AND INTEGRAL TASTE

This database construction shall include data coding, group, attribute and category to complete the proper database system.

3. REPORT SCANNING AND DATA ENTRY

Scanning all the existing boreholes completion reports and store all the data of them into electric file.

4. USER MANUAL

The operation manual shall describe how to select the menu ,how to input, the detailed construction of the system shall be also described in the operation manual for the database manager to manage ,maintain and modify the database system.

5. TRAINING

Training of the use and the management of the modified database system.

6. REPORTING

All the activities of works shall be described and recorded in the work report.

Figure 1: DDCA MySQL database Interface

Output (6) System Design Completed

LOCAIDES GENERAL SUPPLY LIMITED

P.O. Box 33333, Dar es Salaam. Survey, Kinondoni

Tel:2700096 Fax: 2700096

email: locaides@gmail.com,bertharicky@yahoo.com

GROUNDWATER DEVELOPMENT AND MANAGEMENT

CAPACITY DEVELOPMENT PROJECT

DDCAP

OUTPUT (11) OPERATION MANUAL MODIFIED

JUNE 2013

LOCAIDES GENERAL SUPPLY LIMITED

DDCADB USER MANUAL

INTRODUCTION

This operation manual has been prepared to explain about how to use the application of DDCA database .The manual consist of five section .From section 1 to section 5describe on the specification of database agreed among DDCA ,JICA Expert team and contractor while section 5demonstrate on how to use the database including brief explanation on excel function applied in the database, start and input of database ,making well completion and other forms.

2. REQUIREMENT
3.SYSTEM ANALYSIS
4.SYSTEM DESIGN
5.DATABASE MANUAL

1. How to start the DDCADB

As the program of the database is MS-EXCEL soft ware, ensure that the program is installed into your computer. Tostart the database the user should click the icon of file.

The application of the database consist of the following 4 files

1.DDCA Repository
2.DDCADB Excel Database
3.Water Well Completion Form
4.Pump Test Form

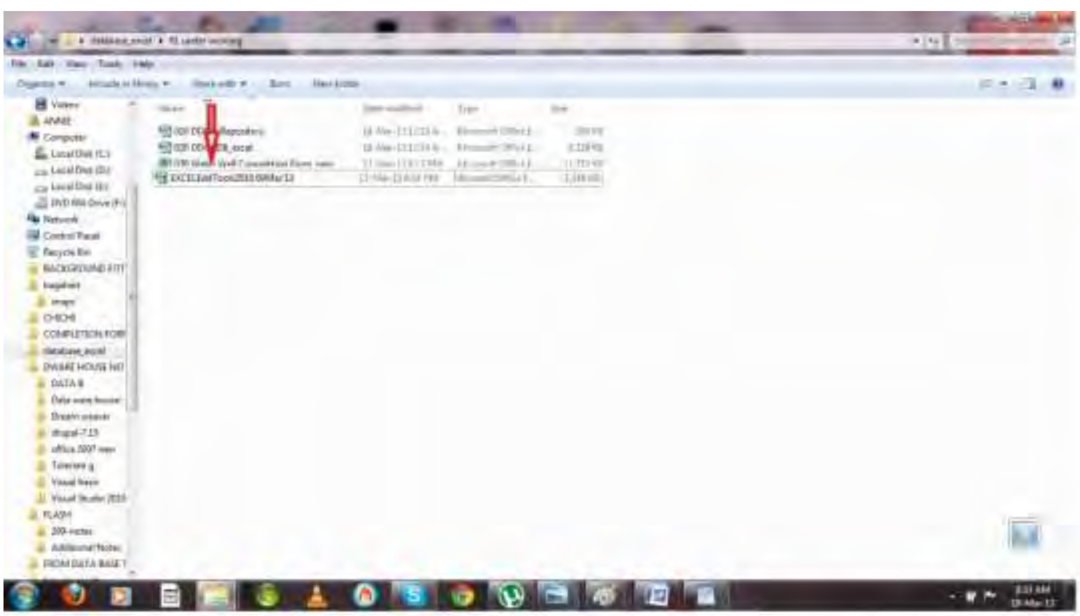


Figure :.Composition of database file

2. How To Enter Data into Data Entry Sheet

For entering data in the database,Double click data entry sheet file. This file is Main database

The main data base include two sheets"DDCADB_main" and "welldata_africa" Basically, the data will be entered to the "DDCADB_ main".

2.1 Data entry into the "DDCADB_main" sheet

The well data submitted by rig incharge to the registry will be entered into the "DDCADB_main" sheet. The attributes in the sheet area ranged base on the order of items in the completion report form. The borehole No should be entered first at the left side column, the other data will be entered

❖ **Steps For Entering Data To Data Entry Sheet**

1. Open the data entry sheet
2. Entering the borehole number into the left end column under the attribute row
3. Start entering the data from the left column next to the borehole no horizontally
4. Cross check the data entered

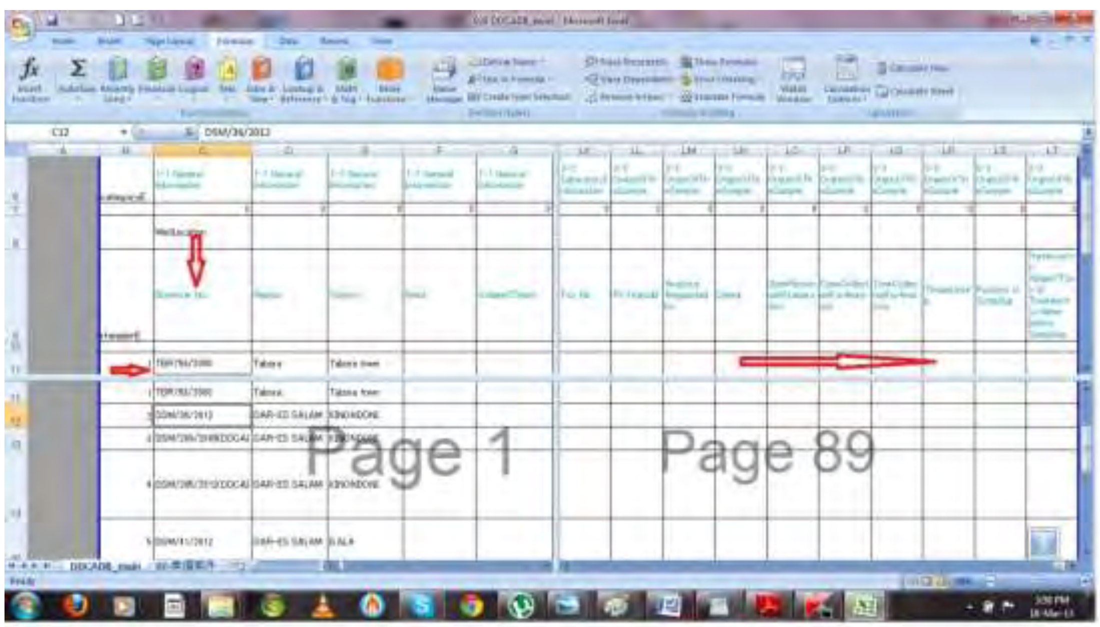


Figure: 2 Data Entry Sheet

2.2.Data Entry into Water Well Completion Report form

The well data submitted by rig incharge to the registry will be entered into the water well completion report form and data will referred direct to the “DDCADB_main” sheet .

❖ **Steps For Entering Data To Water well Completion Form**

5. Open the water well completion report entry sheet
6. Entering the data to each attribute.
7. After entering data click data entry new form
8. Cross check the data entered into “DDCADB_main” sheet

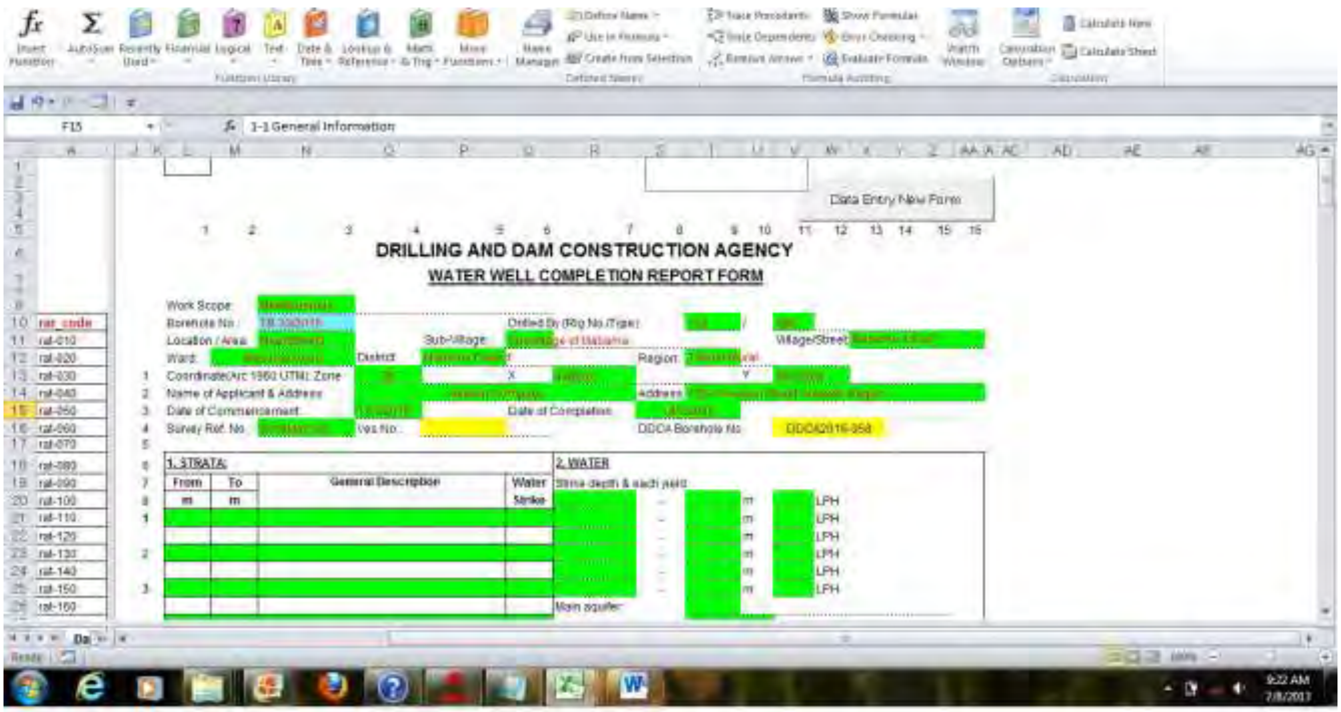


Figure 3: Water Well Completion Entry Sheet.

2.3 Well Database in Africa Countries(WDAF)

Many attributes in WDAF are same as or can be converted from those in the DDCA database. The data of WDAF will be entered by referring to the data entered in the DDCA database with using lookup function**.**

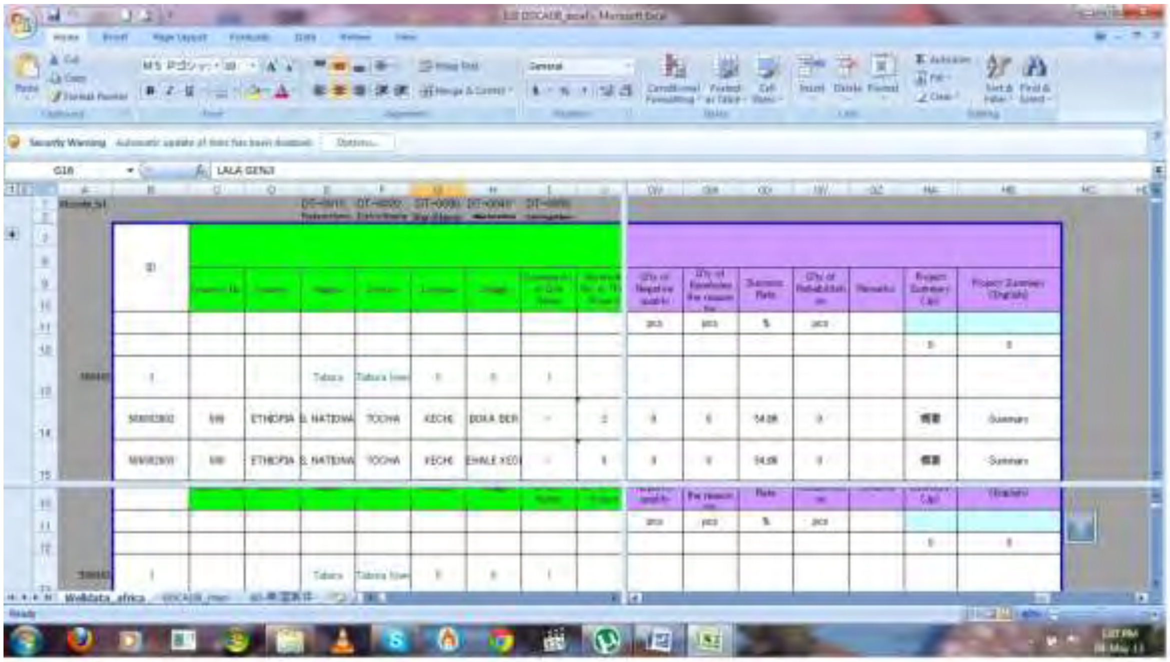


Figure 4: Well Database in Africa Countries

3. How To Make Report

Principally ,The water well completion report is prepared by referring to the data entry sheet with lookupfunctions. When the data entry is completed, the report is ready for print out and submission. I means that the form will not be saved but printed out. There are three types of water well completion form which are old form, form 1and form 2 including the general information on drilled places, person incharge and drilled borehole information such as drilled diameter, depth and yield etc.For another form such as pimp test is filled by typing up. The data of pumping test entered to the data sheet isreferred by the form of pumping test

3.1 Well completion Report Form

The following windows shows one sheet of well completion report form. the borehole no is entered into the top of the sheet. The data entered into the data entry sheet will be shown up in the form by referring to the borehole no.

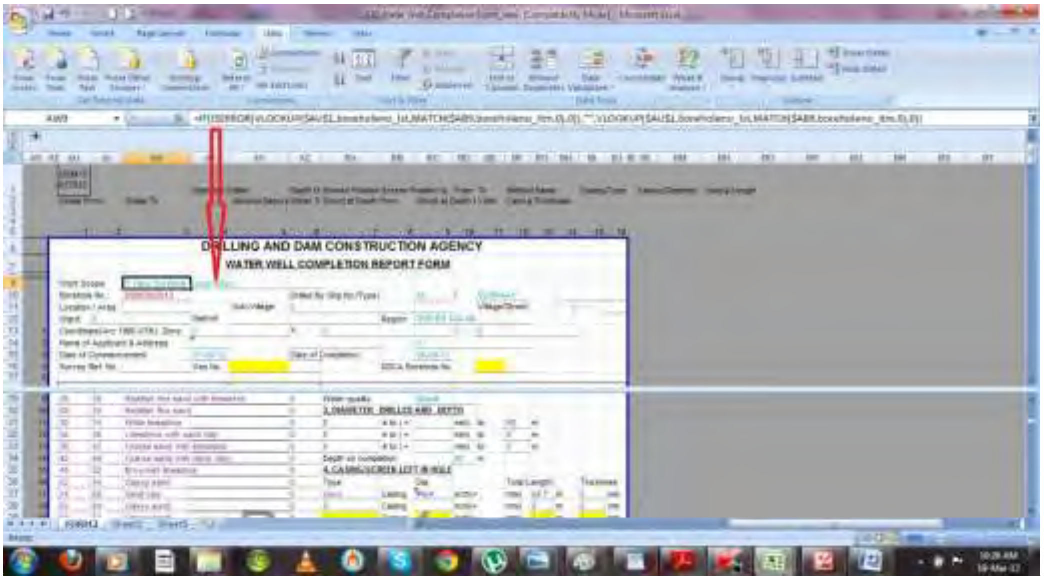


Figure 5: well completion report form

Steps for print out of well completion report form

1. Open well completion form folder
2. Old form, form1 and form 2 are in each sheet
3. Copy borehole no from main database and Paste to the top of the form for each sheet of the form
4. All data are shown by referring to the data entered to the main database(LOOKUP functions).
5. Print out the form required to submit

3.2 Form of Pump Test

There are four records of water level drawdown and water recovery for both constant pump test and step pumping test. The following windows shows the form of constant water recovery pumping test

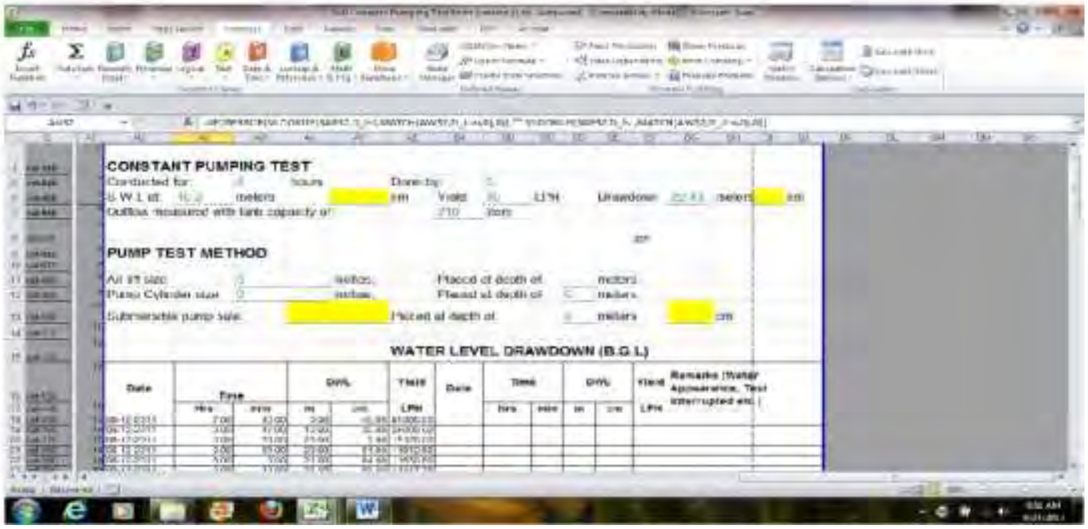


Figure 6: Pumping Test Form

3.3 Data Entry into Summary of pump Test

The well data submitted by rig incharge to the registry will be entered into Summary of pump test and data will referred direct to the “DDCADB_main” sheet .

❖ **Steps For Entering Data To Summary of pump Test**

1. Open the summary of pump test entry sheet
2. Search the borehole number
3. Start entering the data into colored area
4. Cross check the data entered into “DDCADB

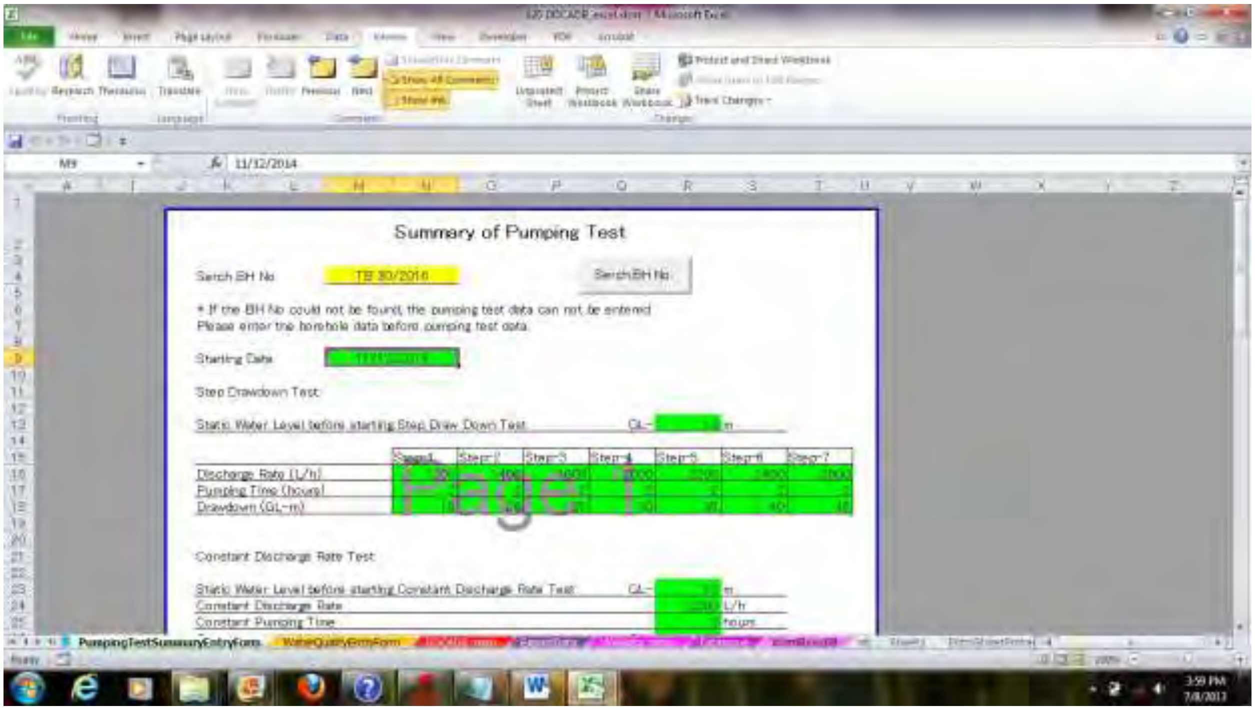


Figure 7: Summary of PumpTest Form

3.4 Data Entry into Water Quality Form

The well data submitted by rig incharge to the registry will be entered into Water quality form and data will referred direct to the "DDCADB_main" sheet .

❖ **Steps For Entering Data Water Quality Form**

1. Open the summary of water quality entry sheet
2. Search the borehole number
3. Start entering the data into colored area
4. Cross check the data entered into "DDCADB

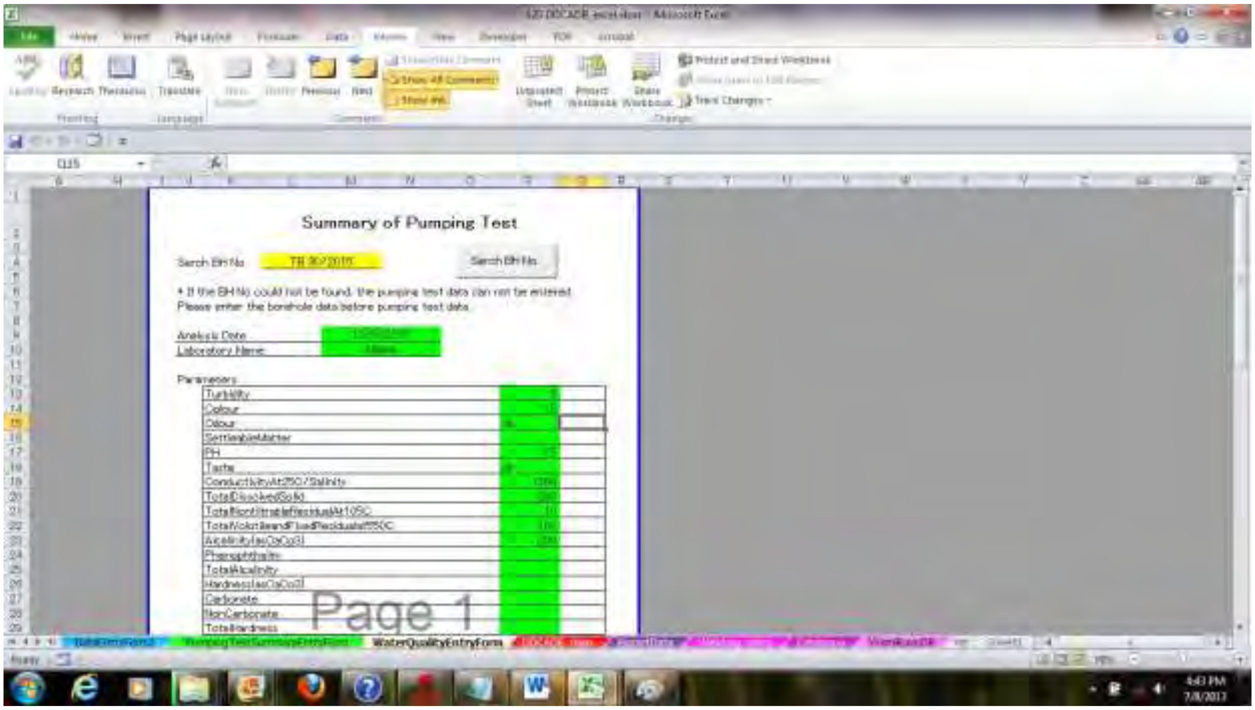


Figure 7.Summary of Water quality Form

4 EXPORT DATA.

These include three forms

1. SUB SAHARAN FORM
2. BOREHOLE CATALOGUE
3. WAMI_RUVU BASIN DB.

❖ **Steps on how to export the data**

1. Clickexport data book
2. Select the data either using ID(From–To) or clicking all the data.
3. Select data limit (transported up to) or click stop exporting
4. Select the form you want to export between three above that are sub saharan form, borehole catalogue and wami_ruvu basin DB.
5. Create new book for exported data
6. Cross check the data in a new book

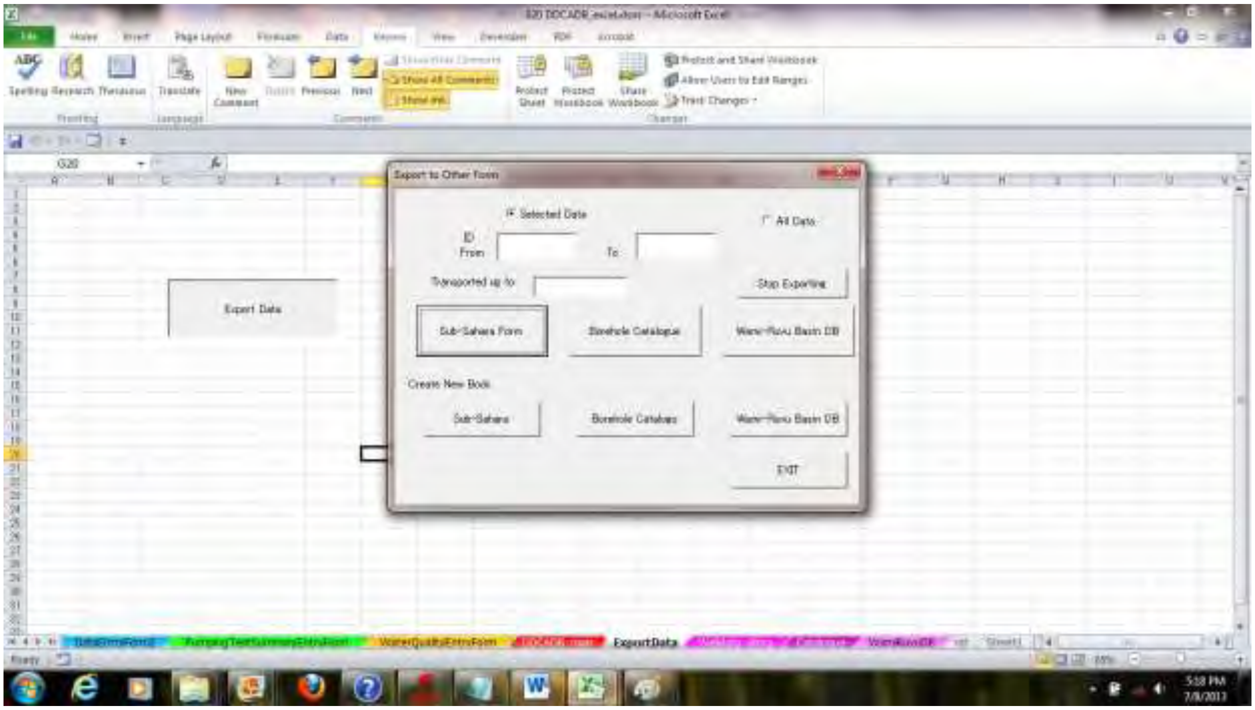


Figure 8: .Export Data Sheet

5 Basicms-EXCEL Functions used in a Database of Well Drilled by DDCA

Some useful ms-Excel functions are applied in the database .LOOKUP functions is Mainly usedfor making the well completion report .LOOKUP functions refer to the information filled in the column, sheet or book. once the formula is set, there is no need to retype up. The other functions such as MATCH,ISERROR and IF functions are also used in the database. As the introductory step to handle the database, this section describes the Ms-Excel functions to be mastered, which are needed for data entry.

5.1 LOOKUP(VLOOKUP; Vertical lookup) Functions

❖ Purpose

Refer to data from other sell, sheet and book

❖ Formula

=vlookup(*lookup_value,table array,Col_index,Approximate match)*

❖ How to set VLOOKUP formula in the column

1. Put equal then write “vlookup”
2. Put open brackets
3. Click the lookup value and put comma
4. Select and put the range of table in which the data to be referred is included, then put coma
5. Put number of column in which the data to referred is located, then put comma
6. Select zero, then put close brackets
7. Press enter

❖ **Example**

Table 1 LOOKUP function

Column

A2:D2-Nauli_itm

	A		B	C	D
1	B3:D6	nauli_lst			
2		Region	DSM	Arusha	Mwanza
3		Morogoro	5000	30000	60000
4		Mbeya	40000	80000	100000
5		Tanga	60000	35000	55000
6		Kagera	70000	65000	25000

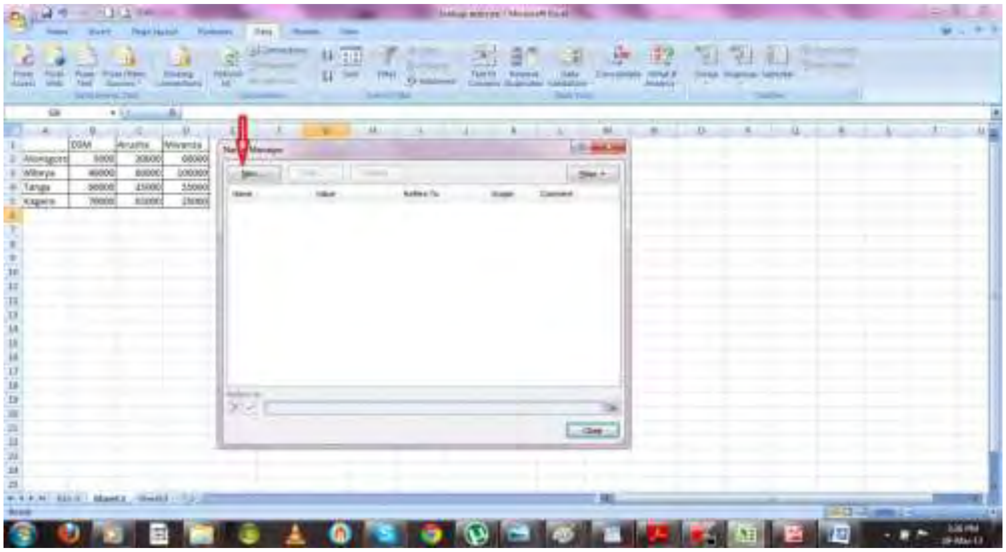
:Naming of table by using "Name manager" as instructed in*Box

Tanga-DSM =vlookup($B$5,nauli_lst,2,0)
=60000
Morogoro-Mwanza =vlookup($B$3,nauli_lst,4,0)
=65000
Kagera-Arusha =vlookup($B$6,nauli_lst,3,0)
=45000

*Name Manager

1. With pressing "ALT",Press"1","N","D"
2. Name manager box will be appeared

3 Click “New” to name



4.Write the name”Nauli_lst” as example table shows
5.Select the range “$B$3:$E$6” to refer
6.Refer to the selected nauli list or nauli item then press ok
7.Close name manager box

Note:$means fixed roworcolumn.There are three types of $ usage,which is either Either $B$3(absolute),$B3(relatively column)or B$3(relatively row).

5.2 MATCH functions

- Purpose
  To find the no. of column which the data locates
- Formula
  =match(value,tablearray,approximate match)
- How to set MATCH formula in the column
  1. Put equal then write “match”
  2. Open brackets
  3. Click the value from the cell and put comma
  4. Select and put the rangeof table in which the data to be refffered is included, then put comma
  5. Select approximate match 0(complete), then put close blackets
  6. Press enter

- Example

Table 2: MATCH functions

	A	B	C	D	E
1	nauli_lst				
2		Region	DSM	Arusha	Mwanza
3		Morogoro	5000	30000	60000
		Mbeya	40000	80000	100000
5		Tanga	60000	35000	55000
6		Kagera	70000	65000	25000

DSM=match(C2,nauli_lst,0)
=3

Arusha=match(D2,nauli_lst,0)
=4
Mwanza=match(E2,nauli-lst,0)
=5

5.3 Combination of VLOOKUP&MATCCH Function

- **Formula**
=vlookup(lookup_value,table array,match(value,table_array,approximate match)
- **How to set VLOOKUP&MATCH formula in the column**
  1. **Put equal then write "vlookup"**
  2. **Open brackets**
  3. **Click the lookup value and put comma**
  4. **Select and put the range of table in which the data to be referred is included, then put comma**
  5. **As "Col_index_number" put match formula in which the data to be referred is located. Then put coma**
  6. **Select Zero, then put close brackets**
  7. **Press enter**

- **Example**
Table 3 Combination of VLOOKUP and MATCH function

	A	B	C	D	E
1	nauli_lst				
2		Region	DSM	Arusha	Mwanza
3		Morogoro	5000	30000	60000
4		Mbeya	40000	80000	100000
5		Tanga	60000	35000	55000
6		Kagera	70000	65000	25000

Tanga-DSM =vlookup($B$5,nauli_lst,match(C$2,nauli_itm,0),0)
=60000
Morogoro-Mwanza=vlookup($B$5,nauli_lst,match(E$2,nauli_itm,0),0)
=65000
Kagera-Arusha =vlookup($B$6,nauli_lst,match(D$2,nauli_itm,0),0)
=45000

5.4 IF Function

- **Purpose**

To return the deduced as defined in case of TRUE and FALSE

- **Formula**

=If(value,True,FALSE)

- **How To Set IF Formula in the column**

Table 4 IF function 1

	A	B	C	D	E
1	Score_lst				
2		Name	Math	Average	Pass/fail
3		Ali	90	50	
4		Juma	45	30	
5		Michael	30	45	
6		Maria	90	50	
7		Godfrey	10	20	

Ali =If(C3>D3,"PASS","fail"
=Pass
Juma =If(C4>,"PASS","FAIL"
=PASS
Michael =If(C5>D5,"PASS,"FAIL")
=FAIL
Maria =if(C6>D7,"PASS",FAIL")
=PASS
Godfrey =if(C7>D7,"PASS","FAIL"

=FAIL

Table 5 IF Functions 2

	A	B	C	D	E
1	Score_lst				
2		Name	Math	Average	Pass/fail
3		Ali	90	50	pass
4		Juma	45	30	pass
5		Michael	30	45	fail
6		Maria	90	50	pass
7		Godfrey	10	20	fail

5.5 ISERROR Function

- **Purpose**

To check the error such as #NULL?,#DIV/0,#VALUE?,#REF?,#NAME?,#NUM?,#N/A,#GETTING_DATA and return TRUE or FALSE.

- **Formula**

=iserror(value)

- **How To Set ISERROR formula in the column**

The formula to refer to to the transport fee Mwanza-Mbeya is as follows; =VLOOKUP($A4,nauli_lst,MATCH(E$2,nauli_itm,0),0)

Table 6 ISERROR functions 1

	A	B	C	D	E
1	nauli_lst				
2		Region	DSM	Arusha	Mwanza
3		Morogoro	5000	30000	60000
4		Mbeya	40000	80000	#DIV/0
5		Tanga	60000	35000	55000
6		Kagera	70000	65000	25000

In case the isserror is happened for the cell of E4,the following formula makes the error show as defined by IF function.
Mwanza-Mbeya

=IF(ISERROR(VLOOKUP($A3,nauli_lst,MATCH(D$3,nauli-ITM,0),0)),"",VLOOKUP($A3,nauli_lst,MATCH(nauli_itm,0),0)

Table 7 ISERROR function 2

	A	B	C	D	E
1	nauli_lst				
2		Region	DSM	Arusha	Mwanza
3		Morogoro	5000	30000	60000
4		Mbeya	40000	80000	
5		Tanga	60000	35000	55000
6		Kagera	70000	65000	25000

5.6 DDCA_Repository

Database repository's prepared for storing the attributes. In case new attribute addition is added, the new attribute will be stored into the repository first and then reflected to the data entry sheet. The attribute stored into the repository are sorted by groups and category. Eachattributes, group and category has data No.With the item code as below.

- GROUP-GR
- CATEGORY-CT
- ATTRIBUTE-AT
- ?ATTRIBUTE-RAT

There are three types of sheet of "GR","CT" and "AT". The following describe details of each sheet

GR list sheet

GR list sheet show the groups with Gr NO.As the following window shows, there are three groups. In case new group is added make sure to re-range rename the table.

1. Drilling
2. Pump test
3. Water quality

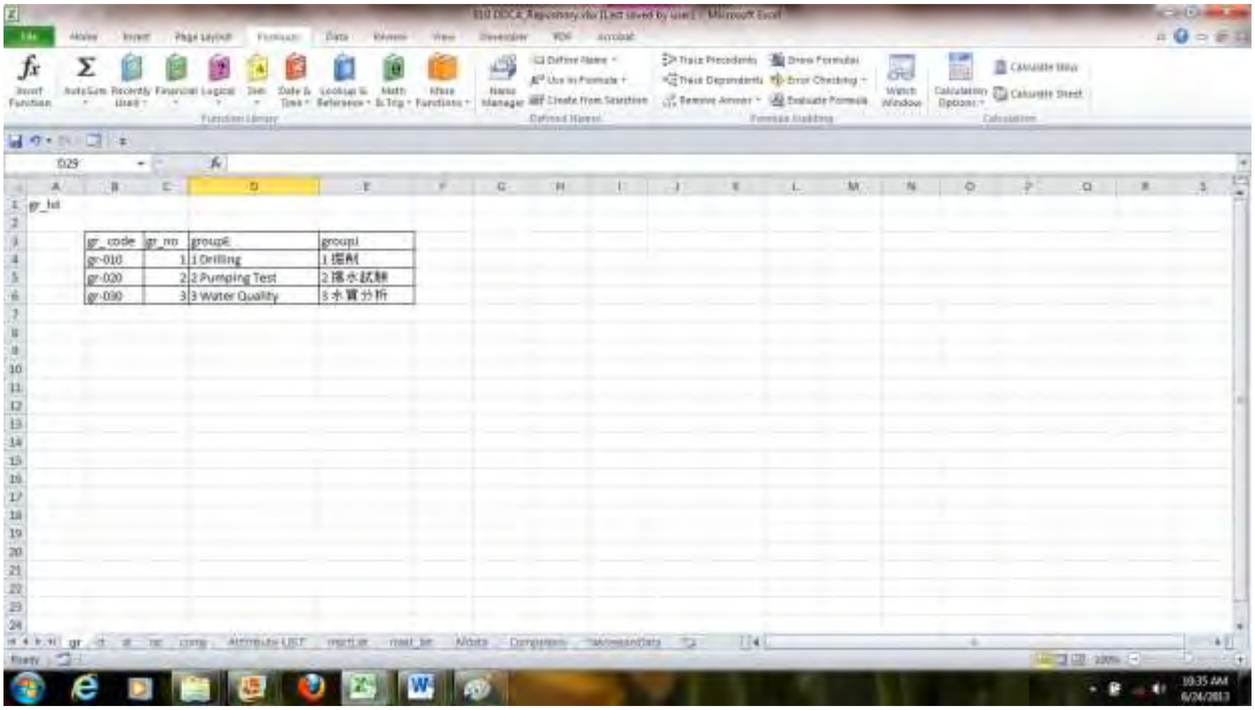


Figure 9 group list(GR list)

CT list sheet

CT list sheet shoe the categories under the group .Each categories has coded the CT no.and refer to the group in the gr –list sheet with using the LOOKUP functions(the cells with blue color).there are 14 categories as the following windows shows.

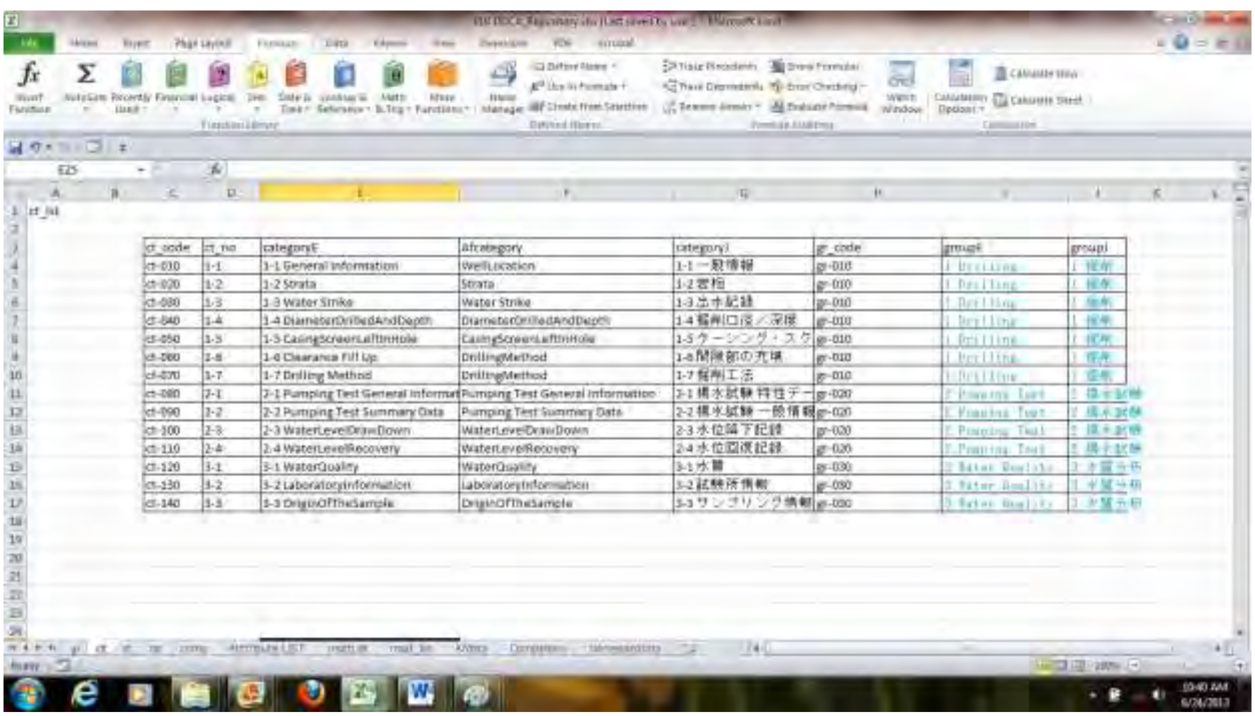


Figure 7 Category List(CT list)

AT list sheet

AT list show the attributes which is under each category and group. Each categories has coded the AT No.and refer to the group in the CT list sheet with using the LOOKUP functions(the cell with blue color).In case the new categories is added, make sure to expand the range of list(re-range and rename) there are 190 attributes as the following window shows

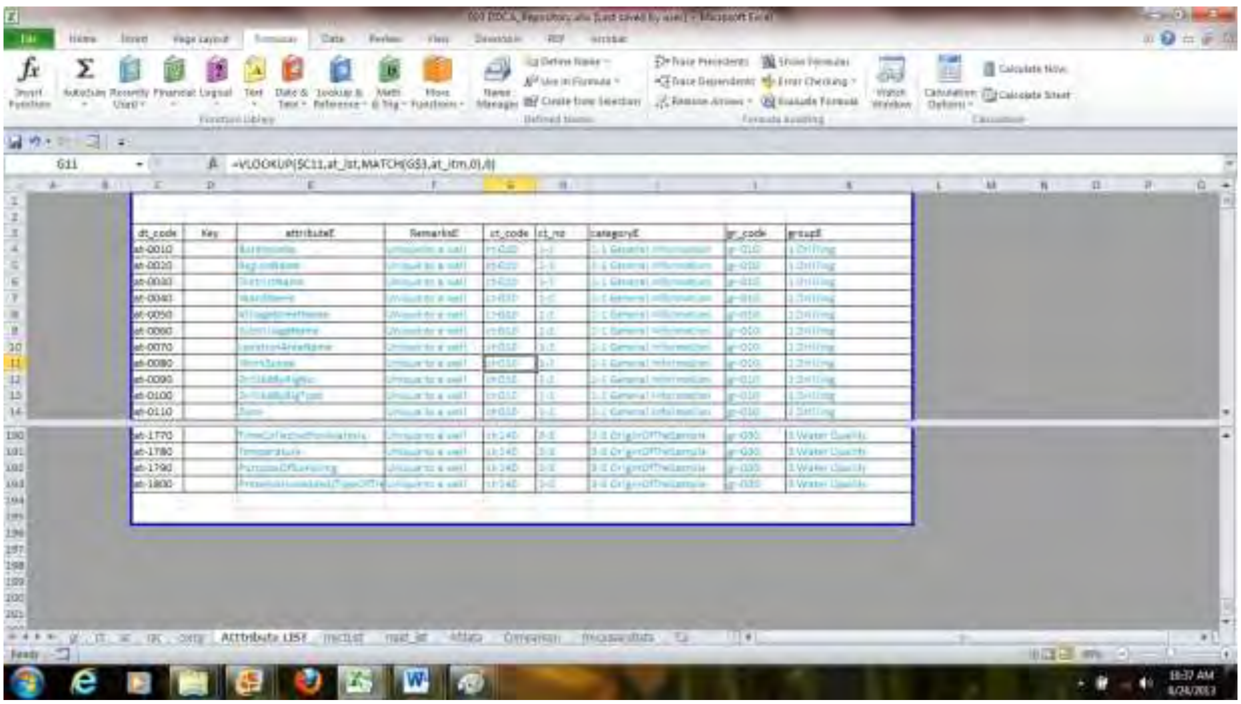


Figure 8 Attribute List(AT list)

RAT list sheet

RAT list sheet show the all attributes unfolding the repeating items. Each data has been coded the RAT No.The group, category and attribute before unfolding the repeating items re-range and rename the first after addition of the new attribute. RAT No. Is stored into the top row in the data entry sheet so as to store the attributes into the data entry sheet so as to store the attributes into the data entry sheet from RAT list sheet in the repository by referring to the RAT No.

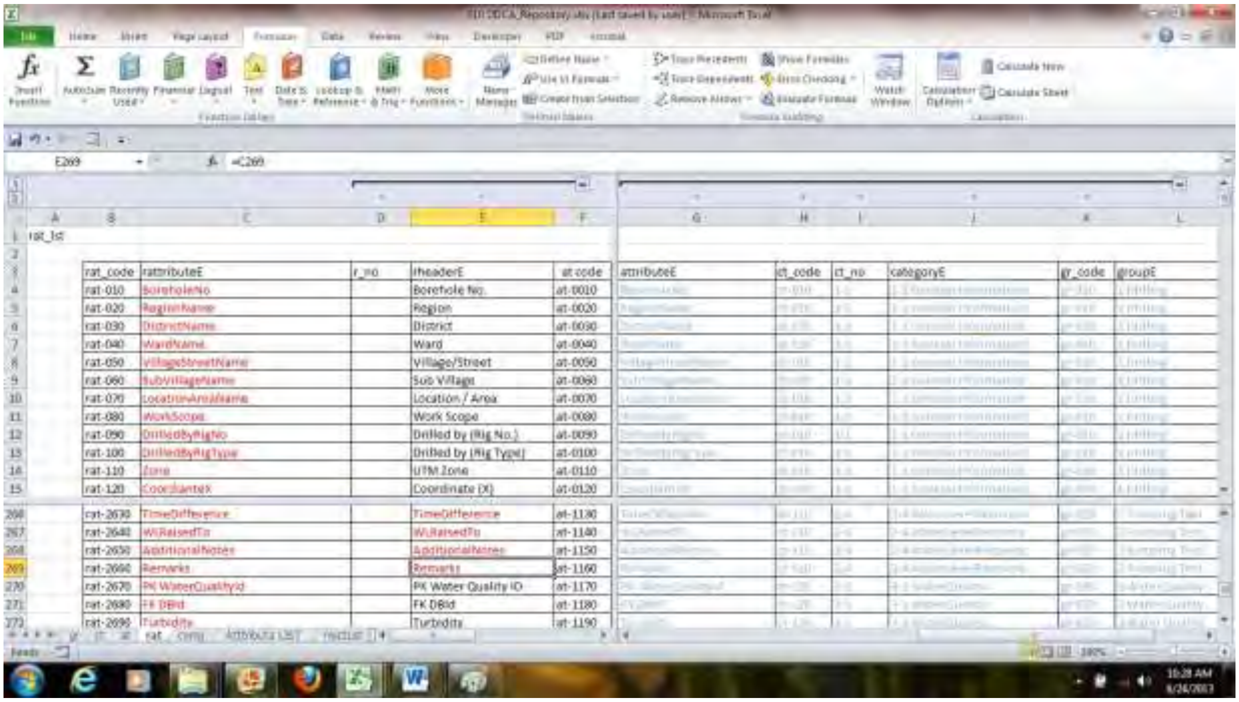


Figure 8: Attribute List(RAT list)

❖ **Steps For Additional Attributes To Repository And Data Entry Sheet**

1. In AT list sheet, insert the row where the new attribute will be stored
2. Code new AT No and enter the new attribute.
3. The vlookup formula is set into the category column
4. Shift to the RAT list sheet and insert the row where the new attributes will be stored
5. Enter the new RAT No.
6. The VLOOKUP formulas of group and category for new RAT items are set
7. The formula for the RAT items is set as set in the cells up and down cells
8. In case the new attribute is repeating items, the formula is set like that of green colour.In case of not repeating items, the formula is set as that of red color
9. Shift to the data entry sheet and insert the column in which the new attribute is stored
10. Set the formula of VLOOKUP so as to quote the attribute from the repository into the data entry sheet.

LOCAIDES GENERAL SUPPLY LIMITED

P.O. Box 33333, Dar es Salaam. Survey, Kinondoni
Tel:2700096 Fax: 2700096
email: locaides@gmail.com,bertharicky@yahoo.com

GROUNDWATER DEVELOPMENT AND MANAGEMENT

CAPACITY DEVELOPMENT PROJECT

DDCAP

OUTPUT (13)
WORK REPORT FOR PHASE-2

APRIL 2013

LOCAIDES GENERAL SUPPLY LIMITED

Contents

Figure

1. EVALULATION OF OPERATION CONDITION

After the training at the end of Phse-1, LOCAIDES and the Client evaluated the test version of the database. And two kinds of challenges were observed as follows.

- It is very tough work to enter borehole data into the excel datasheet.

- It is very likely to be changed by human error.

2. SYSTEM ANALYSIS AND DESIGN FOR IMPROVEMENT

In order to solve the challenges described above, further function was designed as follows.

- Making data entry interface for borehole data entry, pumping test summary data entry and water quality analysis.

- Making sheet protection with password.

As mentioned in the requirement analysis report, a function to export data to other database form is to be added.

These additional functions were designed centering on being simple operation.

3. SYSTEM MODIFICATION FOR IMPROVEMENT AND INTEGRAL TEST

The excel database was modified with addition of function. The added interfaces are shown in Figure 1 to Figure 3. The added data export function is shown in Figure 4 and Figure 5.

The modified database was tested by DDCA users and confirmed that the added functions work well.

Output (6) System Design Completed

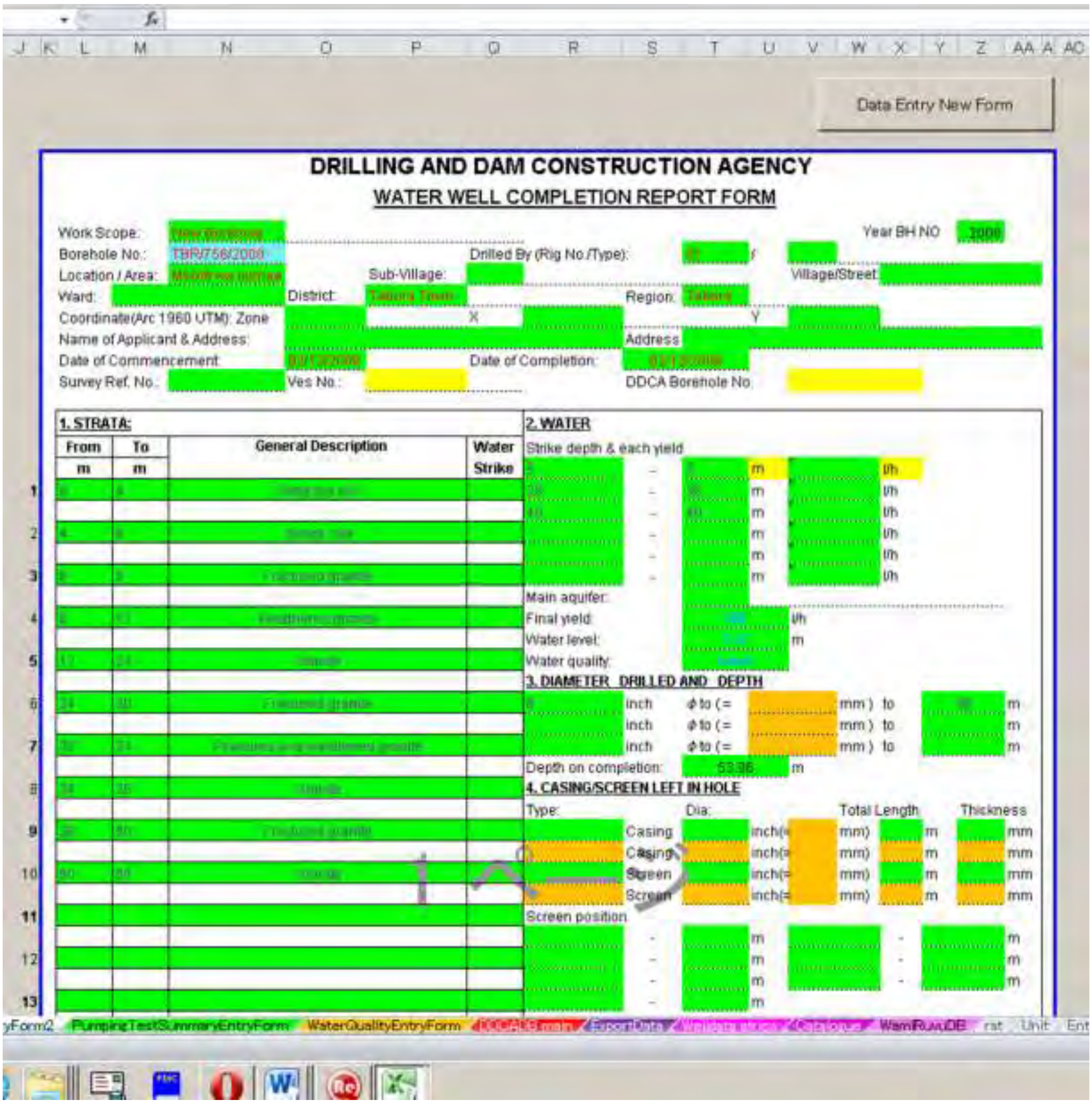


Figure 1: Interface for borehole data entry

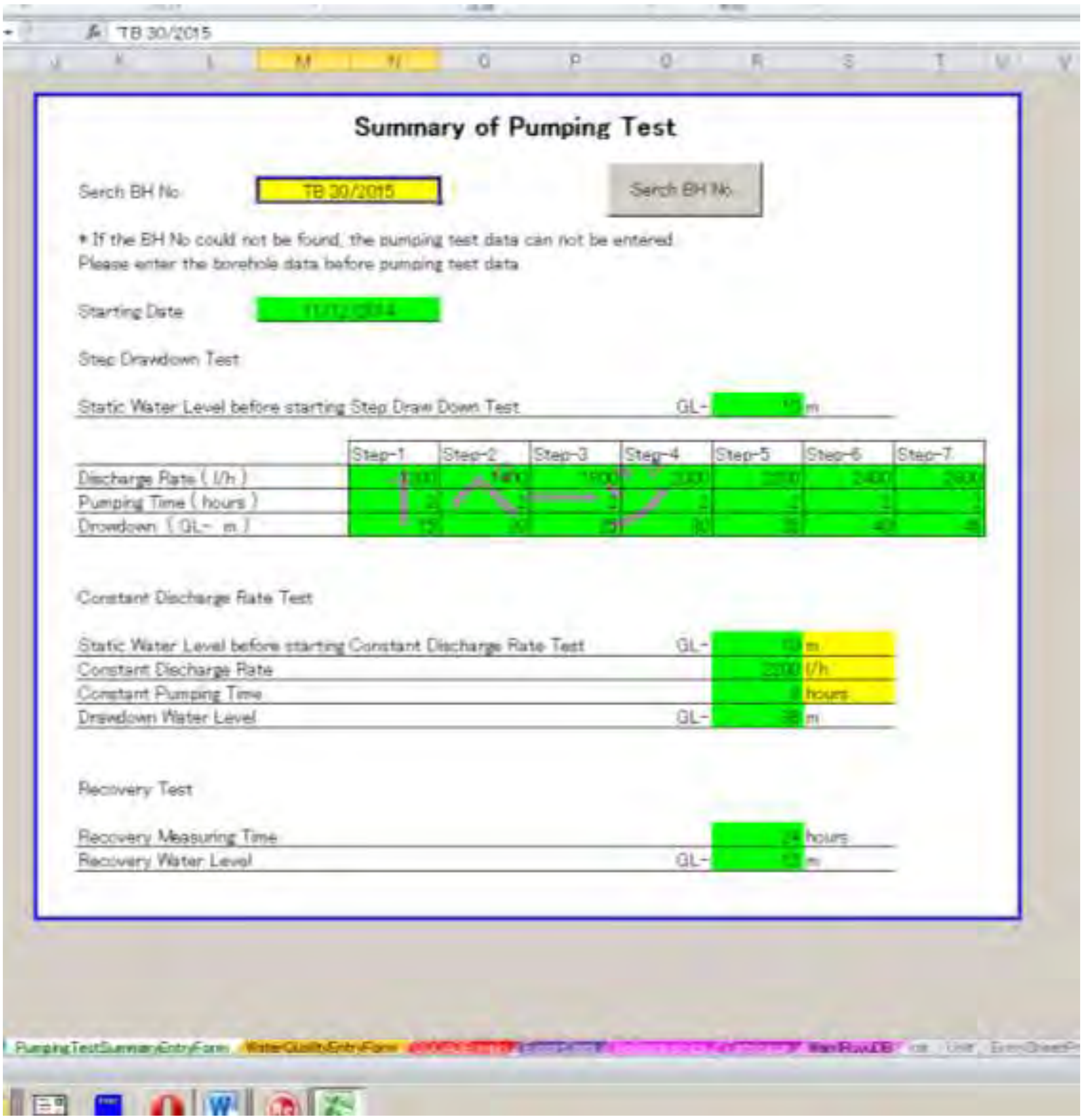
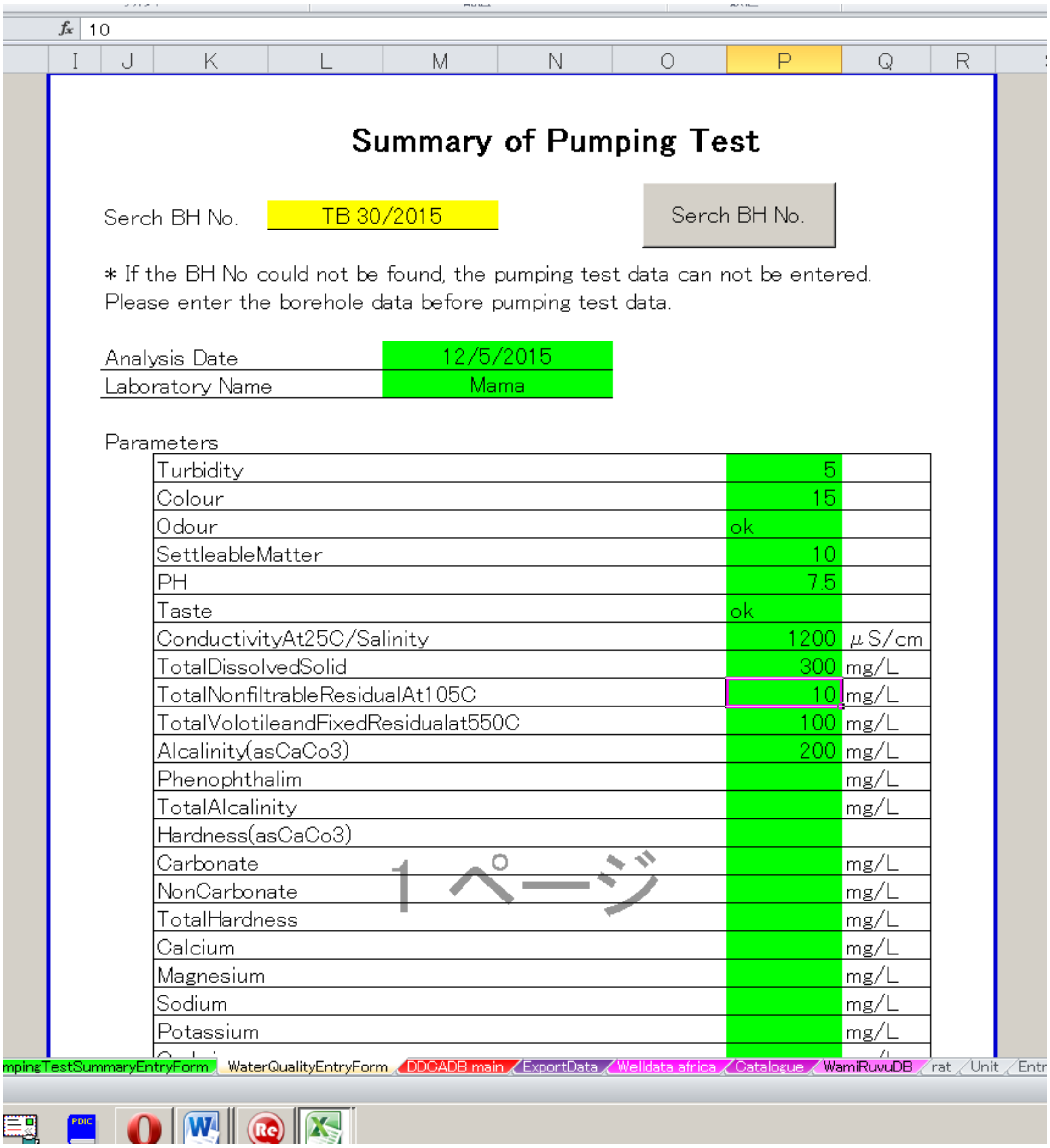


Figure 2: Interface pumping test summary data entry



Summary of Pumping Test

Serch BH No. TB 30/2015 | Serch BH No.

* If the BH No could not be found, the pumping test data can not be entered.
Please enter the borehole data before pumping test data.

Analysis Date	12/5/2015
Laboratory Name	Mama

Parameters

Turbidity	5	
Colour	15	
Odour	ok	
SettleableMatter	10	
PH	7.5	
Taste	ok	
ConductivityAt25C/Salinity	1200	μS/cm
TotalDissolvedSolid	300	mg/L
TotalNonfiltrableResidualAt105C	10	mg/L
TotalVolotileandFixedResidualat550C	100	mg/L
Alcalinity(asCaCo3)	200	mg/L
Phenophthalim		mg/L
TotalAlcalinity		mg/L
Hardness(asCaCo3)		
Carbonate		mg/L
NonCarbonate		mg/L
TotalHardness		mg/L
Calcium		mg/L
Magnesium		mg/L
Sodium		mg/L
Potassium		mg/L

1ページ

mpingTestSummaryEntryForm | WaterQualityEntryForm | DDCADB main | ExportData | Welldata africa | Catalogue | WamiRuvuDB | rat | Unit | Entr

Figure 3: Interface for water quality data entry

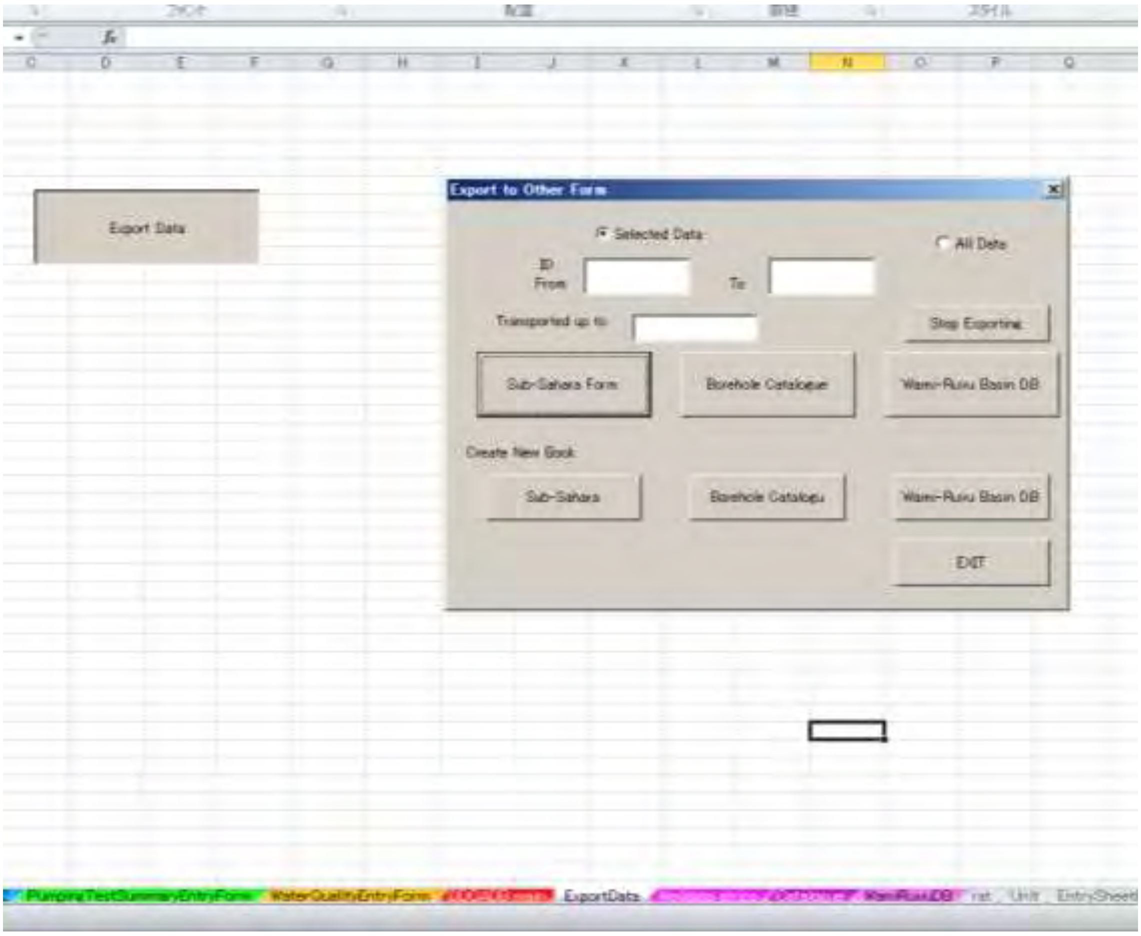


Figure 4: Control form for data export

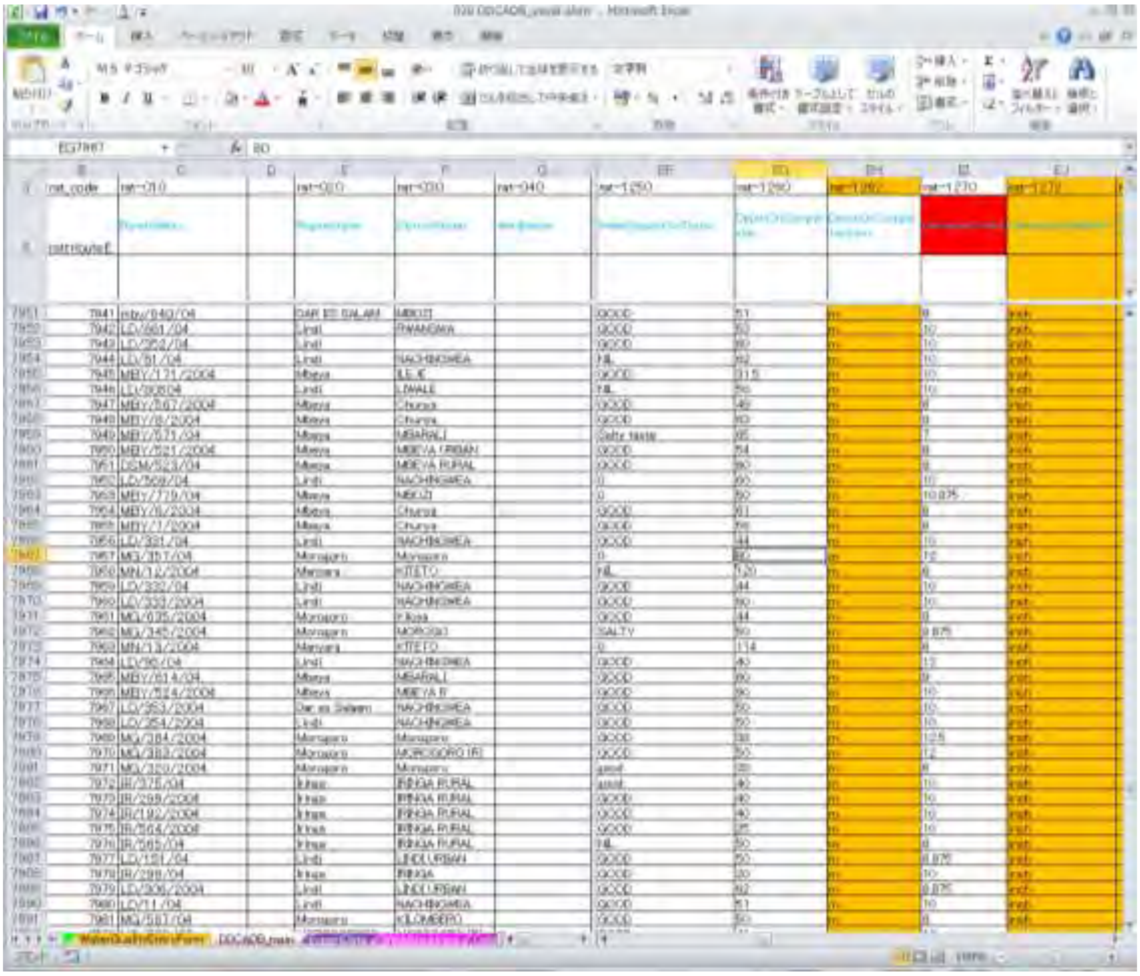


Figure 5: Exported data (Africa sub-sahara well database form)

4. REVISION OF MANUAL

The operation manual was revised by adding new functions described above. The revised manual has already submitted to the Client.

5. TRAINING

Training was held by using modified database and modified manual from 8/July/2013 to 17/July/2013. Furthermore LOCAIDES followed DDCA users from 17/July/2013 to 31/July/2013.

Ministry of Water (MoW)
Drilling and Dam Construction Agency (DDCA)
Japan International Cooperation Agency (JICA)

DDCAP

Guidelines on Hiring of Drilling Eqiupment and Machinery

Version 1

March 2013

Groundwater Development and Management Capacity Development (DDCAP) Project

Table of Contents

List of Tables

List of Figures

1. INTRODUCTION

1.1 BACKGROUND

Aiming at alleviating poverty through improvements in the governance of water resources management and the sustaiblable delivery for water supply and sanitation services, the Government of United Republic of Tanzania (hereinafter referred to as “the Government of Tanzania”) has been implementing the Water Sector Development Program (WSDP) since 2007 to address shortfalls in urban and rural water supply infrastructure, to improve water resources management, and to strengthen the sector institutions and their capacities (MoW 2006 a). The target of the Program is to achieve increase of proportions of the rural population with access to clean and safe water to 90% by 2025. It also calls for increased access to clean and safe water to the urban population to 100% by 2025.

WSDP estimates that approximately 79,000 water points need to be constructed in the Rural Water Supply and Sanitation (RWSS) component in order to meet the target mentioned above. 91% of these water facilities is expected to be sourced with the groundwater, which requires drilling of 1,200 wells annually. The Urban Water Supply and Sanitation (UWSS) component also has high demand of borehole construction in specific regional and district centerrs where surface water sources are scarce. Although private drilling companies are the main actor for groundwater development in WSDP, their current capacity in drilling wells is approximately 600 per annum. In other words, their capacities such as technical abilities and resources have a great gap compared with the demand in the water sector.

Taking this situation into consideration, MoW procures new drilling equipment in WSDP in order to support Drilling and Dam Construction Agency (DDCA) for strengthening of its capacity in borehole construction and providing technical support services to private drilling companies with utilizing the procured equipment. The Strategy for Strengthening Water Well Drilling Industry in Tanzania formulated by MoW in 2006 in parallel with designing of WSDP states necessity to establish the plant and equipment hiring unit within DDCA to manage the equipment procured for the hiring service (MoW 2006 b). This is supported by the Executive Agencies (Drilling and Dam Construction Agency) (Establishment) Order, 1999, which describes that hiring of the drilling equipment to other organizations is a part of the secondary functions of DDCA.

Objectives to establish the equipment hiring service within DDCA are firstly to enable private companies enhance knowledge and skills on water well drilling works through utilization of the equipment hiring and technical instructions to be provided by the Agency as the technical support services. Secondly, it is aimed to create a new revenue source for DDCA which is required to operate the business autonomously.

1.2 PURPOSE AND INTENDED USERS OF THE GUIDELINES

The guidelines are intended to describe the business model and operational principles of the hiring service of drilling equipment to be operated by DDCA. The Manual on Hiring of Drilling Equipment supplements these guidelines and provides a source of reference on daily operation of the hiring service in accordance with its business cycle.

These guidelines are the property of DDCA and to be used by authorized officers of the Agency only. Amendments and additions on the guidelines will be issued from time to time by the Business Support Manager after approval by the management of DDCA and Ministerial Advisory Board (MAB). Hiring Business Unit is responsible to keep all editions of the guidelines approved.

2. ENVIRONMENTAL SCAN

The purpose of this chapter is to describe the internal and external environment of DDCA in establishment of the equipment hiring service to accelarate participation of private drilling companies in WSDP.

2.1 INTERNAL ENVIRONMENT

The internal environment of DDCA can be considered from viewpoints of strength and weakness.

2.1.1 STRENGTH

DDCA can utilize its human resources, facilities, organizational knowledge, and partnership with other institutions and the private sector as its strength to establish and operate the hiring service of drilling equipment. Firstly, DDCA has skilled drilling staff who can be transformed into technical instructors to support capacity development of private drilling companies. As described in Chapter 3, a certain percentage of the private drilling companies express their demand to receive technical support from DDCA to enhance skills and knowledge of their drilling staff. Providing Training of Trainers' courses to them and certifying those who are qualified as the technical instructors, DDCA can make good use of its senior drilling staff to conduct this function.

Secondly, DDCA has office and workshop facilities at the headquarters in Dar es Salaam and five zonal offices. These facilities make it possible for DDCA to 1) promote the hiring business to various entities which are involved in drilling works in every corner of the country, 2) collect needs and perception of (potential) owners/users of boreholes, and 3) provide quick actions for maintenance and repair of equipme for hiring.

Thirdly, DDCA has accumulated knowledge and data on hydrogeological conditions and specifications of boreholes in different areas of the country through implementation of drilling works. These can be regarded as part of "assets" of the organization to add value to the technical instructions to the private sector.

Lastly, the Agency can collaborate with WDMI in development of teaching guide and materials to be used in technical instructions to the private sector in the manner that those contents will supplement curriculum of WDMI, especially for the incumbent of the position of drilling staff. DDCA has also established working relationship with the private drilling companies for years. DDCA sometimes rented the drilling equipment with its drilling staff to private companies. In other case, the Agency hired rigs from the private sector. Informal communication is also maintained between DDCA and some of the drilling companies to exchange information on drilling works. This kind of network with the private sector can be utilized in identification of potential clients and business promotion.

2.2.2 WEAKNESS

While DDCA has advantages to start the hiring service as mentioned above, some weakness are observed in terms of equipment owned by the organization, financial status, and practice of capacity development of its staff members.

Although DDCA currently operates a total of 15 drilling rigs, 11 out of the existing equipment were procured more than 15 years ago and the oldest one ages 52 years. It causes DDCA to spend significant proportion of budget for maintenance and repair of these old rigs due to frequent breakdown. As DDCA has to sequre reliable equipment for operation of its drilling activities, it is difficult for the Agency to reallocate part of the existing rigs to the hiring service.

With regard to the financial status, DDCA relies on the government subventions for initial capital investment for the equipment and part of the recurrent cost. The drilling rigs and supporting equipment have never been replaced with own fund of the Agency as it does not employ the concept of cost recovery of the initial investment from sales from the drilling activities. This practice would affect sustainability of the hiring service since there will be no guarantee of financial resources for the future investment if the government stops provision of subventions to the Agency.

The other weakness is that DDCA does not conduct capacity development of the staff members systematically in accordance with analysis on capacity gaps of each position of the staff. In case of the drilling staff, their capacity development is implemented mostly in the forms of training at external academic institutions or on-the-job training at drilling sites by senior staff at ad hoc basis. It would hinder the Agency from maintaining required number of the technical instructors who possess standard teaching skills.

2.2 EXTERNAL ENVIRONMENT

The external environment of DDCA is analyzed from viewpoints of opportunity and threat.

2.2.1 OPPORTUNITY

Some favorable environment can be observed as opportunities for DDCA to operate the hiring service. First of all, demand for water wells in the country is increasing with growth of population both in rural and urban areas. WSDP projects 90% of water points to be constructed in the Rural Water Supply and Sanitation (RWSS) component will be sourced from groundwater. The urban water supply also relies on the groundwater sources in particular areas where there are no perennial rivers or available amount of water is limited to meed demand.

Secondly, the water well drilling industry, especially the private drilling companies, has inadequate capacity to respond to increasing demand for borehole construction. As described in detail in Chapter 3, there is a limited number of private drilling companies which have conducted drilling works in WSDP. This is partly due to the reason that the marjority of the private drilling companies do not possess any large rotary drilling rigs which can perform DTH drilling, the drilling method used in most part of inland areas of the country. Interest of the drilling companies is very high in terms of participation in drilling works in WSDP as well as expansion of business opportunities in the program. This situation can be regarded as an opportunity for DDCA to provide the hiring service of drilling rigs in combination with technical instructions to the private sector.

Thirdly, DDCA receives financial support and policy guidance from MoW. MoW supports DDCA in procurement of new drilling equipment through WSDP. Part of these items are meant for use for the hiring service. Reinforcement of regulation of the drilling companies by MoW will also create an opportunity for DDCA to respond to needs of the private sector to fulfill allocation of drilling equipment with appropriate specifications and practice of code of conducts in drilling works.

The fourth point is the privilege of exemption from VAT on sales of the Agency. Hirers of the equipment will also benefit from it as the cost they have to bear will be reduced.

2.2.2 THREAT

There are some competitors who hire drilling equipment to others in the country although the number of such companies and available equipment are limited. These competitors operate drilling works as their primary business and rent rigs to others when the equipment is not occupied for their activities. These competitors might pose a threat to DDCA in pricing of rental fees when they intend to maximize the number of hiring period by reducing the price without considering costs to be incurred to manage and maintain the equipment.

Other factors which would become threat for DDCA are shortage of skilled and experienced drillers in the private sector and insufficient understanding of drilling companies as well as groundwater users on legislation related to water resources management. Operation of hired drilling rigs by drillers with few experiences with large rotary rigs entails risks of accident during works. Furthermore, unless drilling companies and groundwater uesrs have good understanding on requirements by laws on procedures of the groundwater development which should be followed by the professionals and owners of wells, respectively, there will be less demand for implementation of proper drilling works.

2.3 CROSS SWOT ANALYSIS

Analysis on internal and external environment of DDCA mentioned in the previous section can be further used to strategize operation of the hiring service. ***Table 1*** shows results of the cross SWOT analysis which describe possible strategic directions in different situations which are categorized into four scenarios mentioned below;

- Maximization of opportunities with utilizing strength of the organization [Strength and Opportunity]
- Transformation of weakness to strength or reinforce weak points to loose opportunities [Weakness and Opportunity]
- Differentiate from others with utilizing strength [Sthrength and Threat]
- Defend from the worst scenario [Weakness and Threat]

Table 1 Cross SWOT Analysis

	Strength	Weakness
Opportunity	***How to seize opportunities?*** - Utilize senior drilling staff as the technical instructors who will be attached to drilling rigs for hiring. - Reinforce workshop facilities and skills of mechanics at some of the zonal offices which are strategically important to provide maintenance and repair of equipment for hiring. - Identify information and service options to which the private drilling companies recognize value and come up with contents of the technical support services including the equipment hiring to satisfy different types of demand.	***How to avoid missing opportunity because of presence of weakness?*** - Allocate six drilling rigs under procurement in WSDP to be fully used for the hiring service. - Employ an internal transaction system in DDCA to be accounted as “sales from the hiring service” for the case that the Agency uses these drilling rigs for its drilling activities. - Apply pricing policy to recover initial investment for the equipment to secure funds for replacement of rigs and other machinery in the future - Conduct capacity assessment and training of the technical instructors and senior drilling staff periodically to - Institutionalize a systematic capacity development support for the staff members of the Agency.
Threat	***How to change threat to opportunity with strength?*** - Differentiate the service contents from the ones provided by other companies through focusing on potential clients who are willing to pay for reliable quality of the equipment and technical instructions by skilled drilling staff at corresponding price. - Enhance teaching skills of the technical instructors enough to provide adequate guidance to and supervision of drilling staff from hirers on site. - Provide guideance to the private drilling companies on legal requirements on groundwater development in cooperation with MoW and WDMI.	***How to avoid the worst situation?*** - Prevent excessive reduction of rental fees to compete with other companies in hiring business. - Apply a certain criteria to screen drilling companies who are qualified as hirers of the equipment.

3. SEGMENTAITON OF POTENTIAL CLIENTS

3.1 BUSINESS ENTITIES IN WATER WELL DRILLING SECTOR IN TANZANIA

Table 2 shows the total number of business entities involved in drilling works, which were identified through the registrations at MoW and Contractors Registration Board (CRB), baseline survey, and the Water Sector Management Information System (MIS). A total of 174 business entities were found from these sources of information. Further examination made it clear that some of the business entities listed had already stopped operation of water well drilling or were specialized in other activities such as soil testing and groundwater exploration. There were also a certain number of organizations which could not be reached due to unavailability of updated information on their contacts.

After excluding these organizations, 104 entities were confirmed to be currently involved in water well drilling either by directly conducting drilling works or contracting out the whole works to other specialized contractors. These 104 business entities are, therefore, regarded as the potential clients of the technical support services of DDCA (***Figure 1***).

There are another 52 entities which status of business operation is currently unknown as some were refused to be interviewed in the baseline survey and others could not be physically located. DDCA will continue to try to establish contacts with these organizations to increase the number of the potential clients for the hiring service.

Table 2 Number of Business Entities in Water Well Drilling Sector in Tanzania

Category	Total	Breakdown	
Total No. of Business Entities Identified	174	126	: Listed in the original list of drilling permit holders of MoW
		27	: Added to the target list of baseline survey
		18	: Registered as specialist contractors (drilling works) under CRB but not on the original list of drilling permit holders of MoW
		3	: Recorded on Water Sector MIS as contractor of drilling works but not on the original list of drillimg permit holders or CRB Directory
No. of Entities which are currently involved in drilling works	**104**		
Interviewed in Baseline Survey	94		
Not interviewed	10	1	: not found
		1	: refused interview
		8	: not on the original list of the registered companies obtained from MoW.
No. of Entities which are not involved in drilling works	18	5	: perform survey works or soil testing only.
		13	: stopped drilling works.
No. of Entities which status is unknown	52	Could not confirm current status of the business as some were refused to be interviewed and others could not be located.	

Note: The status in the table is as of December 2012.

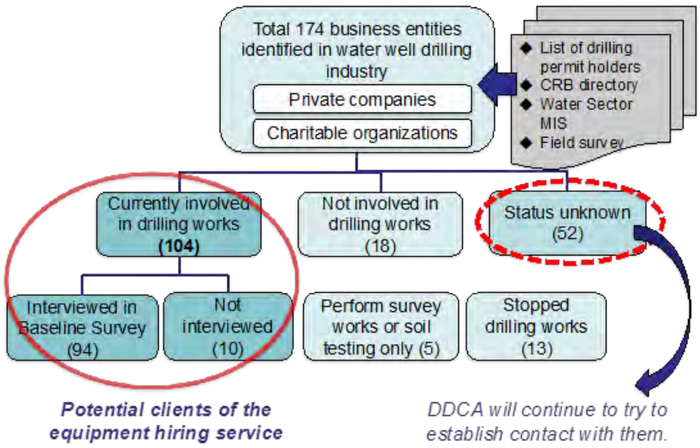


Figure 1 Potential Clinents of the Equipment Hiring Service

3.2 CHARACTERISTICS OF PRIVATE DRILLING COMPANIES

This section describes characteristics of private drilling companies[1] currently involved in water well drilling in the country. Data and information referred here are results of a baseline survey which was conducted in 2012. Analyses were made on 94 companies which operate water well drilling in order to assess capacities of the private drilling companies and their needs for technical support from DDCA.

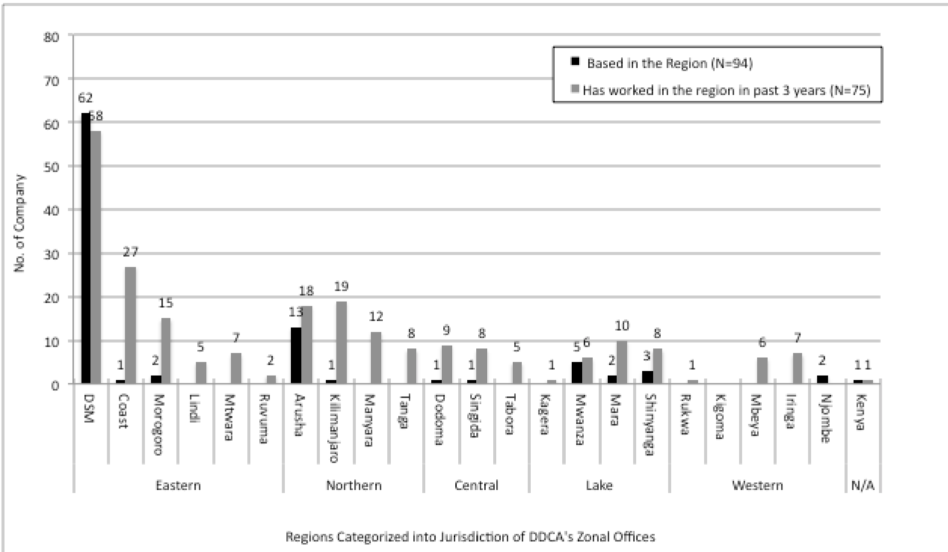
3.2.1 BUSINESS ESTABLISHMENT

(1) Geographical Distribution

The majority of the organization surveyed is established as private companies limited by shares while six of them are formed as NGOs or religious organizations. Offices of these companies[2] are concentrated in major cities in the country. ***Figure 2*** shows distribution of the companies by locations of their offices and project sites where they have worked in the past three years. Regions are grouped into five zones where DDCA operates through its Zonal Offices. 62 companies (65.9%) are based in Dar es Salaam, which is followed by Arusha and Mwanza. Projects the companies have worked in the past three years are located in most of the regions although there are several areas such as Ruvuma, Kagera, Rukwa and Kigoma where few companies have working experience in the same period. Half of the borehole drilling works performed by the companies is located in districts with basement rock-dominant areas or combination of basement rock and other types of geological formation.

[1] The word "privte drilling companies" or "companies" refer to all the organizations interviewed in the baseline survey although the rspondents included NGOs and religious organizations.

[2] The word "private drilling companies" or "companies" refer to all the organizations interviewed in this baseline although the respondents include NGOs and religious organizations.



Note: The number of companies which have worked in the region indicates cumulative figures consolidated from 75 valid cases.

Figure 2　Geographical Distribution of Office and Project Location

It is observed that the companies in each zone have geographical advantage in performing works in the area where they are based. Those which are operating from regions in Eastern Zone have obtained more business opportunities in the same area than the companies in other zones. The same tendency is seen in Northern and Lake Zones, too.

(2) Year of Establishment and Experience in Drilling Works

Half of the private drilling companies surveyed are relatively new as they were established after 2006, which coincides the launch of WSDP (***Figure 3***). The number of companies which start business operation in drilling works doubled in 2009-2011 compared to the preceding period. In these three years, 10-13 companies a year started drilling works as (a part of) their business while there were maximum 7 entities per annum from 1985 to 2008. Nearly 60% (56 nos.) of the companies have fewer than six-year experience in operation of the drilling works.

In comparison of years of experience of the company in drilling works with the number of contracts awarded in WSDP, there is no clear correlation between these two factors. A total of 21 companies were involved in the drilling works as the contractors for 10-village subprojects in RWSS Component of WSDP (Phase 1). Among these organizations, 16 companies are included in the respondents of the baseline survey. As ***Figure 4*** indicates, relatively new companies are awarded contracts more than the ones that have longer experience in operation of drilling works. It implicates that there is possibility for the companies with a few experience in the drilling industry to have business opportunities in WSDP in case that other factors such as experience of key personnel in similar works, arrangement of drilling equipment to be used in the works, and financial status satisfy requirements in evaluation of bidding.

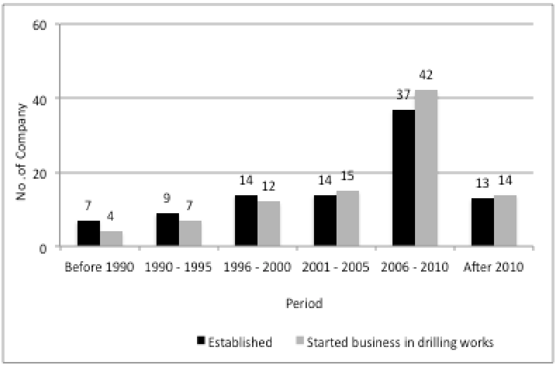


Figure 3 Year of Establishment and Start of Business Operation in Drilling Works

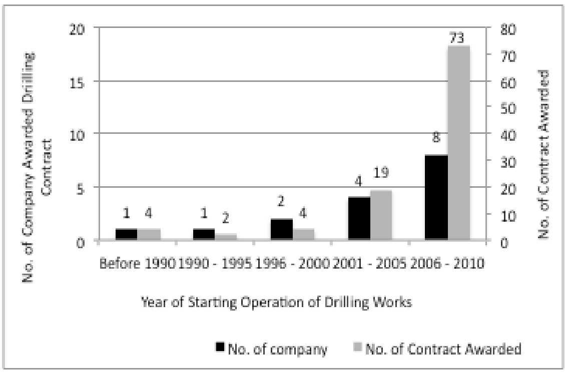
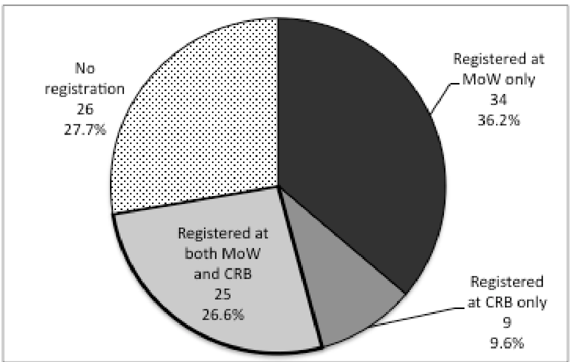


Figure 4 Distributions of Companies Awarded Contracts for Drilling Works in RWSSP/WSDP by Year of Experience of the Organization

(3) Registration to Regulatory Bodies

35 companies are registered at CRB while the number grows to 59 in case of those which are regulated by MoW as the holder of valid water well drilling permit[3]. Of these entities, there are 25 companies (26.6%) which have registration at both CRB and MoW as shown in ***Figure 5.***



Note: Each label in the figure shows category name, number of the case, and its proportion in the total number of the valid cases.

Figure 5 Distribution of Companies by Status of Registration at CRB and MoW

The specialist contractors in drilling works (28 nos.) occupy the majority in the surveyed companies which are registered at CRB. Others, however, possess registration in the areas of civil works, building or electricity only which are not included in the conditions of eligible bidders of drilling works in WSDP.

Attention should be paid to a fact that about 15% of the permits are not renewed annually as per requirement although three fourth of the surveyed companies have once obtained the water well drilling permit from MoW, according to findings from the interviews. This also suggests that MoW should update information on the water well drilling permit holders annually.

Also, one fourth of the companies are registered neither of the authorities, which would hinder these organizations from participating in tendering of drilling works in WSDP. Even if they show high interest in DDCA's hiring business of drilling equipment, possibility of this group to utilize the equipment in WSDP will remain low unless they register themselves at CRB and MoW to satisfy the eligibility.

[3] The validity of the drilling permit is one year. The companies which updated the permit in 2011 or 2012 were counted as the holders of the valid permits in this analysis.

3.2.2 CLIENTS FOR WATER WELL DRILLING

The major clients for water well drilling for the surveyed companies are individual households (90.4%), followed by private companies (81.9%), government (71.3%), and donor/NGO(57.4%) according to ***Figure 6***. 27 companies have never worked for borehole drilling funded by the government.

For approximately 60% of the companies, the drilling works procured by the government account for less than 40% of the total number of contracts and amount of contract values the company has been awarded (***Figure 7***). Meanwhile, the contractors which have been awarded the contracts in WSDP concentrate in the groups that have more than 60% of sales from the contracts with the government. 12 companies out of 21 contractors for drilling works in RWSSP/WSDP (Phase 1) are categorized into these groups. This situation indicates that the companies which regularly work with the government are in the minority while the rest usually deal with demand of the private sector and individual households.

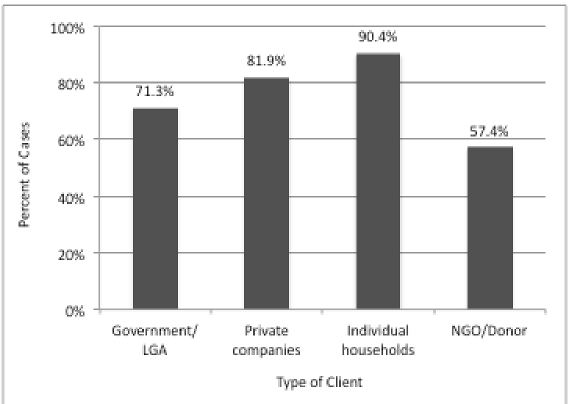
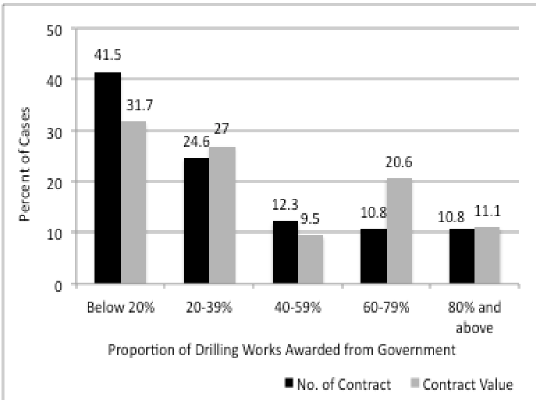


Figure 6 Clients for Water Well Drilling (multiple answers)



Note: No. of valid cases is 65 for the variable of “No. of Contract” and 63 for “Contract Value”.

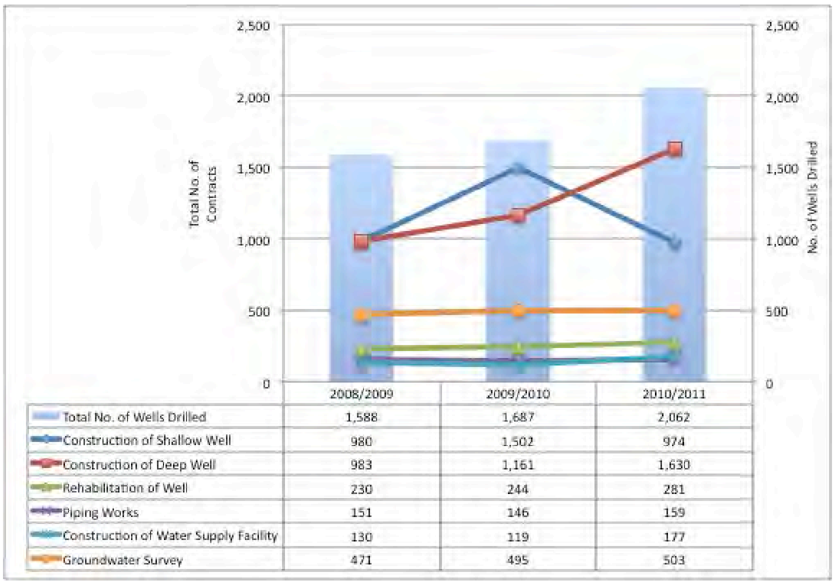
Figure 7 Proportion of Drilling Works Awarded by the Government in Number of Contracts and Contract Values

3.2.3 PERFORMANCE IN THE PAST THREE YEARS

This subsection describes the performance of the companies in drilling works from viewpoints of the number of contracts awarded, number of boreholes drilled, and amount of contract value in the past three years from 2008/2009 to 2010/2011.

(1) Number of Contracts Awarded

In terms of the number of the contracts, the borehole drilling occupies the majority of works awarded to the surveyed companies as a whole. ***Figure 8*** shows an aggregate of number of contracts awarded to the companies for each type of work annually. Information of the graph also includes the grand total of boreholes drilled by the surveyed companies. It indicates that the greater number of the contracts is for drilling of wells, followed by groundwater survey. Works for borehole construction increased steeply in the period while contracts for other works reduce or remained at the same level. As the number of contracts for deep well construction grew, the total of wells drilled also rose accordingly. The increase of the contracts for borehole construction coincides with growth of the numbers of business entities which started the operation of drilling works as well as procurement of contractors for exploratory drilling in RWSSP/WSDP in the same period.



Note: Total number of wells drilled contains both successful and unsuccessful boreholes.

Figure 8 Total Number of Contracts Awarded to and Wells Drilled by the Surveyed Companies in the Past 3 Years

The median of the number of contracts awarded to a company is eight to nine a year in case of drilling of deep wells (***Table 3***). Among 75 companies which provided valid answers on the number of the contracts for drilling of deep wells, approximately 60% (48-54 companies) worked for less than 20 contracts a year (***Figure 9***). Those which had more than 120 contracts a year are contractors which have participated in the drilling works for RWSSP/WSDP (Phase 1).

Table 3 Number of Contracts Awarded in the Past 3 Years per Company

Type of Works	Valid N	Number of Contracts by Fiscal Year					
		2008/09		2009/10		2010/11	
		Mean	Median	Mean	Median	Mean	Median
Construciton of shallow well	23	40.8	2	65.3	2	42.4	6
Construction of deep well	75	13.7	8	15.9	9	21.7	9
Rehabilitation of well	23	10.5	7	11.1	9	12.2	8
Piping works	27	5.8	2	5.4	3	5.9	3
Construction of water supply facility	14	9.3	3.5	8.5	5.5	12.6	7
Groundwater survey	31	15.2	10	16.0	15	16.2	12

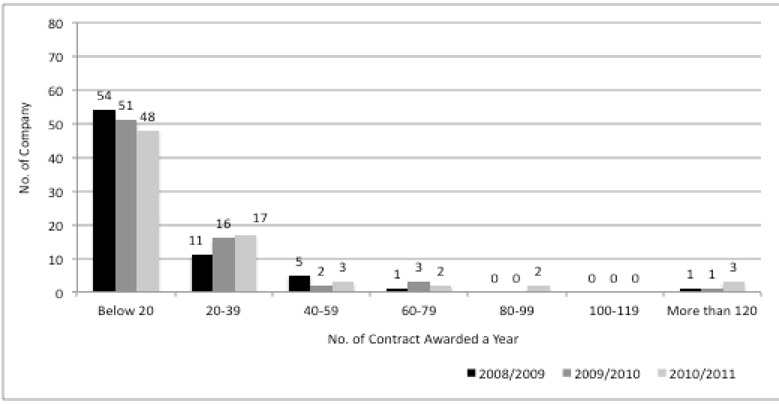
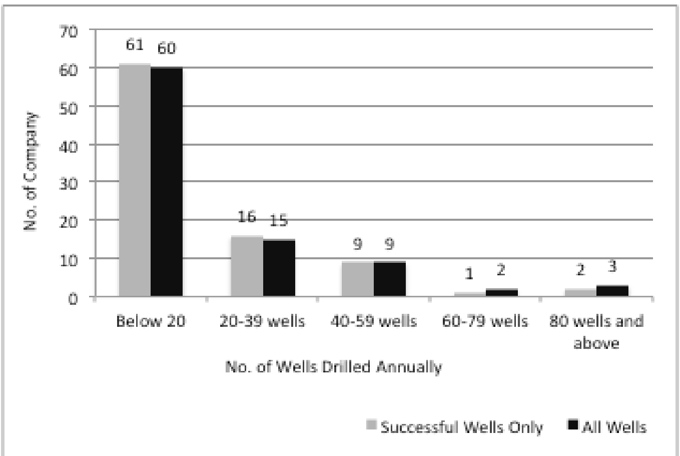


Figure 9 Distribution of Companies by Number of Contracts Awarded for Drilling of Deep Wells per Annum

(2) Number and Type of Wells Drilled

From the valid data obtained from 89 companies, it is estimated that one company drilled 10-13 wells[4] including unsuccessful ones as the median per annum in the period of 2009-2011. Approximately 68% (61 nos.) of the companies drill less than 20 successful wells a year (***Figure 10***). This proportion remains almost same even in case including unsuccessful ones.



Note: The number of valid cases is 89.

Figure 10 Distribution of Companies by Number of Wells Drilled per Annum

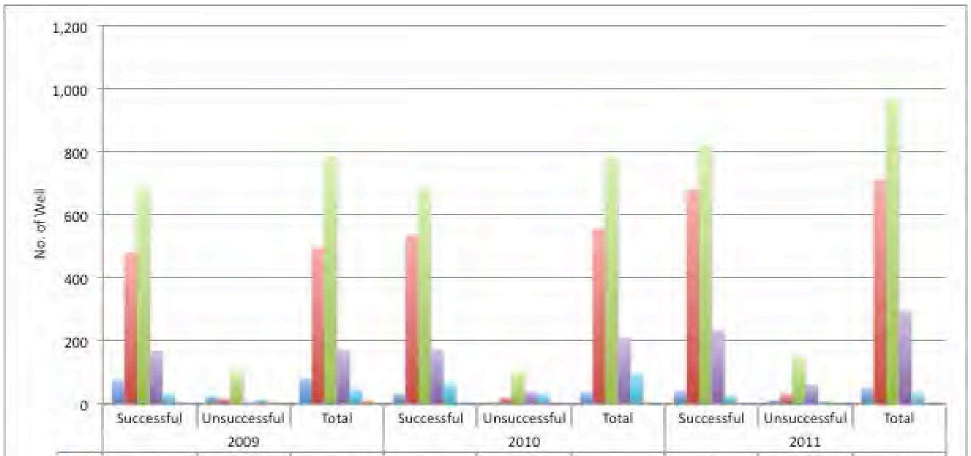
Distribution of these drilled wells was also obtained by type of wells categorized according to use and depth of the well, size of casing pipe, and drilling method as listed in ***Table 4***.

Table 4 Categorization of Well Specifications

Type	Use of Well	Well Depth	Size of Casing Pipe	Drilling Method
1D	Hand pump	30-100m	4" or 5"	DTH
1M	Hand pump	30-100m	4" or 5"	Mud rotary
2D	Medium-scale piped scheme	30-200m	6"	DTH
2M	Medium-scale piped scheme	30-200m	6"	Mud rotary
3D	Large-scale piped scheme	30-200m	8" to 10"	DTH
3M	Large-scale piped scheme	30-200m	8" to 10"	Mud rotary

[4] This number includes the wells drilled with hired equipment. Information could not be obtained from the respondents on the proportion of wells constructed with the drilling equipment owned by the company and those which were drilled with the hired rigs.

The biggest number of wells constructed in the period is Type 2D which is drilled with DTH method and mainly meant for the medium-scale piped water schemes (***Figure 11***). The second largest number is Type 1M constructed with mud rotary drilling method for hand pump water facilities.



	2009 Successful	2009 Unsuccessful	2009 Total	2010 Successful	2010 Unsuccessful	2010 Total	2011 Successful	2011 Unsuccessful	2011 Total
1D	75	25	80	32	4	36	40	11	51
1M	479	16	495	535	21	556	680	32	712
2D	681	105	786	682	101	783	819	150	969
2M	168	3	171	173	37	210	234	61	295
3D	32	13	45	66	32	98	27	8	35
3M	6	5	11	4	0	4	0	0	0

Note: The number of valid cases is 89.

Figure 11 Distribution of Wells Drilled per Annum by All the Surveyed Companies

These water sources constructed in each year vary in depth depending on type of wells. Type 1D and 1M have approximately 90m depth while 2D and 2M are more or less with 100m depth on average. The depth of wells in Type 3D and 3M is in almost same range with those of 2D and 2M. There are no marked changes in the average depth of each type of wells in three years.

The average days required to drill a successful well is five to eight days depending on type of well. Working days involved is relatively smaller in case of use of DTH method, as shown in ***Table 5.*** Type 1D, 2D and 3D, in comparison with the period taken for mud drilling (Type 1M, 2M and 3M). It takes another one or two days in case that pump installation is included in the works.

Table 5 Average Days Required for Drilling Works

Type of Work	No. of Working Days Required per Each Type of Well					
	1D	1M	2D	2M	3D	3M
Drilling a successful well including drilling, development and pumping test	5	6	5	7	7	8
Drilling an unsuccessful well excluding PVC installation, development and pumping test	3	3	2	3	4	4
Pump Installation (hand pump or submersible pump)	2	1	1	1	2	2

Note: The number of valid cases is 93.

Based on information on the type of wells drilled, the proportion of the companies by drilling methods they have experienced is 36.9% with mud rotary drilling only, 35.7% with DTH method only, and 27.4% with both DTH and mud rotary drilling (***Table 6***). This means that approximately 63% of the companies have experience in using DTH drilling method.

With regard to type of water supply facilities, 45.2% of the companies worked for borehole construction for piped schemes only in these three years and 34.5% was involved in drilling works for hand pump water facilities only. The remaining 20.2% has experience of drilling works for both hand pump and piped schemes. From the survey results mentioned above, it is observed that about two third of the companies possess working experience in drilling works with DTH method to construct wells which can be served for the medium-scale piped schemes.

Table 6 Distribution of Companies by Type of Working Experience

Drilling Method	N	%	Valid %
Mud drilling only	31	34.8	36.9
DTH only	30	33.7	35.7
Both DTH and mud drilling	23	25.8	27.4
Total	84	94.4	100
NA	5	5.6	
Total	89	100	

Note: NA (Not applicable: no drilling works were conducted in the period.)

Type of Facility	N	%	Valid %
Piped scheme only	38	42.7	45.2
HP only	29	32.6	34.5
Both HP and piped scheme	17	19.1	20.2
Total	84	94.4	100
NA	5	5.6	
Total	89	100	

(3) Size of a Contract for Deep Well Construction

The drilling works accounts for approximately 80% of the sales of the surveyed companies. Average size of a contract for deep well construction is analyzed in terms of the contract value and number of wells drilled. Valid data was obtained from 59 companies on variables of the number of contract, contract values and number of drilled wells per annum for three successive financial years from 2008/2009 to 2010/2011. The median of a contract value is within a range of Tsh 7million – 8million in these three years, which covers construction of one well (***Table 7***). The number of wells drilled per contract appears small as the major clients for drilling works for the companies are individual households and private sector. In case of the works in WSDP, one contract is made for construction of an average of nine wells.

The contract value awarded by those which have participated in drilling works in WSDP appears relatively larger than the ones without experience in the same programme. The difference becomes much more significant, especially in 2010/2011. With considering that the procurement of contractors for drilling works in RWSSP/WSDP (Phase 1) reached a peak in 2010/2011, the contract value of the companies with experience in WSDP seems to be pushed up by the contracts awarded from the programme. This finding is also supported by the fact that the average value of a contract for drilling works in RWSSP/WSDP (Phase 1) is approximately Tsh20million per well, which was obtained from calculation of actual contract prices of the works conducted by all the 23 contractors involved in the programme, as explained in Section 3.1.3. The drilling works in WSDP provide the contractors with opportunities to have larger size of the contract in terms of its value and the number of boreholes required than those of clients in the private sector.

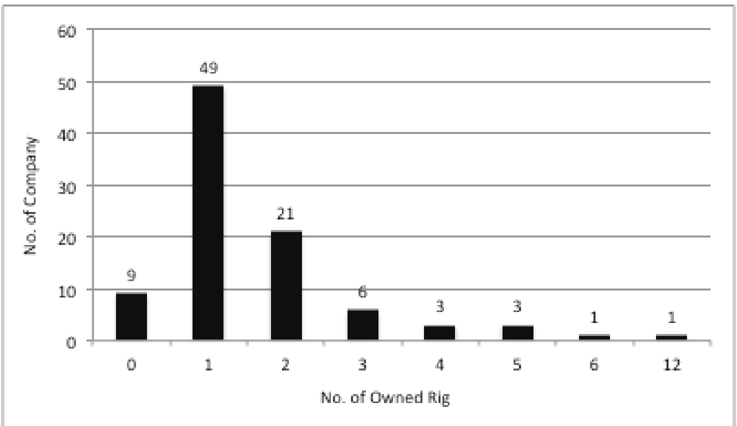
Table 7 Contract Value and Number of Wells Drilled per Contract

Category of Company		Contract Value (Tsh)			No. of Wells Drilled		
		2008/09	2009/10	2010/11	2008/09	2009/10	2010/11
Whole Cases (N=59)	Mean	21,978,884.91	18,105,406.38	19,030,230.28	1.91	3.56	2.75
	Median	7,000,000.00	8,000,000.00	7,729,312.50	1.00	1.00	1.00
Has experience in WSDP (N=13)	Mean	42,495,047.87	50,896,878.47	56,275,838.09	3.72	4.19	3.50
	Median	8,650,000.00	11,834,734.85	14,935,483.87	1.00	1.00	1.00
No experience in WSDP (N=46)	Mean	16,180,838.85	8,838,251.22	8,504,297.64	1.40	3.38	2.54
	Median	6,733,333.33	6,000,000.00	6,333,333.33	1.00	1.00	1.00

3.2.4 POSSESSION OF EQUIPMENT

(1) Drilling Equipment

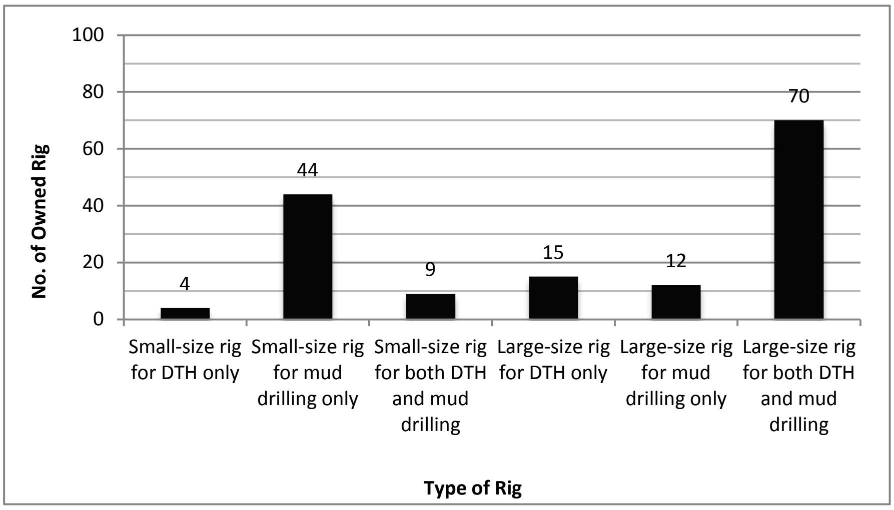
The number of drilling rig owned by a company is one on average. ***Figure 12*** indicates that the capacity of the private companies is relatively small in terms of possession of drilling rigs as 75% of the companies have only one or two sets of the machinery. There is only one entity which owns more than 10 rigs although it is far below the number of drilling equipment that DDCA possesses. Meanwhile, nine organizations have no rigs at all. They hire drilling equipment from others or contract out the whole scope of drilling works to specialized companies.



Note: The number of valid cases is 93.

Figure 12 Distribution of Companies by Number of Rigs Owned

The survey found a total of 156 drilling rigs owned by 84 companies among the surveyed. As a result of categorization of these rigs by capacities, 45.5% (70 nos.) is classified into the large-size rig which can perform both DTH and mud rotary drilling methods (***Figure 13***). The second largest proportion is the small-size rig for mud drilling only with 28.6% (44 nos.). The definition of large-size rig refers to the one that has capacities to drill up to maximum 150m depth and 12-inch diameter.



Note: The number of valid cases is 154. For the remaining 2 rigs, there is no information which can be used to identify specifications and capacity of the equipment.

Figure 13 Distribution of Owned Rigs by Drilling Capacity

Further analysis in ***Figure 14*** shows distribution of companies by the number of owned rig according to the capacities. The proportion of companies which owns more than two units of large-size rigs for both DTH and mud rotary drilling accounts for less than 20% (15 nos.) of the surveyed companies.

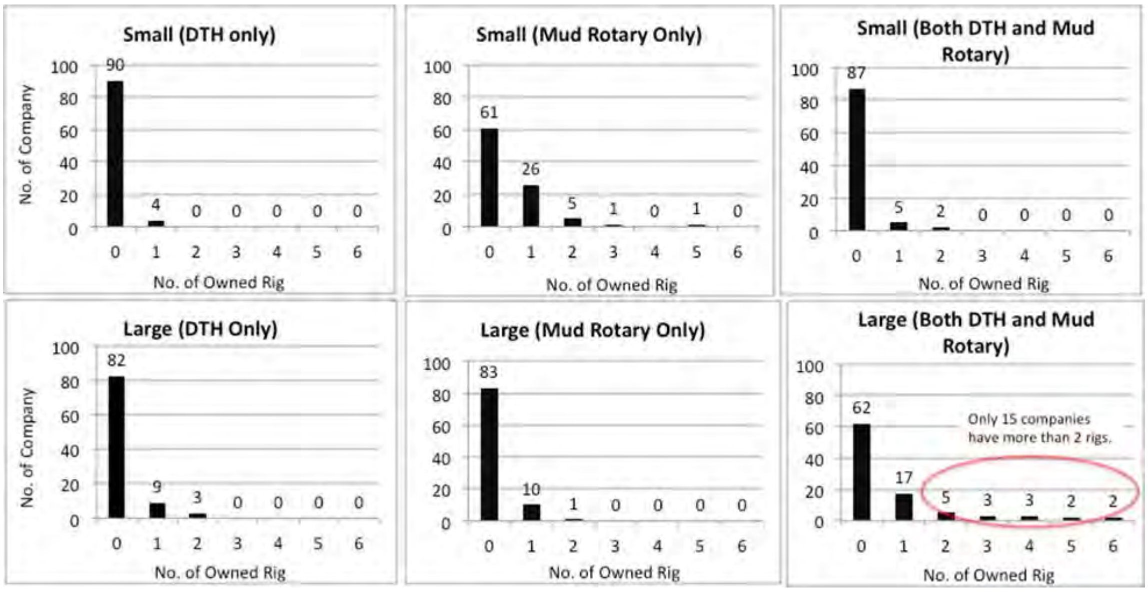


Figure 14 Distribution of Companies by Number of Owned Rigs in Each Type

In order to supplement shortage of the required number of rigs for particular works, 51% of the companies have ever hired drilling rigs from other business entities. This includes 13 companies which have used rigs owned by DDCA. There are more than 30 entities listed as the lender of the rigs. Almost all of these lenders operate drilling works as their business and hire out the equipment to others when it is available.

The cost for hired equipment is mainly charged either by meter or well. ***Table 8*** shows the median of the hiring costs which were actually charged to the respondents. The figures are compared between the small-size drilling rigs which are mostly dominated with PAT model and other types of equipment. The medina of the hiring cost is Tsh 80,000 per meter and Tsh 2million per well for all types of the equipment. The hiring cost for PAT is cheaper than large-size equipment.

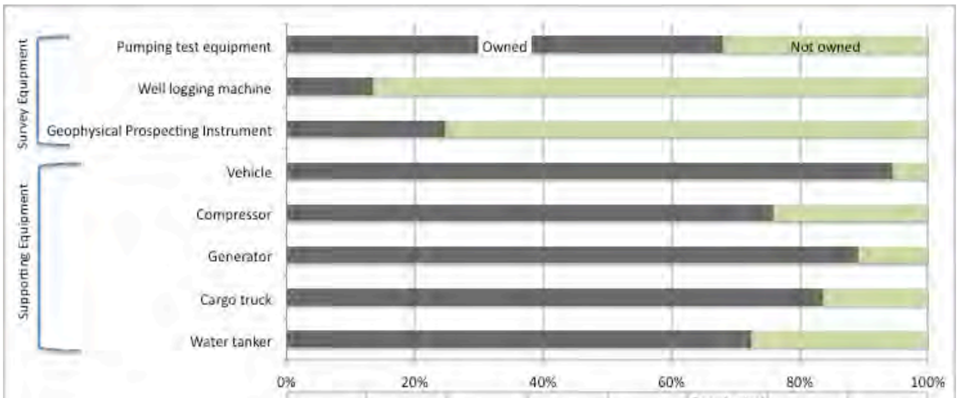
Table 8 Hiring Cost of Drilling Equipment

Charging Method	Type of Rig	N	Median of Hiring Cost (Tsh)
per meter	Small-size (PAT)	6	50,000
	Large-size (Excluding PAT)	19	110,000
	All types	25	80,000
per well	Small-size (PAT)	20	1,500,000
	Large-size (Excluding PAT)	18	6,000,000
	All types	38	2,000,000

(2) Supporting and Survey Equipment

More than 60% of the companies own each type of supporting equipment consisting of water tanker, cargo truck, generator, compressor and vehicle (***Figure 15***). An average of one or two units of each type of the equipment is available in an entity. Meanwhile, the companies which have survey equipment are in small number except for the pumping test unit.

In case that the supporting equipment is not available at the company, the majority utilizes hiring service of those items. In contrast, the proportion of sub-contract becomes larger than use of the hired equipment in case of pumping test unit, well logging machine and geophysical prospecting instrument.



	Water tanker	Cargo truck	Generator	Compressor	Vehicle	Geophysical Prospecting Instrument	Well logging machine	Pumping test equipment
Owned	66	77	82	69	88	23	12	64
Not owned	25	15	10	22	5	70	77	30

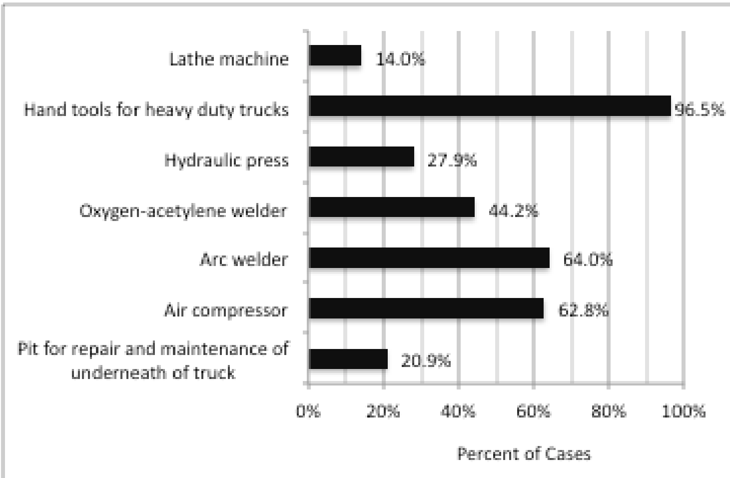
Note: Figures in the table above indicate number of companies while the graph shows its proportion.

Figure 15 Possession of Supporting and Survey Equipment

(3) Maintenance of Drilling Equipment

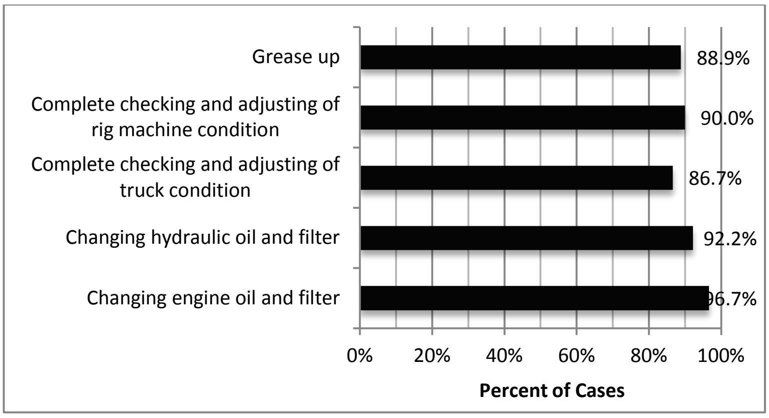
The majority of the companies attend the maintenance of the owned drilling equipment either at their workshops or on site. Only eight companies do not have workshop facilities with them while the rest installs equipment and tools as listed in ***Figure 16***.

With regard to the type and level of routine maintenance of the owned rigs, more than 80% of the companies assess that they can attend all necessary works such as greasing up, checking and adjusting of condition of rigs and trucks, and changing hydraulic oil, engine oil and filters (***Figure 17***).



Note: The number of valid cases is 86.

Figure 16 Workshop Equipment and Tools Owned (multiple options)



Note: The number of valid cases is 90.

Figure 17 Type and Level of Periodical Maintenance of Drilling Equipment the Company can Perform (multiple options)

3.2.5 HUMAN RESOURCES

(1) Staffing

The median number of the staff in one company is 15 in total including non-regular workers. The largest proportion of the companies has 10-19 employees followed by those with below 10 members (***Figure 18)***. These groups account for 70% of the surveyed companies.

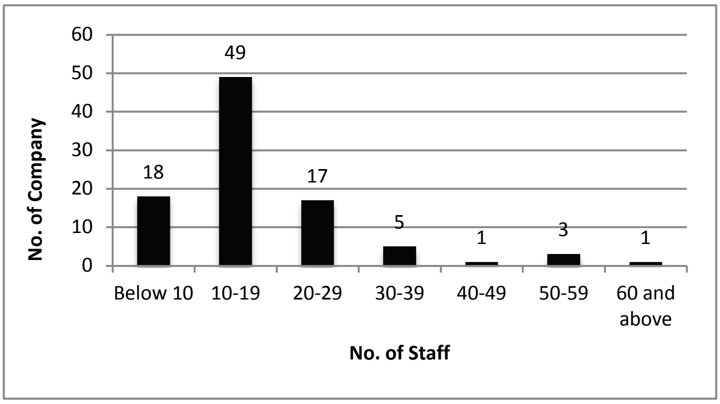


Figure 18 Distribution of Companies by Size of Staff

Drilling staff employed in an entity consists of one drilling supervisor, one driller (rig in charge), one assistant driller, and two workers on average. More than 60% of the companies also have staff in expertise as the engineer or hydrogeologist.

It is observed that the management staff serves as an engineer, hydrogeologist or drilling supervisor in several organizations as they have limited number of human resources. Staff at other position also makes similar arrangement to supplement shortage in staffing.

(2) Working Experience and Qualification of Technical Staff

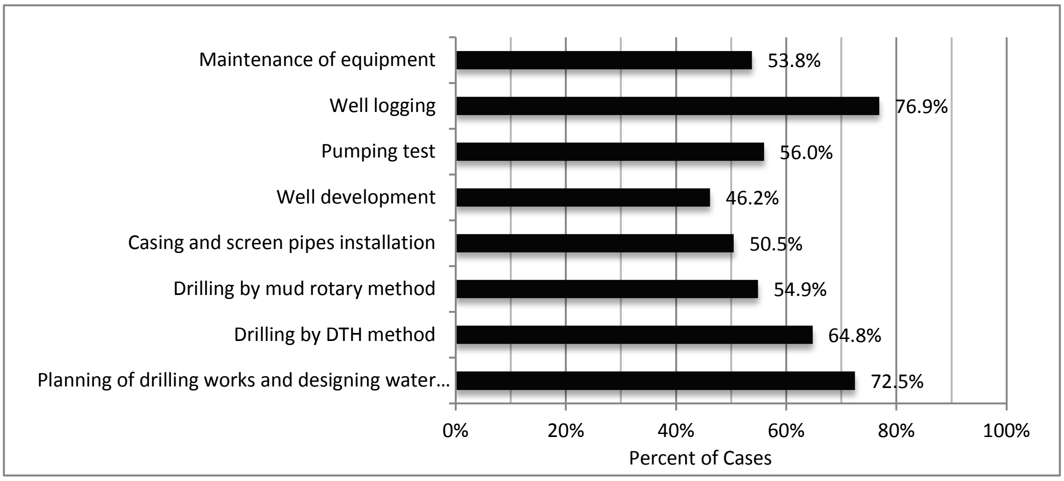
As to working experience of these staff members, the management has the longest period of experience in the drilling industry. The average period of their working experience is 14 years, followed by the engineer, hydrogeologist, drilling supervisor, and driller with 10-12 year career on average. Other employees such as assistant drillers, drilling workers (helpers and assistant technicians), mechanics, welders and plumber have been in the drilling industry for an average of five to eight years.

The majority of the engineers possess bachelor degrees, whereas most of the hydrogeologists and the drilling supervisors possess diplomas. The drillers (rig in charge) and assistant drillers are holding Form IV certificates, whereas the drilling workers are STD VII leavers. STD VII certificate holders are the majority of the workers in the surveyed drilling companies followed by the Form IV certificate holders. It is observed that the proprietors of the drilling companies call some of their staff engineers or hydrogeologist while they only possess FTC, Form VI, Form IV or Basic Certificates which are not qualified for those positions.

(3) Capacity Development of Technical Staff

Of all the companies surveyed, the respondents at 91 entities expressed capacity development needs of their technical staff. The highest proportion of the companies see necessity of strengthening of knowledge and skills of the staff on well logging (76.9%), followed by planning of drilling works and designing of water wells (72.5%), drilling by DTH method (64.8%) as shown in ***Figure 19***. Approximately 30% (29 nos.) of the respondents chose all the areas listed in the same graph as their needs for capacity development of the technical staff.

Only two organizations answered that they did not require capacity development of the technical staff as they have enough skills necessary for drilling works. One of them is a private drilling company which had the largest share in the contracts for drilling works in RWSSP/WSDP (Phase 1) and the other is a charitable organization providing support for water supply projects.

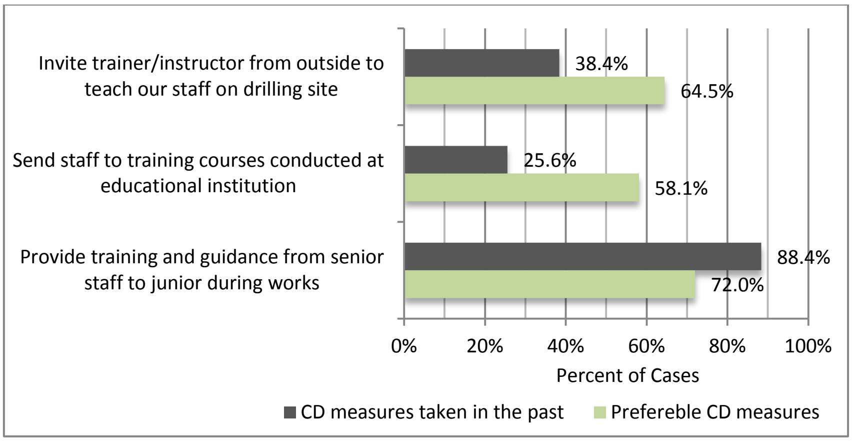


Note: The number of valid cases is 91. Another one case is no answer and two cases are not applicable as the respondents do not see necessity of capacity development of their technical staff.

Figure 19 Areas of Capacity Development Needs of Technical Staff (multiple options)

Aiming at the human resources development of their staff, 89 companies have conducted some forms of the training or sent the selected staff to educational institutions. ***Figure 20*** shows type of capacity development activities the companies have ever employed as well as their preferable measures for the same. Provision of On the Job Training (OJT) from senior staff was most widely practiced among the companies (88.4%). Less than 40% of the companies have also organized training on drilling site by trainers invited from outside and/or sent the staff to educational institutions in contrast to relatively high preference to these measures.

In most cases, the company bore the costs for these capacity development measures. There are only three cases that the staff member paid the cost. It is observed that the companies show tendency to rely on utilizing the experienced personnel in their organizations for capacity development of other staff rather than employing other measures which incur monetary burden.



Note:

1. The number of valid cases for the variable "CD measures taken in the past" is 86. The remaining eight cases are not applicable as the companies have never conducted capacity development for their technical staff.
2. The number of valid cases for the variable "Preferable CD measures" is 93. Another one case has no answer.

Figure 20 Capacity Development Measures (multiple options)

3.2.6 Interest in Business Opportunities

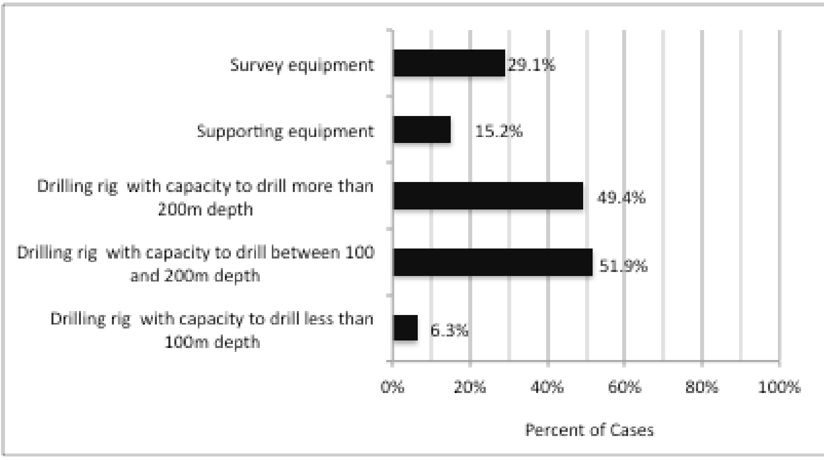
As mentioned earlier, 16 companies among the surveyed have worked as the contractors for drilling works in 10-village subprojects in RWSSP/WSDP (Phase 1). The interviewed companies including the contractors which already had experience in the programme expressed high interest in participating in drilling works in WSDP. Almost all the companies (93 nos.) showed their interest in the programme. The remaining one is a charitable organization which does not operate the drilling works at commercial basis.

78.7% (74 nos.) perceives that there are some obstacles to participate or expand business opportunities in drilling works in WSDP while the rest does not see any such difficulties. Of those obstacles raised by the respondents, the biggest proportion of opinions goes to concern on high requirements in procurement rules for drilling works in WSDP (43.2%). Delay in payment of the contract amount is also pointed out as one of the obstacles. Except for these difficulties related to the implementation procedures of the programme, 36.5% expressed hardships to source sufficient investment fund for the business operation as part of problems in the organizations. The companies which have worked or are working in WSDP also pointed out difficulty in hydrogeological conditions of project areas more frequently than the group without experience in the programme.

3.2.7 Investment for New Drilling Rigs

Nearly three third of the companies only rely on personal funds of proprietors when new investment is required in their business. One third also borrows money from friends, relatives and/or banks.

For those which consider new investment for the drilling equipment, demand for large-size rigs is especially high. 79 companies answered that they had investment plans to purchase new drilling equipment. This number includes the entities which have experience in drilling works in WSDP. The highest demand goes to a drilling rig with capacity to drill 100-200m depth, followed by a rig with drilling capacity of more than 200m depth (***Figure 21***).



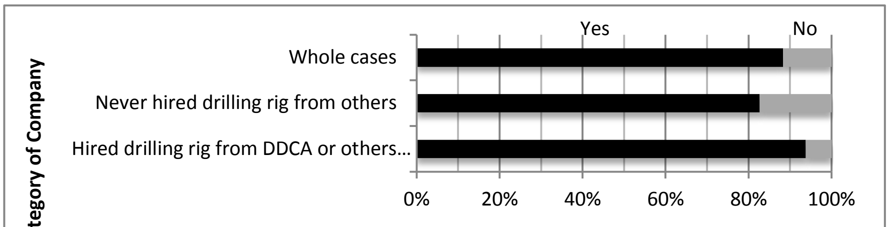
Note: The number of valid cases is 79. Another 11 are not applicable as they do not have any investment plan for new equipment and four have no answer.

Figure 21 Needs of Procurement of New Drilling Equipment (multiple options)

3.2.8 DEMAND FOR TECHNICAL SUPPORT SERVICES OF DDCA

(1) Hiring Service of Drilling Equipment

Of 94 companies interviewed, 88% (83 nos.) showed interest in using the hiring service of drilling equipment from DDCA. These companies expect increase of contracts to be awarded in WSDP (85.5%), acquisition of eligibility to participate in tendering in the same programme (62.7%), and reduction of investment costs for the equipment (47.0%) as major benefits from using drilling rigs hired by DDCA. High expectation to expand business opportunities in drilling works in WSDP is observed on both the companies which already have experience in the programme and those which are interest to participate newly. Regardless of possession of past experience in using hired drilling equipment, needs for DDCA's hiring service is high as shown in ***Figure 22***.

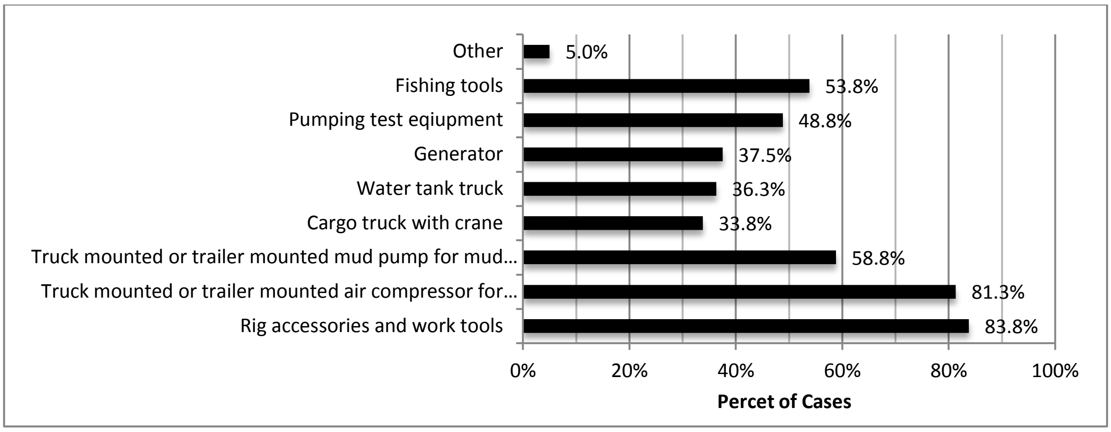


	Hired drilling rig from DDCA or others before	Never hired drilling rig from others	Whole cases
■ Yes	45	38	83
■ No	3	8	11

Note: Figures in the table indicates the number of companies while the graph shows its percentage distribution.

Figure 22 Demand for DDCA's Hiring Service of Drilling Equipment

As to options of the hiring service, these companies much prefer to have hired rigs accompanied with technical staff from DDCA (81.5%) rather than use the equipment only (25.9%). The survey results also shows high demand of the companies to hire truck/ trailer mounted air compressor for DTH drilling as well as rig accessories and work tools (***Figure 23***) together with the drilling machine. Fishing tools, pumping test equipment and mud pump are also selected by half proportion of the companies as items which they would like to hire from DDCA according to their necessity. Meanwhile, generator, water tanker or cargo truck are not in acute needs compared with other supporting equipment. It seems to be due to wide availability of these items for hiring in the market.



Note:

1. The number of valid cases is 80. Another three cases have no answer and 11 cases are not applicable as they are not interested in the hiring service.
2. "Other" includes a flow meter, logging machine, and survey equipment.

Figure 23 Demand for Hiring Supporting Equipment (multiple options)

11 companies which did not show interest in hiring the equipment explained the reasons that they have enough number of drilling rigs. The number of rigs owned by these companies varies from one to six, which implicates that they do not intend to scale up their drilling works by hiring equipment from others.

(2) Other Forms of Technical Support Services

The surveyed companies also showed high demand for other forms of the technical support services of DDCA. Such services refer to technical advice for drilling works on site from the staff of DDCA and provision of hydrogeological information on project areas where DDCA drilled wells in the past. The percentage of the companies expressing their interest in these services is 95.7% (90 nos.), bigger than demand for the hired equipment. Especially, all of these 90 companies expect to access to hydrogeological information kept at DDCA while the number of companies which are interested in receiving technical advice is counted 65 in total (***Figure 24***). 92.5% of the companies are willing to pay for the technical support services to be provided by DDCA.

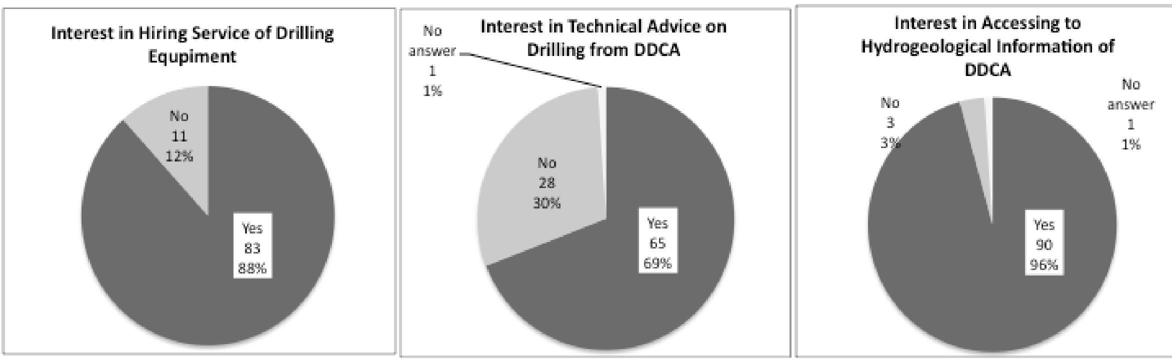
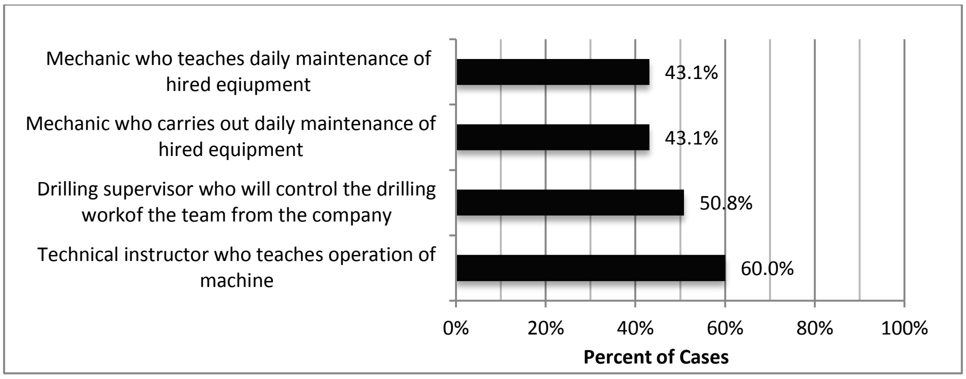


Figure 24 Distribution of Companies by Demand for Different Types of Technical Support Services by DDCA

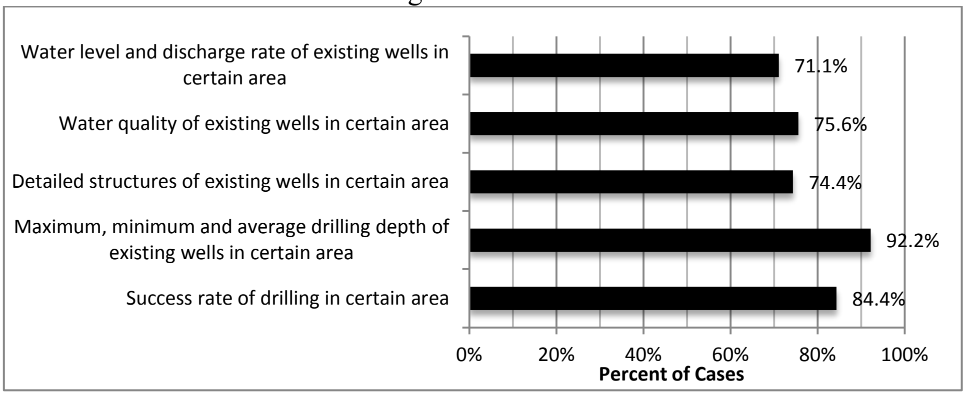
With regard to the technical advice, skilled and experienced instructors are mostly needed by the companies, followed by drilling supervisor who will control drilling works to be conducted by the team from the lessee (***Figure 25***). Some companies also raised necessity of mechanics who will conduct daily maintenance of hired equipment and/or teach the lessee on required maintenance procedures.



Note: The number of valid cases is 65. Another one case has no answer and 28 cases are not applicable as they do not require technical advice from DDCA's staff.

Figure 25 Type of Technical Staff Required for Technical Instruction (multiple options)

As to access to the hydrogeological information kept by DDCA, the respondents are mostly interested in drilling depth of existing wells and success rate of drilling in the areas where they are going to work (***Figure 26***). Other types of information such as discharge rate, water quality and detailed structure of wells are also with high demand.



Note: The number of valid cases is 90. Another one case has no answer and three cases are not applicable as they are not interested in accessing to hydrogeological information at DDCA.

Figure 26 Contents of Hydrogeological Information Required (multiple options)

The survey revealed high demand of the private companies for hiring service of drilling equipment as wells as other forms of technical support services of DDCA. 63.8% (60 nos.) of the surveyed companies have also experience in use of such services provided by DDCA in the past although DDCA had not developed procedures for service provision in formal manner. In most cases, these companies requested DDCA for hydrogeological information and/or technical advice for drilling works while 13 companies have hired drilling rigs from DDCA. Conclusion is drawn from these facts that provision of technical support services by DDCA is not quite new in the drilling industry in Tanzania. Rather, private companies have been keeping expectation that DDCA should play such roles to support strengthening of capacities of the private sector.

3.3 CLASSIFICATION OF THE PRIVATE DRILLING COMPANIES

(1) Criteria for Classification

The technical support services to be provided by DDCA consists of i) hiring of drilling equipment, ii) technical instructions on drilling works on site, and iii) hydrogeological information. Two main criteria listed below are applied to classify the private drilling companies according to their interest in the technical support services as well as current capacities in terms of experience of DTH drilling and possession of equipment to respond to demand for drilling works in WSDP, so as to estimate the number of potential clients with different needs.

1) The company has experience of DTH drilling with a large rotary rig.
2) The company is interested in DDCA's equipment hiring service.

The reasons of selection of above criteria are described below:

1) Experience of DTH Drilling with Large Rotary Rig

In order to obtain business opportunities for drilling works in WSDP, the private drilling companies need to posssess drilling equipment and techniques which correspond to specifications of boreholes required in the program. According to the results of drilling works in the first phase of RWSS component of WSDP, the maximum drilling depth is 114m and the minimum is 78m in minimum on average. Diameter of casing and screen pipes is not less than 150mm in 97% of drilled boreholes[5]. Furthermore, almost of all the project areas of WSDP are with hard rock formation which requires employment of DTH method for drilling.

Contractors for drilling works in WSDP are, therefore, required experience in DTH drilling with large rotary rigs[6]. The companies which fulfill this condition are regarded to be capable of drilling works under WSDP in respects of both equipment and techniques.

2) Interest in DDCA's Eqiupment Hiring Service

The second criterion is set set to identify companies which are interested to hire drilling equipment from DDCA which is the major component of the technical support services by the Agency. A sub-criterion is also considered if the companies are interest in other forms of the technical support services such as technical advice on drilling works and hydrogeological information in case that they do not consider to hire equipment from DDCA. Application of these criteria enables DDCA to further segment the private companies according to their interest in the hiring service and/or other forms of the technical support.

(2) Distribution and Characteristics of the Companies Classified

With applying the above criteria, 94 private drilling companies interviewed in the baseline survey were classified into five groups as shown in ***Table 9***. It is evaluated that 83 companies which belong to Group A and B are the main target to promote the hiring service combined with the tecnnical instructions on site. While Group C and D are currently not showing interest in the hiring service, DDCA will keep the companies in these groups informed on available services for the equipment hiring for their future demand. The characteristics of companies which belong to each group are described below.

---

[5] Calculated from Water Sector MIS and records of Rural Water Supply Division of MoW.

[6] The definition of large rotary rig here refers to the one that has capacities to drill up to maximum 150m depth and 12-inch diameter with both DTH and mud drilling methods.

Table 9 Classification of Private Drilling Companies

Group	Number of Company	Experience of DTH Drilling with Large Rotary Rig	Interest in DDCA's Service	
			Equipment Hiring Service	Technical Advice and/or Hydrogeological Information
A	23	23	17	22
B	60	0	60	58
C	3	3	0	3
D	7	0	0	7
E	1	1	0	0
Total	94	37	83	90

1) Group A

23 companies consisting Group A have experience of DTH drilling with large rotary rigs and are interested in hiring drilling equipment from DDCA. 22 of them are also interest to receive technical advice from and/or access to hydrogeological information at DDCA. Companies of this group have drilling techniques to correspond to drilling works under WSDP. It is supported by the fact that 11 companies in this group have participated in drilling works in WSDP.

As 17 companies of this group have a purchase plan of large drilling rigs, they seem to have an intention to expand their business opportunities in drilling works. The hiring service would provide an advantage to these companies to save investment costs to purchase new rigs.

2) Group B

Group B contains 60 companies, the largest group among five. While this group has no experience of DTH drilling with a large rotary rig, they are interested in hiring drilling equipment from DDCA. Although some of them possess large rotary rigs, they have only used mud rotary drilling method. Others have experience to perform DTH drilling with rigs with small capacity.

52 companies have a purchase plan of drilling rig capable to drill not less than 100m in depth. 58 companies also expressed their interest in technical support services. This proves that they are highly motivated for the capacity development in drilling techniques to gain business opportunities by acquiring skills and knowledge on operation of large rotary rigs to perform DTH drilling which can respond to requirements in WSDP. Currently, only three companies have provided drilling works in WSDP in this group.

3) Group C

The companies in Group C have experience of DTH drilling with large rotary rigs. They are not interested in equipment hiring but willing to use other forms of technical support services of DDCA such as provision of technical instructions on site and hydrogeological information. One company of three in this group has experiences of drilling works under WSDP.

4) Group D

Seven companies consisting Group D have neither experience of DTH drilling with large rotary rigs nor interest in hiring drilling machine from DDCA. However, they are interested in other forms of the technical support services. DDCA can provide technical instructions and/or hydrogeological information according to needs of each company of this group.

5) Group E

Group E is an exceptional case among 94 companies surveyed. It has experience in DTH drilling with large rotary rigs and is not interested in neither hiring of equipment nor accessing to other forms of the technical support of DDCA. Only one company is categorized into this group. The company operates drilling works exclusively for boreholes with large diameter meant for urban water supply. As it is observed that their needs for equipment and drilling techniques are currently satisfied, this group is excluded from the target of the technical support services.

4. SCOPE OF SERVICES TO BE PROVIDED BY DDCA IN THE HIRING BUSINESS

4.1 CONDITIONS CONSIDERED IN FORMULATION OF THE BUSINESS MODEL

MoW has a plan to procure a total of 20 drilling rigs for DDCA in WSDP. However, the ministry has not yet concluded a procurement plan of the remaining number of the drilling equipment. The business model is, therefore, formulated to operate the hiring service with six drilling rigs and supporting equipment which are under procurement in the first phase of WSDP.

4.2 ITEMS TO BE HIRED

Table 10 shows items to be made available for hiring to the private companies. Hirers will choose items necessary to execute contracts with their clients. In case that the hirer needs other equipment which is not listed below, he will procure it in the market or borrow it from DDCA, if available, at cost.

Table 10 List of Equipment to be Hired

Item	Specification	Qty	Remarks
1. Truck mounted drilling rig	Rotary cum DTH, max. depth 150m	6 units	
2. Trailer mounted air compressor	650CFM, 246 psi	5 units	Optional
3. Trailer mounted mud pump	20kg/cm^2, 600 l/min.	5 units	Optional
4. Trailer monted pumping test unit	Generator, riser pipe, submersible pump	5 units	Optional
5. Rig accessories		6 sets	
6. Casing tools		6 sets	
7. Fishing tools	Tap, jack, etc.	6 sets	Optional
8. Direct mud circulation drilling tools & accessories		6 sets	

Rig accessories, casing tools, and direct mud circulation drilling tools and accessories contain i) items which are permanently provided with the drilling rigs and ii) consumables which use is optional for the hirer. Details of the items in each category are shown in ***Table 11***. Maintenance costs need to be considered for those which are equipped with drilling rigs permanently. Meanwhile, the hirer will choose if he uses stocks of consumables kept by DDCA at cost or the ones owned by the hirer.

Table 11 List of Rig Accessories, Casing Tools and Direct Mud Circulation Drilling Tools

No.	Description	Equiped with Rig	Consumable
Rig Accessories			
1	Drill pipes 41/2" 0.D flush type with API 31 1/2"IF BOX and pin joints furnished with wrech squares and steel made protectors,6m long/pc		x
2	Drilling collars 5"0.D,2"IF BOX and pin joints,furnished with wretch squares and steel protectors,6m long/pc	x	
3	Hoisting swivel API 1/2" IF Pin joint	x	
4	Hoisting plug API 1/2" IF Pin joint	x	
5	Drill pipes collar hanger	x	
6	Cross over sub API 3 1/2 IF BOX and pin	x	
7	DTH Hammer assembly for 6 1/4"(150mm) hole drilling API 3 1/2 Regular pin and 8" to 10" hole drillling		x
8	DTH Hammer assembly for 12"(300mm) hole drilling API 3 1/2 Regular pin		x
9	DTH Button Bit for 12"(300mm) hole drilling	x	
10	Bit sub for drill pipes/collar to 6 1/4" DTH Hammer API 3 1/2" Regular box and API 3 1/2" IF Box joint	x	
11	Bit sub for drill pipes/collar to 6 1/4" DTH Hammer API 3 1/2" Regular box and API 3 1/2" IF Box joint	x	
12	DTH Button bit for 6 1/4"(159mm) hole drilling		x
13	DTH Button bit for 8 1/4"(216mm) hole drilling		x
14	DTH Button bit for 10"(254mm) hole drilling		x
16	Bit grindeer for button bit and body dressing,furnished with 15 m long high pressure air hose	x	
17	Tricone roller bits 6 1/2" dia		x
18	Tricone roller bits 8 1/2" dia		x
19	Tricone roller bits 10 1/2" dia		x
20	Tricone roller bits 12 1/2" dia		x
21	Roller bits 8 1/2" dia		x
22	Roller bits 10 1/2" dia		x
23	Roller bits 12 1/2" dia		x
24	Roller bits 14 1/2" dia		x
25	Drag bits three winged 8 1/2" dia		x
26	Drag bits three winged 10 1/2" dia		x
27	Drag bits three winged 12 1/2" dia		x
28	Drag bits three winged 16 1/2" dia	x	
29	Roller bit 16" dia for soft formation	x	
30	Stabilizer for 6 1/4" hole body dia,1.5m long API 3 1/2 IF BOX and pin joints furnished with wretch squares and steel made thread protectors on both ends		x
31	Stabilizer for 8 1/2" hole 5" body dia,1.5m long API 3 1/2 IF BOX and pin joints furnished with wretch squares and steel made thread protectors on both ends		x
32	Stabilizer for 10" hole 5" body dia,1.5 long API 3 1/2 IF BOX and pin joints furnished with wretch squares and steel made thread protectors on both ends	x	
33	Stabilizer for 12" hole 5" body dia,1.5m long API 3 1/2 IF BOX and pin joints furnished with wretch squares and steel made thread protectors on both ends	x	
Casing Tools			
1	a) Casing lamp with bolts,nuts,wrench and sling wire for 4" PVC casing ,3 pairs/sets	x	
2	b) Casing lamp with bolts,nuts,wrench and sling wire for 6" PVC casing ,3 pairs/sets	x	
3	c) Casing lamp with bolts,nuts,wrench and sling wire for 8" PVC casing ,3 pairs/sets	x	
4	d) Casing lamp with bolts,nuts,wrench and sling wire for 10" PVC casing ,3 pairs/sets	x	
5	e) Casing lamp with bolts,nuts,wrench and sling wire for 12" PVC casing ,3 pairs/sets	x	

No.	Description	Equiped with Rig	Consumable
6	f) Casing head for 8" casing	x	
7	g) Casing head for 10" casing	x	
8	h) Casing head for 12" casing	x	
9	i) Casing shoe for 8" casing		x
10	j) Casing shoe for 10" casing		x
11	k) Casing shoe for 12" casing		x
12	l) Casing sub , API 3 1/2 IF BOX to 8 " casing	x	
13	m) Casing sub , API 3 1/2 IF BOX to 10 " casing	x	
14	n) Casing sub , API 3 1/2 IF BOX to 12 " casing	x	
15	o) Casing hoist plug with sling wire for 8" casing	x	
16	p) Casing hoist plug with sling wire for 10" casing	x	
17	q) Casing hoist plug with sling wire for 12" casing	x	
Direct Mud Circulation Drilling Tools & Accessories			
1	Mud testing kit including mud balance ,marsh funnel,viscocity meter with measuring cup sand content kit,stop watch and thermometer		
2	Collapsible water tank with housing bag 3000 Litre capacity	x	
3	Portable water level indicator,dry battery operated type,measuring capacity of 200m	x	

4.3 PLACEMENT OF DRILLING RIGS

Taking into account of convenience of hirers to access to the equipment, DDCA will decide allocation of the drilling rigs and compressors to be newly procured among its headquarter and zonal offices. The column chart in ***Figure 27*** shows the number of private drilling companies interviewed in the baseline survey according to their office locations and project areas where they have worked in the past. The regions are grouped into five zones based on jurisdiction of DDCA's zonal offices. The private companies classified in Group A and B mostly concentrate in Dar es Salaam while around 20 companies operate from Northern part of the country such as Arusha, Mwanza and Shinyanga.

Figure 27 also indicates the rural water supply coverage as of 2011. From the viewpoint of demand for improved water supply, regions which water supply coverage is below the national average are Tabora, Singida, and Dodoma in the central part of the country, Shinyanga, Mara, and Kagera in Lake zone, Rukwa in western zone, and Lindi and Mtwara in eastern zone.

Based on these points, rigs will be allocated depending on the demand for drilling works to the specific time. It also needs to consider capacities of each zonal office in conducting maintenance and repair works of the equipment.

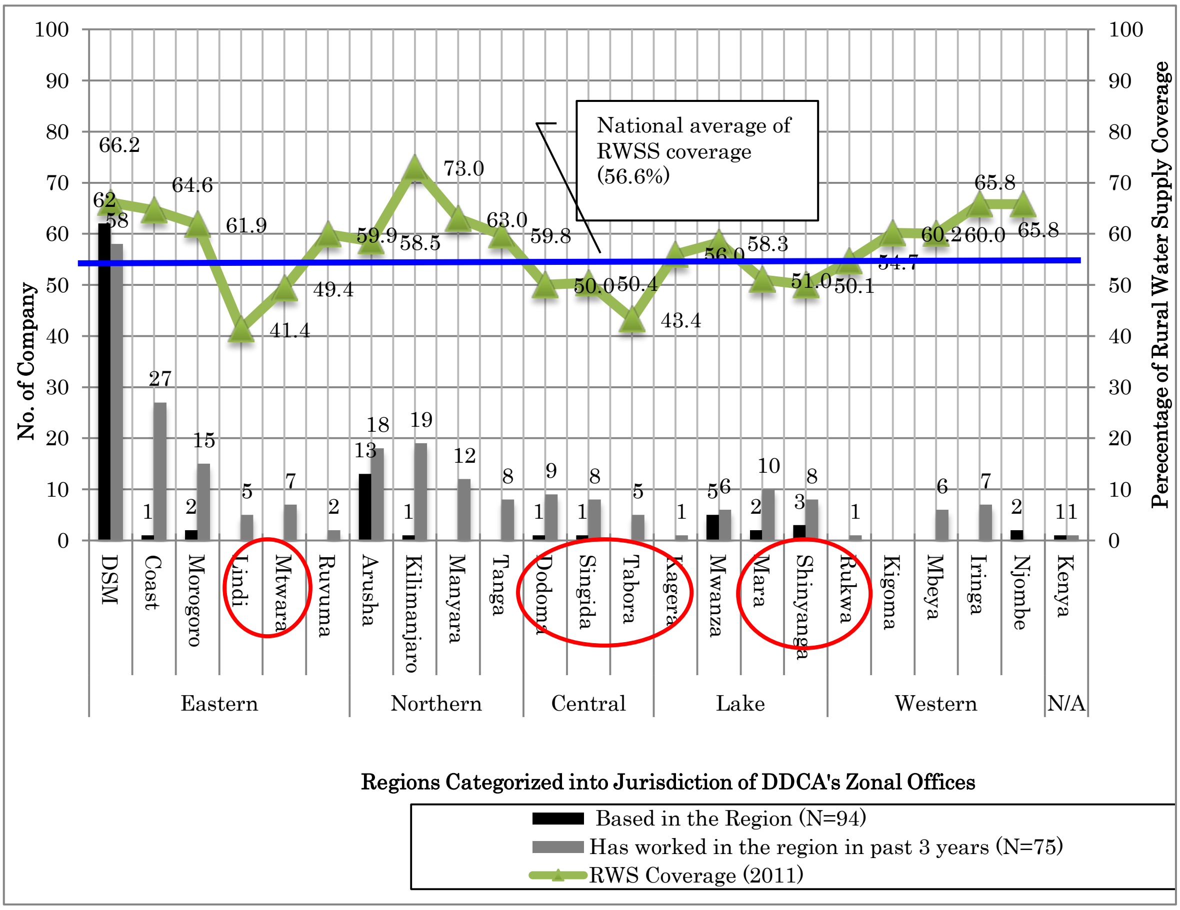


Figure 27 Geographical Distribution of Private Drilling Companies and Rural Water Supply Coverage by Regions

4.4 ALLOCATION OF DRILLING STAFF

DDCA will attach the following staff to the hired equipment (***Table 12***). At least one technical instructor and driver are required for hiring of one set of the drilling rig. The purpose of allocation of these personnel is firstly to ensure liability of operation of the government-owned vehicles and machinery. The government prohibits driving of vehicles registered under the government by personnel from the private sector. Secondly, it is meant for provision of technical instructions to the drilling staff from the hirers on site. It is of cardinal importance that DDCA operationalizes the technical instructions as an integral component in the hiring service in order to support capacity development of the private sector.

Table 12 Roles of DDCA Staff to be Attached to the Hired Equipment

Position	Responsibility in Operation of the Hired Equipment	Required No.
Techncial Instructor	- to teach how to operate the drilling rig. - to provide technical advice on management of the process of drilling works on site. - to supervise and control appropriate use and routine maintenance of the hired equipment.	1 person/ rig
Driver of carrier truck of drilling rig	- to drive trucks owned by DDCA to and from the drilling sites.	1 person/ truck

DDCA will allocate necessary number of the technical instructors and drivers who operate the drilling rigs to be hired. Furhtermore, the technical instructors need to refresh their skills regularly to keep standardized quality of instruction techniques. When it is short of the technical instructors compared to demands, DDCA will appoint additional ones from senior drilling staff in accordance with the Technical Support Plan for the Drillers in DDCA.

4.5 Maintenance of the Equipment

DDCA will be responsible for preventive maintenance and repair works of the equipment before the equipment is hired and after the items are returned from the hirer. Maintenance Section conducts necessary maintenance works in accordance with the guidelines, plan and manuals for maintenance system of the equipment for hiring which are formulated separately.

On the other hand, the hirer will conduct routine maintenance of the hired equipment on site under supervision of the technical instructor from DDCA. DDCA will provide the hirer with a manual for maintenance of the hired equipment which describes procedures of daily maintenance check and safety measures. The hirer wil bear the costs to be incurred for routine maintenance and repairs required during operation of the equipment on site.

For any mechanical troubles which cannot be attended by the drilling staff from the hirer or technical instructor, DDCA will send a mechanic to the site either from the headquarter or the nearest zonal office. The contract will specify demarcation of responsibilities between two parties on maintenance and repair of the equipment.

4.6 Hiring Conditions

The basic hiring model of the drilling equipment is use of a truck mounted drilling rig to be made available with one truck driver and one technical instructor. Hirers will choose other supporting equipment as per their requirements.

(1) Responsibilities in Logistics Arrangement

Table 13 shows demarcation of responsibilities in logistics associated with use of the hired equipment. The owner is responsible to arrange a carrier truck of drilling rig as it is mounted on a truck. A driver for the carrier truck will be from DDCA as the vehicle is registered as the government property. The owner is also responsible for fuel for carrier truck of the rig during mobilization and demobilization. These costs will be recovered from the rental fee of the equipment.

On the other hand, the hirer is responsible for fuel as used during the operation of the equipment on site. The hirer is also responsible to arrange carrier trucks and fuel to be required for transportation of the compressor, mud pump, and pumping test unit.

Table 13 Demarcaiton of Responsibilities in Logisticts of Hired Equipment

Equipment	Responsibilities: Carrier Truck	Fule for Transport	Fuel for Operaiton on Site	Driver for Carrier Truck
Truck mounted drilling rig	Owner	Owner	Hirer	Owner
Trailer mounted aire compressor	Hirer	Hirer	Hirer	Hirer
Trailer mounted mud pump	Hirer	Hirer	Hirer	Hirer
Trailer mounted pumping test unit	Hirer	Hirer	Hirer	Hirer

(2) Standard Operation Days of Equipment

Standard operation days of each type of equipment for hiring is calculated in order to estimate expenditure budget of the hiring service. ***Table 14*** shows calculated annual operation ratio of one drilling rig and other assumptions applied to estimation of the annual operation days of equipment.

Each drilling rig requires periods for transport of the equipment from DDCA yard to sites and between sites. Also, there would be some waiting periods until a new hiring contract is signed. Excluding these non-operation days, it is estimated that one drilling rig can serve for 197 days a year. Approximately 33 boreholes can be drilled with one rig during the annual operation period if it takes six days to construct one borehole as the results of the baseline survey of the private drilling companies indicated.

Other assumptions considered are the number of hiring contract per rig, proportion of drilling methods to be applied, and success rate of borehole drilling. With regard to the number of hiring contract per rig, it is assumed that 10 boreholes will be drilled in a hiring contract based on track records of drilling contracts in WSDP (Phase 1), which makes four contracts per rig per annum. The proportion of drilling methods is estimated as DTH method will be used for the majority of the boreholes to be drilled because of the geological formation of target areas of WSDP. The success rate of the borehole drilling refers to performance of contractors in drilling works in WSDP (Phase 1).

These assumptions should be reviewed time to time based on historical operation records of the equipment so as to improve accuracy of the analysis.

Table 14 Basis of Calculation of Standard Operation Days of Equipment

1.	**Calculated Annual Operation Ratio per Rig**			
1)	No. of days for maintenance	24	days/year	
2)	No. of days for transport between sites	60	days/year	
3)	Standby period	84	days/year	
4)	Total of non-operation days	168	days/year	=1)+2)+3)
5)	Operation days	197	days/year	
6)	No. of days required to drill a well	6	days/well	(baseline survey)
7)	No. of wells which can be drilled	33	wells/rig/year	
2.	**Assumption of Number of Hiring Contract per Rig**			
1)	No. of wells to be drillied in one contract	10 wells		
2)	No. of contract per rig	4 / year		
3.	**Assumption of Proportion of Drilling Method to be Applied**			
1)	Use of DTH method	70% of total number of wells to be drilled		
2)	Use of mud drilling method	30% of total number of wells to be drilled		
3)	Success rate of borehoel drilling	70%		

The standard operation days of the equipment are set in ***Table 15*** by applying the conditions mentioned above.

Table 15 Standard Operation Days of Equipment

	Item	Qty	No. of Operation Days per Annum	Calculation*
1)	Truck mounted drilling rig	6 units	197 days/unit	= 1.5)
2)	Trailer mounted air compressor	5 units	139 days/unit	= 1.6) x 3.1) x 1.7)
3)	Trailer mounted mud pump	5 units	59 days/unit	= 1.6) x 1.7) x 10%
4)	Trailer mounted pumping test unit	5 units	69 days/unit	= 1.7) x 3.3) x 3 days/ well
5)	Rig accessories	6 sets	197 days/set	= 1.5)
6)	Casing tools	6 sets	197 days/set	= 1.5)
7)	Fishing tools	6 sets	79 days/set	= 40% of the operation day of drilling rig
8)	Direct mud circulation drilling tools & accessories	6 sets	59 days/set	= 1.6) x 1.7) x 3.2)

* The numbers in the column refer to the ones in ***Table 14***.

5. QUALIFICAITONS TO BE REQUIRED FOR CLIENTS AND OTHER CONDITIONS

5.1 REQUIREMENTS TO APPLICANTS

DDCA will hire the equipment to qualified private drilling companies which will fulfill criteria listed below;

- To possess a valid water well drilling permit issued by MoW.
- To be registered as the specialist contractor at CRB.
- To have at least one permanent employee among the drilling staff to be on site with the hired equipment and to receive the technical instructions from DDCA.

(1) Registration to CRB and MoW

Registrations at MoW and CRB are required by relevant laws, respectively, as the contractors to execute a certain type of works governed by these organizations. For water well drilling permit, the Groundwater (Exploration and Drilling) Licensing Regulation 2011 of the Water Resources Management Act 2009 is in the proess of formulation by MoW and to be enacted soon.

For CRB registration, MoW is considering to stipulate possession of the CRB registration as one of the conditions to issue a water well drilling permit in the said regulations. Registration as the specialist contractor is also one of the conditions for contractors for drilling works in WSDP.

According to results of the baseline survey, most of the companies classified into Group A have both valid drilling permit of MoW and registration at CRB (***Figure 28***). In contrast with this situation, Group B is occupied by the companies which have the drilling permit only or no registration at all. If these conditions are applied, around 23 companies in Group A and Group B have higher advantage than others to access to the hiring service. DDCA will update information on status of registration of the potential clients continuously.

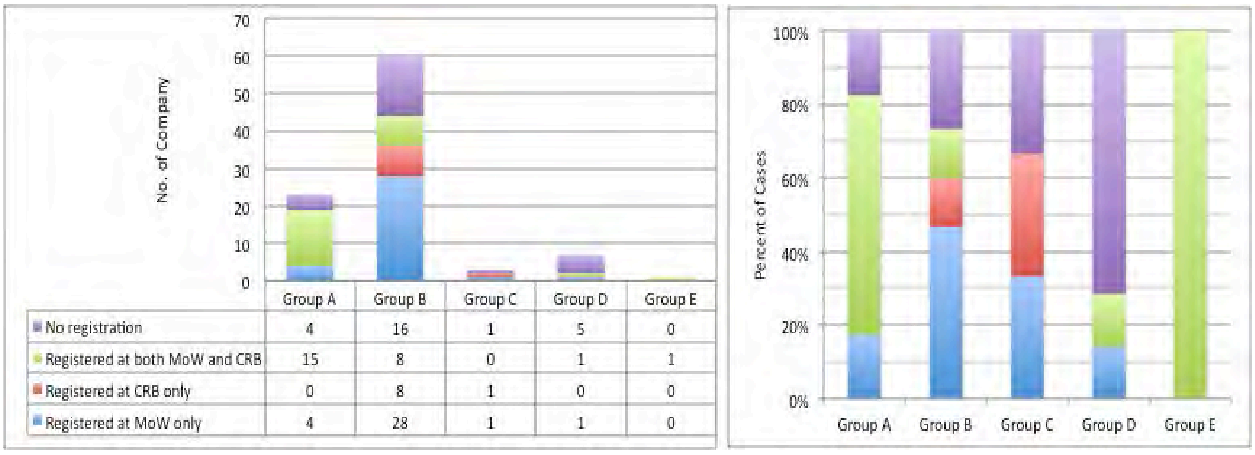


Figure 28 Status of Registration at CRB and MoW by Classification of the Surveyed Companies

(2) Drilling Staff of the Hirer

The third condition is set based on intention that the hirer will utilize skills and knowledge acquired from the technical instructors in other drilling works in the future by transferring such skills and knowledge from the trained personnel to others.

5.2 USE OF THE HIERED EQUIPMENT

(1) Priority among Projects

The equipment to be hired should be primarily utilized in drilling works for WSDP in order to contribute for attainment of the programme goal for improvement of water supply coverage in the country. Meanwhile, it is predicted that the number of procurement for drilling works in WSDP will much vary from time to time as the first phase of the programme experienced. The equipment will also be hired for the use in drilling works to be procured by the private sector including individual households in order to mitigate reduction of operation ratio of the equipment during the period when procurement in WSDP is not concentrated. WSDP counts improvement of water supply by the private sector into the water coverage.

(2) Priority among Applicants

Segmentation of the surveyed companies identified a total of 83 business entities which are interested in the equipment hiring service. These were further divided into two groups. Group A (23 nos.) already possesses experience in operation of DTH method with a large rotary drilling rig. Group B (60 nos.) has no experience in DTH drilling with a large rotary rig.

It is expected that the project will create greater effect on Group B than Group A in terms of increase of number of contractors which can perform drilling works in WSDP (***Table 16***). In case that DDCA needs to choose hirers among applicants due to limited number of the available rigs, the first priority in selection will, therefore, be given to the companies classified into Group B.

Table 16 Classified Groups of Private Drilling Companies and Project Effect Potential

Group	Number of Company	Experience of DTH Drilling with Large Rotary Rig	Interest in DDCA's Service: Equipment Hiring Service	Interest in DDCA's Service: Technical Advice and/or Hydrogeological Information from DDCA	Experience of Drilling Works in WSDP	Project Effect Potential (5: highest, 1: lowest)
A	23	23	17	22	11	4
B	60	0	60	58	3	5
C	3	3	0	3	1	3
D	7	0	0	7	1	2
E	1	1	0	0	0	1
Total	94	37	83	90	16	

5.3 USE OF THE EQUIPMENT BY DDCA FOR ITS OWN DRILLING ACTIVITIES

DDCA also plans to use the equipment for hiring in its own drilling works. In such cases, Drilling Project Department will "hire" the equipment from Hiring Business Department and transfer the fund equivalent to the rental fee to the account for the hiring service while the first priority in use of the equipment will be given to applicants from the private sector.

6. LAWS AND REGULATIONS TO BE FOLLOWED

6.1 LIABILITY OF INSURANCE FOR THE HIRING EQUIPMENT

It was confirmed that there was no particular legal requirement for DDCA to start the hiring service. Hiring of equipment to other organizations is included as the secondary function of DDCA in the Executive Agencies (Drilling and Dam Construction Agency) (Establishment) Order, 1999, by which DDCA is legally recognized to operationalize such function.

With regard to the administrative procedures, DDCA needs to decide arrangements of insurance for machinery and vehicles to be hired out. All the equipment owned by DDCA belongs to the Government of Tanzania and is insured by Ministry of Finance and Economic Affairs (MoFEA). The Treasury of MoFEA is responsible for registration and management of all the government-owned vehicles and machinery.

The arrangement of the insurance of the hired equipment varies depending on how the business is going to be operated and what are to be charged as the rental fee to hirers. In case that the equipment hiring is operated as part of the governmental services and to recover operation costs only, MoFEA will insure the equipment in the same manner with other equipment that DDCA uses for its own drilling works. On the other hand, if it pursuits profits at commercially viable basis, the responsible party for the insurance needs to be agreed in a contract between DDCA and the hirer.

6.2 TAXATION

As to taxation of the hiring service, the Value Added Tax (VAT) will not be charged to the service as DDCA is exempted from taxation of VAT on its sales.

6.3 REGULATIONS RELATED TO THE GROUNDWATER DEVELOPMENT

MoW regulates development and use of groundwater in the framework of the Water Resources Management Act of 2009. Regulations governing the groundwater development in the framework of the Water Resources Management Act include the following;

(1) Water Resources Management (Water Abstraction, Use and Discharge) Regulations, 2010

The regulation specifies procedures for administering permits for water use, groundwater development, and wastewater discharge. The Act requires water users to apply for a water use permit at Basin Water Board (BWB) when they intend to divert, dam, store, abstract or use surface water or groundwater[7]. The water use permit allows a water user to exclusively use the water resources within the terms and conditions specified in the permit. Meanwhile, the discharge permit is issued to regulate those who discharge effluents from any commercial, industrial or agricultural source or from any sewerage works or trade waste systems into surface water or underground strata.

In case that owners or users of wells plan to construct, enlarge, or deepen wells, they are obliged to apply for a groundwater permit prior to commencement of the works. The Act regards that construction of a well by a person without a groundwater permit is an offence. Further, an application for a water use permit is required for the owner or user of the well when the source is successfully developed for water abstraction.

Although it is water users who are responsible to apply for these permits, drilling contractors should also be aware of these regulations, especially in the context of the groundwater development, as the water users would require information and report on drilling works from the contractors for submission to BWB.

(2) Groundwater (Exploration and Drilling) Licensing Regulations, 2011

MoW is currently preparing the Groundwter (Exploration and Drilling) Licensing Regulations to regulate professionals who undertake works relating to groundwater prospecting and construction of wells. Taking over the existing water well drilling permitting system, the draft regulations stipulate necessity of acquisition of a groundwater drilling license by any person who is involved in groundwater drilling activities. Other licenses or permits newly created or reinforced by the regulations are the groundwater exploration license, drillers license and drilling clearance permit.

DDCA will provide advice to hirers to consult with MoW for required procedures to acquire licenses and permits necessary for operation of drilling works by hirers. The Water Resources Management Act also mentions the following with regard to the groundwater development;

- The Minister responsible for Water has power to prescribe in regulations the minimum distance for the sinking, enlargement or deepening of wells.
- Those who are engaged in drilling of wells or groundwater explorations are required to keep and submit any relevant data on groundwater to BWB.
- BWB has power to determine the safe yield of any aquifer for the purpose of guiding determinations concerning the abstraction and use of water from the aquifer.

DDCA will keep itself updated about new regulations formulated in the Water Resources Management Act so that legal requirements in the groundwater development will be incorporated into administration of the equipment hiring service where necessary.

---

[7] Application for a water use permit is exempted for the following caeses, provided that its purpose of water abstraction is for domestic use;

- Any person having lawful access to any water course uses the same for domestic purposes without construction of any works.
- Any person being a legal occupier of land constructs a shallow hand dug well not exceeding a depth of 15m and uses the water for domestic purposes.
- The owner or occupier of any land constructs any works for rainwater harvesting or for recycling of used water other than in a river or stream and abstracts and uses the water conserved or recycled for domestic purposes. The works should not exceed 20m capacity of water.

7. ESTABLISHMENT OF THE HIRING BUSINESS UNIT

7.1 JOB DESCRIPTION

DDCA will establish the Hiring Business Unit under the Business Support Department in order to manage daily operation of the hiring service. The Unit will be responsible for tasks mentioned below;

- To administer hiring process including appraisal and selection of the qualified hirers, contract management, and customer care.
- To keep and update information of particulars of clients.
- To coordinate with other departments in the organization for arrangement of the technical instructors and other required staff, maintenance of the hired equipment, and procurement of consumables and other materials for the drilling equipment as may be necessary.
- To prepare the budget for operation of the hiring service to be included in annual budget proposals of DDCA.
- To set/review and propose the tariff for approval by the management of DDCA.
- To prepare monthly reports on operational and financial status of the service provision.
- To coordinate with Marketing and Public Relations (PR) Section in preparation of PR materials and communication with potential clients for business promotion.

Figure 29 shows an organigram of DDCA which includes structure of the Business Support Department with Hiring Business Unit.

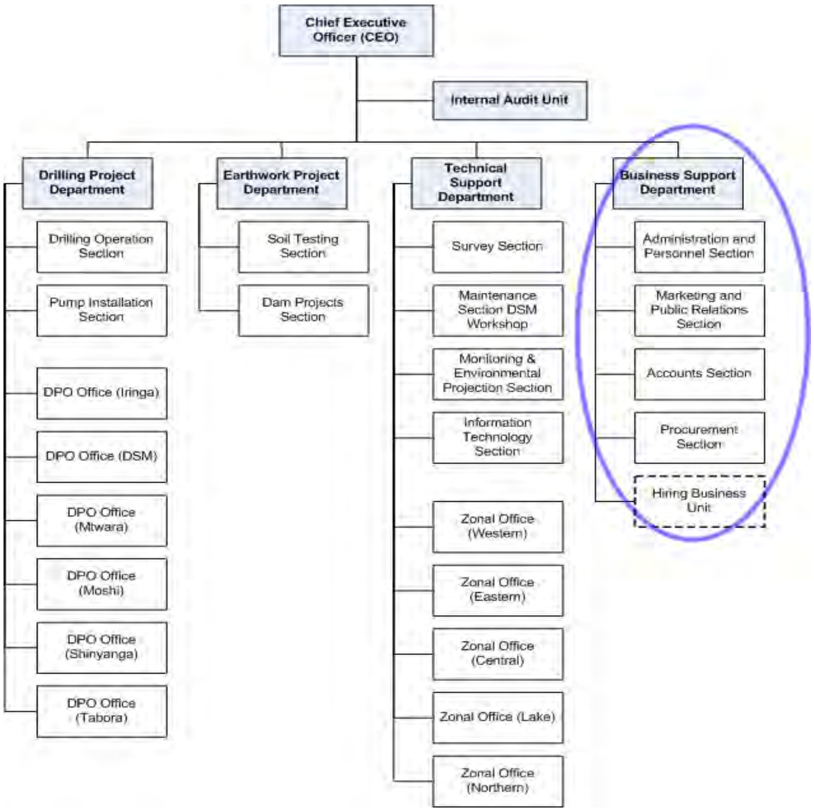


Figure 29 Organizational Structure of DDCA with the Hiring Business Unit

The Unit will involve the legal officer(s) of DDCA in contract management for the hiring service and seek advice from the Legal Unit of MoW when necessary. The Unit will also work closely

with the Procurement Section of DDCA to purchase consumables and spare parts of drilling equipment in time for its hiring.
In the long-term, DDCA will consider if it should transform the Unit to the Hirng Business Department. Establishment of the Hiring Business Department needs approval from Presient's Office-Public Service Management (PO-PSM). DDCA will follow necessary procedures for application for establishment of the new department through MoW when it resolves to do so.

7.2 PERSONNEL ARRANGEMENT PLAN

A full-time administration officer and an assistant staff are required in the Unit to be supervised by the manager of the Business Support Department who will serve concurrently as the head of the Unit. DDCA is planning to reallocate existing staff to fulfill the staffing plan for the Hiring Business Unit instead of recruiting new personnel. The staffing plan will be reviewed from time to time according to volume of works to be involved in the Unit staff.

8. PERFORMANCE MANAGEMENT

8.1 KEY PERFORMANCE INDICATORS

Applying the key performance indicators listed below, the Hiring Business Unit will monitor process, output and outcomes of the equipment hiring service.

Table 17 Key Performance Indicators of the Equipment Hiring Service

Purpose	Indicators	Means of Verification	Frequency of Monitoring
1. Process Management	1-1. Drilling equipmemt is hired in accordance with the procedures established. 1-2. All drilling equipment for hiring is maintained in accordance with the maintenance plan. 1-3. Internal management accounting document for hiring is reported periodically to the management.	1-1. Records for hiring 1-2. Maintenance records of drilling eqiupment for hiring 1-3. Reports on hiring service	1-1. Daily 1-2. Monthly 1-3. Monthly
2. Managemene t of Output of the Service	2-1. The number of operation days of a drilling rig for hiring reaches to 141 days per annum on average, the break even line of the hiring business[8], by 2016. 2-2. More than 80% of the registered water well drilling companies utilize some forms of the technical support services by 2016. 2-3. More than 80% of private drilling companies, which used the technical support services provided by DDCA, consider that the services they received helped their business activities.	2-1. Records for hiring 2-2. Records for hiring 2-3. Feedback forms from clients	2-1. Monthly 2-2. Monthly 2-3. Each hiring conctract, Monthly
3. Management of Outcomes	3-1. The number of private companies which use the technical support services of DDCA and participate in drilling works in WSDP increases by	3-1. Records for hiring, Water Sector MIS	3-1. Annually

[8] See Section 11.3 for an estimation of the break even line of the hiring business.

Purpose	Indicators	Means of Verification	Frequency of Monitoring
	122% by 2018, compared to the status before official launch of the service provision. 3-2. The number of wells planned in WSDP is constructed by 2015.	3-2. MoW Annual Water Sector Status Report, Water Sector MIS	3-2. Annually

8.2 PERFORMANCE MONITORING REPORT

The Hiring Business Unit will prepare the following reports to be submitted to the management team of DDCA and MAB;

- Monthly report to be submitted not later than 10 days after the end of the month
- Annual report to be submitted not later than 14 days after the end of the year

The above reporting procedures notwithstanding, DDCA shall report promptly to the Ministry on any major event likely to affect efficient and effective utilization of the equipment.

9. OUTLINE OF THE BUSINESS FLOW

The hiring service will be operated in a Plan-Do-Check-Action (PDCA) cycle as described in ***Figure 30***. It starts from preparation of annual operation plan and budget of the hiring service which is to be incorporated into the annual budget of DDCA. Rental fees as well as placement of drilling rigs and other equipment for hiring at DDCA headquarters and/or its zonal office(s) should be decided in the course of formulation of the annual operation plan and budget. The implementation stage involves various administrative procedures in accordance with the process of equipment hiring described in detail in ***Figure 31***. Procedures instituted should be followed and recorded properly to ensure accountability and transparency. The performance of the hiring service will be monitoring from time to time to check;

- if there are any gaps between what has been planned and implemented, and
- if the expected output and outcomes are realized.

Actions should be taken to solve problems and improve the process management based on findings from the monitoring. These improved solutions should also be reflected in the planning stage of the subsequent cycle.

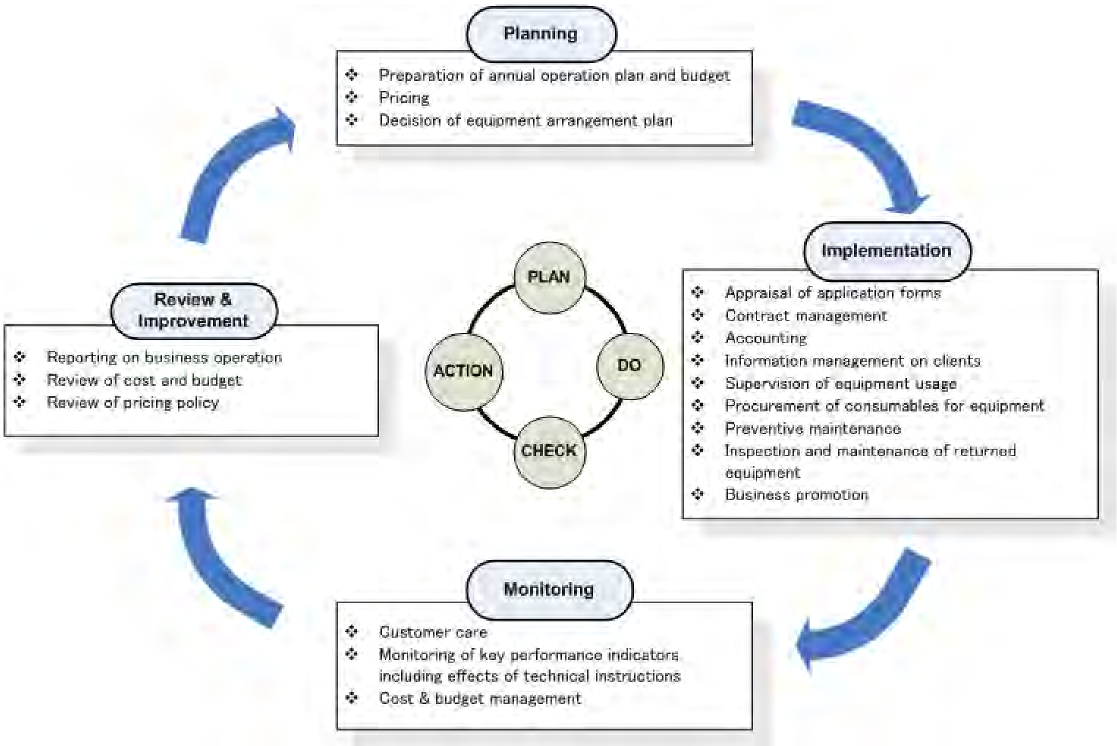


Figure 30 Business Cycle of the Hiring Service

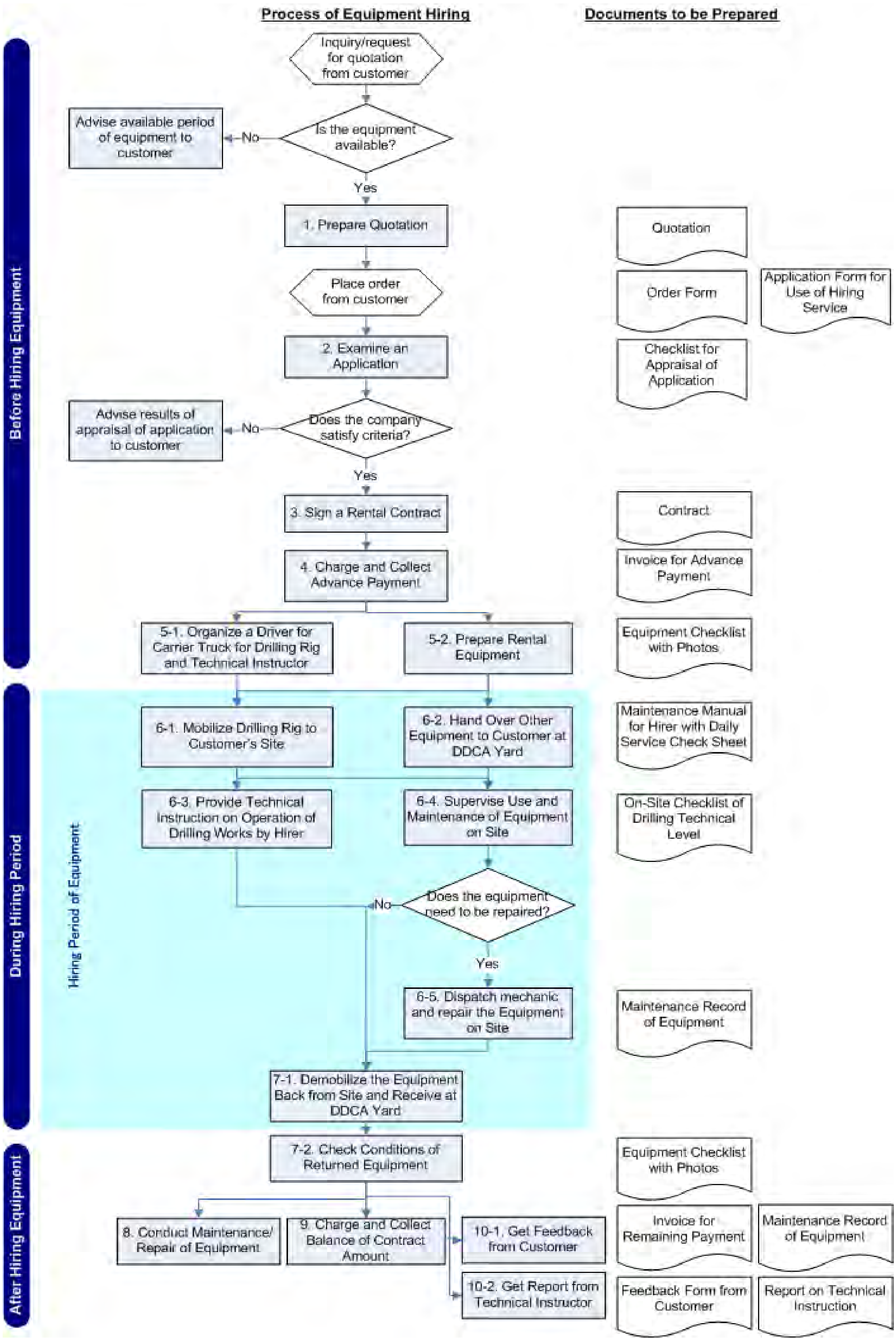


Figure 31 Process of Equipment Hiring

10. BUSINESS PROMOTION

DDCA will promote the launch of technical support services including the equipment hiring to potential clients. While the priority target is those which are classified into Group A and Group B according to the results of the baseline survey, identification of new potential clients needs to be conducted simultaneously. As mentioned in Section 3.3.3, there are 10 companies which were not interviewed in the baseline survey although it was confirmed that these were also operating drilling works. These companies should also be included in the target of the business promotion.

Means of the business promotion to be employed include mailing brochures explaining the service contents to identified companies, introducing it to participants in regular and/or extraordinary meetings of Drilling Association of Tanzania (DAT) and CRB, and publicize on newsletters to be issued by CRB for its members.

11. FINANCE

11.1 BUDGET PREPARATION

The Hiring Business Unit is responsible to prepare budget for operation of the hiring service to be incorporated into the annual budget of DDCA. For the budget prepration, reference should be made to accounting manuals of DDCA.

(1) Expenditure

Table 18 in the next page shows an estimated annual expenditure of the hiring service for the case that depreciation cost of the hiring equipment is considered. Approximately Tsh 912 million will be required for annual operation of the service. Cost items considered in the estimation can be categorized into the direct cost and indirect cost. The direct cost consists of 1) maintenance cost of equipment, 2) fuel and lubricants, 3) consumables for drilling rigs, 4) allowance for staff to be attached to the drilling rigs, and 5) depreciation of the equipment. The indirect cost, i.e. selling, general and administrative expenses, include 1) allowance for the management team for monitoring, 2) allowance for mechanics for repair works of the equipment on site, 3) advertisement cost, 4) stationery, and 5) other expenses such as staff salaries, utilities, office rent, and cost for staff training. For comparison purpose, the estimated annual expenditure without depreciation cost is indicated in ***Table 19***. Basis of the estimation is explained below;

1) Maintenance Cost of Equipment

3.5% of the equipment price is considered as the annual maintenance cost for drilling rigs, air compressors, mud pumps, and pumping test units. The percentage is based on historic costs for maintenance of existing drilling rigs by DDCA.

As mentioned in Section 4.2, rig accessories, casing tools, and direct mud circulation drilling tools and accessories contain i) items which are permanently provided with the drilling rigs and ii) consumables which use is optional for the hirer. Maintenance costs are considered for those which are equipped with drilling rigs permanently. 3.5% of the price of each item is applied as the maintenance cost for these accessories and tools. Remaining parts are considered as consumables. Also, all items in the category of steel working casing are regarded as consumables, hence no maintenance cost included in the budget.

Table 18 Expenditure Budget for Annual Operation of the Hiring Service (with Depreciation Cost)

	Item	Unit	Unit Cost	Q'ty	Amount (Tsh)	Note
1.	Maintenance Cost of Equipment					
1)	Truck mounted drilling rig	unit	14,610,133	6	87,660,800	for 1 year operation
2)	Trailer mounted air compressor	unit	2,188,480	5	10,942,400	ditto
3)	Trailer mounted mud pump	unit	1,721,600	5	8,608,000	ditto
4)	Trailer mounted pumping test unit	unit	5,277,760	5	26,388,800	ditto
5)	Rig accessories	set	2,215,467	6	13,292,800	ditto
6)	Casing tools	set	592,000	6	3,552,000	ditto
7)	Fishing tools	set	55,733	6	334,400	ditto
8)	Direct mud circulation drilling tools & accessories	set	757,333	6	4,544,000	ditto
	Sub-Total				**155,323,200**	
2.	Fuel and Lubricants					
1)	Fuel for a carrier truck for drilling rig	lit	2,200	2,901	6,381,540	for 1 year operation with 6 rigs
2)	Lubricant for a carrier truck for drilling rig	lit			127,631	2% of fuel cost
3)	Fuel for vehicle (for monitoring)	lit	2,200	1,371	3,017,143	6 days/quarter x 4 x 200km/day
4)	Lubricant for vehicle (for monitoring)	lit			60,343	2% of fuel cost
	Sub-Total				**9,586,657**	
3.	Consumables for Drilling Rigs					
1)	8" casing shoe	Pcs	29,232	10	292,320	70% of the required quantity of consumables for 1 year operation with 6 rigs
2)	10" casing shoe	Pcs	49,344	14	690,816	
3)	8" steel casing	Pcs	15,232	3	45,696	
4)	10" steel casing	Pcs	27,104	4	108,416	
5)	4-1/2" drill pipe	Pcs	25,616	4	102,464	
6)	DTH Hammer for 12" hole	Pcs	196,432	2	392,864	
7)	6-1/4" DTH bit	Pcs	69,744	12	836,928	
8)	8-1/4" DTH bit	Pcs	200,688	21	4,214,448	
9)	10" DTH bit	Pcs	31,120	3	93,360	
10)	8-1/2" tricone roller bit	Pcs	96,208	3	288,624	
11)	10-1/2" tricone roller bit	Pcs	111,760	3	335,280	
12)	12-1/4" tricone roller bit	Pcs	26,480	1	26,480	
13)	8-1/2" roller bit	Pcs	81,984	4	327,936	
14)	10-1/2" roller bit	Pcs	107,904	6	647,424	
15)	12-1/2" roller bit	Pcs	17,168	1	17,168	
16)	10-1/2" drag bit	Pcs	47,616	5	238,080	
17)	12-1/2" drag bit	Pcs	6,688	1	6,688	
18)	6-1/4" stabilizer	Pcs	50,560	6	303,360	
19)	8-1/2" stabilizer	Pcs	56,368	6	338,208	
	Sub-Total				**9,306,560**	
4.	Allowance					
1)	Technical Instructor	day	65,000	1,542	100,230,000	1 person/rig x 6 rigs (total operaiton days/rig + transport)
2)	Driver for truck for rig	day	30,000	1,542	46,260,000	1 person/rig x 6 rigs (total operaiton days/rig + transport)
	Sub-Total				**146,490,000**	
5.	Depreciation of Equipment for Hiring					
1)	Truck mounted drilling rig	Unit	41,743,040	6	250,458,240	Depreciation rate: 10%
2)	Trailer mounted air compressor	Unit	6,252,960	5	31,264,800	ditto
3)	Trailer mounted mud pump	Unit	4,918,400	5	24,592,000	ditto
4)	Trailer mounted pumping test unit	Unit	15,079,520	5	75,397,600	ditto
	Sub-Total				**381,712,640**	
	Direct Cost - Total				**702,419,057**	
6.	Selling, General and Administrative (SGA) Expenses					
1)	Allowance for Management Team (for monitoring)	day	65,000	48	3,120,000	6 days/ quarter x 2 persons
2)	Mechanic	day	45,000	355	15,975,000	30% of operation days of 6 rigs
3)	Advertisement on New Service - Brochures	pcs	1,200	500	600,000	
4)	A4 paper	Rim	10,000	24	240,000	
5)	Other expenses	27%	of direct cost		189,653,145	
	Indirect Cost - Total				**209,588,145**	approx. 30% of the direct cost
	Grand Total				**912,007,202**	

Table 19 Expenditure Budget for Annual Operation of the Hiring Service (without Depreciation Cost)

	Item	Unit	Unit Cost	Q'ty	Amount (Tsh)	Note
1.	Maintenance Cost of Equipment					
1)	Truck mounted drilling rig	unit	14,610,133	6	87,660,800	for 1 year operation
2)	Trailer mounted air compressor	unit	2,188,480	5	10,942,400	ditto
3)	Trailer mounted mud pump	unit	1,721,600	5	8,608,000	ditto
4)	Trailer mounted pumping test unit	unit	5,277,760	5	26,388,800	ditto
5)	Rig accessories	set	2,215,467	6	13,292,800	ditto
6)	Casing tools	set	592,000	6	3,552,000	ditto
7)	Fishing tools	set	55,733	6	334,400	ditto
8)	Direct mud circulation drilling tools & accessories	set	757,333	6	4,544,000	ditto
	Sub-Total				**155,323,200**	
2.	Fuel and Lubricants					
1)	Fuel for a carrier truck for drilling rig	lit	2,200	2,901	6,381,540	for 1 year operation with 6 rigs
2)	Lubricant for a carrier truck for drilling rig	lit			127,631	2% of fuel cost
3)	Fuel for vehicle (for monitoring)	lit	2,200	1,371	3,017,143	6 days/quarter x 4 x 200km/day
4)	Lubricant for vehicle (for monitoring)	lit			60,343	2% of fuel cost
	Sub-Total				**9,586,657**	
3.	Consumables for Drilling Rigs					
1)	8" casing shoe	Pcs	29,232	10	292,320	70% of the required quantity of consumables for 1 year operation with 6 rigs
2)	10" casing shoe	Pcs	49,344	14	690,816	
3)	8" steel casing	Pcs	15,232	3	45,696	
4)	10" steel casing	Pcs	27,104	4	108,416	
5)	4-1/2" drill pipe	Pcs	25,616	4	102,464	
6)	DTH Hammer for 12" hole	Pcs	196,432	2	392,864	
7)	6-1/4" DTH bit	Pcs	69,744	12	836,928	
8)	8-1/4" DTH bit	Pcs	200,688	21	4,214,448	
9)	10" DTH bit	Pcs	31,120	3	93,360	
10)	8-1/2" tricone roller bit	Pcs	96,208	3	288,624	
11)	10-1/2" tricone roller bit	Pcs	111,760	3	335,280	
12)	12-1/4" tricone roller bit	Pcs	26,480	1	26,480	
13)	8-1/2" roller bit	Pcs	81,984	4	327,936	
14)	10-1/2" roller bit	Pcs	107,904	6	647,424	
15)	12-1/2" roller bit	Pcs	17,168	1	17,168	
16)	10-1/2" drag bit	Pcs	47,616	5	238,080	
17)	12-1/2" drag bit	Pcs	6,688	1	6,688	
18)	6-1/4" stabilizer	Pcs	50,560	6	303,360	
19)	8-1/2" stabilizer	Pcs	56,368	6	338,208	
	Sub-Total				**9,306,560**	
4.	Allowance					
1)	Technical Instructor	day	65,000	1,542	100,230,000	1 person/rig x 6 rigs (total operaiton days/rig + transport)
2)	Driver for truck for rig	day	30,000	1,542	46,260,000	1 person/rig x 6 rigs (total operaiton days/rig + transport)
	Sub-Total				**146,490,000**	
	Direct Cost - Total				**320,706,417**	
5.	Selling, General and Administrative (SGA) Expenses					
1)	Allowance for Management Team (for monitoring)	day	65,000	48	3,120,000	6 days/ quarter x 2 persons
2)	Allowance for Mechanic	day	45,000	355	15,975,000	30% of operation days of 6 rigs
3)	Advertisement on New Service - Brochures	pcs	1,200	500	600,000	
4)	A4 paper	Rim	10,000	24	240,000	
5)	Other expenses	24%	of the direct cost		76,969,540	
	Indirect Cost -Total				**96,904,540**	approx. 30% of the direct cost
	Grand Total				**417,610,957**	

2) Fuel and Lubricants

Costs for fuel and lubricants are considered for i) carrier trucks for drilling rigs for those transportation between DDCA's yard and client's site as well as from one drilling site to the other and ii) vehicles for monitoring visits by the management team.

Fuel costs for operation of the rig plant and other equipment are not included in the budget as hirers are responsible to put in fuel on the hired equipment as they use.

3) Consumables for Drilling Rigs

Items included as consumables are bits, DTH hammers, stabilizers, casing shoes, steel work casing, and drill pipes. Hirers can decide if they use their own stocks of these items for drilling works or they buy necessary tools and accessories from DDCA. The cost of consumables considered here is, therefore, to have some stocks of these items to be sold to the hirers when necessary. As there would be some cases that the hirers use these items which they keep or procure new ones from other suppliers, 70% of the required quantity of consumables for one-year operation of six drilling rigs is included in the budget.

4) Allowance

One technical instructor and driver for carrier truck for rig plant will be attached to each drilling rig. Their field allowances are considered as a part of the direct cost of the hiring service. Number of days considered for one person is a total of operation days and time to be taken for transportation of a drilling rig.

5) Depreciation of Equipment

The depreciation of the equipment is regarded as a part of the direct cost to operate the hiring service. The annual depreciation rate of 10% is applied to fixed assests, i.e. drilling rigs, air compressors, mud pumps and pumping test units, in accordance with the Executive Agencies Project, Drilling and Dam Construction Agency, Accounting Manual – IFMS (2002). A straight-line method is applied to calculation of depreciation to write off the cost of these assets for a 10-year economic life.

6) Selling, General and Administrative Expenses

The allowance for the management team for monitoring visits is calculated with the basis of six days per quarter per person. It is assumed that two senior staff members will visit the hirers' drilling sites in a team or separately to oversee services provided by the technical instructors.

The indirect cost also includes the allowance for mechanics who will attend repair works and services of the hired equipment on site when necessary. It is estimated that the mechanics will be involved in these field works for 30% of the operation days of six drilling rigs.

Other expenses such as staff salaries, utilities, office rent, and cost for staff training are calculated as the proportion to the direct cost so that the total of the indirect cost accounts for approximately 30% of the direct cost. It is difficult to estimate more accurate amount of the selling, general and administrative expenses at this stage as the current practice of cost accounting by DDCA does not consider how the indirect cost is distributed to each type of service the Agency operates. The budgeting method of the indirect cost should be reviewed based on the actual cost accounting by services as well as departments.

(2) Revenue

The revenue is estimated as shown in ***Table 20*** based on the proposed rental fee and operation days of each equipment for hiring. The expected revenue from the hiring service is approximately Tsh 1,545 million.

Table 20 Estimated Annual Sales

	Item	Annual Sales/ Unit (Tsh)	Q'ty	Annual Total Sales (Tsh)
1)	Truck mounted drilling rig	154,933,408	6	929,600,448
2)	Trailer mounted air compressor	23,207,440	5	116,037,200
3)	Trailer mounted mud pump	18,255,072	5	91,275,360
4)	Trailer mounted pumping test unit	55,969,488	5	279,847,440
5)	Rig accessories	12,075,312	6	72,451,872
6)	Casing tools	3,772,944	6	22,637,664
7)	Fishing tools	820,336	6	4,922,016
8)	Direct mud circulation drilling tools & accessories	4,822,896	6	28,937,376
	Total	273,856,896		**1,545,709,376**

11.2 PRICING POLICY

Rental fees of the equipment for hiring is set with considering costs, as listed below, for operation of the service and a certain percentage of markup. Decpreciation cost will also be recovered from the rental fee so that DDDCA will put aside a certain proportion of fund for replacement of the equipment in the future.

- Maintenance costs of the equipment
- Fuel and lubricants
- Consumables
- Allowance
- Advertisement
- Stationary
- Depreciation
- Other administrative expenses

Market prices for hiring of drilling rigs and other construction machinery in Tanzania are aslo referred in order to check if the proposed rental fees are kept at a reasonable level in comparison with competitors. ***Figure 32*** shows a formula used for calculation of the rental fees. ***Table 21*** and ***Table 22*** further indicate acquisition costs of the equipment and proportion of the hiring service cost, respectively. The proportion of the service cost is calculated to obtain the ratio of management cost, i.e. fuel and lubricants, consumables, and allowance for technical instructors and drivers, to the unit cost of equipment and that of the selling, general and administrative cost to the direct cost.

The daily rental fee of each item of the equipment is proposed in ***Table 23***, which cost structure is shown in ***Table 24***. The prices are set at daily basis and to be charged to for the hiring period which starts when the equipment is moved out from DDCA's yard and ends when the same is retuned to the Agency. The hirer has to pay the rental fee during the hiring period even if the equipment is not operated on site. This is due to consideration of the opportunity cost of the equipment as well as personnel cost for technical instructors and drivers.

The rental fees without inclusion of depreciation of the equipment and those cost structures are also provided in ***Table 25*** and ***Table 26*** for reference. It is desired that the investment cost for the equipment is recovered from the rental fees by including the depreciation cost into the price calculation since DDCA needs to secure own funds for replacement of the equipment for hiring even though there is no allocation of subventions from MoW.

Taking the following points into account, DDCA will review pricing of the rental fees and set strategically appropriate prices;

- Willingnes to pay by different types of potential clients for the hiring service
- Level of reasonable profit to sustain the business
- Measures to minimize costs to secure the reasonable profit within the price set in consideration of the willingness to pay by potential clients

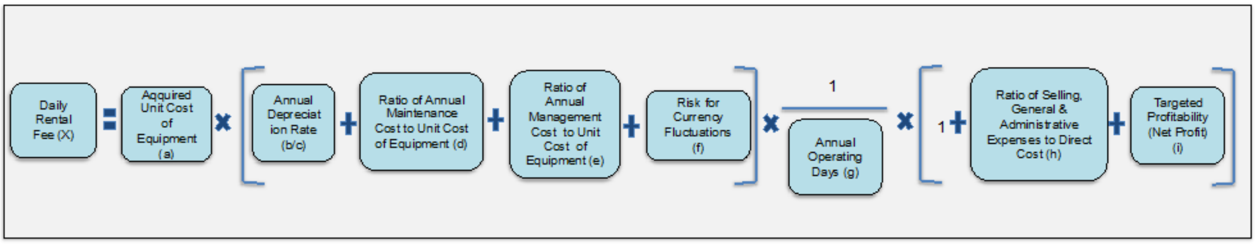


Figure 32 Formula for Pricing of Rental Fee

Table 21 Acquisition Cost of Equipment for Hiring

	Item	Unit Cost (US$)	Q'ty	Total (US$)	Note
1)	Truck mounted drilling rig	260,894.00	6	1,565,364.00	
2)	Trailer mounted air compressor	39,081.00	5	195,405.00	
3)	Trailer mounted mud pump	153,700.00	5	768,500.00	
4)	Trailer mounted pumping test unit	94,247.00	5	471,235.00	
5)	Rig accessories	39,558.73	6	237,352.38	excluding items categorized as consumables
6)	Casing tools	10,580.65	6	63,483.90	excluding items categorized as consumables
7)	Fishing tools	2,538.39	6	15,230.34	
8)	Direct mud circulation drilling tools & accessories	13,522.34	6	81,134.04	
	Total			3,397,704.66	excluding items categorized as consumables

Table 22 Proportion of Hiring Service Cost

Category for Pricing	With Depreciation		Without Depreciation		Note
	Amount (Tsh)	Proportion	Amount (Tsh)	Proportion	
Depreciation	381,712,640	41.9%	0	0%	
Maintenance Cost	155,323,200	17.0%	155,323,200	37.2%	
Management Cost	165,383,217	18.1%	165,383,217	39.6%	Fuel & lubricants, consumables, and allowance
Selling, General & Administrative Expense	209,588,145	23.0%	96,904,540	23.2%	
Total	912,007,202	100%	417,610,957	100%	
Ratio of Management Cost to Equipment Cost		3.0%		3.0%	
Ratio of SGA to Direct Cost		29.8%		30.2%	

Table 23 Rental Fee of Drilling Equipment (with Depreciation Cost Considered)

		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(X)		
	Item	Unit Cost of Equipment (US$)	Depreciation	Economic Life	Maintenance Cost	Management Cost	Risks for Exchange Rate	Operation Day/Year	SGA	Net Profit	Daily Rental Fee (USD)	Daily Rental Fee (Tsh)	Rental Fee per Borehole (Tsh)
1)	Truck mounted drilling rig	260,894.00	100%	10	3.5%	3.0%	10%	197	30%	10%	491.54	786,464	4,718,784
2)	Trailer mounted air compressor	39,081.00	100%	10	3.5%	3.0%	10%	139	30%	10%	104.35	166,960	
3)	Trailer mounted mud pump	30,740.00	100%	10	3.5%	3.0%	10%	59	30%	10%	193.38	309,408	
4)	Trailer mounted pumping test unit	94,247.00	100%	10	3.5%	3.0%	10%	69	30%	10%	506.97	811,152	
5)	Rig accessories	39,558.73			0.6%	3.0%	10%	197	30%	10%	38.31	61,296	367,776
6)	Casing tools	10,580.65			2.9%	3.0%	10%	197	30%	10%	11.97	19,152	114,912
7)	Fishing tools	2,538.39			1.4%	3.0%	10%	79	30%	10%	6.49	10,384	
8)	Direct mud circulation drilling tools & accessories	13,522.34			2.9%	3.0%	10%	59	30%	10%	51.09	81,744	

(Exchange Rate: 1USD = Tsh 1,600)

Rental Fee of a Drilling Rig with Rig Accessories and Casing Tools per Borehole: Tsh 5,201,472

Item 5), 6) and 8) above contain only accessories and tools to be attached to the drilling rigs for hiring. Consumables are not included.

Table 24 Structure of Rental Cost of Drilling Eqiupment (with Depreciation Cost Considered)

	Item	Depreciation Cost	Maintenance Cost	Management Cost	Risks for Exchange Rate	SGA	Net Profit	Annual Total Cost	Daily Rental Fee (USD)
1)	Truck mounted drilling rig	26,089.40	9,131.29	7,936.88	26,089.40	20,661.95	6,924.70	96,833.62	491.54
2)	Trailer mounted air compressor	3,908.10	1,367.84	1,188.92	3,908.10	3,095.09	1,037.30	14,505.35	104.36
3)	Trailer mounted mud pump	3,074.00	1,075.90	935.17	3,074.00	2,434.51	815.91	11,409.49	193.38
4)	Trailer mounted pumping test unit	9,424.70	3,298.65	2,867.17	9,424.70	7,464.05	2,501.52	34,980.79	506.97
5)	Rig accessories	0	237.35	1,203.45	3,955.87	1,610.26	539.67	7,546.60	38.31
6)	Casing tools	0	306.84	321.88	1,058.07	503.31	168.68	2,358.78	11.97
7)	Fishing tools	0	35.54	77.22	253.84	109.39	36.66	512.65	6.49
8)	Direct mud circulation drilling tools & accessories	0	392.15	411.37	1,352.23	643.23	215.58	3,014.56	51.09

Table 25 Rental Fee of Drilling Equipment (without Depreciation Cost Considered)

	Item	(a) Unit Cost of Equipment (US$)	(b) Depreciation	(c) Economic Life	(d) Maintenance Cost	(e) Management Cost	(f) Risks for Exchange Rate	(g) Operation Day/Year	(h) SGA	(i) Net Profit	(X) Daily Rental Fee (USD)	Daily Rental Fee (Tsh)	Rental Fee per Borehole (Tsh)
1)	Truck mounted drilling rig	260,894.00			3.5%	3.0%	10%	197	30.2%	10%	307.18	491,488	2,948,928
2)	Trailer mounted air compressor	39,081.00			3.5%	3.0%	10%	139	30.2%	10%	65.21	104,336	
3)	Trailer mounted mud pump	30,740.00			3.5%	3.0%	10%	59	30.2%	10%	120.85	193,360	
4)	Trailer mounted pumping test unit	94,247.00			3.5%	3.0%	10%	69	30.2%	10%	316.82	506,912	
5)	Rig accessories	39,558.73			0.6%	3.0%	10%	197	30.2%	10%	38.41	61,456	368,736
6)	Casing tools	10,580.65			2.9%	3.0%	10%	197	30.2%	10%	12.01	19,216	115,296
7)	Fishing tools	2,538.39			1.4%	3.0%	10%	79	30.2%	10%	6.51	10,416	
8)	Direct mud circulation drilling tools & accessories	13,522.34			2.9%	3.0%	10%	59	30.2%	10%	51.23	81,968	

(Exchange Rate: 1USD = Tsh 1,600)

Rental Fee of a Drilling Rig with Rig Accessories and Casing Tools per Borehole: Tsh 3,432,960

Item 5), 6) and 8) above contain only accessories and tools to be attached to the drilling rigs for hiring. Consumables are not included.

Table 26 Structure of Rental Cost of Drilling Eqiupment (without Depreciation Cost Considered)

	Item	Depreciation Cost	Maintenance Cost	Management Cost	Risks for Exchange Rate	SGA	Net Profit	Annual Total Cost	Daily Rental Fee (USD)
1)	Truck mounted drilling rig	0	9,131.29	7,936.88	26,089.40	13,040.48	4,315.76	60,513.81	307.18
2)	Trailer mounted air compressor	0	1,367.84	1,188.92	3,908.10	1,953.42	646.49	9,064.77	65.21
3)	Trailer mounted mud pump	0	1,075.90	935.17	3,074.00	1,536.50	508.51	7,130.08	120.85
4)	Trailer mounted pumping test unit	0	3,298.65	2,867.17	9,424.70	4,710.83	1,559.05	21,860.40	316.82
5)	Rig accessories	0	237.35	1,203.45	3,955.87	1,630.66	539.67	7,567.00	38.41
6)	Casing tools	0	306.84	321.88	1,058.07	509.68	168.68	2,365.15	12.01
7)	Fishing tools	0	35.54	77.22	253.84	110.77	36.66	514.03	6.51
8)	Direct mud circulation drilling tools & accessories	0	392.15	411.37	1,352.23	651.38	215.58	3,022.71	51.23

11.3 BREAK-EVEN ANALYSIS

The break-even point in sales is obtained to estimate the minimum requirement of the annual operation days of one drilling rig. ***Table 27*** shows the estimated income and profit based on the revenue and expenditure indicated in Section 11.1. Items in the sales cost and administrative expenses are further categorized into the fixed cost and variable cost. The break-even point in sales can be calculated with the formula mentioned below;

Break-Even Point (in Sales) = Fixed Cost / 1 – (Variable Cost / Total Sales)

In case of the proposed business operation model, the break-even point in sales is approximately Tsh 733.4 million which is equivalent to the sales from hiring of drilling rigs for 846 unit days. The minimum requirement of the operation days of one drilling rig is, therefore, 141 days per annum to meet the break-even point. The business operation would suffer a loss if the hiring period of a drilling rig falls below 141 days a year. ***Figure 33*** shows estimated sales cost as well as profit or loss according to increase of the total of sales.

Table 27 Estimated Income and Profit

Item	Fixed Cost	Variable Cost	Amount (Tsh)	Proportion to Sales (%)
Revenue from Hiring Service			1,545,709,376	
Total of Sales			1,545,709,376	100%
Depreciation of Equipment for Hiring	x		381,712,640	24.7%
Maintenance Cost of Equipment		x	155,323,200	10.0%
Fuel and Lubricants		x	9,586,657	0.6%
Consumables for Drilling Rigs		x	9,306,560	0.6%
Allowance		x	146,490,000	9.5%
Total Cost of Sales			702,419,057	45.4%
Gross Profit			843,290,319	54.6%
Allowance for Management Team for Monitoring		x	3,120,000	0.2%
Allowance for Mechanic		x	15,975,000	1.0%
Advertisement on New Service	x		600,000	0.0%
Stationery (A4 paper)	x		240,000	0.0%
Other expenses	x		189,653,145	12.3%
Total of Administrative Expenses			209,588,145	13.6%
Net Operating Profit/ Loss			633,702,174	41.0%

Total of Fixed Costs	572,205,785	
Total of Variable Costs	339,801,417	
Variable Cost Ratio	22.0%	
Break Even Point (in Sales)	733,442,250	
Break Even Ratio	47.5%	
No. of Operation Days of Drilling Rig to Achieve BEP	846	days
No. of Operation Days of 1 Drilling Rig to Achieve BEP	141	days

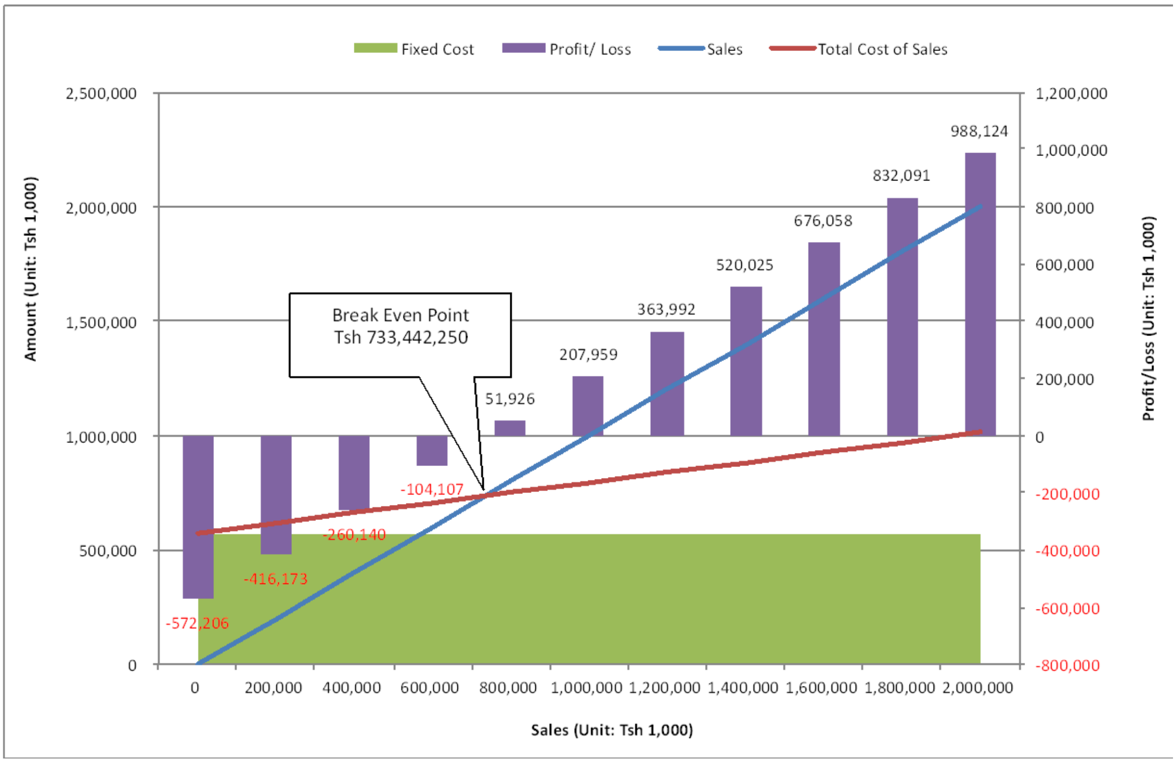


Figure 33 Break-Even Point in Sales

11.4 Accounting

DDCA is responsible to open and operate a special account for all transactions related to the equipment hiring service. The account shall be audited by Controller and Auditor General (CAG) or his appointee. In order to comply with Regulation 29 of Public Finance Act, the draft annual accounts should be ready latest by 15th September every year. The Annual Accounts shall be prepared on accrual basis in accordance with international/national standard format specified in the accounting manual.

In addition to the financial accounting required by the relevant laws and regulations, it is desired that DDCA will employ cost control as well as calculation of profits and losses by activity as a part of the managerial accounting.

11.5 Investment Plan

Sustainable operation of the hiring service requires both augmentation and replacement of the equipment to respond to demand by potential clients. Although MoW has not yet made it clear about a plan to purchase the remaining 12 units of drilling rigs in the subsequent phases of WSDP, it will be an opportunity for DDCA to increase available service options. DDCA will analyze demand of different types of clients and review combination of options of the equipment hiring and technical instruction. The Agency should approach MoW to procure appropriate types and specificaitons of equipment which will meet such service options.

Ministry of Water (MoW)
Drilling and Dam Construction Agency (DDCA)
Japan International Cooperation Agency (JICA)

DDCAP

Manual on Hiring of Drilling Equipment and Machinery

Version 1

March 2013

Groundwater Development and Management Capacity Development (DDCAP) Project

Table of Contents

List of Tables

List of Figures

1. PURPOSE AND INTENDED USERS OF THE MANUAL

This manual is intended to describe the business flow and procedures of daily operation of the hiring service of drilling equipment. It supplements the Gudelines on Hiring of Drilling Equipment which explains the business model and operation principles of the hiring service by DDCA.

This manual is the property of DDCA and to be used by authorized officers of the Agency only. Amendments and additions on the manual will be issued from time to time by the Business Support Manager after approval by the management of DDCA and Ministerial Advisory Board (MAB). Hiring Business Unit is responsible to keep all editions of the manuals approved.

2. PLANNING

2.1 PREPARATION OF ANNUAL PLAN

The annual plan of the hiring service is the basis for budgeting the business operation in the year. ***Annex 1*** shows a form for annual plan of operation of hiring service. The plan should include, but not limited to, the following contents;

(1) Basis of Calculation of Standard Operation Days of Equipment

The standard operation days of each type of equipment shows the estimated number of days for which one item of the equipment is to be hired annually. These are calculated in order to estimate expenditure budget. Parameters to be used for calculation of the standard operation days of equipment are shown in ***Table 1***. Historical records of the business operation are important reference data to set these parameters in order to make the plan more accurate.

Table 1 Parameters for Calculation of Standard Operation Days of Equipment

	Parameter	Reference Data
1.	**Calculated Annual Operation Ratio per Rig**	
1)	No. of days for maintenance per year	Historical records
2)	No. of days for transport between sites per year	Historical records
3)	Standby period of the equipment at DDCA yard per year	Historical records
4)	Total of non-operation days per rig per year	= 1.1) + 1.2) +1.3)
5)	Operation days per rig per year	= 365 days – 1.4)
6)	Average No. of days required to drill a well	Baseline survey (6 days/well), Historical records
7)	Average No. of wells which can be drilled per one rig per year	= 365 days / 1.6)
2.	**Assumption of Number of Hiring Contract per Rig**	
1)	No. of wells to be drilled in one contract	Historic records
2)	No. of contract per rig	= 1.7) / 2.1)
3.	**Assumption of Proportion of Drilling Method to be Applied**	
1)	Use of DTH method	Historical records
2)	Use of mud drilling method	Historical records
3)	Success rate of borehole drilling	Historical records

(2) Standard Operation Days of Equipment

Once the basis of calculation is set, the standard operation days of each item for hiring can be set as mentioned in ***Table 2.***

Table 2 Formula for Calculation of Standard Operation Days of Equipment

	Item	Calculation*
1)	Truck mounted drilling rig	= 1.5)
2)	Trailer mounted air compressor	= 1.6) x 3.1) x 1.7)
3)	Trailer mounted mud pump	= 1.6) x 1.7) x 10%
4)	Trailer mounted pumping test unit	= 1.7) x 3.3) x 3 days/ well
5)	Rig accessories	= 1.5)
6)	Casing tools	= 1.5)
7)	Fishing tools	= 40% of the operation day of drilling rig (The percentage should be reviewed based on hiritorical records.)
8)	Direct mud circulation drilling tools & accessories	= 1.6) x 1.7) x 3.2)

* The numbers in the column refer to the ones in Table 1.

(3) Equipment Arrangement Plan

Allocation of drilling rigs and other equipment among the headquarters and zonal offices should be decided with considering the following points;

- Geographical distribution of offices of potential hirers
- Geographical distribution of demand of construction of boreholes
- Capacity of each zonal office to attend repair and maintenance works

Information on the equipment arrangement plan will be used to estimate revenue and expenditure by station of the equipment.

(4) Pricing

The rental fee of each item for hiring is set with applying the formula shown in ***Figure 1***. Factors listed below should also be considered to finally decide the prices;

- Willingness to pay by different types of potential clients for the hiring service
- Level of reasonable profit to sustain the business
- Measures to minimize costs to secure the reasonable profit within the price set in consideration of the willingness to pay by the potential clients

Reason why these additional factors should be taken into account is that the cost-based pricing would result into decrease of sales itself if costs are reduced. In this situation, incentives to minimize costs are undermined during the business operation. Therefore, willingness to pay by different types of potential clients should be considered to set conditions of the service options including the rental fees for each type of client.

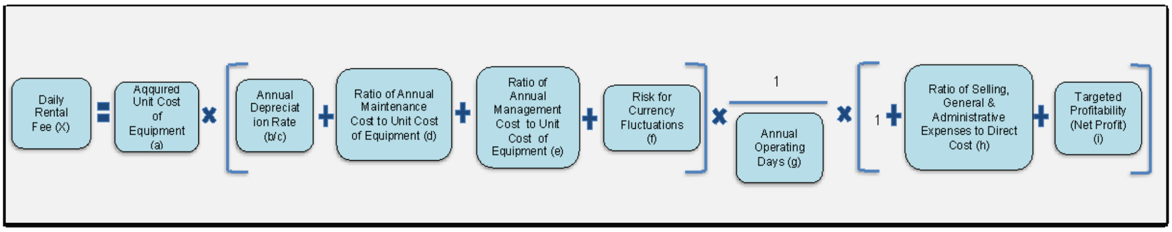


Figure 1 Formula for Pricing Rental Fee

2.2 BUDGETING

The budget for operation of the hiring service is to be included in the annual budget proposal of DDCA. For the budget preparation, reference should be made to accounting manuals of DDCA for overall guidance. Items listed in ***Table 3*** should be considered as expenditure budget. The revenue budget should be prepared based on estimation of sales from hiring of each item of the equipment with taking the standard operation days and proposed rental fees into account.

Table 3 Cost items to be Considered in Expenditure Budget

	Cost Item	Note
I.	Direct Cost	
1.	Maintenance Cost of Equipment	- Approximately 3.5% of the equipment price is applied while the percentage should be reviewed based on historical records of the maintenance cost. - Items consisting of rig accessories, casing tools, and direct mud circulation drilling tools and accessories are categorized into 1) items which are parmanently provided with the drilling rigs and 2) consumables which use is optional for the hirer. Maintenance cost should be considered for items grouped into 1) for these accessories and tools.
2.	Fuel and Lubricants	- The cost is to be considered 1) to drive carrier trucks for drilling rigs between DDCA's yard and client's site as well as from one drilling site to the other and 2) to conduct monitoring visit by the management team. - Fuel cost for operation of the rig plant and other equipment do not have to be included in the budget as hirers are responsbile to put fuel on the hired equipment as they use.
3.	Consumables for Drilling Rigs	- Items categorized into 2) mentioned in 1. Maintenance Cost are considered as consumables for drilling rigs. These items include bits, DTH hammers, stabilizers, casing shoes, steel work casing, and drill pipes. - DDCA will procure these items to keep as stocks for reselling to hirers when necessary. - Minimum level of stock of each item should be decided based on demand and historical records on sales of these items.
4.	Salary and Allowance for Staff to be Attached to Rigs	- Salaries and allowances for the technical instructors and drivers for carrier trucks for drilling rigs are to be considered. - Working days on site is calculated as a total of standard operation days and time to be take for transportation of drilling rigs.
5.	Depriciation of Equipment for Hiring	- The annual depreciation rate of 10% is applied to drilling rigs, air compressors, mud pumps, and pumping test units in accordance with the accounting manual of DDCA. The straight-line method is applied to culculation of depreciation.
II.	Indirect Cost – Selling, General and Administrative Expenses	
1.	Allowance for Management Team for Monitoring	- Frequency of the monitoring visit by the management team should be decided to estimate required amount of allowance.
2.	Allowance for Mechanic	- The cost is considered for the cases that mechanics are called for repair and maintenance of the equipment on site. - The number of working days on site should be estimated based on historical records of such maintenance activities.
3.	Advertisement cost	- For printing brochures, advertising in newspaper or any other media
4.	Stationery	
5.	Other Indirect Cost to be Partly Covered by Sales from the Hiring Service	Costs to be considered include, but not limited to, the following; - Salaries of administrative staff at the Hiring Business Unit and other departments/sections who are involved in administration and management of the hiring service. - Utilities - Office rent - Cost for training of staff of the Hiring Business Unit including the technical instructors

Hiring Business Unit should formulate the annual operation plan including equipment allocation, pricing and budgeting in consultation with Accounts Section, Procurement Section, Marketing and Public Relations Section, Maintenance Section, and zonal offices.

3. BUSINESS PROMOTION

Business promotion of the hiring service should be planned in the way that particular information reaches to specific (groups of) clients rather than treating the whole potential clients in same manner. Messages to be delivered and media to be used for the publicity should be chosen with considering characteristics of the potential clients.

Options of media for the advertisement are as follows;

- Mailing brochures to identified companies
- Introducing the service contents in regular and/or extraordinary meetings of Drilling Association of Tanzania (DAT) and Contractors' Registration Board (CRB)
- Advertising on newsletters of CRB for its members
- Advertising on newspaper

After deciding messages to be delivered to potential clients and means of publicity, materials for the advertisement should be designed and produced. ***Annex 2*** shows a sample brochure of the hiring service which is meant to be used during the lead time for launch of the service once all the details on the equipment and rental fees are confirmed.

Hiring Business Unit should prepare the plan for business promotion in cooperation with Marketing and Public Relations Section.

4. IDENTIFICATION OF CLIENTS

Annex 3 contains a contact list of private drilling companies and other entities which operate drilling works. These organizations were identified through the baseline survey of the private drilling companies. Although some of them were confirmed to be no longer in operation of the drilling works or not found about the status of their business due to unavailability of contact addresses, information on the list should be updated if there are any changes observed in the process of business promotion.

While iformation on the identified potential clients are maintained and updated, new clients should also be cultivated continuously. Information listed below can be referred to identify new potential clients;

- List of drilling companies holding water well drilling license issued by MoW
- CRB Directory
- Advertisement on newspaper
- Telephone directory
- Information from zonal offices of DDCA on drilling companies operating in respective zones

5. PROCESS OF EQUIPMENT HIRING

Figure 2 shows process of the equipment hiring starting from inquiries from potential clients up to return of the rented items. Administrative procedures to be followed in each stage of the process are summarized in ***Table 4***.

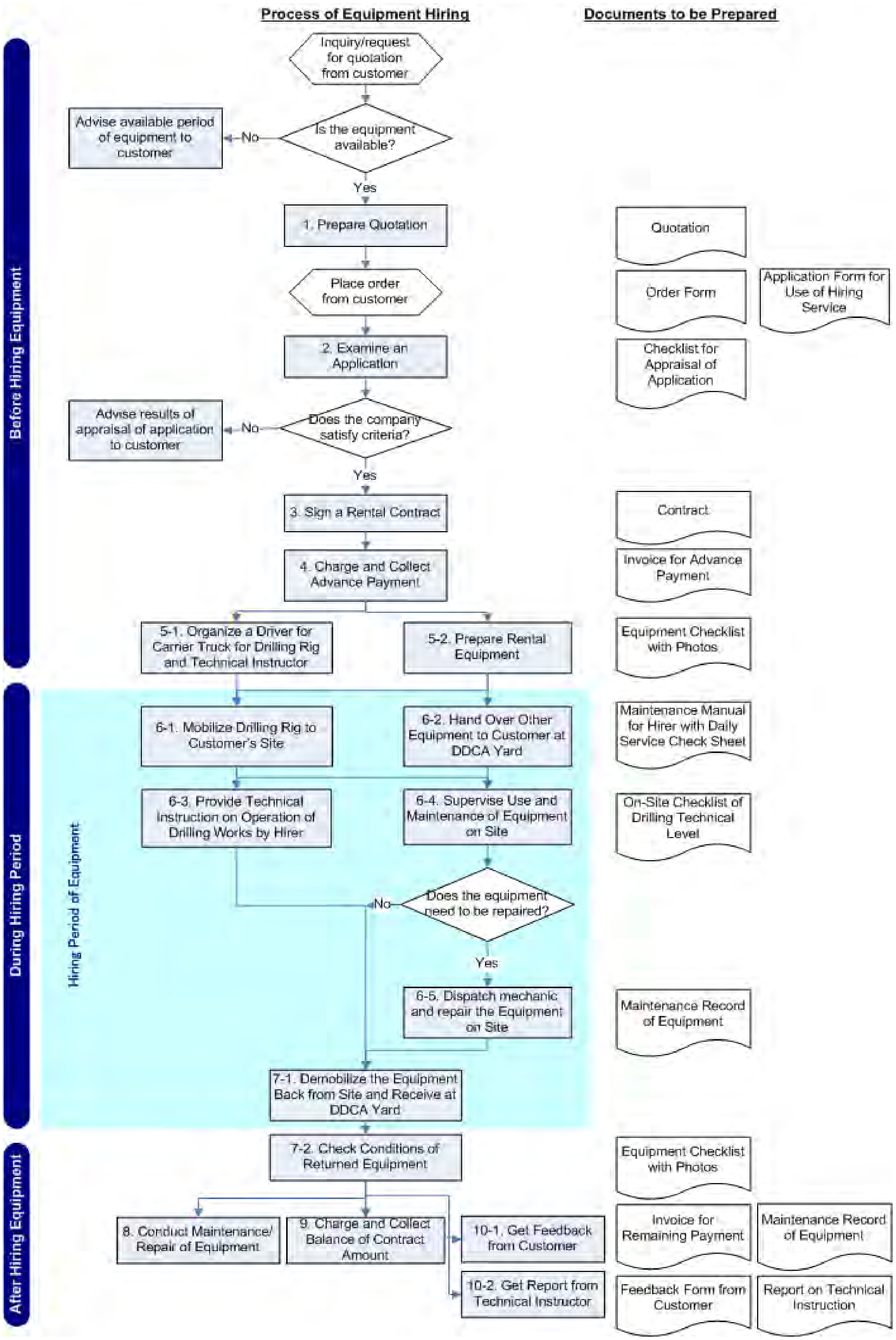


Figure 2 Process of Equipment Hiring

Table 4 Procedures of Equipment Hiring

Process	Procedure
1. Prepare Quotation	- Confirm if the requested equipment is available for the period inquired. - Provide a quotation if the item is available or write an advice on available period of the equipment if it is to be occupied.
2. Examin Application	- Receive an order and application form from a client. - Make an appraisal of the application based on the checklist to confirm if the client satisfies qualifications. - Advise restuls of appraisal to the client.
3. Sign a Rental Contract	- Prepare a rental contract. - If some conditions need to be changed or added to the standard contract form, consult with a Legal Officer on the conditions. - Explain terms and conditions to the client. - Sign two originals of the contract and give one to the client while the oher to be filed.
4. Charge and Collect Advance Payment	- Prepare a bill for an advance payment. - Confirm receipt of an advance payment.
5-1. Organize Personnel to be Attached to the Rig	- Inform a driver and technical instructor on the hiring period of the drilling rig, drilling sites, and particulars of the cllient. - Make arrangement of allowance for the staff.
5-2. Prepare Rental Equipment	- Submit a hiring equipment order form to Maintenance Section to inform of the equipment to be hired, the hiring period, drilling sites, and particlulars of the client. - Install necessary accessories and tools according to the order. - Refuel the carrier truck for rig palnt. - Check conditions of the equipment according to the equipment checklist. - Make sure that the equipment is services, cleaned and ready for hand over to the client. - Take photos of the equipment to be hired to record its condition before hiring.
6-1. Mobilize Drilling Rig to Client's Site	- Receive a signature from the client on the hiring equipment order slip and equipment checklist. - Start with the client to drilling site.
6-2. Hand Over Other Equipment to Client at DDCA Yard	- Receive a signature from the client on the hiring equipment order slip and equipment checklist. - Hand over all items ordered. - Provide the client with a maintenance manual for hirer with daily service check sheet and explain salient points on the daily service.
6-3. Provide Technical Instruction on Operation of Drilling Works	- The technical instructor gives advice on drilling works to the team from the client. - The technical instructor records observations on skills of the drilling team and management of the drilling works by the client in an on-site checklist of drilling technical level.
6-4. Supervise Use and Maintenance of Equipment on Site	- The technical instructor gives advice to the drilling team from the client on daily maintenance activities and safety measure to operate the equipment.
6-5. Dipatch Mechanic and Repair Equipment on Site	- The technical instructor informs Business Hiring Unit of damages on the equipment which requires repair works by a mechanic from DDCA. - Inform Maintenance Section of condition of the equipment and other details. - Make arrangement of allowance and means of transport for the mechanic. - Send the mechanic to client's site. - The mechanic attend the repair works and record the works conducted in the maintenance record of the equipment.
7-1. Demobilize the Eqiupment Back from Site and	- The driver demobilizes the drilling rig from the site. - Receive all the equipment from the client at DDCA yard.

Process	Procedure
Receive at DDCA Yard	
7-2. Check Condition of Returned Equipment	- Receive a signature from the client on a returning slip. - Check condition of the equipment according to the equipment checklist and record any defects which were not observed before hiring. - Take photos of the equipment to record its condition after hiring. - Confirming the condition of the equipment by comparing the "hiring equipment check list (before and after hiring)" and the photos of the hiring equipment (before and after hiring) - Receive a signature from the client on the equipment checklist which describes condition of the equipment after hiring.
8. Conduct Equipment Maintenance/ Repair	- Wash and clean the equipment. - Inspect the equipment in accordance with the periodic service checklist. - Repair damages or defects on the equipment. - Inform Business Hiring Unit of necessity of procurement of accessories, tools, or spares of the equipment, if any
9. Charge and Collect Balance of Contract Amount	- Prepare a bill for remaining payment including repair cost incurred due to misuse of the equipment by the client, if any. - Send the bill to the client together with 1) feedback form from the client and 2) a copy of hiring equipment checklist and photos showing condition of equipment before and after hiring in case that there are any defects on the equipment caused from misuse by the client. - Confirm receipt of the payment.
10-1. Get Feedback from Client	- Collect a feedback form filled by the client. - Check if any acitons should be taken to claims raised by the client.
10-2. Get Report from Technical Instructor	- Collect the on-site checklist of drilling technical level and report from the technical instructor. - Confirm with the technical instructor if any actions should be taken to improve service provision.

6. APPRAISAL OF APPLICATIONS

Hiring Business Unit will make an appraisal of each application form for the equipment hiring submitted by clients. The purpose of the appraisal is to screen qualified drilling companies which satisfy conditions mentioned below;

- To possess a valid water well drilling permit issued by MoW.
- To be registered as the specialist contractor at CRB.
- To have at least one permanent employee among the drilling staff to be on site with the hired equipment and to receive the technical instructions from DDCA.

Annex 6 and ***Annex 8*** show an application form for the equipment hiring and checklist for appraisal of applications, respectively. In case that the applicant does not meet the conditions on possession of drilling permit and/or registration at CRB, Hiring Business Unit should give advice to the company to consult with the respective authorities for required procedures.

7. CONTRACT MANAGEMENT

The contract management involves the following procedures;

- Preparation of the standard contract form
- Preparation of a contract for each case of hiring
- Signing of the contract
- Billing and collection of payment
- Check of fulfillment of terms and conditions by both parties
- Claim on implementation of obligations of the hirer

Preparation and revision of the standard contract form should be done in consultation with Legal Officers of DDCA. Further advice can also be obtained from Legal Unit of MoW when necessary.

Once the appraisal of the application form is completed and the hirer is selected, Hiring Business Unit prepares a rental contract of the equipment. A sample contract form is attached in ***Annex 9***. Particulars on the hirer, equipment to be hired, hiring period and charges should be filled in the first page of the contract form while general conditions of the contract is to be stipulated in the following pages.

8. ALLOCAITON OF STAFF TO BE ATTACHED TO THE HIRED EQUIPMENT

One driver and technical instructor will be attached to each drilling rig to be hired. Roles of these personnel should be referred to the Guideline on Hiring Drilling Equipment. The technical instructors will provide guidance and advice to the drilling team of the client on operation of drilling rigs and implementation of the works on site in accordance with the Capacity Development Support Plan for the Private Sector and Technical Manual for Drilling Works.

The technical instructors should record the on-site checklis of the drilling technical level based on observations of works conducted by the client's drilling team. The technical instructors should also prepare a report on technical instruction to be submitted to Hiring Business Unit after completion of the hiring period. ***Annex 10*** shows a report from on technical instruction

9. MAINTENANCE

9.1 DEMARCATION OF RESPONSIBILITIES IN MAINTENANCE OF THE HIRED EQUIPMENT

DDCA will be responsible for preventive maintenance and repair works of the equipment before the equipment is hired and after the items are returned from the hirer. Maintenance Section conducts necessary maintenance works in accordance with the guidelines, plan and manuals for maintenance system of the equipment for hiring which are formulated separately.

On the other hand, the hirer will conduct routine maintenance of the hired equipment on site under supervision of the technical instructor from DDCA. DDCA will provide the hirer with a maintenance manual for hirer with daily service check sheet which describes procedures of daily maintenance check and safety measures. The hirer wil bear the costs to be incurred for routine maintenance and repairs required during operation of the equipment on site.

For any mechanical troubles which cannot be attended by the drilling staff from the hirer or technical instructor, DDCA will send a mechanic to the site either from the headquarter or the nearest zonal office. When any damages or defects occur on the equipment and repair works by the mechanic are required, the technical instructor will inform Hiring Business Unit of details on condition of the equipment upon confirmation with the hirer. Costs to remedy damages or defects caused on the equipment by misuse of the hirer should be borne by the hirer.

9.2 Preventive Maintenance

Maintenance Section is responsible to conduct preventive maintenance of the equipment for hiring to keep it in good condition. The Maintenance Guidelines and Manual should be referred to for implementation of the preventive maintenance works.

9.3 Inspection and Maintenance of Returned Equipment

Using the equipment checklist (***Annex 11***), Maintenance Section will check condition of the equipment to be hired before handing over to the hirer and after receiving it. Pictures of the equipment should be taken to record condition of before and after the hiring in order to check if any damages or defects occur on the equipment during the hiring period.

Maintenance Section will send a mechanic to the client's site to attend repair works when Hiring Business Unit requests it upon receipt of notice of breakdown of the equipment. The mechanic will fill in the maintenance record describing problems, causes, repair works conducted, and spares replaced.

In case that the hiring period extends more than one month, Hiring Business Unit will make an arrangement to dispatch a mechanic to the client's site to get the equipment serviced even if there is no breakdown or defect reproted.

10. HANDLING OF ACCIDENT

10.1 Insurance

This section will be finalized after DDCA decides demarcation of responsibility on insurance cost based on consultation with MoW and Ministry of Finance and Economic Affairs.

10.2 Handling of Accident Cases

The equipment to be hired should have a sticker on its body to clearly indicate that it belongs to DDCA.

This section will be finalized after DDCA decides demarcation of responsibility on insurance cost based on consultation with MoW and Ministry of Finance and Economic Affairs.

11. INFORMATION MANAGEMENT ON CLIENT

Hiring Business Unit will keep and update particulars of the clients and comments from them about services provided by DDCA. Information to be maintained by the Unit includes, but not limited to, the following;

- Name, physical address and contact of the organization
- Name and position of the representative person for contact
- Year of acquisition/ renewal of the water well drilling permit issued by MoW
- Registration No. of the specialist contractor at CRB
- Records of equipment hired and hiring period
- Contract amount

- No. of boreholes drilled (both successful and unsuccessful) with the hired equipment, drilling sites
- Feedback from (***Annex 12***) from the client on technical instruction, condition and capacity of equipment, rental fees, etc.

12. FINANCIAL MANAGEMENT

12.1 ACCOUNTING

Accounts Section is responsible for the financial accounting of the hiring service, which is supposed to be conducted in accordance with the accounting manuals of DDCA. In addition to the financial accounting required by the relevant laws and regulations, the cost control as well as calculation of profits and lossess by the hiring service should be conducted by Business Hiring Unit in conjunction with Accounts Section as a part of the managerial accounting.

12.2 REPORTING

Hiring Business Unit will compile the financial status of the hiring service based on sales and expenditure records at Accounts Section and included it in the monthly reports.

13. ASSET MANAGEMENT

13.1 PROCUREMENT OF CONSUMABLES

Maintenance Section will report it to Hiring Business Unit when there is necessity to replace spare parts and/or purchase accessories and tools of the equipment for hiring. Hiring Business Unit will inform details on required items to Procurement Section for further arrangement to purchase them. A procurement plan of the consumables should be prepared to ensure timely arrangement of the required items.

13.2 REPLACEMENT PROCUREMENT OF DRILLING EQUIPMENT

Hiring Busienss Unit will make a plan for replacement of the equipment or procurement of new items in consultation with Procurement Section and Accounts Section. Replacement of the equipment should be implemented based on procedures for depreciation of the equipment and plant stipulated in the accounting manual. For investment for new items of equipment, Hiring Business Unit will analyse which type of equipment is required by different groups of clients.

14. PERFORMANCE MONITORING

Business Hiring Unit should prepare monthly reports on business operation not later than 10 days after the end of every month. The report describes operational and financial status of the hiring service. ***Annex 13*** shows a monthly report form. The Unit should compile an annual report based on the monthly reports and submit it not later than 14 days afte the end of every year. Performance indicators listed in ***Table 5*** should be used for monitoring and reporting.

Table 5 Performance Indicators of the Equipment Hiring Service

Purpose	Indicators	Means of Verification	Frequency of Monitoring
1. Process Management	1-1. Drilling equipmemt is hired in accordance with the procedures established. 1-2. All drilling equipment for	1-1. R ec or ds	

Purpose	Indicators	Means of Verification	Frequency of Monitoring
	hiring is maintained in accordance with the maintenance plan. 1-3. Internal management accounting document for hiring is reported periodically to the management.	for hiring 1-2. Maintenance records of drilling equipment for hiring 1-3. Reports on hiring service	
2. Managemenet of Output of the Service	2-1. The number of operation days of a drilling rig for hiring reaches to 141 days per annum on average, the break even line of the hiring business[1], by 2016.	2-1. Records for hiring	2-1. Monthly
	2-2. More than 80% of the registered water well drilling companies utilize some forms of the technical support services by 2016.	2-2. Records for hiring	2-2. Monthly
	2-3. More than 80% of private drilling	2-3. Feedback forms from clients	2-3. Each hiring conctract, Monthly

[1] See Section 11.3 for an estimation of the break even line of the hiring business.

Purpose	Indicators	Means of Verification	Frequency of Monitoring
3. Management of Outcomes	companies, which used the technical support services provided by DDCA, consider that the services they received helped their business activities. 3-1. The number of private companies which use the technical support services of DDCA and participate in drilling works in WSDP increases by 122% by 2018, compared to the status before official launch of the service provision. 3-2. The number of wells planned in WSDP is constructed by 2015.	3-1. Records for hiring, Water Sector MIS 3-2. MoW Annual Water Sector Status Report, Water Sector MIS	3-1. Annually 3-2. Annually

ANNEXES

1. **FORM FOR ANNUAL PLAN OF OPERATION OF HIRING SERVICE**
2. **SAMPLE BROCHURE OF HIRING SERVICE**
3. **CONTACT LIST OF PRIVATE DRILLING COMPANIES**
4. **FORM FOR REQUEST FOR QUOTATION**
5. **QUOTATION FORM**
6. **APPLICATION FORM FOR HIRING OF DRILLING EQUIPMENT**
7. **ORDER FORM**
8. **CHECKLIST FOR APPRAISAL OF APPLICATIONS**
9. **SAMPLE CONTRACT FORM**
10. **FORM FOR REPORT ON TECHNICAL INSTRUCTION**
11. **CHECKLIST OF EQUIPMENT**
12. **FEEDBACK FORM FROM CLIENT**
13. **MONTHLY REPORT FORM**

Annex 1 Form for Annual Plan of Operation of Hiring Service

Annual Plan of Operation of Hiring Service for (Year)

1. Items to be Hired and Equipment Arrangement Plan

Item	Specification	Qty	Station

2. Basis of Calculation of Standard Operation Days of Equipment

1.	**Calculated Annual Operation Ratio per Rig**		
1)	No. of days for maintenance	days/year	
2)	No. of days for transport between sites	days/year	
3)	Standby period	days/year	
4)	Total of non-operation days	days/year	=1)+2)+3)
5)	Operation days	days/year	
6)	No. of days required to drill a well	days/well	
7)	No. of wells which can be drilled	wells/rig/year	
2.	**Assumption of Number of Hiring Contract per Rig**		
1)	No. of wells to be drillied in one contract	wells	
2)	No. of contract per rig	/ year	
3.	**Assumption of Proportion of Drilling Method to be Applied**		
1)	Use of DTH method	% of total number of wells to be drilled	
2)	Use of mud drilling method	% of total number of wells to be drilled	
3)	Success rate of drilling	%	

3. Standard Operation Days of Equipment

	Item	Qty	No. of Operation Days per Annum	Calculation

4. Pricing of Rental Fees

	Item	Price (Tsh)	Condition (if different prices are set for different service options)

5. Budget

5-1. Revenue

No.	Item	Annual Sales/ Unit (Tsh)	Q’ty	Annual Total Sales (Tsh)
	Total			

5-2. Expenditure

No.	Item	Unit	Unit Cost	Q’ty	Amount (Tsh)	Note
	Direct Cost – Total					
	Indirect Cost – Total					
	Grand Total					

Annex 2 Sample Brochure of Hiring Service (Front)

Drilling and Dam Construction Agency (DDCA)

We offer hiring service of drilling equipment for water well construction

Picture of the Equipment

Truck Mounted Drilling Rig (6 units)

Rotary cum DTH
Maximum drilling depth 150m

Picture of the Equipment

Trailer Mounted Air Compressor (5 units)

650CFM, 246 psi

Picture of the Equipment

Trailer Mounted Mud Pump (5 units)

20kg/cm^2, 600 l/min.

Picture of the Equipment

Trailer Mounted Pumping Test Unit (5 units)

Generator, riser pipe, submersible pump

- Bits, DTH hammer, drill pipes and other consumables are on sale from our stocks if you need them.
- The truck mounted drilling rig will be hired with a truck driver and technical instructor who provides technical assistance and guidance on operation of the rig to your drilling team including a rig operator on site. Per diem for the truck driver and technical instructor is included in the rental fee. The owner (DDCA) is responsible for fuel for the carrier truck of the rig plant during mobilization from and demobilization to DDCA's yard and for transportation among hirer's sites.
- The hirer (client) is responsible for fuel as used during the operation of the rig plant on site.
- The hirer is also responsible to arrange carrier trucks and fuel for transportation of the compressor, mud pump, and pumping test unit when these items are hired.

Picture of technical instructors providing guidance to a drilling team on site

Support for Capacity Development of Your Drilling Team

Our technical instructors are specialized in providing hands on training and guidance to drilling teams in various technical areas related to drilling works. Such areas include drilling techniques, borehole logging, casing program/ installation, gravel packing, well development, well investigation, tool fishing, well rehabilitation, puming test, and water quality analysis. The technical instructors will help your staff members in the drilling team enhance their skills to conduct quality works with efficiency.

Annex 2 Sample Brochure of Hiring Service (Back)

- Conditions for Use of DDCA's Equipment Hiring Service –

The drilling equipment for hiring was procured by the Ministry of Water to facilitate participation of private drilling companies in works for exploratory drilling and development of production wells under the Water Sector Development Program (WSDP) aiming at increase of water supply coverage to 90% in rural area and 100% in urban area by 2025. DDCA operates the hiring service of these drilling rigs and other equipment as a part of the technical support service for private drilling companies. In the light of this background and expected outcomes from utilization of the procured equipment, those who would like to use this hiring service are expected to satisfy the following conditions as the hirer;

[Requirements to Applicants]

1. To possess a valid water well drilling permit issued by the Ministry of Water.
2. To be registered as a specialist contractor at the Contractors Registration Board (CRB).
3. To have at least one permanent employee among the drilling staff to be on site with the hired equipment and to receive guidance from a technical instructor attached from the owner.

[Use of the Equipment]

The first priority is given to those who are going to use the equipment for drilling works funded by WSDP or any other government-funded water supply projects. The equipment will also be made available to those who work for borehole drilling financed by the private sector including individual households.

Please consult with the Ministry of Water and CRB, respectively, for procedures required for acquisition of a water well drilling permit and contracotor's registration.

Request quotation → Submit application form & order form → Sign a rental contract → Settle advance payment → Receive equipment at DDCA's yard → Mobilize equipment and operate on site → Return equipment to DDCA's yard → Confirm condition of equipment → Settle the balance

Process of Equipment Hiring

For further information:

Hiring Business Unit
Drilling and Dam Construction Agency (DDCA)

Tel: +255-22-2410430 / 255-22-2410299 Fax: +255-22-2410430
Email:
P.O. Box 55658 Ubungo, Off University Road, Kinondoni, Dar es Salaam

Annex 3 Contact List of Private Drilling Companies

Involvement in Drilling Works (1: Yes, 2: No, 3: Unkown)	Company Name	CRB Registration/ Classification	Possession of MoW Drilling Permit Confirmed in Survey (1: Yes, 2: No)	Latest Year of Renewal of MoW Drilling Permit Confirmed in Survey	Experience in Drilling Works in WSDP (1: Yes, 2: No)	P.O.Box	Region	District	Ward	Sub-ward/Village	Street/Sub-Village	Plot No.	Tel.	Fax	E-mail	Note
1	Africa Poverty Wells, Water Works and Environmental Ltd	Specialist Drilling Contractor-Class 3 (SPC3/0340/07/07)	2		2	P.O.BOX 605	MWANZA				Kitangiri Street	Plot.No.42, Block B	0754614334			The company has neither drilling rigs nor drillers. Conducts drilling with hired rigs and drillers.
1	Al-Water Well Drillers	Not Registed	1	2012	2	4964	DSM	Ilala	Jangwani	Jangwani	Morogoro Road/ Msimbazi street	JANGWAN/40	0754263582		eddie02sehel@yahoo.com	
1	AL-TTAI Drilling company Ltd	Not registered	1	2011	2	23485	DSM	Ilala	Mchafukoge	Algeria			222133455		fahmy-f@hotmail.com	
1	Amini Tech Company Ltd	In Process	1	2009	2	2241 DSM	DSM	Kinondoni	Kimara	Kimara Matangini	Morogoro Road	Squater Area	0784880100/ 0658780100		aminitech@gmail.com	
1	Aqua Well drilling Company Ltd	specialist Contractor: Class 2	1	2011	1	13795 DSM	DSM	Ilala	Mchikichini	Mchikichini	Msimbazi Street	2 block J	222181866	22218867	info@aquawell.co.tz	
1	Aquaman Drillers Ltd	In Process	1	2011	1	14764 ARUSHA	ARUSHA	ARUSHA	Njiro	Njiro		233 Block C	0787901010	25500483	aquamandrillers_arnd@yahoo.com	
1	Ardhi Water Wells Ltd	Not Registered	1	2012	1	38520	DSM	Ilala	Gerezani			80	0716990777		ardhiwaterwells@gmail.com	
1	Arusha Aggregates Ltd	Specialist Contracto Drillingr: Class 3 (SPC3/0417/8/09), Civil Works Contractor: Class 6 (C6/0757/8/09)	1	2011	2	2547 Arusha	Arusha	Arusha	Sakina	Urundini, Geleza Mwendo Street	Majengo Saccon	176 Blou9ck "FF" Sakina	0783906980	0727508962/ 025489556	arusha aggregates@yahoo.com/ info@arushaaggregates.com	
1	AS Drilling Company Ltd	Not Registered	1	2011	2	12125	ARUSHA	Arusha Town	Njiro	Njiro	Njiro Road	199 Njiro	0784269777		asdrilling@gmail.com	
1	Ashraf Water Wells Drilling Company	In Process	1	2011	2	1691 DSM	DSM	Kinondoni	Makongo			KAW/MKG/437	0715475600			
1	B.R.A	Not Registered	2		2	10693	DSM	Ilala	Gerezani	Omari Lonao	Sikukuu/Somari	44	2185485			
1	Bahadele Drilling Company	Not Registered	1	2012	2	25081	DSM	Ilala	Buguruni	Sokoni/Madenge	Madenge	08/Buguruni	222862724			
1	Basat Contractors Ltd	Civil works Contractor: Class 5	1	2008	2	12545	DSM	Ilala	Gerezani Kariakoo	Kariakoo/Mnazi mmoja	Lumumba street		222183931	222183931	basattz@yahoo.com	
1	Bubujiko Enterprises	In Process	1	2012	2	732 DSM	DSM	Temeke	16 Mtoni	Mtoni	Kilwa Road	House No. 83	0755533921		bubujikoenterprises@gmail.com	
1	Chem Chem Drilling Co. Ltd	Specialist Contractor: Class 2	1	2011	2	12893 ARUSHA	Arusha	Arusha	Ungalimited			136-138 Unga Ltd	0786551221		chemchemdrillingtz@gmail.com	
1	Chem Chem Well Drilling Company	Not Registered	2		2	45243	DSM	Temeke	Chang'ombe	Chang'ombe	Dry Dox Area	113/112-chang'ombe road	0713759183	22856315	chemchem77@hotmail.com	
1	Chimba Resources	Specialist Contractor Drilling: Class 1 (SPC1/0279/01/10)	1	2011	1	169 DSM	DSM	Kinondoni	Mikocheni "B"		Sembeti	154 BLK A	0786200535/ 0684200111		mwita25@gmail.com	
1	Civotech Ltd	Specialist Drilling Contractor-Class 2 (SPC2/0131/12/10)	2		2	P.O.BOX 22312	DSM			Ubungo Area	Mandela Road	Plot.No.561	022-2451376			The company has neither drilling rigs nor drillers. Conducts drilling with hired rigs and drillers.
1	CJEJOW Company Ltd	Specialist Drilling Contractor-Class 3 (SPC3/0525/6/11)	1		2	P.O.BOX 1030	SONGEA				MBINGA ROAD	ROOM NO.13,KAURA BUILDING,	025 2602166/ 0755 398165/ 0754 769622		nkndl@yahoo.com	
1	CMG Construction Company Ltd	Civil Works Contractor:Class 3, Building Contractor: Class 3	1	2012	2	235 MWANZA	Mwanza	Nyamagana	Maiwa	Nyakato	Musoma Road	70,71,72,73	0754854166	282570677	cmg@nbcl.biz	
1	Coast Water Well Company	In Process	1	2011	2	5066 DSM	DSM	Ilala	Kisutu	Kisutu	Upanga/ Al Hassan Mwinyi	299/72	0713777877		mohd540@gmail.com	
1	Drill Mat & Ground Water Services Ltd	In Process	1	2011	2	35812DSM	DSM	Kinondoni	Mlalakuwa		Sam nujoma	113/114	0754619498		drimadril@gmail.com	
1	Drilling Spares and Services Ltd	Not Registered	1	2010	2	40859-00100 NAIROBI,KENYA	Kenya	Nairobi		Mombasa Road	L/R 209/10795		0722204761	(020) 3540208	dss@inconnect.co.ke	
1	Efam Limited	Specialist Contractor: Class 2 (SPC2/0121/3/10)	1	2011	1	14014	DSM	Kinondoni	Makubusho	Kijitonyama	Ali Hassan Mwinyi	40	222771473		fatma@efamtz.com/ jihagula@efamtz.com	
1	ELCT Southern Dioces (Konde Diocese)	Not Registered	2		2	97 Njombe	Njombe	Njombe	Njombe Town				0762581836/ 0769698995/ 0764768944		electsd@yahoo.com	

Involvement in Drilling Works (1: Yes, 2: No, 3: Unkonwn)	Company Name	CRB Reginstration/ Classification	Possession of MoW Drilling Permit Confirmed in Survey (1: Yes, 2: No)	Latest Year of Renewal of MoW Drilling Permit Confirmed in Survey	Experience in Drilling Works in WSDP (1: Yes, 2: No)	P.O.Box	Region	District	Ward	Sub-ward/Village	Street/Sub-Village	Plot No.	Tel.	Fax	E-mail	Note
1	Future Century Limited	Specialist Contractor: Class 1, Foreign	1	2011	2	301 BAGAMOYO	COAST	Bagamoyo	Kitopeni	Bagamoyo Road			0715339360/ 0774291110		info@futurecentury.com/futurecentury@hotmail.com	
1	Gaimo Construction Co. Ltd	Building Contractor: Class 3 (B3/0285/6/11)	1	2011	2	13489	ARUSHA	ARUSHA	Ololieni	Moshono	Mandela Road		0754264837	272502112	gaimo.connstruction@gmail.com	
1	Gem and Rock Ventures Co. Ltd	Civil Works Contractor: Class 5 (C5/0371/08/2009)	1	2012	2	2701	ARUSHA	Arusha City Centre	Mjini Kati		Azimio Street	7,8, & 9 BLOCK 'F' ARUSHA CITY	27 2508462	27 2508462	gemrock@habari.co.tz	
1	Geotech Resources Exploration & Development Ltd	Specialist Drilling Contractor- Class 2 (SPC2/0111/12/08)	2		2	P.O.BOX 114	MBEYA				Karume Avenue, Sokoine Stadium		0754-853987			The company has neither drilling rigs nor drillers. Conducts drilling with hired rigs and drillers.
1	Drilling Partinership Co. Ltd (GETA)	Not Registered	1	2012	2	30319 DSM	DSM	Kinondoni	Ursno Estate	Ursno Estate		53	0762215654		jkahendaguza@yahoo.co.uk	
1	Global Resource Alliance-TZ	Not Registered	1	2011/2012	2	721 MUSOMA	Mara	Musoma	Nyakato	Baruti	Baruti	Rwe Yard	282622787		estheraph@yahoo.com	
1	Global Tech Drillig and Exploration Ltd	In process	2		2	19996 DSM	Mwanza	Ilemela	Bwiru				0762/0655786007		globaltech@gmail.com/globaltech@yahoo.com	
1	Groundwater Exploration & Well Construction Co. Ltd	Specialist Contractor Class 1 (Reg No: SPC1/0243/12/08)	1	2011	2	11464	Mwanza	Nyamagana	Nyamagana	Nkuruma/Uhuru	Uhuru/M/Nkuruma		0754593401		geweco98@yahoo.co.uk/andysangija@yahoo.com	
1	Ham Drillers Ltd	In process	1	2012	2	888	DSM	Kinondoni	Kawe	Kanga street	Tembo	343 Block E	0715586187		hamdrillers@yahoo.com	
1	Himalaya Enterprises LTD	Not registered (Registered to BRELA)	1	2011	2	40774	DSM	Ilala	Segerea	Tabata Segerea	Segerea Road	They don't know/ Not seen at the gate	0782796297/ 0654819864		hxp600@163.com	
1	Holland Farm Ltd	Water Well Drilling Contractor: Class 7	1	2007	2	8152	DSM	Temeke	Kigamboni	(Tua Moyo) Magogoni	Mji Mwema Road	TMK/KGN/TMY7/37	0713565758		daddyatik@yahoo.com	
1	Humac Services Ltd	In process	2		2	162 MWANZA	Mwanza	Nyamagana	Mahina	Humac	Musoma Road	162163 industry Area/ Block-Igoma	0784823150		truckstar@yahoo.com	
1	Hydro Tech (T) Ltd	Specialist Contractor: Class 2 (SPC 2/0002/3/2000)	1		1	32803 DSM	DSM	Kinondoni	Kijitonyama	New Lutheran Church (Mwenge)	Nzasa	291/43	222772823	222772823	hydrotecht@gmail.com	
1	J.N.M Mining Services Ltd	Not Registered	2		2	11940	DSM	Kinondoni	Sinza	Sinza	Mori Road		0658440278/ 0784440278/ 0755440278		jmwakabage@gmail.com/jmwakabage@yahoo.com	
1	K'S Interprice LTD	In Process	2		2	993	Kilimanjaro	Moshi	Kiboroloni	Kiboroloni	Kiboroloni		0272754327/ 0689350157		ksenterprise Ltd@gmail.com	
1	Karumba Drilling Engineering & Transport Co. Ltd	Specialist Drilling Contractor- Class 3 (SPC3/001/4/99)	1		2	P.O.BOX 1195	SONGEA			Kijitonyama		Plot. No.775	025-2602443			
1	Kikim Building Geotechnical and Drilling Contractors	C6/0359703, Civil Work Class 6	2		2	79360	DSM	Ilala	Jangwani	Morogoro Road/ Bibi Titi	UWT/ Morogoro Road	Bakwata Building	02222180927/65	(022)22180927	kikiim1974@yahoo.com	
1	Kilimanjaro Water Well Drilling	Not Registered	1	2011	2		DSM	Kinondoni	Wazo	Tegeta Kibaoni	Bagamoyo Road		0713-543889		kilimanjarodrilling@yahoo.com	
1	Kimani Minerals Ltd	Not Registered	2		2	70812	DSM	Kinondoni	Ubungo	Ubungo Plaza	Morogoro Road	Ubungo Plaza 10th floor	0758074630	(022) 2460948	sgwamaka@paulsam.co.tz	
1	Layne Drilling (T) Ltd	specialist Contractor: Class 2	1	2011	2	726 MOROGORO	Morogoro	Morogoro Urban	Mwembe songo	Msamvu area	Magodoro	22 Block "C"	0787989499		mal.edmonds@layne.com	
1	Development Company Limited	Not Registed	1	2012	2	35599	DSM						0657228608		lrdcl.tz@gmail.com	
1	Lima Economic and Development Group	In Process	1	2011	2	10946 DSM	DSM	Temeke	Machimbo	Yombo Vituka	Limbowa	V/MACA/1948	0786472240		ledegro@yahoo.com	
1	Lugoba Stones and Construction Co. Ltd	Specialist Contractor: Class 1	2		2	39819 DSM	DSM	Kinondoni	Ursno Estate			53	0789161607		jkahendaguza@yahoo.com	
1	Lweru Water Wells Drilling Company Ltd	Not Registered	1	2012	2	71711	DSM	Kinondoni	Kawe	Mbezi beach		42E (Block J)	0715782452		info@lweruwaterwellsdrilling.com	
1	M & M (T) Ltd	Not Registered	2		2	31609	DSM	Kinondoni	Kawe	Mbezi Juu			0784274651		mmtzltd@gmail.com/irmnyau@yahoo.com	
1	Maji Tech Engineering Ltd	Specialist Contractor Drilling and Waterworks: Class 1	1	2012	1	189	Arusha	Arumeru	Maji ya Chai	Mommela Road	Kiwawa		0736502476/ 0784667163	0736502476	sales@majitech.com	
1	Make Eng and Water Works Ltd	Specialist Contractor: Class 2 (SPC2/0070/05/06)	1	2012	1	12240	DSM	Kinondoni	Ubungo	Urafiki	Morogoro Road	Block H	0752991448	2552460286	makeengineering@yahoo.com	

Involvement in Drilling Works (1: Yes, 2: No, 3: Unkonwn)	Company Name	CRB Reginstration/ Classification	Possession of MoW Drilling Permit Confirmed in Survey (1: Yes, 2: No)	Latest Year of Renewal of MoW Drilling Permit Confirmed in Survey	Experience in Drilling Works in WSDP (1: Yes, 2: No)	P.O.Box	Region	District	Ward	Sub-ward/Village	Street/Sub-Village	Plot No.	Tel.	Fax	E-mail	Note
1	Marata Plumbers & Drillers Ltd	In Process	1	2011	2	13805 DSM	DSM	Kinondoni	Mwenge	Mwenge	Aly Hassan Mwinyi		0715804666		maratatz@yahoo.com/jmachange@yahoo.com	
1	Maswi drilling company Ltd	Specialist Contractor: Class 2 (Reg No. SPCI/0287/5/10)	1	2012	1	2197 MWANZA	DSM	Ilala	Kariakoo	Jangwani	Skukuu/msimbazi	plot No.8, block 36	0786469765	282560638	maswidrillngcoltd@yahoo.com	
1	Mavonda's Company Ltd	Building Contractor: Class 4 (B4/0330/8/09)	1	2010	2	63242	DSM	Ilala	Upanga	Bibi titi	Bibi titi	Sido BLG	222150011	222150011		
1	MC Water Wells Drilling Co. Ltd	Not Registered	1	2010	2		DSM	Temeke	Kitunda	Kitunda	Banana-Kitunda Road		0713933807/ 0717118858			
1	Mkongo Building & Civil Works Consructors		1		1											
1	MR. Water Drilling Company Ltd	Not registered	1	2011	2	8383	DSM	Ilala	Kinyerezi	Kinyrezi	Kifuru	Block "B"-129	0787879946			
1	Msabi (Maji Safi kwa Afya Bora Ifakara)	Not Registered	2		2	284	Morogoro	Ifakara	Ifakara	Ifakara Town	Kilosa Road		0767896254/ 0657643844/ 0688688635		msabiwater@gmail.com	
1	Muwanya Well Drilling	In Process	1	2012	2	97 DSM	DSM	Kinondoni	Kambangwa	Kanga street		595	0717700655		muwanyadrilling@gmail.com	
1	Nassa GeneralTraders Limited	Not Registered	1	2011	2	36 Bariadi	Shinyanga	Bariadi	Sima	Ndoba	CCM Ground	125 Block A	0783532662/ 0756510162		nassageneral@yahoo.com	
1	Nile Well Drillers (Sole Propriator)	In process	1	2011	2	22313	DSM	Ilala	Ilala-Boma/AM	Ilala	Lindi/Arusha street	8 of 1	0713228265/ 0784418191		niledrillers@hotmail.com	
1	Nyakilang'anyi Construction Ltd	Civil Works Contractor: Class 2, Specialist Contractor: Class 2, Building Contractor: Class 4	1	2011	1	28	Mara/Dar es salaam	Musoma	Nyakato	Baruti	industrial area		0784254012	282620422	ncl_62@yahoo.com	
1	O.C. I Industrial Holdings Ltd	specialist Contractor: Class 2	1	2011	2	35009 DSM	DSM	Kinondoni	Mlalakuwa Ngalapa	Mlalakuwa	Bagamoyo Road	Kawe/M/71	0713614122		ckaaya@yahoo.com	
1	Oroteti Ltd	Not Registered	1	2005	2	65	ARUSHA	Arusha	Themi	Njiro Nanenane Ground	Nanenane		0754480771		oroteti@yahoo.com	
1	Paramount Drill Wells Limited	Not Registered	1	2012	2	72883	DSM	Ilala	Kisutu	Azikiwe	Azikiwe	727/10	0754308081	222124542	paramount.wells@yahoo.com	
1	PNR Services Ltd	Specialist Contractor: Class 1, Electrical Contracgtor: Class 1	1	2011	1	6014	DSM	Kinondoni		Bwawani	Dunga Street	267	222761967	222761967	pnrservices-tz@yahoo.com	
1	Pumps International & Solar Ltd	Specialist Drilling Contractor- Class 2 (SPC2/0072/07/06)	1		1	P.O.BOX 2635	DSM	Temeke		Kiwalani	Nyerere Road	Plot.No.26	22 2862544/ 0755-785453		pumpsandsolar@gmail.com	The company has neither drilling rigs nor drillers. Conducts drilling with hired rigs and drillers.
1	Rahmy Company Ltd	In Process	1	2011	2	38575 DSM	DSM	Ilala	Buguruni	Buguruni sheli	Uhuru Road		0713726052	0719387800	rdrilling@yahoo.com	
1	Rehoboth Mining and Water Well Drilling Co	Not Registered	2		2	1940	ARUSHA	Arusha	Sekei	Sakina	East Africa		0755427254		rehobothdrilling@hotmail.com	
1	Research and Ground Water Drilling Co. Ltd (REGWA)	Not Registered	1	2009	2	1806 UPANGA	DSM	Kinondoni	Ubungo	Ubungo		DDCA-Building		20226551450/ 202255938131	regwa2011@gmail.com	
1	RRS Water Well Drilling Company	Not Registered	2		2	45 DSM	DSM	Ilala	Segerea	Liwiti-Segerea	Segerea Road		0717477740			
1	Ruko's Genaral Supplies Co. Ltd	Not Registered	1	2012	2	1145	DSM	Kinondoni	Mwananyamala	Lowa	Mwinyijuma	MNY/KMB/415	222760069		marerorukonge@yahoo.com	
1	Seba Drilling and Construction Ltd	Specialist Contractor: Class 2	1	2011	2	25487 DSM	DSM	Ilala	Bungoni	Uhuru	Uhuru road		0784277780	2861941	twalal@hotmail.com	
1	Serengeti Ltd	Specialist Contractor Drilling: Class 3	1	2008	2	72374	DSM	Kinondoni	Mikocheni "A"	Regent Estate	Kairuki Road	279	0754444454	222773438	serengetilimited@gmail.com	
1	Serving Friends International	Not registered	1	2011	2	2565	Arusha	Arusha	Uzunguni		Uzunguni Near Tanapa Staff Houses	34	0764858329	0732979940	tanzania@ngosfi.org	
1	Shy Builders Ltd	Specialist Contractor: Class 2 (SPC2/0124/07/2010)	1	2012	1	187	Shinyanga	shinyanga	Town	mwamakaranga	Uhuru street		0788038888	282763361	dbhiku@yahoo.com	
1	SMS Amour Investment	Specialist Contractor: Class 1	1	2011	2	65335	DSM	Ilala	Jangwani	Ukami	Rumumba Street (kariakoo/ Ukami Road)	Harare Inn Hotel	0756400600/ 0788466660	222180074	info@smsdrilling.com	

Involvement in Drilling Works (1: Yes, 2: No, 3: Unkonwn)	Company Name	CRB Reginstration/ Classification	Possession of MoW Drilling Permit Confirmed in Survey (1: Yes, 2: No)	Latest Year of Renewal of MoW Drilling Permit Confirmed in Survey	Experience in Drilling Works in WSDP (1: Yes, 2: No)	P.O.Box	Region	District	Ward	Sub-ward/Village	Street/Sub-Village	Plot No.	Tel.	Fax	E-mail	Note
1	SN-TECH (T) Ltd	Specialist Contractor: Class 2 (SPC2/0084/04/07)	1	2009	2	70848	DSM	Ilala				444/129	2128007	2128006	info@snpomps.com	
1	Snub Pro Africa Ltd	Not Registered	1	2011	2	19126	DSM	Kinondoni	Sinza		Area E	SNY/SNE 1664	222461747		abdulghafurtz@yahoo.com	
1	Society of the Precious Blood Water Project	Not Registered	2		2	1951	Dodoma	Dodoma	Mivuji	Mivuji	Kinaoni	95	0713436380		cpps-water@maf.or.tz	
1	Participatory Organisation (SHIPO)	Not Registered	2		2	227 Njombe	Njombe/ Iringa	Njombe			Songea- Makambako Highway	1000X Airport	262782989		info@shipotz.org	
1	Sparr Drilling Company Ltd	Specialist Contractor Drilling and Water Works: Class 1	1	2012	1	1522	MWANZA	MWANZA			MABATINI SINAI AREA	BLOCK #8 PLOT CC	0688 905510	282500285	sparrtz@sparr.co.ke/ketan @sparr.co.ke	
1	Star Water Pumps	Not Registed	1	2009	2	21788	DSM	Ilala	Jangwani	Udoe	Kariakoo		0755434411		sanguya2010@hotmail.co m	
1	Summer Communication Co., Ltd		1		1											
1	Sustainable Environment Management Action (SEMA)	Not Registered	2		2	365 SINGIDA	SINGIDA	Singida Municipality		Utemini Industrial	Singida Industrial Area		0754595638		semasingida@gmail.com	
1	Talha Water Well Drillers Ltd	Not Registered	2		2	24115,DSM	DSM	Temeke			Samora Road		0713403121			
1	Techno Drillers Co. Ltd	In Process	1	2012	2	12146	ARUSHA	ARUSHA			Old Police Line				technodrillers@gmail.com	
1	Uchama Drilling and Biogas Services	Not Registered	2		2	2774	DSM	Ilala	Kariakoo	Mhonda	Mhonda road		0715817081	222182322	atilioalex@yahoo.com	
1	UK Global Trading Ltd	In Process	1	2011	2	66612 DSM	DSM	Kinondoni	Kunduchi	Tegeta Kibaoni	Bagamoyo Road	KUN/3220	0713255046/ 0784462396		tanza8@yahoo.com	
1	Vacuum Rotary Drilling Company	Not Registered	1	2012	2	3219 DSM	DSM	Kinondoni			Msasani	plot no 22	0687872157/ 0713290620	.	bereddy@vrdrilling.com	
1	Victoria Boreholes Drilling Ltd	Specialist Drilling Contractor- Class 1	1		1	P.O.BOX 1352	DSM	Kinondoni		Mikocheni B		Plot.No.77 Block A	0783671668/ 0783671669			
1	Water and Environmental Development Company Ltd	Specialist Contractor: Class 1	2		2	125 SHINYANGA	Shinyanga	Shinyanga Town	Chanmaguha	Matanda		426	282762767	282762767	mwanashaally@yahoo.com	
1	Water International Services LTD	Not Registered	2		2		DSM	Kinondoni	Upanga	Bibi titi			0733750139		info@waterafrica.net	
1	Water Solutions Drilling Co. Ltd	Specialist Contractor: Class 1	1	2011	1	2780 Arusha	Arusha	Arusha	Mjini Kati		Boma Road		0272545442/ 0754691256	272509924	info@watersolutionstz.com	
1	Water Well Services Ltd	Not Registered	1	2011	2		DSM	Kinondoni	Afrikana	Afrikana	Bagamoyo Road	Squater Area	0717700931/ 0769049932			
1	Water Wells Services Ltd	Specialist Contractor: Class 2 (SPC2/0071/07/06)	1		2	72671	DSM	Kinondoni	Kijitonyama	Behind Inter House			0767334314		w.leo@yahoo.com/w.leo@g mail.com	
1	Watter Hub Tanzania LTD	Specialist Contractor: Class 3	1	2011	1	77132	DSM	Ilala	Ilala	Ilala	Uhuru street	mwalimu house	0773889888	222128006	watterhub@gmail.com	
1	Wells Technology Co. Ltd	Not Registered	1	2011	2	34120	DSM	Kinondoni	Sinza	Sinza kwa Remmy	Chipukizi		0766114881		wellstechnology@gmail.co m	
1	Enironmental Sanitation Projects Maintenance Organization)	Not Registered	1	2011	2	38340	DSM	Kinondoni	Ubungo	Ubungo Mataa	University Road	DDCA HQ	222410738		wepmo-org@yahoo.com/ wepmoprojects@hotmail.co m	
1	Willy Enterprises Ltd	Civil works contractor: Class 5	1	2011	2	436 ARUSHA	ARUSHA	ARUSHA	Ngarenaro		Ngarenaro Rd		0754281392	222860209	willyenter99@yahoo.com	
1	Winam General Treders Ltd	Specialist Contracto: Class 3 (SPC3/0417/8/2009)	1	2012	1	11969 DSM	DSM	Ilala	Segerea	Migombani	Makumbusho str		0784363838/ 0752363838		winamdan@gmail.com	
1	World Islamic Propagation and Humanitarian Services (WIPAHS)	Not Registered	2		2	1895	DSM	Ilala	Kisutu	Mtendeni	Morogoro - Mtendeni Road		222113278/ 0784786424/ 0773786424		admin@wipahs.com/human itarian@cats-net.com	
1	Yell Ltd		1		1											

Involvement in Drilling Works (1: Yes, 2: No, 3: Unkonwn)	Company Name	CRB Reginstration/ Classification	Possession of MoW Drilling Permit Confirmed in Survey (1: Yes, 2: No)	Latest Year of Renewal of MoW Drilling Permit Confirmed in Survey	Experience in Drilling Works in WSDP (1: Yes, 2: No)	P.O.Box	Region	District	Ward	Sub-ward/Village	Street/Sub-Village	Plot No.	Tel.	Fax	E-mail	Note
2	Capital Drilling (T) Ltd	Specialist Drilling Contractor- Class 1 (SPC1/0285/05/10)	2		2	P.O.BOX 63138					Mkuyuni Industrial Area	Plot.No.36&37	0784684184			Performs survey works only
2	Friedkin Conservation Fund		1		2	P. O. BOX 2785 ARUSHA	ARUSHA				BURKA					
2	KLR Malenga Drilling Company Ltd		1		2	DAR ES SALAAM	DSM									
2	LBS Water Well Drilling Company		2		2	Closed	DSM	Ilala	Tabata	Tabata-Sigara	Tabata Road	Squater Area	0222807528/ 0717477740		lbsdrilling@yahoo.com	
2	Masochi Water Resource Exploration Co. Ltd		2		2	157	Dodoma	Dodoma	Hazina X	Kigamboni	Kigamboni	33	0754696400		bonifaceamcharo@yahoo.com	Performs survey works only
2	Mikindani Sana Ltd		1		2	P. O. BOX 664 MTWARA	MTWARA									
2	Mingoyo Contractors		1		2	DAR ES SALAAM	DSM	Kinondoni		MIKOCHENI		PLOT 432				
2	Mmeku Water Wells Drilling Co.		1		2	DAR ES SALAAM	DSM				ALGERIA STREET					
2	Nyanza Bottling Co. Ltd		1		2	P. O. BOX 2086 MWANZA	MWANZA					PLOT 73 NYAKATO INDUST. AREA				
2	Okuto Drilling Co. Ltd		1		2	P. O. BOX 10131 ARUSHA	ARUSHA									
2	Sendstar Co.Ltd	Specialist Drilling Contractor- Class 3 (SPC2/0143/5/11)	2		2	P.O.BOX 14012	DSM				SAMORA AVENUE	ACACIA BUILDING	0713776622		send-star@yahoo.com	Soil testing
2	Shinyanga Urban Water Supply &Sanitation Authority		2		2	298	Shinyanga	Shinyanga	Kambarage	Lubingo			282762073		majimamlakashuoasa@yahoo.com	
2	Tachi International Drilling Co. Ltd		1		2	DAR ES SALAAM	DSM				NSSF BUILDING MWENGE AREA					
2	Tansformer Agr.&Const.		1		2	P.O. BOX DAR ES SALAAM	DSM		MIKOCHENI							
2	The Water Family Company (T) Ltd		2		2	2590	Dodoma	Dodoma mjini	Kiwanja Cha Ndege	Oyster bay		Block C Plot 64	0784353687/ 0754353687		fcwater@ymail.com	Performs survey works only
2	Water Well Application Systems Ltd		1		2	P. O. BOX 1918 ARUSHA	ARUSHA				MNAZI HOTEL(ARUSHA)					
2	Wema Consult (T) Limited		2		2	67371	DSM	Kinondoni	Bunju	Basihaya	Bagamoyo Road	2014-Bloch H	0754884579/ 0773103686/ 222630539		info@wemaconsult.com	Performs survey works only
2	Winners Traders International		1		2	DAR ES SALAAM	DSM									
3	1st Contractors Ltd	Specialist Drilling Contractor- Class 3 (SPC3/0525/6/11)	2		2	P.O.BOX 80181	DSM	Temeke			Stadium Area, Opp.NBC Chang'ombe	Plot.No.65 Block T	0718857485/ 0713808022		1stcontractors@gmail.com	
3	AG Well Drilling Ltd		1		2	P. O. BOX 66229	DSM				AZIKIWE STREET					
3	Al-Nasser General Traders Ltd		1		2	DAR ES SALAAM	DSM				NARUNG'OMBE/LUMUMBA STREET					
3	Al-Sagaaf Drille Ltd		1		2	DAR ES SALAAM	DSM			KARIAKOO	SOMALI STREET					
3	Al-Wattan Drilling Co., Ltd.		1		2	DAR ES SALAAM	DSM									
3	Amandus Enterprises		1		2	DAR ES SALAAM	DSM									
3	Aqwe Drilling and ConstrutionLtd	Specialist Drilling Contractor- Class 1 (SPC1/001/7/99)	2		2	P.O.BOX 172 MOS	KILIMANJARO/MOSHI				Lema Road, Shanti Town		0272750300/ 0754306229/ 698590		aquatech@eoltz.com	
3	Armitage Engineering (T) Ltd	Specialist Drilling Contractor- Class 2 (SPC2/0141/5/11)	1		2	P.O.BOX 15118	DSM	Kinondoni		Hananasif	Cham Cham Street	Plot.No.35 Block 3	0756898867		armitage@live.co.uk	

Involvement in Drilling Works (1: Yes, 2: No, 3: Unkonwn)	Company Name	CRB Reginstration/ Classification	Possession of MoW Drilling Permit Confirmed in Survey (1: Yes, 2: No)	Latest Year of Renewal of MoW Drilling Permit Confirmed in Survey	Experience in Drilling Works in WSDP (1: Yes, 2: No)	P.O.Box	Region	District	Ward	Sub-ward/Village	Street/Sub-Village	Plot No.	Tel.	Fax	E-mail	Note
3	Ausdrill Tanzania Ltd	Specialist Drilling Contractor-Class 1 (SPC1/0269/7/09)	2		2	P.O.BOX 221	GEITA/DSM				Bibi Titi Road	Geita Gold Mine,and 5th Floor Nyerere Towers,	2520500/ 0767992506/ 0789707107			
3	Boleyn International (T) Ltd		1		2	DAR ES SALAAM	DSM									
3	CM-Well Boring Co., Ltd		1		2	621884 DAR ES SALAAM	DSM									
3	DEZO Civil Construction Co., Ltd		1		2	104678 DAR ES SALAAM	DSM									
3	Drill Master Africa		1		2	MWADUI MINES SHINYANGA	SHINYANGA									
3	Dynamic Drillers Ltd		1		2	DAR ES SALAAM/ P. O.	DSM									
3	Eastland Water Well Drill Co., Ltd		1		2	DAR ES SALAAM	DSM									
3	Fedako Ltd		1		2	DAR ES SALAAM	DSM	Kinondoni			MAFERE STR	PLOT 65/32				
3	Franki International Projects(Guernsey) Ltd	Specialist Drilling Contractor-Class 1 (SPC1/008/9/01)	2		2	P.O.BOX 11991	DSM			Kiwalani Area	Nyerere Road	Plot.No.91	222861644/ 0757859770		michaels@franking.com	
3	Geoges Well Construction		1		2	DAR ES SALAAM	DSM									
3	GEWECO Ltd		1		2	P. O. BOX 11464 MWANZA	MWANZA	Mwanza Town								
3	Great Ruaha Drilling and Exploration Ltd		1		2	DAR ES SALAAM	DSM	Ilala		UPANGA	ALY KHAN ROAD	135				
3	Handei Tanzania Co. Ltd	Specialist Drilling Contractor-Class 3 (SPC3/0518/5/11)	2		2	P.O.BOX 98	SONGEA			Mfaranyaki	Lituhi Street	Plot. No.16, Block Y	0782233233			
3	Hardware Drilling Company Arusha		1		2											
3	HMM Commercial Investment Co.		1		2	P. O. BOX 6784 MOROGORO	MOROGORO									
3	Homepride Construction Co., Ltd		1		2	P. O. BOX 464 MBOZI, MBEYA	MBEYA	ILALA			BUNGONI					
3	Hydro Works Construction (T) Ltd		1		2	DAR ES SALAAM	DSM									
3	Islamic Foundation		1		2	P. O. BOX 6011 MOROGORO	MOROGORO	MOROGORO								
3	Jidar Industries (T) Ltd		1		2	DAR ES SALAAM	DSM									
3	K'S Butarane Co., Ltd		1		2	DAR ES SALAAM	DSM									
3	KADET		1		2	DAR ES SALAAM	DSM									
3	Kanisa la Kiinjili la Kilutheri		1		2	P. O. BOX 97 NJOMBE	IRINGA	NJOMBE								
3	Karumba Drilling Co.Ltd		1		2	DAR ES SALAAM	DSM	Kinondoni			MIOGONI STR					
3	Lingai Construction Co.Ltd	Specialist Drilling Contractor-Class 3 (SPC3/0247/10/05)	2		2	P.O.BOX 33165	DSM				Sukari Road	Plot. No.33-34 EX TEXCO BUILDING	0784312077		cngainayo@yahoo.com	
3	Major Drilling Tanzania Ltd	Specialist Drilling Contractor-Class 1 (SPC1/0255/04/09)	2		2	P.O.BOX 2409	MWANZA				Kiseke-Ilemela	Plot.No.729/741	0787571857			
3	Mirishos Fresh Water Drilling Company		1		2	DAR ES SALAAM	DSM			SEGEREA/BUZA LULENGE						
3	Mlaki Building And Water Eng. Co.		1		2	DAR ES SALAAM	DSM									

Involvement in Drilling Works (1: Yes, 2: No, 3: Unkonwn)	Company Name	CRB Reginstration/ Classification	Possession of MoW Drilling Permit Confirmed in Survey (1: Yes, 2: No)	Latest Year of Renewal of MoW Drilling Permit Confirmed in Survey	Experience in Drilling Works in WSDP (1: Yes, 2: No)	P.O.Box	Region	District	Ward	Sub-ward/Village	Street/Sub-Village	Plot No.	Tel.	Fax	E-mail	Note
3	MM Water And Onland Works Co.		1		2	DAR ES SALAAM	DSM				SUM NUJOMA ROAD					
3	Mucoba Enterprises		1		2	DAR ES SALAAM	DSM									
3	Nanra Construction Ltd		1		2											
3	Ntuzugiani East Africa Ltd		1		2	DAR ES SALAAM	DSM									
3	Oriental Construction.Ltd		1		2	P.O.BOX 48364 NAIROBI KENYA	KENYA									
3	Pioneer Well Drilling Ltd		1		2	DAR ES SALAAM	DSM	KINONDONI			ADA ESTATE					
3	Pollo Italia Tanzania Ltd		1		2	DAR ES SALAAM	DSM									
3	PP Setty International Ltd		1		2	DAR ES SALAAM	DSM				ZANAKI STREET					
3	Schlumberger Seaco Inc.	Specialist Drilling Contractor-Class 1 (SPC1/0275/11/09)	2		2	P.O.BOX 60081	DSM				Daima Street	Plot No.100 Block A	0786303420/ 0784706348			
3	Sweat Water Well (T) Ltd		1		2	DAR ES SALAAM	DSM				REGENT ESTATE					
3	Tandrill Ltd	Specialist Drilling Contractor-Class 1 (SPC1/0230/06/08)	2		2	P.O.BOX 6215	MWANZA			Isamilo Area		Plot No.193	0784833595/ 0787374898			
3	Twabaha Construction Ltd		1		2	DAR ES SALAAM	DSM			TABATA						
3	Umoja Drilling & Construction Engineers	Specialist Drilling Contractor-Class 3 (SPC3/002/4/99)	2		2	P.O.BOX 17	SONGEA	Songea			Majengo B Street		0784480402/ 0784467226			
3	Undergroundwater Wells Co. Ltd		1		2	DAR ES SALAAM	DSM	Ilala		KARIAKOO	LUMUMBA/MKUNGUNI					
3	VTECOS Investment Company Ltd	Specialist Drilling Contractor-Class 3 (SPC3/0345/09/07)	2		2	P.O.BOX 329	BUKOBA				Zam Zam Area	Plot No.1 Arusha Street	2220751/ 0754330355/ 0754430355			
3	Water Trans International Ltd		1		2	DAR ES SALAAM	DSM				MJIMWEMA-KIGAMBONI	PLOT 24 BLOCK A				
3	Well Drilling Company Ltd		1		2	DAR ES SALAAM	DSM									

Annex 4 Form for Request for Quotation

Drilling and Dam Construction Agency

Request for Quotation

1.	Business Entity Name		
2.	Mailing Address		
3.	Physical Address Region:	District:	
	Ward:	Street:	
	Plot No.:		
4.	Telephone/Mobile	5. Fax	
6.	E-mail		
7.	Contact Person	Name	Position
		Phone	

Hiring of Drilling Equipment

Please tick	Item	Q'ty	Hiring Period		
			Start	End	Total Days
	Truck mounted drilling rig				
	Trailer mounted air compressor				
	Trailer mounted mud pump				
	Trailer mounted pumpint test unit				
	Rig accessories*				
	Casing tools*				
	Fishing tools				
	Direct mud circulation drilling tools & accessories*				

* Please refer to the attached list for items included in rig accessoris, casing tools and direct mud circulation drilling tools and accessories.

Purchase of Consumables

Please tick	Description	Q'ty
	Drill pipes 41/2'' 0.D flush type with API 31 1/2''IF BOX and pin joints furnished with wrech squares and steel made protectors,6m long/pc	
	DTH Hammer assembly for 6 1/4''(150mm) hole drilling API 3 1/2 Regular pin and 8'' to 10'' hole drillling	
	DTH Hammer assembly for 12''(300mm) hole drilling API 3 1/2 Regular pin	
	DTH Button bit for 6 1/4''(159mm) hole drilling	
	DTH Button bit for 8 1/4''(216mm) hole drilling	
	DTH Button bit for 10''(254mm) hole drilling	
	Tricone roller bits 6 1/2'' dia	

Please tick	Description	Q'ty
	Tricone roller bits 8 1/2'' dia	
	Tricone roller bits 10 1/2'' dia	
	Tricone roller bits 12 1/2'' dia	
	Roller bits 8 1/2'' dia	
	Roller bits 10 1/2'' dia	
	Roller bits 12 1/2'' dia	
	Roller bits 14 1/2'' dia	
	Drag bits three winged 8 1/2'' dia	
	Drag bits three winged 10 1/2'' dia	
	Drag bits three winged 12 1/2'' dia	
	Stabilizer for 6 1/4'' hole body dia,1.5m long API 3 1/2 IF BOX and pin joints furnished with wretch squares and steel made thread protectors on both ends	
	Stabilizer for 8 1/2'' hole 5'' body dia,1.5m long API 3 1/2 IF BOX and pin joints furnished with wretch squares and steel made thread protectors on both ends	
	Casing shoe for 8'' casing	
	Casing shoe for 10'' casing	
	Casing shoe for 12'' casing	

Any special instructions, comments, and other inquiries

Signature Print Name

Date

RFQ No. ______________________

Date (Received) ______________________

Date (Replied) ______________________

Name ______________________

List of Rig Accessories and Tools Attached to the Drilling Rig

No.	Description
I. Rig Accessories	
1	Drilling collars 5''0.D,2''IF BOX and pin joints,furnished with wretch squares and steel protectors,6m long/pc
2	Hoisting swivel API 1/2'' IF Pin joint
3	Hoisting plug API 1/2'' IF Pin joint
4	Drill pipes collar hanger
5	Cross over sub API 3 1/2 IF BOX and pin
6	DTH Button Bit for 12''(300mm) hole drilling
7	Bit sub for drill pipes/collar to 6 1/4'' DTH Hammer API 3 1/2'' Regular box and API 3 1/2'' IF Box joint
8	Bit sub for drill pipes/collar to 6 1/4'' DTH Hammer API 3 1/2'' Regular box and API 3 1/2'' IF Box joint
9	Bit 15rinder for button bit and body dressing,furnished with 15 m long high pressure air hose
10	Drag bits three winged 16 1/2'' dia
11	Roller bit 16'' dia for soft formation
12	Stabilizer for 10'' hole 5'' body dia,1.5 long API 3 1/2 IF BOX and pin joints furnished with wretch squares and steel made thread protectors on both ends
13	Stabilizer for 12'' hole 5'' body dia,1.5m long API 3 1/2 IF BOX and pin joints furnished with wretch squares and steel made thread protectors on both ends
II. Casing Tools	
1	Casing lamp with bolts,nuts,wrench and sling wire for 4'' PVC casing ,3 pairs/sets
2	Casing lamp with bolts,nuts,wrench and sling wire for 6'' PVC casing ,3 pairs/sets
3	Casing lamp with bolts,nuts,wrench and sling wire for 8'' PVC casing ,3 pairs/sets
4	Casing lamp with bolts,nuts,wrench and sling wire for 10'' PVC casing ,3 pairs/sets
5	Casing lamp with bolts,nuts,wrench and sling wire for 12'' PVC casing ,3 pairs/sets
6	Casing head for 8'' casing
7	Casing head for 10'' casing
8	Casing head for 12'' casing
9	Casing sub , API 3 1/2 IF BOX to 8 '' casing
10	Casing sub , API 3 1/2 IF BOX to 10 '' casing
11	Casing sub , API 3 1/2 IF BOX to 12 '' casing
12	Casing hoist plug with sling wire for 8'' casing
13	Casing hoist plug with sling wire for 10'' casing
14	Casing hoist plug with sling wire for 12'' casing
III. Direct Mud Circulation Drilling Tools & Accessories	
1	Mud testing kit including mud balance ,marsh funnel,viscocity meter with measuring cup sand content kit,stop watch and thermometer
2	Collapsible water tank with housing bag 3000 Litre capacity
3	Portable water level indicator,dry battery operated type,measuring capacity of 200m

Annex 5 Quotation Form

Drilling and Dam Construction Agency

Quotation

Date				Quotation No.
1.	Business Entity Name			
2.	Mailing Address			
3.	Physical Address			
	Region:			District:
	Ward:			Street:
	Plot No.:			
4.	Telephone/Mobile			5. Fax
6.	E-mail			
7.	Contact Person	Name		Position
		Phone		

Hiring of Drilling Equipment

Item	Q'ty	Hiring Period			Unit Price (Tsh)	Amount (Tsh)
		Start	End	Total Days		
					Total Amount	

Purchase of Consumables

Item	Q'ty	Unit Price (Tsh)	Amount (Tsh)
		Total Amount	

Annex 6 Application Form for Hiring of Drilling Equipment

Drilling and Dam Construction Agency

Application for Hiring of Drilling Equipment

Section A: Applicant Information			
1.	Business Entity Name		
2.	Mailing Address		
3.	Physical Address Region:		District:
	Ward:		Street:
	Plot No.:		
4.	Telephone/Mobile		5. Fax
6.	E-mail		
7.	Contact Person	Name	
		Position	
8.	Year of Establishment of the Organization		9. Year of Starting of Drilling Operations
10.	Business Type	[ ] Sole Proprietor [ ] Partnership [ ] Corporation [ ] Not for Profit [ ] Other (specify:)	
11.	Contractors Registration Board (CRB) Registration	Registration No.	
		Date of Registration	
12.	Water Well Drilling Permit No. Issued by Ministry of Water	Permit No.	
		Date of Issuance/ Renewal	
Section B: Drilling Works to be Conducted with the Hired Equipment			
1.	Owner of the Work	[ ] Government [ ] Private Business Entity [ ] Individual Household [ ] External Support Agencies (Donor)	
2.	Outline of the Work	No. of Production Wells to be Constructed with Hired Rig(s)	
		Use of Water Source	[ ] Domestic water supply [ ] Irrigation [ ] Livestock watering [ ] Industrial use [ ] Other use (specify:)
		Planned Service Options for Water Supply	[ ] Hand Pump [ ] Piped Scheme with Public Taps [ ] Piped Scheme with House Connections
3.	Drilling Team	No. and Position of Permanent Staff to be Assigned in Drilling Team	
Section C: Acknowledgement and Authorization			
Signature Date			Print Name

Please attach copies of CRB registration certificate and water well drilling permit.

Application No. __________
Date (Received) __________
Date (Replied) __________
Results of Appraisal __________
Name __________

Annex 7 Order Form

Drilling and Dam Construction Agency

Order Form / Rental Contract

1.	Business Entity Name		
2.	Mailing Address		
3.	Physical Address		
	Region:		District:
	Ward:		Street:
	Plot No.:		
4.	Telephone/Mobile		5. Fax
6.	E-mail		
7.	Contact Person (Office)	Name	Position
		Phone	
8.	Contact Person (Site)	Name	Position
		Phone	
9.	Site Location	Region	District
		Ward	Village/ Street
10.	Hiring Period	Start	End
11.	Special Instructions		

Hiring of Drilling Equipment

Item	Q'ty	Hiring Period			Unit Price (Tsh)	Amount (Tsh)
		Start	End	Total Days		
					Total Amount	

Purchase of Consumables

Item	Q'ty	Unit Price (Tsh)	Amount (Tsh)
		Total Amount	

Signature	Print Name
Date	

This order form constitutes an Individual Contract for hiring of drilling equipment when the Hirer signs and submits it to DDCA. General provisions on the rental contract are stipulated in the general conditios of the drilling equipment rental contract.

Quotation No. ______________________

Application No. ______________________

Order Form No. ______________________

Date (Received) ______________________

Date (Replied) ______________________

Name ______________________

Technical Instructor ______________________

Driver ______________________

Annex 8 Checklist for Appraisal of Applications

Checklist for Appraisal of Applications for Use of Hiring Service

The application forms submitted by private drilling companies should be checked if all the conditions specified below are satisfied;

1. To possess a valid water well drilling permit issued by the Ministry of Water.
   - ☐ Is a copy of the permit attached to the application form?
   - ☐ Is the permit still within one-year valid period? (A permit issued/renewed in last or this financial year should be submitted.)

2. To be registered as the specialist contractor at the Contractors' Registration Board.
   - ☐ Is a copy of the registration certificate from CRB attached to the application form?
   - ☐ Is the applicant regisetered as a Specialist Contractor?

3. To have at least one permanent employee among the drilling staff to be on site with the hired equipment and to receive the technical instructions from DDCA.
   - ☐ Is there at least one permanent staff included in the drilling team?

The Hiring Business Unit should send an applicant a written notice of results of appraisal of the application within five (5) business days from recipt of the application form. The Unit will give advice to the applicant who does not meet the conditions to consult with MoW and CRB to obtain necessary permit/ registration.

Annex 9 Sample Contract Form

General Conditions on the Drilling Equipment Rental Contract

Article 1. General Provisions

1. The general conditions on the drilling equipment rental contract (hereinafter referred to as 'the contract') determines its general provisions regarding the contractual relationship of the Owner and the Hirer.
2. The Owner provides the rental of movable property and other related services under the conditions stipulated in the agreement (rental and other services are hereinafter referred to as 'rental') to the Hirer.

Article 2. Individual Contract

1. Conclusion of a rental contract for each property (hereinafter referred to as 'Individual Contract') is done by the Hirer and the Owner in accordance to the agreement.
2. Individual Contracts will be effected when the Hirer submits a signed order sheet which clearly defines necessary details such as the name of the property, quantity, hiring period, and place of use, and when the Owner agrees with the request.
3. If there is a discrepancy between the conditions stipulated in the Individual Contract and the agreement, the condition in the Individual Contract shall prevail.
4. Conditions regarding Individual Contracts will be determined by prior agreement between the Hirer and the Owner.

Article 3. Hiring Period

1. The hiring period starts on the date the Hirer receives the property from the Owner (date of rental commencement) and ends on the date the Hirer returns it to the Owner (date of rental termination).
2. A written consent of the Owner is required for the extension or reduction of the hiring period.

Article 4. Rental Fee

1. The rental fee generally refers to the 'rental charges' of the property.
2. The Hirer shall pay the Owner the rental fee for the agreed hiring period even if there is a period where the Hirer, for any reason or circumstance, does not, or is unable to, use the property.
3. In principle, the rental fee is charged for eight (8) hours of use of the property per day. When the property use exceeds eight (8) hours, extra fees will be incurred.

Article 5. Guaranty Deposit

1. The Owner is entitled to request the Hirer a guaranty deposit to guarantee fulfilment of obligations of the Hirer stated in the contract. The Hirer shall deposit the requested amount of guaranty upon a request from the Owner. The guaranty deposit shall not incur interest.
2. When any of the items described in Article 19, under Clause 1, applies to the Hirer, the Owner shall appropriate the guaranty deposit for settlement of the outstanding balance and financial obligation of the Hirer, including rental fees.

Article 6. Permits

The Hirer shall at its own expense apply for and obtain any permits, licenses, certificates, permission, or exemptions which may be required for and in connection with the entry and use of the property on the site. The Owner shall be responsible for any permits, licenses, certificates, permission or exemptions which may be required for legal operation of the property including any insurance required.

Article 7. Fuel

The Hirer shall be responsible for providing fuel and oil as necessary for transportation and operation of the property on Hirer's site, except for the fuel for transportation of carrier trucks of drilling rigs which shall be taken care by the Owner.

Article 8. Property Handing Over, Exemptions

1. When the Hirer receives the property from the Owner, the Owner shall issue an equipment checklist to the Hirer, and the Hirer shall sign on it upon completion of inspection with the Owner as specified in Article 9.
2. The Owner shall hand over the property to the Hirer on the date of rental commencement.
3. As a general rule, the handing over shall be carried out at the office of the Owner.
4. If the handing over is carried out in a place other than stated in the previous Article, the Hirer shall bear any of the resultant costs.
5. Responsibility for accidents related to carrying, transporting, and loading and unloading of the property shall rest with the Hirer when the Hirer conducts the work and when the Hirer requests any other party other than the Owner to conduct the work, and with the Owner when the Owner conducts the work.
6. The Owner shall not be liable for delay or failure of property handing over in the result of an event such as a natural disaster and man-made events, including electricity restriction, transport accidents, traffic restriction, conflict with employees of the Hirer or third parties, or interference of third parties, and any other events not accountable to the Owner's fault.

Article 9. Property Inspection

1. The Hirer shall inspect the specifications, capacity, functions and quantity of the property on the Owner's yard for any defects or deviations against the descriptions in the equipment checklist issued by the Owner immediately after the receipt of the property.
2. The Hirer shall immediately notify the Owner of any nonconformity, incompleteness, insufficiency or defects. When notified by the Hirer, it is the responsibility of the Owner to repair or replace the property.

Article 10. Warranty

1. The Owner guarantees the condition of the property at the point of handing over. The Owner is not liable for the compatibility of the property with the purpose of the Hirer. When there is no notification regarding defects of the property immediately after the handing over, it is regarded that the property was handed over in good condition.
2. When the Owner is liable for damages regarding hired property in incidents of the Owner's fault, the maximum amount is the amount of the rental fee charged for the Individual Contract, and also limited to the amount already paid by the Hirer.
3. The Owner shall not be liable for indirect, special, or incidental losses (such as construction delay, idling, profit that would have been generated, profit loss, opportunity loss, etc.) inflicted to the Hirer or third party caused by the fault of the property.

Article 11. Maintenance, Management and Monthly Inspection of the Property

1. The Hirer shall manage the property in accordance with the property's appropriate use and capacity, manage its safekeeping, and maintain the condition of the property for the period of the reception of the property until the completion of the property return.
2. The Hirer must consult the maintenance manual for hirer with daily service check sheet prior to use, carry out a start-up inspection, and conduct necessary maintenance work prior to commencing operation.
3. Preventive maintenance and safekeeping costs of the property shall be borne by the Hirer.
4. Receiving advice from the technical instructor dispatched from the Owner, the Hirer shall be responsible for conducting daily inspection and self-check for the properties that require them.
5. If the instalment, storage, or use of the property incurs damages to a third party, the Hirer shall be responsible for solving the conflict, and the Owner shall not be liable.

Article 12. Examination of the Property

The Owner, with advanced notice to the Hirer, has the right to inspect the hired property's conditions of use and safekeeping at the site of its operation. During such events, the Hirer shall be cooperative.

Article 13. Prohibited Matter

1. The Hirer shall not engage in any act which infringes on the right of ownership of the Owner, including taking out a mortgage on the property, or transferring it to a third party.
2. The Hirer shall not allow operation and handling of the property by anyone but qualified persons.
3. The Hirer, without written approval of the Owner, shall not conduct any of the following actions.

(1) Attachment of new equipment, parts, or accessories to the property, or removal of already attached items.
(2) Modification of the property, or modification of its functions and capacity.
(3) Use of the property for purposes other than what it is intended for.
(4) Transportation of the property to any other place from where the Hirer indicated in the order sheet.
(5) Transfer of the leasing rights under an Individual Contract, or sub-lease of the property to a third party.
(6) Establishment of the right of pledge, mortgage, or any other rights on the property.
(7) Deletion or removal of any identifying marks or displays of ownership.

Article 14. Duty to Give Notice

1. The Hirer and Owner shall contact the other party immediately by the quickest practical method, as well as notifying the party in writing, when any of the following occur.

(1) When theft, destruction, or damage was occurs to a hired property
(2) When the Owner or Hirer's address is changed
(3) When the Owner or Hirer's representative is changed
(4) When there is a major change in business operation
(5) When compulsory execution or any other legal and factual infringement occurred to the hired property by a third party

Article 15. Measures to be Taken upon Completion of Individual Contract and Return of the Property

1. Upon completion of the Individual Contract, the Hirer shall immediately return the property to the site stated in the contract. The Owner shall check conditions of the property upon its reception and record it in the equipment checklist which copy shall be provided to the Hirer.
2. The cost of transport and other related costs for transfer of the property shall be borne by the Hirer, except for fuel for the carrier trucks of drilling rigs which shall be taken care by the Owner.
3. The return of the property shall be done in the presence of the Hirer and the Owner. However, if the Hirer is unable to be present, the Hirer has no right to object the inspection of the Owner.
4. The property shall be returned in the same condition as when it was hired. If there is any damage, loss, missing parts, etc., the Hirer shall be responsible for restoring the property to the original state, or the Hirer shall pay the cost of restoration (repair cost, cleaning cost, etc.) to the Owner.

Article 16. Property Compensation

1. The Hirer shall be responsible for the obligations stated in the agreement for damages, destruction or theft of the property, for any circumstance including natural disaster.
2. If the Owner provides repair work for the damage of the property, the Hirer shall pay the equivalent cost amount to the Owner.
3. The Hirer shall pay the Owner the cost of replacement of the property if the property right of the Owner is not deemed to be recovered for property which was destroyed, stolen, etc., or the damage of the property at the point of the return is beyond repair.
4. The Hirer shall provide compensation for the business suspension damage, if the repair or replacement of the property requires time.

Article 17. Measures and Compensation for Damages in Cases of Non-Return of the Property

1. The Hirer shall bear full responsibility to compensate for damages incurred to the Owner by

non-return of the property.
2. The Owner shall take necessary legal measures when the Hirer does not return the property despite the completion of the Individual Contract or contract cancellation in accordance with Article 19.

Article 18. Insurance
1. The Owner shall obtain compulsory automobile liability insurance and automobile insurance (personal reparations, property damage liability, and passenger reparations) for all vehicles with number plates, and liability insurance for any other property.
2. The insurance required by the previous clause does not cover damages caused by natural disaster, negligence or deliberate misuse by the Hirer, or cases stated in the exemption clause of the insurance contract.
3. The Hirer shall take legal measures and notify the Owner immediately when an insurable contingency has occurred, regardless of its size, and submit documents to the Owner as instructed.

Article 19. Contract Cancellation
1. The Owner retains the right to cancel the contract without notification, if any of the following is applicable.
(1) When the Hirer violated the articles of this contract or Individual Contract.
(2) When the Hirer delayed fulfilling its financial obligations to the Owner, including the rental fee, repair fee and other fees.
(3) When the check or bill issued or certified was not honoured, or when the Hirer became insolvent or fell under the condition of suspension of payment.
(4) Disposition for failure to pay taxes and public dues, temporary restraining order for execution of other obligations, writ of attachment, auction, or other disposition of the government authority was received, or bankruptcy, civil rehabilitation, corporate reorganisation was declared, or when the business operation is in de facto non-operational state, for instance, when it started liquidation.
(5) When the Hirer does not carry out proper maintenance of the property, or when it violated the use of the property determined by the law and other regulations.
(6) When the Hirer dissolved, deceased, or became a Person with Limited Capacity, or its address or location became unlocatable.
(7) When an incident severely degrades the financial status of the Hirer, or such an incident is deemed objectively imminent.
(8) When the Hirer conducts an iniquitous deed (illegal or threatening to the public order) regarding the use of the hiring service.
2. When the Owner cancels the contract in accordance with the previous clause, the Hirer shall return the property to the Owner without delay and shall pay the Owner the rental fee up for until the date of property return and all the related fees.
3. If any of the items described in Clause 1 apply to the Hirer, the Hirer forfeits its right to the hiring period, and shall pay the outstanding balance to the Owner.

Article 20. Measures for Contract Cancellation
1. The Hirer shall return the property to the determined location without delay upon a request of property return from the Owner in accordance to the previous Article.
2. When the Hirer fails to return the property immediately, the Owner shall enter the operation site of the property to retrieve it. If there are damages, the Hirer shall bear the cost.
3. The Hirer shall bear all costs of transport for the property return and transfer and any other related costs, except for fuel for the carrier trucks of drilling rigs which shall be taken care by the Owner.
4. The Hirer shall bear the cost for repair, if the property is damaged or there are discrepancies from the original condition, at the point of property return.
5. The return of the property shall be done under the presence of the Hirer and the Owner, when the Hirer is absent from the handing over, it is regarded that the Hirer has no objection to the result

of the inspection by the Owner.
6. The Hirer shall fulfil obligations stated in the contract until the property return is complete.
7. The Owner shall not be liable for damages incurred to the Hirer from cancellation of the contract.

Article 21. Early Termination

1. Early termination during the Individual Contract period is not allowed. However, if the Hirer requests an exemption from the Owner for a special case, and if the Owner acknowledges its legitimacy, early termination is permissible.
2. When early termination is approved in accordance to the previous clause, the Hirer immediately carries out the procedures in accordance with Article 14.

Article 22. Compensation for Contract Cancellation

When the property was returned in accordance with Article 19, the Hirer shall pay a predetermined amount of compensation for damages. If it is not predetermined, it shall be determined by mutual consent between the Hirer and the Owner.

Article 23. Joint and Several Surety

The Hirer shall appoint a joint and several surety if the Owner requests it. The joint and several surety shall jointly and severally bear contract obligations with the Hirer.

Article 24. Exclusive Agreement Jurisdiction

If conflicts arise between the Hirer and the Owner regarding the rental contract, a court that has jurisdiction over the address of the headquarters, or a branch of the Owner, shall be the venue for the first trial.

Article 25. Supplementary Conditions

The Hirer and the Owner shall solve any situation that is not described in the agreement or Individual Contract, in good faith.

Annex 10　Form for Report on Technical Instruction

Report on Technical Instruction to Private Drilling Companies

Date of Submission			
Name of Technical Instructor			
Name of Client			
Hiring Period of Drilling Rig			
Location of Drilling Site			
No. of Boreholes Drilled with the Hired Rig	Total	Production Well	Dry
Average Depth of Boreholes Drillied	m	m	m
Diameter of Boreholes Drilled	inch	inch	inch
Observations on Skills of Drilling Team			
Observations on Management of Work Schedule			
Technical Advice/ Guidance Given to the Client on Site			
Difficulties Encountered during Technical Instruction			

The on-site checklist of drilling technical level should be attached to the report for submission.

Annex 11 Checklist of Equipment

Checklist of Equipment

No. of Order Form		Business Entity Name	
Name and No. of Hired Item			
Handing Over of Equipment			
Date			
Defects Found on Equipment before Hiring			
Name of Hirer			
Signature			
Name of Officer in Charge			
Signature			
During Hiring Period			
Fault on Drilling Rig Reported during Hiring Period			
Measures Taken to Remedy the Fault on the Rig			
Return of Equipment			
Date			
Defects Found on Equipment after Hiring			
Name of Hirer			
Signature			
Name of Officer in Charge			
Signature			

Pictures of the equipment should be taken before and after hiring and attached to this checklist.

Annex 12 Feedback Form from Client

Client Feedback Form on Hiring Service of Drilling Equipment

Thank you for taking the time to fill out this form. Your feedback is important and will help us deliver quality service to you. When completed please either:

Email to: ____________________ or Fax to: ________________________

No. of Order Form	Business Entity Name

Question	Answer
Hiring of Equipment	
How was timeliness of availability of the equipment you hired this time?	☐ Equipment was available right on time when we needed. ☐ We had to wait for equipment to be available.
Was the equipment handed over to you as per agreed time and date?	☐ Yes ☐ No
How would you rate condition of the equipment you hired this time?	☐ Very good ☐ Good ☐ Fair ☐ Poor ☐ Very poor
How would you evaluate usefulness of technical advice/ guidance from our technical instructor?	☐ It helped us aquire new skills/ knowledge on the drilling works. ☐ It helped us recognize the importance of certain skills/ knowledge anew. ☐ We could not receive any useful advice/guidance we expected.
How would you evaluate cost you paid for the hiring service?	☐ Very expensive compared with value of the service. ☐ Expensive, but the service has corresponding value. ☐ Fair ☐ Very cheap compared with value of the service.
Purchase of Consumables	
Did you receive consumables you ordered to purchase by the time you required for construction works?	☐ Yes ☐ No ☐ We did not buy consumables from DDCA.
Overall Satisfaction and Comments/ Suggestions	
What factor(s) made you to choose our hiring service?	☐ Availability of equipment in the period we needed ☐ Availability of equipment which others do not hire out ☐ Price of the rental fee ☐ Reliability of condition of equipment ☐ Specifications and capacity of equipment ☐ Availability of technical instructor who provides advice/ guidance on site ☐ Other (Please specify:)
How would you rate level of your overall satisfaction on our hiring service against your expectation?	☐ Very high ☐ High ☐ Fair ☐ Low ☐ Very low
Could you tell us about areas which you would like to receive futher technical advice/guidance from our technical instructor, if any?	
Any other comments/ suggestions	

Annex 13 Monthly Report Form

Monthly Report on Operation of Hiring Service

Month/ Year ___________________

1. Sales

Item	Amount (Tsh)		
	This Month	Last Month	Cumulative (Month to Date)
Drilling rig			
Air compressor			
Mud pump			
Pumping test unit			
Rig accessories			
Casing tools			
Fishing tools			
Direct mud circulation drilling tools & accessories			
Consumables _________			
Consumables _________			
Consumables _________			
Consumables _________			
Consumables _________			
Consumables _________			
Total			

2. Cost

Cost Item	Drilling Rig	Air Compressor	Mud Pump	Pumping Test Unit	Other Items for Hiring	Consumables	Total
Variable Cost							
Sub-Total							
Marginal Profit							
Fixed Cost							
Sub-Total							
Operating Profit							

3. Operation Days and Sales by Items for Hiring

(1) Drilling Rig

Equipment No.	Operation Days	Sales (Tsh)	No. of Contracts	Average Contract Value (Tsh)	No. of BH Drilled
No.1					
No.2					
No.3					
No.4					
No.5					
No.6					
Total					
Cumulative					
Average					

(2) Air Compressor

Equipment No.	Operation Days	Sales (Tsh)	No. of Contracts	Average Contract Value (Tsh)	No. of BH Drilled
No.1					
No.2					
No.3					
No.4					
No.5					
Total					
Cumulative					
Average					

(3) Mud Pump

Equipment No.	Operation Days	Sales (Tsh)	No. of Contracts	Average Contract Value (Tsh)	No. of BH Drilled
No.1					
No.2					
No.3					
No.4					
No.5					
Total					
Cumulative					
Average					

(4) Pumping Test Unit

Equipment No.	Operation Days	Sales (Tsh)	No. of Contracts	Average Contract Value (Tsh)	No. of BH Drilled
No.1					
No.2					
No.3					
No.4					
No.5					
Total					
Cumulative					
Average					

4. Appraisal of Applications for Use of Hiring Service

(1) No. of Applications Received ________

(2) No. of Applications which Satisfy Requirements ________

(3) Distribution of Applications Rejected

a. No water well drilling permit ________

b. No CRB registration as a specialist contractor ________

c. No availability of permanent employee in the drilling team ________

5. Rental Contracts Signed in the Month

	Name of Hirer	Contract Amount (Tsh)	Hiring Period	Hired Equipment	Location of Drilling Site	Client of Hirer for Drilling Works	No. of BH to be Drilled with Hired Equipment	Use of BH
1.								
2.								
3.								
4.								
5.								

6. Troubles/ Accidents on Equipment for Hiring

7. Complaints/ Comments/ Suggestions Received from Clients

8. Other Issues (if any)

Preapred by ____________________ on ____________________

Ministry of Water (MoW)
Drilling and Dam Construction Agency (DDCA)
Japan International Cooperation Agency (JICA)

DDCAP

Maintenance Guideline

Maintenance System for Hiring Equipment

Version 1

March 2013

Groundwater Development and Management Capacity Development (DDCAP) Project

Contents

Tables

Figures

1 BACKGROUND

Aiming at alleviating poverty through improvements in the governance of water resources management and the sustaiblable delivery for water supply and sanitation services, the Government of United Republic of Tanzania (hereinafter referred to as "the Government of Tanzania") has been implementing the Water Sector Development Programme (WSDP) since 2007 to address shortfalls in urban and rural water supply infrastructure, to improve water resources management, and to strengthen the sector institutions and their capacities (MoW 2006). The target of the Programme is to achieve increase of proportions of the rural population with access to clean and safe water to 90% by 2025. It also calls for increased access to clean and safe water to the urban population to 100% by 2025.

WSDP estimates that approximately 79,000 water points need to be constructed in the Rural Water Supply and Sanitation (RWSS) component in order to meet the target mentioned above. 91% of these water facilities are expected to be sourced with the groundwater, which requires drilling of 1,200 wells annually. The Urban Water Supply and Sanitation (UWSS) component also has high demand of borehole construction in specific regional and district centres where surface water sources are scarce. Although private drilling companies are the main actor for groundwater development in WSDP, their current capacity in drilling wells is approximately 600 per annum. In other words, their capacities such as technical abilities and resources have a great gap compared with the demand in the water sector.

Taking this situation into consideration, MoW procures new drilling equipment in WSDP in order to support Drilling and Dam Construction Agency (DDCA) for strengthening of its capacity in borehole construction and providing technical support services to private drilling companies with utilizing the procured equipment. "The Strategy for Strengthening Water Well Drilling Industry in Tanzania" formulated by MoW in 2006 in parallel with designing of WSDP states necessity to establish the plant and the equipment hiring unit within DDCA to manage the equipment procured for the hiring service (MoW 2006). This is supported by the Executive Agencies (Drilling and Dam Construction Agency) (Establishment) Order, 1999, which describes that hiring of the drilling equipment to other organisations, is a part of the secondary functions of DDCA.

A maintenance system was established by the Project in order to maintain the equipment for the hiring services properly. DDCA is responsible for preventive maintenance and repair works of the equipment before and after the equipment is hired. On the other hand, the hirer will conduct routine maintenance of the hired equipment on site under supervision and instruction of the technical instructor from DDCA.

This is the first version of maintenance guideline for the hiring equipment to operate maintenance system for hiring equipment. The maintenance of the equipment for hiring service should be implemented in accordance with the guideline, plan and manual on the maintenance system of the hired equipment. The guideline indicates the principles of the maintenance system for the hiring equipment.

The equipment hiring service by DDCA starts April 2013 and continues the service during the entire project period. Accordingly, the maintenance guideline will be updated and/or modified by reflecting the results of the activities.

2 DOCUMENTS FOR MAINTENANCE SYSTEM

The documents, namely maintenance guideline (this document), maintenance plan and maintenance manual for the hiring equipment were prepared by the DDCAP project, in order to manage the maintenance system for the hiring equipment. The roles and the contents of each document are summarized as follows.

Document 1: Maintenance Guideline

The guideline stipulates the operation principles of the maintenance system as well as the roles and responsibility of both the owner (DDCA) and the hirer (private companies). Under the system to hire drilling equipment and machineries, the guideline aims at keeping good working conditions of the hiring equipment and machinery in order to accommodate the demand of the private drilling companies.

Document 2: Maintenance Plan

The maintenance plan demonstrates the plans for the periodic service, spare parts, consumable parts, tools, procurement, staff assignment, training and budget. The maintenance works for the hiring equipment should be carried out according to the maintenance plan.

Document 3: Maintenance Manual

The separate maintenance manuals for the owner and the hirer were provided. The manuals indicate the method and procedures of the maintenance works by each party.

3 PRECONDITION OF MAINTENANCE WORKS FOR HIRING EQUIPMENT

3.1 SPECIFICATION OF WELLS TO BE DRILLED BY USING HIRING EQUIPMENT

The hiring equipment are primarily used for the drilling works for WSDP in order to contribute for its programme goal. According to the results of the drilling works of phase 1 of RWSS component of WSDP, the specifications of wells are summarized as the following:

- Average depth: 95.9 m
- Casing and screen pipes: mainly 150 mm (6") of nominal diameter (95 % of all contracts), pvc made

Both DTH and mud drilling methods are employed. From the above results, standard specifications of wells for these two methods are as shown in ***Figure 1***. The DTH drilling methods are estimated to occupy 70 % of the cases of drilling, according to the past experiences of DDCA. This percentage shall be annually reviewed and modified from the results of the annual results of the drilling by the hiring equipment.

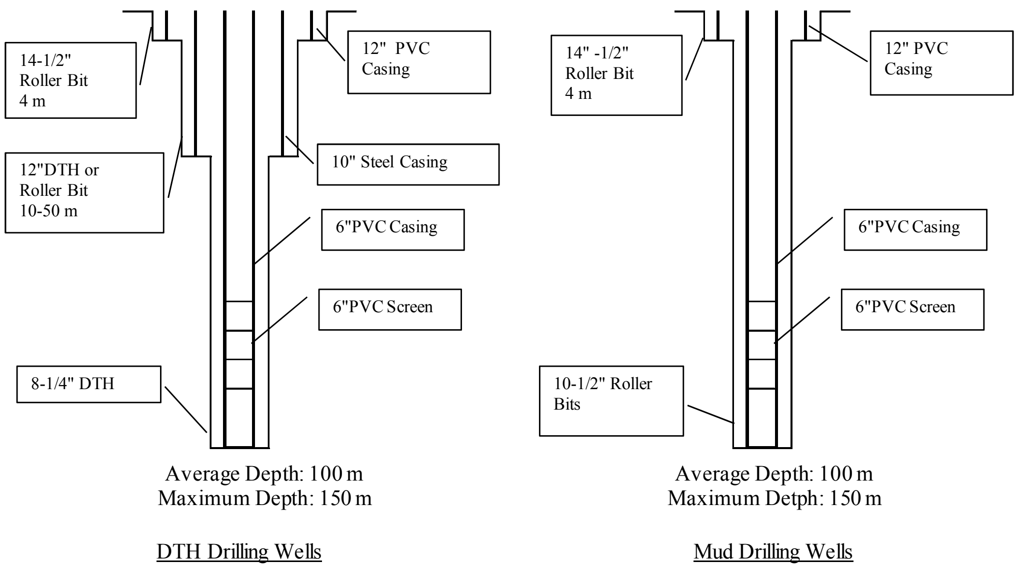


Figure 1 Standard Specification of Wells Drilled under WSDP

3.2 DRILLING EQUIPMENT TO BE HIRED

MoW is now procuring the drilling equipment with the fund of WSDP. It consists of two of 300 m drilling rigs and six of 150 m drilling rigs, necessary rig accessories, supporting equipment such as air compressors and pumping test units etc., and supporting vehicles. Two 300 m rigs are planned to be used for DDCA's own drilling works and 150 m rigs are for both DDCA's works and hiring to the private companies. A set of 150 m drilling rig with accessories were designed so as to be capable of drilling wells of which specifications are described in 3.1. A combination of the components of drilling equipment varies depending on the drilling method to be employed and design of a well. Therefore, a suitable combination will be selected by a hirer according to their needs with the consultation by DDCA. ***Table 1*** shows the major drilling equipment to be hired. The machineries such as drilling rigs, air compressors, mud pumps, pumping test units are the principal target of the maintenance activities.

Table 1 Drilling Equipment for Hiring

Item	Specification	Qty
I. New Equipment to be Procured in WSDP		
1. Truck mounted drilling rig	Rotary cum DTH, max. depth 150m	6 units
2. Trailer mounted air compressor	650CFM, 246 psi	5 units
3. Rig accessories	Drill pipes, DTH bit, work casing, etc.	1 set for each rig
4. Fishing tools	Tap, jack, etc.	1 set for each rig
5. Trailer mounted mud pump	20kg/cm^2, 600 l/min.	5 units
6. Trailer mounted pumping test unit	Generator, riser pipe, submersible pump	5 units

Table 2 shows the detailed contents of "3 Rig accessores" of ***Table 1.*** Necessary items will be selected for hiring according to the hirer's needs. Items with the check of the column "Maintenance" are materials capable to be worn and/or small machineries to be maintained. The reduction of the materials and conditions of the machineries shall be inspected by the maintenance section before and after the hiring. Other items with the check in "Consumable" consist of DTH bits, roller bits, stabilizers etc. They are consumed after the use in drilling of several wells. However, it is difficult to predict their lives since they depend on the specific coditions of each wells such as geology, drilling diameter, depth etc. Therefore, if a hirer want to DDCA to procure these consumables, DDCA will sell them to the hirer. In other way, calculated lumpsum price will be charged in the hiring tariff for DDCA to supplement the consumed materials.

Inspection of such miscellaneous items before and after hiring, maintenance of small machineries and supplementation of the consumed materials are one of important activities of the equipment maintenance, too.

Table 2 List of Rig Accessories, Casing Tools, Fishing Tools, Steel Casing and Direct Mud Circulation Drilling Tools

No.	Description	Unit	Qty	Maintnance	Consumable
Rig Accessories					
1	Drill pipes 41/2" O.D flush type with API 31 1/2"IF BOX and pin joints furnished with wrech squares and steel made protectors,6m long/pc	Pcs	30		x
2	Drilling collars 5"0.D,2"IF BOX and pin joints,furnished with wretch squares and steel protectors,6m long/pc	Pcs	3	x	
3	Hoisting swivel API 1/2" IF Pin joint	Pcs	3	x	
4	Hoisting plug API 1/2" IF Pin joint	Pcs	3	x	
5	Drill pipes collar hanger	Pcs	3	x	
6	Cross over sub API 3 1/2 IF BOX and pin	Pcs	3	x	
7	DTH Hammer assembly for 6 1/4"(150mm) hole drilling API 3 1/2 Regular pin and 8" to 10" hole drillling	Assy	3		x
8	DTH Hammer assembly for 12"(300mm) hole drilling API 3 1/2 Regular pin	Assy	3		x

No.	Description	Unit	Qty	Maintnance	Consumable
9	DTH Button Bit for 12"(300mm) hole drilling	Pcs	5	x	
10	Bit sub for drill pipes/collar to 6 1/4" DTH Hammer API 3 1/2" Regular box and API 3 1/2" IF Box joint	Pcs	3	x	
11	Bit sub for drill pipes/collar to 6 1/4" DTH Hammer API 3 1/2" Regular box and API 3 1/2" IF Box joint	Pcs	3	x	
12	DTH Button bit for 6 1/4"(159mm) hole drilling	Pcs	10		x
13	DTH Button bit for 8 1/4"(216mm) hole drilling	Pcs	10		x
14	DTH Button bit for 10"(254mm) hole drilling	Pcs	5		x
16	Bit grindeer for button bit and body dressing,furnished with 15 m long high pressure air hose	Pcs	1	x	
17	Tricone roller bits 6 1/2" dia	Pcs	4		x
18	Tricone roller bits 8 1/2" dia	Pcs	4		x
19	Tricone roller bits 10 1/2" dia	Pcs	4		x
20	Tricone roller bits 12 1/2" dia	Pcs	4		x
21	Roller bits 8 1/2" dia	Pcs	4		x
22	Roller bits 10 1/2" dia	Pcs	4		x
23	Roller bits 12 1/2" dia	Pcs	4		x
24	Roller bits 14 1/2" dia	Pcs	4		x
25	Drag bits three winged 8 1/2" dia	Pcs	4		x
26	Drag bits three winged 10 1/2" dia	Pcs	4		x
27	Drag bits three winged 12 1/2" dia	Pcs	4		x
28	Drag bits three winged 16 1/2" dia	Pcs	0	x	
29	Roller bit 16" dia for soft formation	Pcs	0	x	
30	Stabilizer for 6 1/4" hole body dia,1.5m long API 3 1/2 IF BOX and pin joints furnished with wretch squares and steel made thread protectors on both ends	Pcs	3		x
31	Stabilizer for 8 1/2" hole 5" body dia,1.5m long API 3 1/2 IF BOX and pin joints furnished with wretch squares and steel made thread protectors on both ends	Pcs	3		x
32	Stabilizer for 10" hole 5" body dia,1.5 long API 3 1/2 IF BOX and pin joints furnished with wretch squares and steel made thread protectors on both ends	Pcs	3	x	
33	Stabilizer for 12" hole 5" body dia,1.5m long API 3 1/2 IF BOX and pin joints furnished with wretch squares and steel made thread protectors on both ends	Pcs	3	x	
Casing Tools					
1	a)Casing lamp with bolts,nuts,wrench and sling wire for 4" PVC casing ,3 pairs/sets	Pcs	2	x	
2	b)Casing lamp with bolts,nuts,wrench and sling wire for 6" PVC casing ,3 pairs/sets	Pcs	2	x	
3	c)Casing lamp with bolts,nuts,wrench and sling wire for 8" PVC casing ,3 pairs/sets	Pcs	2	x	
4	d)Casing lamp with bolts,nuts,wrench and sling wire for 10" PVC casing ,3 pairs/sets	Pcs	2	x	
5	e)Casing lamp with bolts,nuts,wrench and sling wire for 12" PVC casing ,3 pairs/sets	Pcs	2	x	
6	f)Casing head for 8" casing	Pcs	2	x	
7	g)Casing head for 10" casing	Pcs	2	x	
8	h)Casing head for 12" casing	Pcs	2	x	
9	i)Casing shoe for 8" casing	Pcs	2		x
10	j)Casing shoe for 10" casing	Pcs	2		x
11	k)Casing shoe for 12" casing	Pcs	2		x
12	l)Casing sub , API 3 1/2 IF BOX to 8 " casing	Pcs	2	x	
13	m)Casing sub , API 3 1/2 IF BOX to 10 " casing	Pcs	2	x	
14	n)Casing sub , API 3 1/2 IF BOX to 12 " casing	Pcs	2	x	
15	o)Casing hoist plug with sling wire for 8" casing	Pcs	2	x	
16	p)Casing hoist plug with sling wire for 10" casing	Pcs	2	x	

No.	Description	Unit	Qty	Maintnance	Consumable
17	q)Casing hoist plug with sling wire for 12" casing	Pcs	3	x	
	Fishing Tools				
1	a)Fishing taper tap,API 3.5" IF BOX JOINT	Pcs	2		
2	b)Fishing die overshoot API 3 1/2 IF BOX JOINT	Pcs	2		
3	c) Drill pipe clamp with bolt nut wretch and sling wire 2 pairs/seat	Pcs	2	x	
4	d) Hydraulic jack with hand operated pump hose and pressure gauge,50 ton capacity,2 jacks/seats	Pcs	2	x	
5	e)Fishing magnet	Pcs	1		
	Steel Work Casing				
1	a) Steel work casing ,threaded flush joint type 8"(216.3 mm O.D /190.9 MM I.D) 3m long /pc	Pcs	15		x
2	b) Steel work casing ,threaded flush joint type 10"(267mm O.D /242MM I.D) 3m long /pc	Pcs	15		x
3	c) Steel work casing ,threaded flush joint type 14"(356mm O.D /344MM I.D) 3m long /pc	Pcs	0		
	Direct Mud Circulatin Drilling Tools				
1	Mud testing kit including mud balance ,marsh funnel,viscocity meter with measuring cup sand content kit,stop watch and thermometer	Pcs	1		
2	Collapsible water tank with housing bag 3000 Litre capacity	Set	2	x	
3	Portable water level indicator,dry battery operated type,measuring capacity of 200m	Set	2	x	

4 MAINTENANCE ACTIVITIES IN THE PROCESS OF HIRING

Various activities of the maintenance shall be conducted according to each phase of equipment hiring as shown in ***Figure 2.*** Condition check of the hiring equipment is conducted by following "hiring equipment service check sheet"prior to hiring. Before delivery of the equipment to the hirer, photos of the equipment shall be taken to verify the condition. During hiring, the owner is responsible for daily maintenance with using "daily service check sheet" under the supervision of the technical instructor dispatched from the owner. In case of the breakdown of the equipment on site, the mechanic from the owner will be dispatched to the site. When the equipment is returned by the hirer, the condition check will be conducted by the owner in presence of the hirer by following the "hiring equipment service check sheet". Photos of the equipment shall be taken to verify the condition if it is as same as before hiring. Besides these maintenance activities which shall follow the timing of the hiring, the periodic service maintenance shall be conducted according to the kilometrage or operating hours of each equipment.

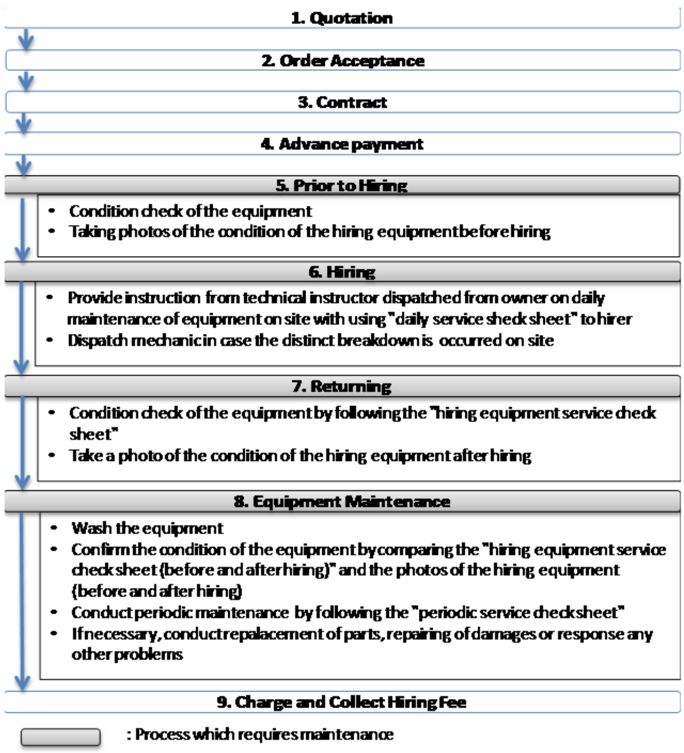


Figure 2 Maintenance Activities to be Implemented During Hiring

5 CONTENTS OF MAINTENANCE

5.1 SCOPE OF MAINTENANCE

The baseline survey which was conducted in the project revealed that the maintenance of DDCA's existing drilling equipment was implemented on the basis of the "breakdown maintenance", instead of the "preventive maintenance". The periodic service are conducted only for vehicles by the manufacturer's agent in Tanzania. However, the quality of their services is not satisfactory and the prices are expensive. The maintenance of the other equipment such as drilling, air compressor mud pumps etc. are only the repairing for the breakdown or the replacement of parts after the wearing. Such "break down maintenance" system causes the delay of repairing due to the lack of the stock of the spare parts and the shortening of the machine lives because leaving certain breakdown will leads further breakdown of the other parts of mechanical and/or hydraulic system. Therefore, in order to keep the good conditions of machine without the distinct interruption of the hirer's drilling work, the "preventive maintenance" system is adopted to formulate this maintenance system for the hiring equipment, which includes the maintenance activities based on the operating hours or kilometrages bases maintenance plan, spare parts stockage according to the hiring plan and condition check system before and after hiring. In this context, the following maintenance activities are defined to be components of the maintenance actvitiies.

Condition check

In order to assure the good conditions of the equipment, the condition check will be conducted before and after hiring by using "condition check sheet". It will be done in the workshop of DDCA by the owner in presence of the hirer.

Periodic service maintenance

Once the timing of kilometrage or operation hours which needs replacement or repairing are confirmed from the records, the periodic service mainantenance will be done by the owner. The condition of the exhaustion and damage of the parts are also confirmed so that the necessary measures such as replacement of the spareparts are taken before they are worn out completely. The record of the periodic service maintenance will be filled into the form of "periodic service maintenance check sheet".

Daily service maintenance

The daily service maintenance will be done by the hirer in order to avoid the troubles or breakdowns during equipment operation. The hirer will conduct it by using the "daily service check sheet" under the supervision of technical instructor dispatched from the owner.

Repairing

The repairing works consist of the replacement of spareparts and fixing of parts. In principle, the necessary repairing works are to be done under the responsibility of the owner. If a breakdown happens on site, the owner will mobilize the mechanics to the site for the repairing. In case that repairing works are caused due to the faults or negligence of the hirer during the operation of the hiring equipment, the owner will charge the cost for the repairing to the hirer.

Figure 3 Flow of Mainteance in a Year

The flow of the maintenance works in a year is shown in ***Figure 3***. Condition check, periodic service maintenance and daily service maintenance are done in constantly either before, during or after hiring. On the other hand, the repairing work will be done in case the breakdowns or malfunctionality is occurred unexpectedly.

5.2 RESPONSIBILITY OF OWNER AND HIRER

The assignement of the resiponsibility of the owner and the hirer related to the maintenance activivies shall be clearly defined in the agreement of the hiring between the owner and the hirer. Not only the maintenance works but also the case of loss or damage of equipment and safety measures shoud be stipulated. The responsibility of each aspect between the owner and the hirer is as described below.

Condition check

Owner:

- For the commencement of the contract in delivery of the hiring equipment, in case that any defects are detected, the owner should repair the equipment or replace it to a substituted one.
- Upon the receiving the equipment after finishing of the operation of the hiring equipment, the condition will be inspected by the owner to confirm in presence of the hirer if the equipment is as it were before hiring.

Hirer:

- Before receiving the equipment, the hirer shall inspect the condition of hiring equipment in the presense of the owner in order to confirm that there is no defect for the operation. The standard, specification, efficiency, function and number of the equipment shall be confirmed, too.
- When any defect is detected, the hirer shall immediately inform of it to the owner so that the owner takes necessary measures such as the repairing of the equipment or replacement of the parts.
- The condition check shall be done by the owner in presence of the hirer when the hiring equipment is returned to the owner. Without the hirer's presence there, the hirer has no right to reject the result of inspection from the owner.
- The equipment shall be returned with the same condition as it was before hiring. When damages or defects are detected upon returning, the hirer shall recover it as the same condition of the original one or compensate for the cost of repairing to the owner.

Periodic service maintenance

Owner:

- When the equipment reaches the operation hours or kilometres which requires replacement of the spare parts or reparing from the record, periodic maintenance shall be conducted. The cost of the service is borne by the owner.
- The periodic service maintenance shall be planned so that it is conducted on time during the spare time of the hiring.
- The intensive use of the particular equipment shall be avoided. It shall be confirmed and adjusted from the past record of the periodic service check sheet in order for balanced operation of the hiring equipment.

Daily service maintenance

Owner:

- The technical instructor dispatched from the owner shall supervise the daily service maintenance to be conducted by the hirer on site.

Hirer:

- The hirer shall conduct the daily service maintenance on site during hiring including the days when the equipment is not operated.

- In case that any troubles and breakdowns are detected as the result of the daily service maintenance, the hirer shall inform the owner of it immediately.

Repairing

Owner:

- The owner shall keep necessary spare parts for the periodical replacement, the parts easy to be worn out and any other general parts based on the spare parts procurement plan.
- According to the maitenance plan, the spare parts shall be kept in the stock for the periodic service maintenance and/or repairing so as not to cause the interruption of the drilling works by the hirer.
- The repairing and maintenance shall be conducted when the equipment is not hired out. The reservation status of the hiring equipment shall be confirmed in advance.
- When certain parts are found to be old, the owner shall repair or replace the parts immediately before it is worn out completely.

Hirer:

- The repairing cost will be compensated when the breakdown is ocurred as a result of operation mistake or intentional damage by the hirer.
- When the hirer causes damages to a third party during the installation, storage and operation of the equipment, the hirer settles the situation on its own responsibility.

Case of loss or damage of equipment

Hirer:

- When the equipment suffers damages or theft during the hiring period, the hirer shall be responsible for the items stipulated in the contract, irrespective of the reason, whether it is natural disasters such as earthquakes, tsunamis, eruptions, typhoons, or any other.
- When the equipment cannot be returned to the owner due to the loss of equipment or considerable damages at the time of the acceptance inspection upon the return of the equipment, the hirer shall make a compensation which worth the replacement of the equipment.
- When the repairing or replacement caused by the fault of the hirer requires some time, the hirer shall compensate for the damages and losses such as the suspension of operation to be shouldered by the owner.

Safety measures

Owner:

- When the maintenance on site is impossible, substitute drilling equipment shall be arranged with the agreement of the hirer so that the suspension of the operation of hiring equipment is limited to minimum.

Hirer:

- The hirer shall follow the principles of i) persons involved in drilling operations must pay high attention to safety in order to avoid dangers for themselves and others. ii) the operation shall be safely conducted by proper daily inspections, equipment handling and consideration of environment on site as well, during the operation of hiring equipment
- In cases that major equipment troubles or damages happen during operation, the owner's mechanic will be dispatched to the site to conduct the inspection and repairing.
- When any accident or trouble happens, the hirer shall inform the owner of it. In cases of accidents during operation or transportation, the situation must firstly be confirmed. If the accident is resulted in injury or death, the injured person must be transferred to the place for shelter or hospital first, followed by the inspection of the drilling equipment.

– The response should be taken emergently by following the procedure as shown in ***Figure 4*** when the accidents are happened.

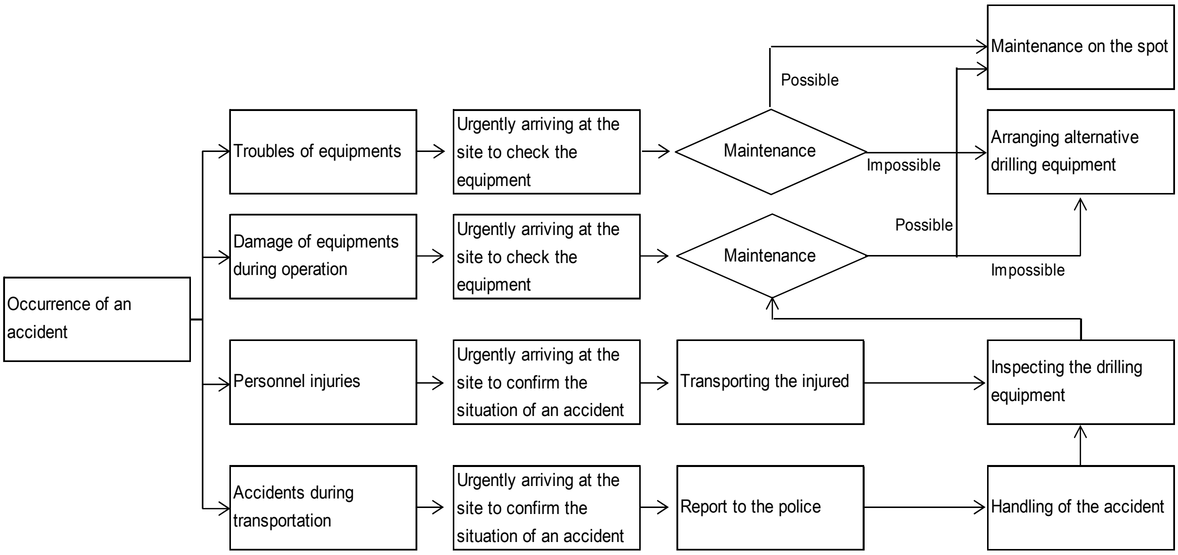


Figure 4 General Response to Mechanical Problems and Accidents

6 MAINTENACE ORGANIZATION

Figure 5 shows the organization structure of DDCA. The hiring business will be operated by the hiring business unit to be installed under the business support department in order to commence the hiring business. With the intimate relationship between the hiring business unit, the maintenance section under the technical support department will be in charge of the maintenance for the hiring equipment in addition the one for DDCA's existing equipment.

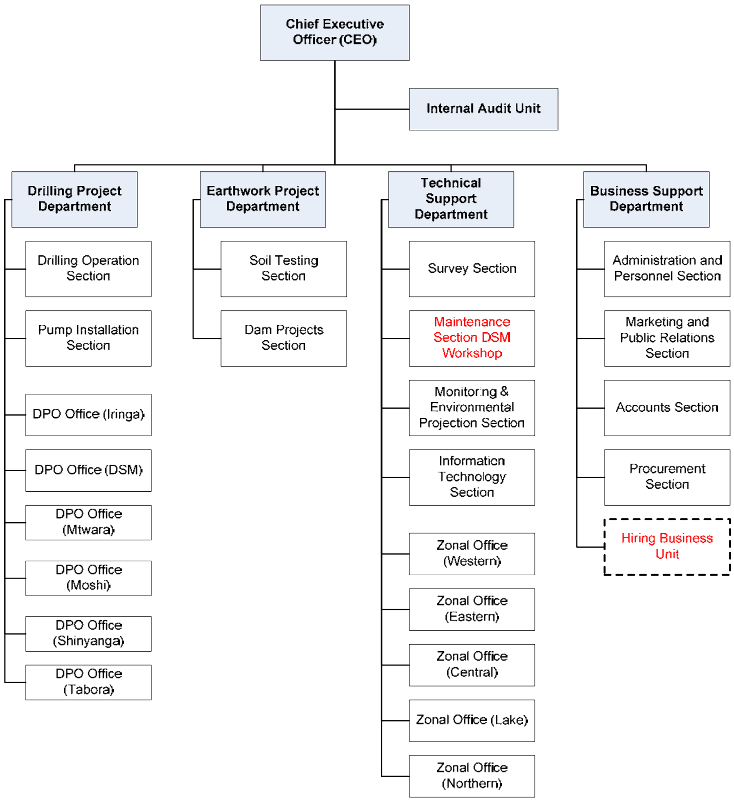


Figure 5 Organization Structure in DDCA

Currently, the technical support department has 62 staffs. Among them, 23 staffs are allocated in the maintenance section and it is further divided into four sections of "Garage", "Panel Beating and Spray Paint", "Auto Electric" and "Earth Work Moving Plant", each section of which corresponds to the different field of the maintenance, as shown in ***Figure 6***. The maintenance section is headed by three engineers, the head of maintenance section, the assistant head and the mechanical engineer.

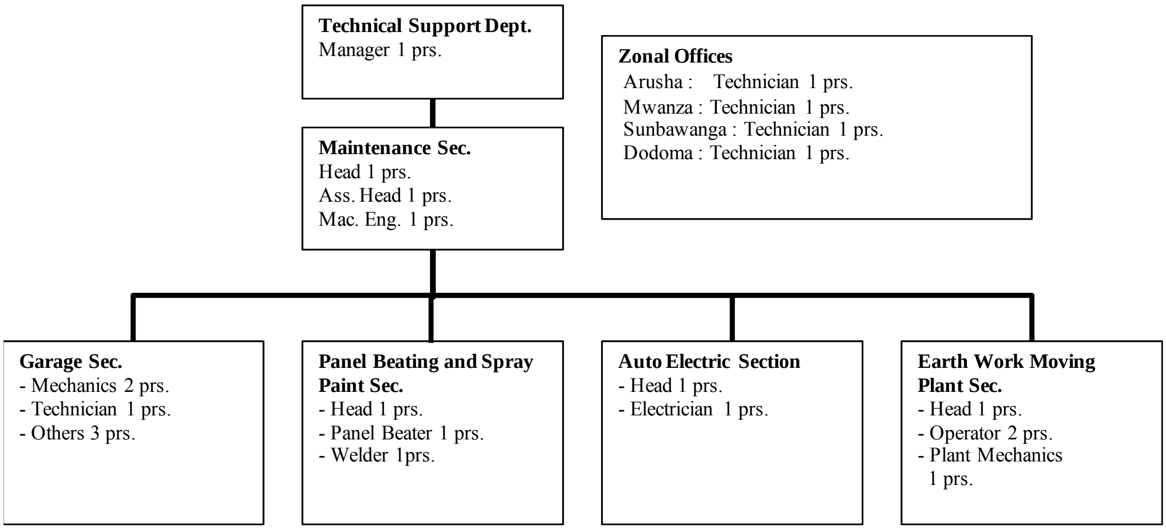


Figure 6 Organization of Maintenance Section

The headquarters of DDCA are located in Dar es Salaam and 5 zonal and 6 DPO offces are locted in the country as shown in ***Figure 7***. These offices can be considered to be "future local base" for the maintenance as to be depots for equipment and the workshop for maintenance. However, in the beginning of the operation of the hiring business, it is preferable to directly manage all the equipment by the headquarters in Dar es Salaam. According to the progress of the business and the quantitative trend of the hiring by each area, the maintenance organization including local offices shall be reorganized with the consideration of the use of local resources such as the existing workshop facilities of DDCA's offices and the basin water offices.

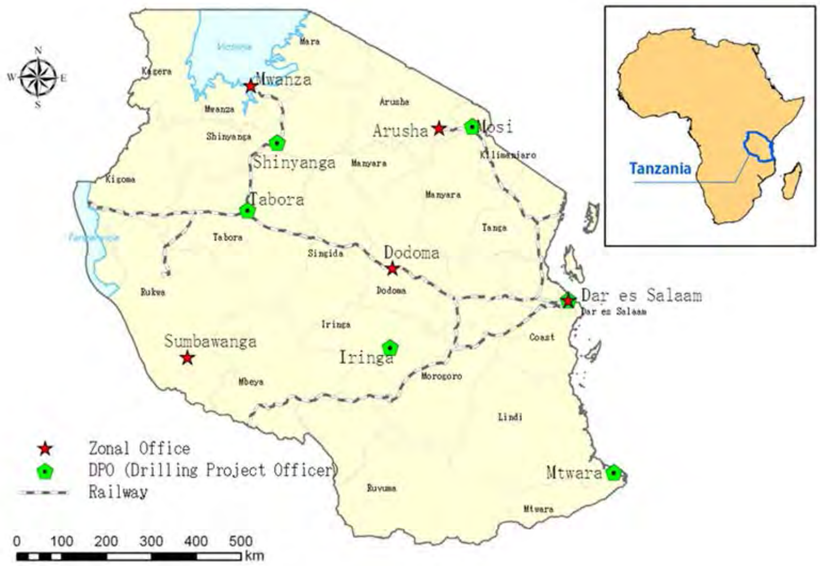


Figure 7 Locations of DDCA Zonal and DPO Offices in the Country

7 FORMULATION OF MAINTENANCE PLAN

7.1 PLANNING

The maintenance plan shall be formulated by the maintenance section by following the annual operation plan of hiring service to be formulated by the hiring business unit. According to the annual operation plan of hiring service, the timing of periodic service maintenance shall be estimated. Then the quantity of the spare parts to be kept shall be calculated based on the operation plan of each equipment. The procurement of mechanical tools and the allocation of maintenance staff shall be also considered to conduct the maintenance activities. The utilization of the resources in branch offices such as zonal and DPO offices of DDCA shall be considered in formulation of the plans as well.

7.2 CONTENTS OF MAINTENANCE PLAN

The maintenance plan consists of 10 components. ***Table 3*** shows the contents of each component. Each plan shall be formulated by the maintenance section in due conformity with the annual operation plan of operation of hiring service to be formulated by the hiring business unit. The maintenance plan compiled with these components will be incorporated into the final version of annual plan of operation of hiring service. At the end of the fiscal year, the next maintenance plans shall be prepared according to the result of the annual review of the maintenance activities.

Table 3 Maintenance Plans

Plan	Contents
1. Annual Action Plan	Outline of annual maintenance activities
2. Periodic Service Maintenance Plan	Plan of periodic service maintenance, replacement of spare parts and consumable parts of each equipment
3. Daily Service Plan	Plan of daily service
4. Repairing Plan	Plan of repairing of breakdown
5. Spare parts and Consumable Parts Control and Procurement Plan	Inventory of store parts and consumable parts Plan for the procurement of spare parts and consumable parts for periodic service maintenance and repairing
6. Maintenance Tools Control and Procurement Plan	Inventory of maintenance tools Listing-up of necessary tools and procurement plan
7. Maintenance Equipment Control and Procurement Plan	Condition check of maintenance equipment Listing-up of necessary equipment and procurement plan
8. Personnel Assignment Plan	Personnel assignment to each maintenance activity
9 Technicl Enhancement Plan	Action plan for the enhancement of maintenance techniques and skills
10 Budget Plan	Budget plan for the maintenance activities and the procurement

8 REVISION OF MAINTENANCE SYSTEM

8.1 MONITORING AND EVALUATION OF SYSTEM

The maintenance work will be operated in a Plan-Do-Check-Action (PDCA) cycle as shown in ***Figure 8***. It starts from preparation of annual action plan and budget plan which is to be incorporated into the annual plan of operation of hiring business. The implementation stage involves various maitnenance activities in accordance with the process of maintenance described in detail in ***Figure 8***. The performance of the maintenance will be monitored from time to time to check;

– If there is any gaps between what has been planned and implemented, and
– If the expected output and outcomes are realized.

Action should be taken to solve problems and improve the process management based on findings from the monitoring. These improved solutions shall also be reflected in the planning stage in the subsequent cycle.

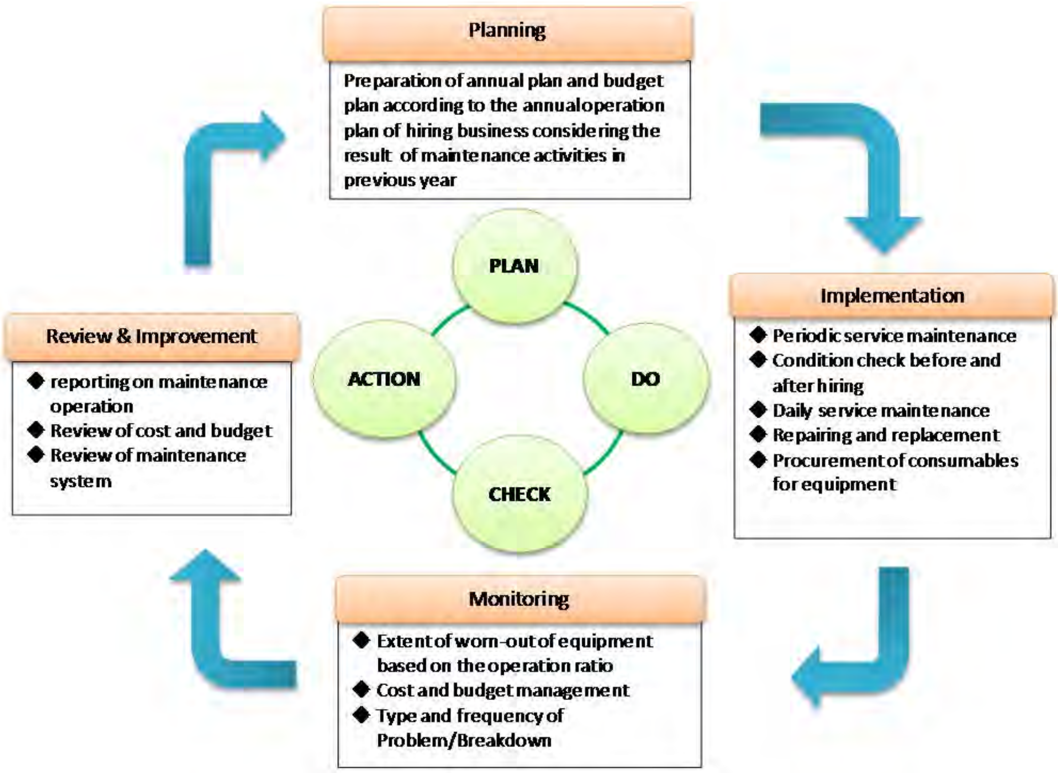


Figure 8 Cycle of Maintenance Operation

Maintenance section shall prepare monthly and annual reports to be submitted to the hiring business unit so that the unit can prepare the following reports to be submitted to the management team of DDCA and MAB;

– Monthly report to be submitted not later than 10 days after the end of the month

– Annual report to be submitted not later than 14 days after the end of the year.

The above reporting procedures notwithstanding, DDCA shall report promptly to MoW on any major even likely to affect efficient and effective utilization of the equipment.

8.2 PROCEDURE FOR REVISION OF SYSTEM

At this moment, the first version of the maintenance guideline, plan and manuals are prepared. They shall be reviewed and revised until the commencement of the trial operation. Once the contents of the business model for the equipment hiring system are determined, these documents shall be also finalized accordingly. After the start of the trial operation of the maintenance system, continuous revision shall be carried out in order to improve the maintenance system of hiring equipment.

Ministry of Water (MoW)
Drilling and Dam Construction Agency (DDCA)
Japan International Cooperation Agency (JICA)

DDCAP

Maintenance Plan

Maintenance System for Hiring Equipment

Version 1

March 2013

Groundwater Development and Management Capacity Development (DDCAP) Project

Contents

Tables

Figures

1 BACKGROUND

Ministry of Water (MoW) formulated a "Strategy for Strengthening Water Well Drilling Industry in Tanzania" in 2006, and mandated the capacity development of private drilling companies to DDCA (Drilling and Dam Construction Agency) by launch their new services such as a hiring of drilling equipment and technical instructions. The reason behind is the capacity of private drilling companies such as technical abilities and resources have a great gap compared with the demand of groundwater development under the Water Sector Development Programme (WSDP).

Accordingly, the Groundwater Development and Management Capacity Development Project (DDCAP) was launched on March 2012, under the technical assistance of Japan International Cooperation Agency (JICA). A purpose of the project is to "enhance the DDCA's capacity to support the water well drilling industry" by strengthening of DDCA's techniques for groundwater development and their capacity of technology transfer toward private drilling companies, and by establishment of an equipment hiring system in DDCA.

A maintenance system was established by the Project in order to maintain the equipment for the hiring service properly. DDCA is responsible for preventive maintenance and repair works of the equipment before and after the equipment is hired. On the other hand, the hirer will conduct routine maintenance of the hired equipment on site under supervision and instruction of the technical instructor from DDCA.

This is first version of maintenance plan for the hiring equipment to operate maintenance system for hiring equipment. The maintenance of the equipment for hiring service should be implemented in accordance with the guideline, plan, and manual on the maintenance system of the hired equipment. The maintenance plan indicates the plans for the periodical service maintenance, spare parts, consumable parts, tools, procurement, staff assignment, training and budget. After the commencement of the equipment hiring service by DDCA, the maintenance plan will be updated and/or modified by reflecting the results of the activities as well as the maintenance guideline.

2 DOCUMENTS FOR MAINTENANCE SYSTEM

The documents, namely maintenance guideline, maintenance plan (this document) and maintenance manual for the hiring equipment were prepared by the DDCAP project, in order to manage the maintenance system for the hiring equipment. The roles and the contents of each document are summarized as follows.

Document 1: Maintenance Guideline

The guideline stipulates the operation principles of the maintenance system as well as the roles and responsibility of both the owner (DDCA) and the hirer (private companies). Under the system to hire drilling equipment and machineries, the guideline aims at keeping good working conditions of the hiring equipment and machinery in order to accommodate the demand of the private drilling companies.

Document 2: Maintenance Plan

The maintenance plan demonstrates the plans for the periodic service, spare parts, consumable parts, tools, procurement, staff assignment, training and budget. The maintenance works for the hiring equipment should be carried out according to the maintenance plan.

Document 3: Maintenance Manual

The separate maintenance manuals for the owner and the hirer were provided. The manuals indicate the method and procedures of the maintenance works by each party.

3 CONTENTS OF PLAN

Table 1 shows the contents of the maintenance plan. These sub-plans are prepared according to the principle of the maintenance guideline. The activities described in the plans will be conducted by referring to the maintenance manual.

Table 1 Maintenance Plans

Sub-Plan	Contents
1. Annual Action Plan	Outline of annual maintenance activities
2. Periodic Service Maintenance Plan	Plan of periodic service maintenance, replacement of spare parts and consumable parts of each equipment
3. Daily Service Plan	Plan of daily service
4. Repairing Plan	Plan of repairing of breakdown
5. Spare parts and Consumable Parts Control and Procurement Plan	Inventory of store parts and consumable parts Plan for the procurement of spare parts and consumable parts for periodic service maintenance and repairing
6. Maintenance Tools Control and Procurement Plan	Inventory of maintenance tools Listing-up of necessary tools and procurement plan
7. Maintenance Equipment Control and Procurement Plan	Condition check of maintenance equipment Listing-up of necessary equipment and procurement plan
8. Personnel Assignment Plan	Personnel assignment to each maintenance activity
9 Technical Enhancement Plan	Action plan for the enhancement of maintenance techniques and skills
10 Budget Plan	Budget plan for the maintenance activities and the procurement

4 ANNUAL ACTION PLAN

4.1 ACTION PLAN INTENDED FOR PREVENTIVE MAINTENANCE

Concerning the maintenance of drilling equipment of DDCA and the private drilling companies, the inspection works as “preventive maintenance” are not always conducted, because the maintenance tends to be conducted as repair services in response to problems. This may cause serious accidents because problems are not detected beforehand, and important parts of the vehicle may become completely damaged. In order to smoothly utilize the drilling equipment and efficiently continue drilling operations, “preventive maintenance” placing emphasis on inspection works following appropriate maintenance and management plan of equipment is necessary. In order to efficiently operate hiring services to the private companies, plan for equipment maintenance based on “preventive maintenance” will be necessary.

4.2 DETAILS OF ANNUAL ACTION PLAN

The maintenance plans for the hiring equipment will be prepared, implemented and reviewed according to the schedule shown in ***Figure 1***. As for the budget plan, since the fiscal year of Tanzania starts in July, the amount of spare parts for the following fiscal year should be calculated in November (6 months in advance) after examining the condition of the equipment. It is preferable that the spare parts are purchased at 2 separate times, one at the beginning and the other one at the middle of the fiscal year. The latter purchase will be made depending on the stock so that the excess stock or out of stock shall be avoided.

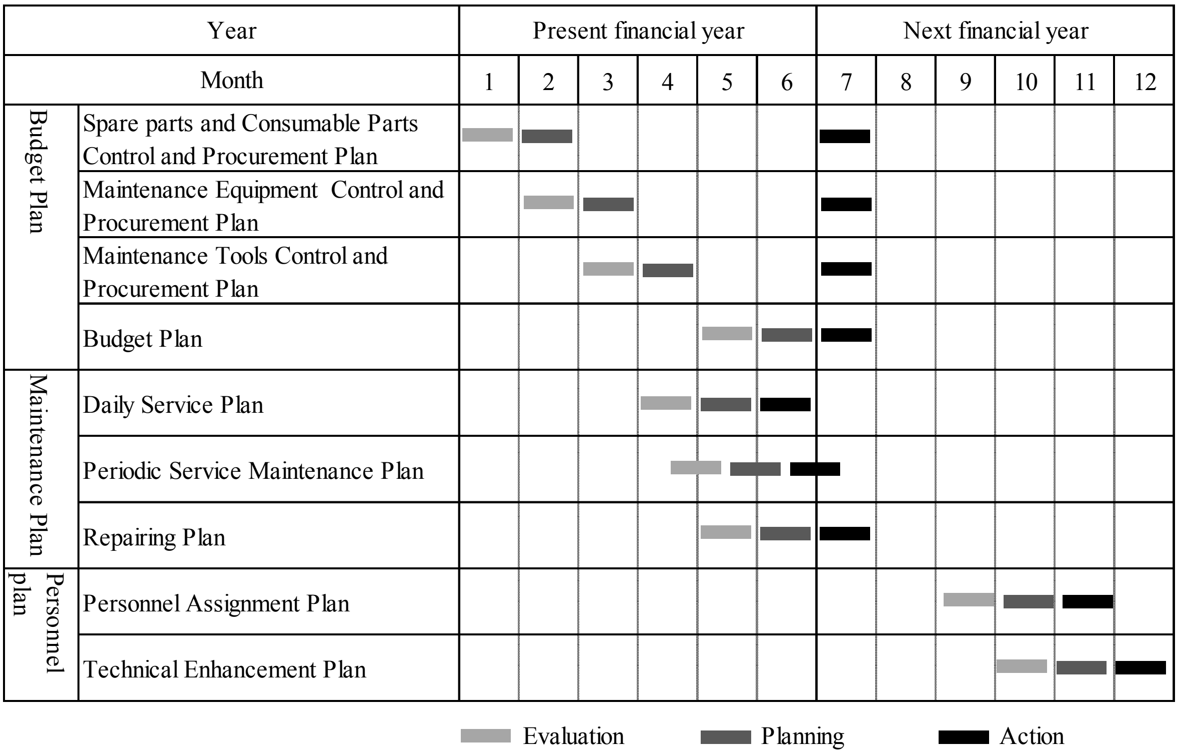


Figure 1 Annual Action Plan for Maintenance of Hiring Equipment

5 PERIODIC SERVICE MAINTENANCE PLAN

5.1 MANAGEMENT OF PERIODIC SERVICE MAINTENANCE

Three officers of the head, the assistant head, the mechanical engineer of the DDCA maintenance section are responsible to manage the periodic service. The implementation of the periodic services is supervised by these officers. The periodic service schedule for the following year shall be determined by them based on the mileage of vehicles and operation hours of the hiring equipment which were confirmed through the implementation of the periodic services. The TCO (Transport Control Officer) of DDCA who are in charge of the management of the vehicle operation will be informed of the next schedule.

5.2 UTILIZATION OF PERIODIC SERVICE MANUAL AND PERIODIC SERVICE CHECK SHEET

The periodic service shall be conducted by mechanics of DDCA at the workshop in the headquarters according to the record of mileage and operation period. The basic principles of the periodic maintenance are as follows.

- Periodic service shall be conducted in accordance with the inspection items shown in the "periodic service check sheet (***Figure 2***)".
- The spare parts and oils shall be replaced in every periodic service. These spare parts and oils should be prepared prior to the service period.
- The operator of the equipment, who checks the daily mileage and operation hours of the equipment, will decide the timing of the periodic service. The DDCA maintenance section will arrange for the periodic service accordingly.
- In case troubles and malfunction are detected in the periodic service, they shall be reported to the management of the maintenance section.

Periodic service check sheet

Date	Type	Model	Reg. No.	Mileage	Checked by
				km	

✔	OK	×	Change	A	Adjust	C	Clean up	T	Tighten	L	Lubricant

Service truck

Oil, Filter and water

		Qty.
	Engine oil (amount, leakage)	
	Engine oil filter (leakage)	
	Fuel filter (leakage)	
	Air cleaner (blocking)	
	Hydraulic oil (amount, leakage)	
	Hydraulic oil filter (leakage)	
	Power steering (amount, leakage)	
	Brake oil (amount, leakage)	
	Clutch oil (amount, leakage)	
	Transmission (amount, leakage)	
	Differential (amount, leakage)	
	Radiator, coolant (amount, leakage)	
	Battery (amount, loosening)	

Engine room

	Fan belt (damage, loosening)
	Fan (damage, loosening)
	Injector pump, Nozzle (leakage)
	Generator (damage, condition)
	Starter (damage, condition)

Outside

	Brake air tank, piping (leakage, condition)
	Brake air tank Drain (leakage, condition)
	Front Brake hose, pipe (leakage, damage)
	Brake lining front (leakage, damage, wear-out)
	Rear Brake hose, pipe (leakage, damage)
	Brake lining rear (leakage, damage, wear-out)
	Parking brake (condition, damage, wear-out)
	Hydraulic pump, cylinder(leakage, condition)
	Tire (depth of ditch, damage)
	Wheel nut bolt (damage, loosening)
	Frame, body (tightening, damage)
	Lights / Miller (tightening, damage)
	Attachment (Crane, Water tank)

Driving

	Engine general (start, running sound, smoking)
	Foot brake
	Hand brake
	Clutch / Transmission
	Steering
	Noise

Comments:

Figure 2 Periodical Service Check Sheet

6 DAILY SERVICE PLAN

6.1 DAILY SERVICE MAINTENANCE MANAGEMENT

The daily service maintenance will be conducted during hiring period by the hirer under the supervision of the technical instructor dispatched from DDCA with using "daily service check sheet". Eventually, the "daily service check sheet" will be submitted to the DDCA maintenance section.

6.2 UTILIZATION OF DAILY SERVICE MANUAL AND DAILY SERVICE CHECK SHEET

The daily service maintenance shall be conducted before and after the operation of equipment according to the items shown in "daily service check sheet" (***Figure 3***). The basic principles of the daily service maintenance are as follows.

- The operator of the hiring equipment from the hirer conducts the daily service.
- The operator will pay attention to the condition of the equipment in entire operation. In case that strange noise, smell, vibration, liquid leakage are detected, he will swiftly suspend the operation and report to the technical instructor dispatched from DDCA.

Daily service check sheet ✔: Good X: Not good —: Nothing

Type: Truck mounted rig		Date								
Model:			Start	End	Start	End	Start	End	Start	End
Reg. No.:		Hours								
Checked by:		Time	:	:	:	:	:	:	:	:
Place	Contents		Check		Check		Check		Check	
Engine	Engine oil (amount, leakage)									
	Fuel (amount, leakage)									
	Air filter (blocking)									
	Radiator (coolant water leakage)									
	Fan belt (condition)									
Hydraulic pump	Hydraulic pump (condition)									
	Hydraulic hose and pipe									
	Hydraulic oil (leakage)									
	Hydraulic oil (level)									
Hydraulic oil cooler	Hydraulic oil (leakage)									
	Fan (condition)									
Mud pump	Mud pump (condition)									
	Hydraulic hose and pipe (leakage)									
	Cylinder (condition)									
	Gear oil (level)									
	Greasing									
Control panel	Hydraulic oil (leakage)									
	Control switch (condition)									
	Control meter (condition)									
Rotation gear box	Gear oil (level)									
	Hydraulic oil (leakage)									
Mast	Wire rope (condition)									
	Hydraulic motor (condition)									
	Hydraulic hose and pipe (leakage)									

Remarks

Figure 3 Daily Service Check Sheet

7. REPAIRING PLAN

7.1 REPAIRING WORK

The repairing work consists of replacement of the spare parts and fixing. In principle, the repairing shall be done in case of i) the breakdown is occurred while operation on site, ii) the timing of the periodic maintenance comes. The repairing will be done by the owner.

7.2 CASE NECESSARY FOR REPAIRING

Table 2 summarizes the case necessary for repairing the drilling equipment and vehicles. Each component will have the specific problems and the several experts will respond to them. Necessary spare parts for general repairing will be procured according to the repairing plan. If another case is happened while operation of the equipment hiring, it will be added into the plan.

Table 2 General Maintenance Plan

Part of the vehicle	General problem	Person in charge of repair	Location of repairing works
Engine of the vehicle	Oil or water leakage	Person in charge of drilling	Drilling site

Part of the vehicle	General problem	Person in charge of repair	Location of repairing works
	Engine trouble	Mechanic of the Dar es Salaam garage	Drilling site or the Dar es Salaam garage
	Engine start-up failure	Mechanic of the Dar es Salaam garage	Dar es Salaam garage
	Problems with the fuel system	Mechanic of the Dar es Salaam garage	Outsourcing
Vehicle chassis	Problems with the tyres and wheels	Person in charge of drilling	Drilling site
	Problems with the suspension	Mechanic of the Dar es Salaam garage	Drilling site or the Dar es Salaam garage
	Problems with the brake	Mechanic of the Dar es Salaam garage	Drilling site or the Dar es Salaam garage
	Problems with the steering	Mechanic of the Dar es Salaam garage	Dar es Salaam garage
	Problems with the transmission and differential systems	Mechanic of the Dar es Salaam garage	Dar es Salaam garage
Drilling equipment	Oil leakage of the oil pressure system	Person in charge of drilling	Drilling site
	Problems with the oil pressure system	Mechanic of the Dar es Salaam garage	Drilling site or the Dar es Salaam garage
	Welding repair	Person in charge of drilling Welder of Dar es Salaam garage	Drilling site or the Dar es Salaam garage

8 SPARE PARTS AND CONSUMABLE PARTS CONTROL AND PROCUREMENT PLAN

8.1 PROCUREMENT OF SPARE PARTS

8.1.1 SPECIFICATION OF SPARE PARTS

The spare parts are classified into the following three categories.

(1) Spare parts used for periodic service (periodic service spare parts)

– Spare parts used at periodic service
– Filters (air filter, engine oil, fuel, hydraulic oil)
– Oils (engine oil, gear oil, power steering oil, hydraulic oil, radiator coolant)

The quantity of spare parts required annually for periodic service can be calculated according to the mileage and operated hours of the equipment for each case supposed in the repairing plan. The spare parts shall be purchased after calculating the required quantity with using the “calculating sheet for required spare parts”.

(2) General spare parts necessary during while operation

The spare parts necessary for general operation of the equipment hiring will be mainly the following items.

– Tires
– Batteries
– Brake, Clutch (brake lining, crutch disc, brake cup seal)
– Engine spare parts (fan belt, radiator hose)

– Oil seals, bushes, hoses (hub seal, hydraulic seal, bush, high pressure hose)

The quantity of spare parts required for periodic service maintenance can be estimated from the mileage and operation hours of the equipment. However, even before the required timing of the replacement has not yet come, the necessity of the replacement could be happened by any chance. The quantity of the spare parts including additional ones will be calculated with using the "calculating sheet for required spare parts".

(3) Spare parts for emergency due to accidents and collision

The spare parts needed emergently due to the unexpected accidents or corrosion will be estimated as the following items.

– Window glass, lights(windshield, light bulbs, lens)

– Engine(alternator, starter, radiator)

– Chassis(shock absorber, leaf spring)

It is preferable that at least one set of these items for each equipment are prepared for the case of emergency.

8.1.2 Spare Parts Procurement Plan

Following procedures are necessary, in order to estimate the necessary quantities of spare parts and their budget for the annual use of the hiring equipment:

(1) Set the annual operation mileage and operation hours of each equipment according to the annual operation plan of the hiring business,

(2) List up the necessary parts to be replaced and their replacement timing (mileage or operation hours) of each equipment,

(3) Investigate the unit prices of the parts,

(4) Calculate the annual necessary quantities of each parts from (1) and (2),

(5) Calculate the cost for procurement from (3) and (4).

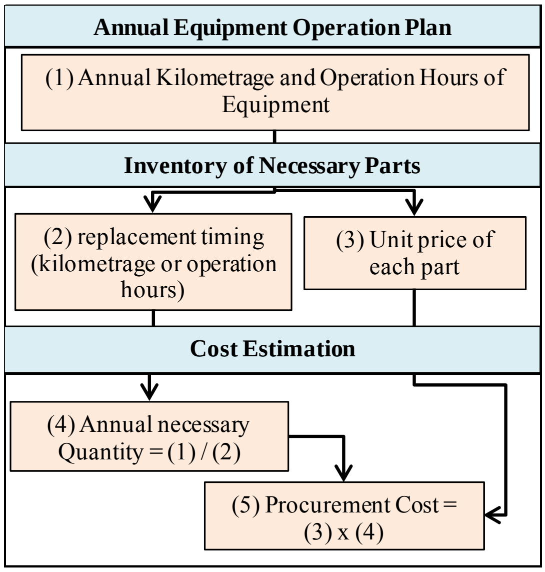


Figure 4 Procedure of Spare Parts Procurement Plan

The above procedures are summarized in ***Figure 4***.

Currently, DDCA has not received the operation manuals of each equipment from the supplier, which provide the list of necessary spare parts and the replacement timing. In this reason, the maintenance section estimated the quantities and the budget of spare parts procurement for a drilling rig from their experience. According to this estimation for a drilling rig, the budget of spare parts procurement for other hiring equipment was estimated. The actual estimation for a rig using the above procedures is described below:

(1) Operation Plan of a Drilling Rig

A drilling rig consists of two components of a rig truck and a rig plant. ***Table 3*** shows the annual operation plan for each component for three years.

Table 3 Annual Operation Plan of Drilling Rig

Equipment	Replacement Timing	Annual Mileage	Nos.	Mileage / Operation Hours		
				1st Year	2nd Year	3rd Year
Rig Truck	Mileage	20,000	6	20,000	40,000	60,000
Rig Plant	Operation Hours	1,500	6	1,500	3,000	4,500

(2) Replacement Timing of Parts for a Drilling Rig

Table 4 Shows the list of spare parts and their replacement timing. Principally, replacement timing of spare parts for rig truck is based on the mileage and the one for rig plant is based on operation hours.

Table 4 Replacement Timing of Spare Parts for Rig Truck and Rig Plant

Rig Truck			Rig Plant		
Category	Parts	Replacement (mileage/ year)	Category	Parts name	Replacement (operation hours / year)
Filters	Engine oil filter	10,000km	Filters	Engine oil filter	250h
	Fuel filter	30,000km		Fuel filter	1,000h
	Water separator	30,000km		Water separator	1,000h
	Air filter	60,000km		Air filter	2,000h
	Hydraulic filter	2 year		Hydraulic filter	3,000h
Oil	Engine oil	10,000km	Oil	Engine oil	250h
	Transmission oil	30,000km		Gear oil	1,500h
	Differential oil	30,000km		Hydraulic oil	3,000h
	Hydraulic oil	2 year		Grease	250h
	Power steering oil	100,000km	Consumable	Battery	1 year
	Grease	10,000km		Fan belt	1 year
Consumable	Tire	90,000km		Hydraulic hose	2 years
	Battery	1 year			
	Brake lining	60,000km			
	Brake oil seal	60,000km			
	Fan belt	50,000km			

(3) List of Spare Parts and Unit prices for a Drilling Rig

Table 5 shows the inventory of spare parts for a rig truck and a rig plan. This contains necessary quantities for each replacement and unit prices of each spare parts, in addition to the information of the annual mileage and operation hours of each equipment and replacement timing of each spare parts described in above (1) and (2).

Table 5 Inventory of Spare Parts for Rig Truck and Rig Plant

No	Parts	Replacement Criteria	mileage / Operation Hours	Qty	Unit	Unit Price (Tsh)
1 Parts for Rig Truck						
1-1 Filter for Truck						
1-1-1	Engine oil filter	Mileage	10,000	1	pc.	300,000
1-1-2	Fuel filter	Mileage	30,000	1	pc.	200,000
1-1-3	Water separator	Mileage	30,000	1	pc.	200,000
1-1-4	Air cleaner	Mileage	60,000	1	pc.	300,000
1-2 Oil for Truck						
1-2-1	Engine oil	Mileage	10,000	25	litter	10,000
1-2-2	Transmission oil	Mileage	30,000	15	litter	5,000
1-2-3	Differential oil	Mileage	30,000	15	litter	5,000
1-2-4	Hydraulic oil	Years	2	100	litter	5,000
1-2-5	Power steering oil	Mileage	100,000	15	litter	8,000
1-2-6	Grease	Mileage	10,000	0.5	kg	5,000
1-3 Consumption parts for Truck						
1-3-1	Tire	Mileage	90,000	4	pc.	1,500,000
1-3-2	Battery	Years	1	2	pc.	500,000
1-3-3	Brake lining	Mileage	60,000	1	set	600,000
1-3-4	Brake oil seal	Mileage	60,000	1	set	400,000

No	Parts	Replacement Criteria	mileage / Operation Hours	Qty	Unit	Unit Price (Tsh)
1-3-5	Fan belt	Mileage	50,000	1	set	100,000
1-3-6	Rubber bush	Mileage	50,000	1	set	600,000
1-4 Other parts for Truck						
1-4-1	Grass	Mileage	35,000	1	set	500,000
1-4-2	Lights	Mileage	35,000	1	set	1,000,000
1-4-3	Electric	Mileage	35,000	1	set	500,000
1-4-4	Others	Mileage	35,000	1	lot	200,000
2 Parts for Rig Plant						
2-1 Filter for Drilling Rig						
2-1-1	Engine oil filter	Hours	250	1	pc.	300,000
2-1-2	Fuel filter	Hours	1,000	1	pc.	200,000
2-1-3	Water separator	Hours	1,000	1	pc.	200,000
2-1-4	Air cleaner	Hours	2,000	1	pc.	300,000
2-1-5	Hydraulic oil filter	Hours	3,000	1	pc.	200,000
2-2 Oil for Drilling Rig						
2-2-1	Engine oil	Hours	250	25	litter	10,000
2-2-2	Gear oil	Hours	1,500	40	litter	5,000
2-2-3	Hydraulic oil	Hours	3,000	400	litter	5,000
2-2-4	Grease	Hours	250	1	k g	5,000
2-3 Consumption parts for Drilling Rig						
2-3-1	Battery	Years	1	2	pc.	1,000,000
2-3-2	Fun belt	Years	1	1	set	100,000
2-3-3	Hydraulic hose	Years	2	1	set	1,500,000
2-3-4	Others	Years	1	1	set	200,000

(4) Budget of Spare Parts Procurement for a Drilling Rig

Table 6 Shows the budget plan of spare parts procurement for a drilling rig for 3 years. The necessary spare parts to be replaced are differently estimated by each year. Accordingly, the maintenance section estimated the quantities of spare parts and their budget for each year of 3 years' use. The average of 3 years' budget was reported to the account section of DDCA as a first year's budget.

The calculated annual budget for maintenance of a drilling rig is Tsh 14,625,667 (sum of Tsh 6,295,667 and Tsh 8,330,000). The CIP price of a drilling rig is US$260,894 (x 1,600 Tsh/US$ = Tsh 417,430,400). According to these calculations, an annual budget for maintenance of a drilling rig is equivalent to 3.5 % of the price of a drilling rig. Since DDCA has not received the operation manuals of each equipment which shall give the necessary information of spare parts inventory, this 3.5 % is adapted to estimate the annual spare parts procurement budget for other equipment. After the final delivery of the equipment and manuals and the 1st year's operation of the hiring business, the spare parts procurement plan and budget shall be adjusted based on the manuals' instructions and the results of the operation of the hiring business.

Table 6　3 Year’s Spare Parts Procurement Budget Plan for a Drilling Rig

No.	Parts	Replacement Criteria	Mileage / Years	Qty	Unit	Unit Price (Tsh)	1st Year		2nd Year		3rd Year		Total	
							Qty	Amount (Tsh)	Qty	Amount (Tsh)	Qty	Amount (Tsh)	Qty	Amount (Tsh)
One Rig Truck														
1-1-1	Engine oil filter	Mileage	10,000	1	pc.	300,000	2	600,000	2	600,000	2	600,000	6	1,800,000
1-1-2	Fuel filter	Mileage	30,000	1	pc.	200,000	1	200,000	0	0	1	200,000	2	400,000
1-1-3	Water separator	Mileage	30,000	1	pc.	200,000	1	200,000	0	0	1	200,000	2	400,000
1-1-4	Air cleaner	Mileage	60,000	1	pc.	300,000	0	0	1	300,000	0	0	1	300,000
1-2-1	Engine oil	Mileage	10,000	25	litter	10,000	50	500,000	50	500,000	50	500,000	150	1,500,000
1-2-2	Transmission oil	Mileage	30,000	15	litter	5,000	10	50,000	10	50,000	10	50,000	30	150,000
1-2-3	Differential oil	Mileage	30,000	15	litter	5,000	10	50,000	10	50,000	10	50,000	30	150,000
1-2-4	Hydraulic oil	Years	2	100	litter	5,000	0	0	100	500,000	0	0	100	500,000
1-2-5	Power steering oil	Mileage	100,000	15	litter	8,000	3	24,000	3	24,000	3	24,000	9	72,000
1-2-6	Grease	Mileage	10,000	0.5	kg	5,000	1	5,000	1	5,000	1	5,000	3	15,000
1-3-1	Tire	Mileage	90,000	4	pc.	1,500,000	1	1,500,000	1	1,500,000	1	1,500,000	3	4,500,000
1-3-2	Battery	Years	1	2	pc.	500,000	2	1,000,000	2	1,000,000	2	1,000,000	6	3,000,000
1-3-3	Brake lining	Mileage	60,000	1	set	600,000	0	0	1	600,000	0	0	1	600,000
1-3-4	Brake oil seal	Mileage	60,000	1	set	400,000	0	0	1	400,000	0	0	1	400,000
1-3-5	Fun belt	Mileage	50,000	1	set	100,000	0	0	1	100,000	0	0	1	100,000
1-3-6	Rubber bush	Mileage	50,000	1	set	600,000	0	0	1	600,000	0	0	1	600,000
1-4-1	Grass	Mileage	35,000	1	set	500,000	1	500,000	0	0	1	500,000	2	1,000,000
1-4-2	Lights	Mileage	35,000	1	set	1,000,000	1	1,000,000	0	0	1	1,000,000	2	2,000,000
1-4-3	Electric	Mileage	35,000	1	set	500,000	1	500,000	0	0	1	500,000	2	1,000,000
1-4-4	Others	Mileage	35,000	1	lot	200,000	1	200,000	0	0	1	200,000	2	400,000
	Total							6,329,000		6,229,000		6,329,000		18,887,000
	Annual Average													6,295,667
One Rig Plant														
2-1-1	Engine oil filter	Hours	250	1	pc.	300,000	6	1,800,000	6	1,800,000	6	1,800,000	18	5,400,000
2-1-2	Fuel filter	Hours	1,000	1	pc.	200,000	2	400,000	1	200,000	2	400,000	5	1,000,000
2-1-3	Water separator	Hours	1,000	1	pc.	200,000	2	400,000	1	200,000	2	400,000	5	1,000,000
2-1-4	Air cleaner	Hours	2,000	1	pc.	300,000	1	300,000	1	300,000	0	0	2	600,000
2-1-5	Hydraulic oil filter	Hours	3,000	1	pc.	200,000	1	200,000	0	0	1	200,000	2	400,000
2-2-1	Engine oil	Hours	250	25	litter	10,000	150	1,500,000	150	1,500,000	150	1,500,000	450	4,500,000
2-2-2	Gear oil	Hours	1,500	40	litter	5,000	40	200,000	40	200,000	40	200,000	120	600,000
2-2-3	Hydraulic oil	Hours	3,000	400	litter	5,000	200	1,000,000	200	1,000,000	200	1,000,000	600	3,000,000
2-2-4	Grease	Hours	250	1	k g	5,000	6	30,000	6	30,000	6	30,000	18	90,000
2-3-1	Battery	Years	1	2	pc.	1,000,000	2	2,000,000	2	2,000,000	2	2,000,000	6	6,000,000
2-3-2	Fan belt	Years	1	1	set	100,000	1	100,000	1	100,000	1	100,000	3	300,000
2-3-3	Hydraulic hose	Years	2	1	set	1,500,000	0	0	1	1,500,000	0	0	1	1,500,000
2-3-4	Others	Years	1	1	set	200,000	1	200,000	1	200,000	1	200,000	3	600,000
	Total							8,130,000		9,030,000		7,830,000		24,990,000
	Annual Average													8,330,000

8.1.3 DRILLING CONSUMABLE PLAN

Rig accessories of which detailed contents are shown in the maintenance guideline include drilling consumables such as DTH hammers, DTH bits, roller bits, steel casings etc. These consumables are consumed in drilling of several boreholes. It is difficult to charge the fixed tariff for the drilling consumables as their lives varies depending on the specifications of each boreholes and drilling conditions. Therefore, the drilling consumables will not be hired. The hirers shall procure for themselves necessary quantities of drilling consumables or they will purchase them from DDCA. In order to respond to the hirers' demand of the purchase of the drilling consumables, DDCA shall keep necessary quantities as stocks. DDCA shall estimate the necessary quantities of the drilling consumables and their budget from the past experiences and the results of the operation of the hiring business.

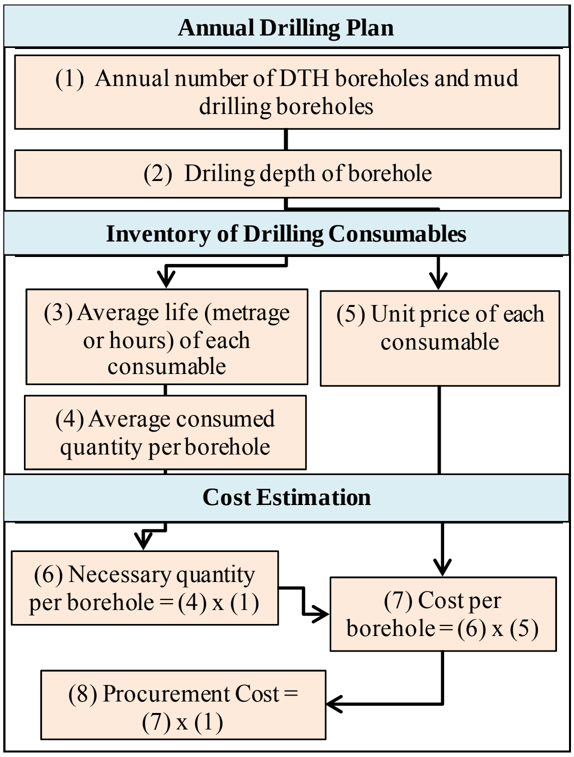


Figure 5 Procedure of Drilling Consumable Procurement Plan

Following procedures are necessary, in order to estimate the necessary quantities of drilling consumables and their budget for the annual drilling works under the hiring business:

(1) Set the annual number of DTH boreholes and mud drilling boreholes based on the annual operation plan of the hiring business,

(2) Set the average depth of borehole,

(3) List-up the necessary drilling consumables and their lives for DTH drilling borehole and mud drilling borehole,

(4) Estimate the necessary quantities of drilling consumables per borehole for DTH drilling borehole and mud drilling borehole,

(5) Investigate the unit prices of drilling consumables,

(6) Calculate the quantities of drilling consumables per borehole for DTH drilling borehole and mud drilling borehole,

(7) Calculate the procurement cost of drilling consumables per borehole for DTH drilling borehole and mud drilling borehole,

(8) Annual procurement cost of drilling consumables.

The above procedures are summarized in ***Figure 5***.

Number of DTH boreholes and mud drilling boreholes under the annual drilling plan for the hiring business, average drilling depth, inventory of drilling consumables shall be annually reviewed for the formulation of the procurement plan of the drilling consumables. The estimation for the 1st year using the above procedures is described below:

(1) Annual Drilling Plan under Annual Operation Plan of Hiring Business

The following annual drilling plan was prepared under the annual operation plan of the hiring business and described in Chapter 4 of the guidelines on hiring of drilling equipment and machinery. The total number of boreholes to be drilled is 33, of which 23 is DTH for boreholes (70 %) and 10 is for mud drilling boreholes (30 %). These percentages were estimated from the past experience of DDCA. Average drilling depth is 100 m. This is from the results of the drilling works in the rural water supply component of WSDP.

Table 7 Annual Drilling Plan for the 1st Year of the Hiring Business

Item	Plan
Number of DTH boreholes to be drilled	23
Number of mud drilling boreholes to be drilled	10
Total number of boreholes to be drilled	33
Average Drilling Depth	100 m

(2) Inventory of Drilling Consumables

Table 8 Summarizes the necessary drilling consumables respectively for a DTH borehole and a mud drilling borehole, with the information of their lives, average consumed quantities per borehole, unit prices, amount per borehole etc.

Table 8 Necessary Drilling Consumables for a DTH Borehole and Mud Drilling Borehole

Hole	Dia.	Depth	Metrage(?)	Consumable Bits and Casing	Metrage(?)	Penetration (m/h)	Life (Hour)	Operation Hours	Unit Numbers of BH	Consumed Number / BH	Unit Price CIP Dar es Salaam (US$)	Amount (US$)	Amount (Tsh)
DTH Drilling Borehole (Drilling Depth : 100 m)													
Surface Hole	12-1/2"	0 to 5 m	5	Roller Bit	1	5	45	0.200	227	0.00440	2823.09	12.42	19,872
	12-1/2"			Tricone Roller Bit	1	3.5	75	0.286	263	0.00380	5515.69	20.96	33,536
	12-1/2"			Drag Bit	3	6	120	0.500	238	0.00420	996.38	4.18	6,688
	10"			Steel Casing	5				33	0.03000	564.62	16.94	27,104
	10"			Casing Shoe	5				10	0.10000	308.4	30.84	49,344
Conductor Hole	10-1/2"	5 to 30 m	25	DTH	10	7	1000	1.429	714	0.00140	10675.53	14.95	23,920
	10-1/2"			DTH Bit	10	7	50	1.429	35	0.02860	972.66	27.82	44,512
	10-1/2"			Roller Bit	5	4.5	35	1.111	32	0.03170	1636.91	51.89	83,024
	10-1/2"			Tricone Roller Bit	3	3	70	1.000	70	0.01430	3582.23	51.23	81,968
	10-1/2"			Drag Bit	7	5.5	100	1.273	79	0.01270	822.02	10.44	16,704
	8"			Steel Casing					33	0.03000	453.12	13.59	21,744
	8"			Casing Shoe					10	0.10000	260.96	26.10	41,760
Production Hole	8-1/4"	30 to 100 m	70	DTH	70	7	1000	10.000	100	0.01000	10675.53	106.76	170,816
	8-1/4"			DTH Bit	70	7	45	10.000	5	0.22220	806.6	179.23	286,768
Pilot Hole	6-1/4"	30 to 100 m	35	DTH	35	7	1000	5.000	200	0.00500	10675.53	53.38	85,408
	6-1/4"			DTH Bit	35	7	40	5.000	8	0.12500	498.19	62.27	99,632
Replacement			100	Drill Pipe					33	0.03000	533.78	16.01	25,616
	8-1/4"			Stabilizer					25	0.04000	880.73	35.23	56,368
	6-1/4"			Stabilizer					25	0.04000	789.99	31.60	50,560
											Total Amount (Tsh)	765.84	1,225,344
Mud Drilling Borehole (Drilling Depth: 100 m)													
Surface Hole	12-1/4"	0 to 5 m	5	Roller Bit	1	5	45	0.200	227	0.00440	2823.09	12.42	19,872
	12-1/4"			Tricone Roller Bit	1	3.5	75	0.286	263	0.00380	5515.69	20.96	33,536
	12-1/4"			Drag Bit	3	6	120	0.500	238	0.00420	996.38	4.18	6,688
	10"			Steel Casing	5				33	0.03000	564.62	16.94	27,104
	10"			Casing Shoe	5				10	0.10000	308.4	30.84	49,344
Production Hole	10-1/2"	5 to 100 m	95	Roller Bit	45	4.5	35	10.000	4	0.28570	1636.91	467.67	748,272
	10-1/2"			Tricone Roller Bit	30	3	70	10.000	7	0.14290	3582.23	511.90	819,040
	10-1/2"			Drag Bit	20	5.5	100	3.636	27	0.03640	822.02	29.92	47,872
Pilot Hole	8-1/2"	5 to 100 m	50	Roller Bit	25	4	30	6.250	5	0.20830	1708.09	355.80	569,280
	8-1/2"			Tricone Roller Bit	25	2.5	65	10.000	7	0.15380	3250.11	499.87	799,792
Replacement			100	Drill Pipe					33	0.03000	533.78	16.01	25,616
	8-1/4"			Stabilizer					25	0.04000	880.73	35.23	56,368
	6-1/4"			Stabilizer					25	0.04000	789.99	31.60	50,560
											Total Amount (Tsh)	2033.34	3,253,344

(3) Drilling Consumable Procurement Plan and Budget

Based on the annual drilling plan and the inventory of the drilling consumables for DTH boreholes and mud drilling boreholes, described in above (1) and (2), the quantities and budget for the drilling consumables for the 1st year of the hiring business were estimated as shown in ***Table 9***. In the condition that the annual number of boreholes to be drilled is 33, the cost for drilling consumables is Tsh 60,715,888. However, DDCA needs not to purchase all the quantity in the beginning of the operation year, since the actual contents of the consumables will be changed according to the results of the drilling works and the selection of the hirers on whether they purchase the drilling consumables for themselves or from DDCA. Accordingly, DDCA's engagement to ensure the smooth implementation of the hiring business is to keep certain part of the annual quantities of drilling consumables and make prompt supplementation after selling the drilling consumables to the hirers.

Table 9 Annual Procurement Plan and Budget for Drilling Consumable

Item	Consumed Numbers / BH						Consumed Number for 33 boreholes / rig		
	DTH Drilling	Mud Drilling	Average Number / BH (DTH: 70 %, Mud Drilling: 30 %)	Unit Price CIP Dar es Salaam (US$)	Amount (US$)	Amount (Tsh)	Consumed Number	Amount (US$)	Amount (Tsh)
8" casing shoe	0.1	0	0.07	261	18.27	29,232	2.3	600.21	960,336
10" casing shoe	0.1	0.1	0.1	308.4	30.84	49,344	3.3	1017.72	1,628,352
8" steel casing	0.03	0	0.021	453.1	9.52	15,232	0.69	312.65	500,240
10" steel casing	0.03	0.03	0.03	564.6	16.94	27,104	0.99	558.97	894,352
4-1/2" drill pipe	0.03	0.03	0.03	533.8	16.01	25,616	0.99	528.44	845,504
DTH Hammer for 12" hole	0.0164	0	0.0115	10676	122.77	196,432	0.3772	4026.81	6,442,896
6-1/4" DTH bit	0.125	0	0.0875	498.2	43.59	69,744	2.875	1432.30	2,291,680
8-1/4" DTH bit	0.2222	0	0.1555	806.6	125.43	200,688	5.1106	4122.21	6,595,536
10" DTH bit	0.0286	0	0.02	972.7	19.45	31,120	0.6578	639.82	1,023,712
8-1/2" tricone roller bit	0	0.1538	0.0461	3250	149.83	239,728	1.538	4998.67	7,997,872
10-1/2" tricone roller bit	0.0143	0.1429	0.0529	3582	189.50	303,200	1.7579	6297.20	10,075,520
12-1/4" tricone roller bit	0.0038	0.0038	0.0038	5516	20.96	33,536	0.1254	691.67	1,106,672
8-1/2" roller bit	0	0.2083	0.0625	1708	106.76	170,816	2.083	3557.95	5,692,720
10-1/2" roller bit	0.0317	0.2857	0.1079	1637	176.62	282,592	3.5861	5870.12	9,392,192
12-1/2" roller bit	0.0044	0.0044	0.0044	2823	12.42	19,872	0.1452	409.91	655,856
10-1/2" drag bit	0.0127	0.0364	0.0198	822	16.28	26,048	0.6561	539.33	862,928
12-1/2" drag bit	0.0042	0.0042	0.0042	996.4	4.18	6,688	0.1386	138.10	220,960
6-1/4" stabilizer	0.04	0.04	0.04	790	31.60	50,560	1.32	1042.79	1,668,464
8-1/2" stabilizer	0.04	0.04	0.04	880.7	35.23	56,368	1.32	1162.56	1,860,096
				Total Amount	1,146	1,833,920		37,947	60,715,888

9 MAINTENANCE EQUIPMENT CONTROL AND PROCUREMENT PLAN

The work environment of the maintenance section including maintenance tools and equipment is an important factor for the smooth implementation of the maintenance activities. The baseline survey in the Project revealed that DDCA's maintenance tools were not sufficient and the equipment got aged. Conditions of the maintenance tools were improved by the procurement of new tools by the Project. The maintenance section conducted the survey of the existing maintenance facilities and listed up the list of necessary maintenance equipment to be procured with the 1st and 2nd priorities as shown in ***Table 10***.

Table 10 List of Required Equipment in each Section

No.	Equipment	Specification	Qty.	Price (Tsh)	1st Priorirty	2nd Priority
Maintenance Section						
1	air compressor	20bar	1	1,800,000		1,800,000

No.	Equipment	Specification	Qty.	Price (Tsh)	1st Priorirty	2nd Priority
2	washing machine		1	3,000,000	3,000,000	
3	hydraulic press		1	1,000,000	1,000,000	
4	injection nozzle tester		1	800,000		800,000
5	valve sharpener		1	650,000		650,000
6	high lift jack		1	600,000	600,000	
7	pipe bending machine		1	600,000	600,000	
8	torque wrench	0-100/100-400	2	560,000	560,000	
9	puller		1	250,000	250,000	
10	compression gauge		4	1,000,000		1,000,000
11	Micrometre screw gauge		1	200,000		200,000
12	cooling system tester		1	200,000		200,000
13	tire press		1	200,000	200,000	
14	valve seat grinding set		1	150,000		150,000
15	RPM meter		1	110,000		110,000
16	bench vice		2	200,000	200,000	
17	injector tool		1	100,000		100,000
18	valve spring compressor		2	180,000	180,000	
19	telescopic gauge		1	75,000		75,000
20	air hose		1	70,000	70,000	
21	die UNC		1	70,000	70,000	
22	die MM		1	70,000	70,000	
23	hole punch		2	140,000	140,000	
24	wheel spanners		3	198,000		198,000
25	hydraulic jack	10ton	1	60,000	60,000	
26	armatures tester		1	55,000		55,000
27	pressure gauge		1	50,000	50,000	
28	filter strap		2	100,000	100,000	
29	piston ring squeezer		1	45,000	45,000	
30	die gauge		1	45,000	45,000	
31	hydraulic jack	5ton	1	40,000	40,000	
32	thread gauge		2	80,000	80,000	
33	honing tool		1	40,000		40,000
34	Venire calliper		1	35,000	35,000	
35	tire lever		4	128,000	128,000	
36	die handle		2	60,000	60,000	
37	battery terminal cleaner		1	30,000		30,000
38	chain spanner		2	50,000	50,000	
39	air gun		1	25,000	25,000	
40	grease pump HD		1	200,000	200,000	
41	foot pump		1	20,000		20,000
42	die UNF		1	10,000	10,000	
43	hacksaw blade		10	100,000	100,000	
44	hand pump		1	8,000	8,000	
45	hacksaw frame		1	3,500	3,500	
46	Oil filter pump		1	200,000	200,000	
47	Hexagon wrench set		1	300,000	300,000	
Sub-total					8,479,500	5,428,000
Panel beating and spray paint section						
1	Welding machine	Generator 3phase 5kw	1	2,000,000		2,000,000
2	Air compressor	300L with accessories	1	2,000,000	2,000,000	
3	Spray gun		1	500,000	500,000	
4	Spray mask	Heavy duty	1	400,000	400,000	
5	Bench drill		1	1,000,000	1,000,000	
6	Power hacksaw		1	500,000		500,000
7	Rivet machine		1	200,000	200,000	
8	Panel beating tools		1	1,500,000	1,500,000	
9	Body jack	5ton	1	1,000,000		1,000,000
10	Chain block		1	500,000		500,000

No.	Equipment	Specification	Qty.	Price (Tsh)	1st Priorirty	2nd Priority
	hammer	1set	1	500,000	500,000	
	Body file			100,000	100,000	
Sub-total					6,200,000	4,000,000
Auto electric section						
1	Battery tester		1	500,000		500,000
4	Battery charger		1	2,000,000	2,000,000	
5	Hydrometer		1	200,000	200,000	
6	Boosting cable		1	300,000		300,000
Sub-total					2,200,000	800,000

Table 11 shows the cost of the necessary maintenance equipment for each section under the maintenance section. Total cost is Tsh 27,107,500 for which 1st priority is Tsh 16,879,500 and 2nd priority is Tsh 10,228,000. DDCA shall proceed the procurement of the maintenance equipment as well as the annual control of the conditions of the maintenance tools and equipment, in order for the smooth implementation of the maintenance activities.

Table 11 Cost of Necessary Maintenance Equipment

Section	1st priority (Tsh)	2nd priority (Tsh)	Total (Tsh)
Garage section	8,479,500	5,428,000	13,907,500
Panel beating and spray paint section	6,200,000	4,000,000	10,200,000
Auto electric section	2,200,000	800,000	3,000,000
Total (Tsh)	16,879,500	10,228,000	27,107,500

10 PERSONNEL ASSIGNMENT PLAN

10.1 ALLOCATION OF HIRING EQUIPMENT

It is preferable that the rig-mounted trucks are kept at each district office for hiring service in order to curtail the costs of relocation. Since it is possible that there will be no drilling operations in a certain district for a long period of time, it is necessary to draw up an allocation plan that reflects the current drilling situations so that the equipment can be effectively utilized. It is also proposed that the equipment be allocated at the DPO (Drilling project officer) office of the Mtwara and Tabora districts, as it will be difficult to cover the whole of Tanzania with the current 4 district offices.

10.2 STAFF ALLOCATION

(1) Increasing the number of staff

Considering the current number of hiring equipment (8 drilling equipment, 5 support trucks and 1water tank), periodic services must be conducted 26 times annually. In addition, the vehicles for DDCA works (7 drilling equipment and 5 support trucks) require 26 periodic services per year, making the number 50 times a year. Moreover, considering the repairs of vehicles damaged by accidents (36 times a year should it occur 3 times a month), it is feared that the 3 mechanics posted at the DDCA Dar es Salaam garage will not be enough to appropriately conduct the maintenance of hiring equipment.

(2) Reviewing the current staff allocation

At the moment, the mechanics of Dar es Salaam garage are dispatched in order to conduct serious repairs of drilling equipment. The mechanics are allocated in Arusha, Mwanza, Dodomca and Mbeya. ***Figure 6*** shows the headquarters and branch offices of DDCA where the mechanics are. However since minor repairs and inspection of the DDCA's drilling equipment are conducted by the drillers, the mechanics allocated at these 4 locations are rarely engaged in maintenance works. When hiring the equipment to the private companies however, the DDCA will be responsible for the repairs of the equipment, and it will be obliged to mobilize these mechanics in order to swiftly and appropriately conduct repairs. Prior to the start of the hiring system, it will be necessary to revise the allocation of the mechanics and decide the person in charge of the repairs according to the location to which the equipment will be hired to.

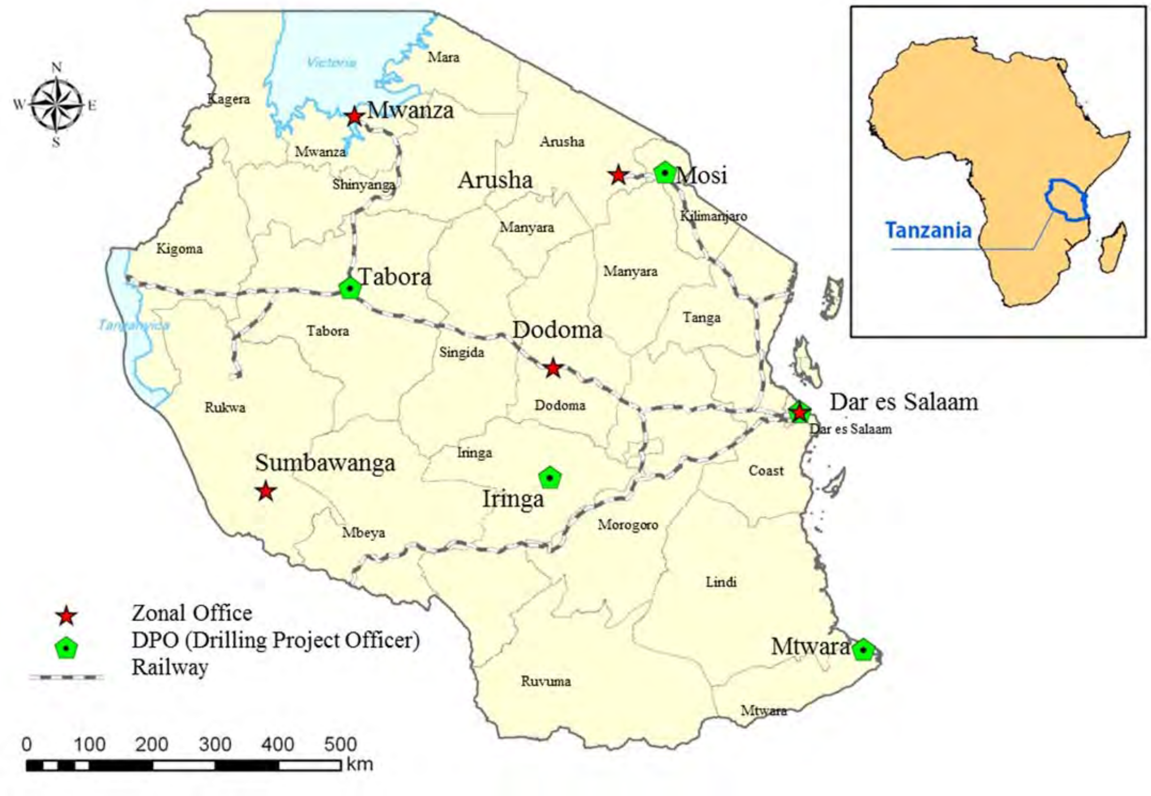


Figure 6 Allocation and Management Area of the Hiring Equipment

11 TECHNICAL ENHANCEMENT PLAN

The technical maintenance training for the mechanics of the maintenance section were held 9 times, on every Wednesday afternoon from 14:00 to 15:30. The knowledge and ability of the mechanics became evident through the trainings, and the expert will implement the following plan in order to further improve the technical ability of the mechanics during the next dispatch (8 weeks, 12 hours of seminar).

Table 12 Plan for Training

Area	Item	Contents	Schedule
Basic knowledge	Calculation	Speed, torque, engine revolution Pressure Fuel consumption	1hour
Vehicle	Engine	2 stroke engine basics	0.5hour
		4 stroke engine basics Valve timing diagram Valve clearance Turbo charger	1hours
		Diesel engine Fuel system Water system Oil system	1hours
	Chassis	Transmission basics Differential basic	0.5hour
		Brake system basic	1hours
	Electric	Electrical basics Battery, Alternator, Starter, Lights	3hours

Area	Item	Contents	Schedule
	Trouble shooting	Engine, chassis	1hours
Hydraulic system	Structure	Hydraulic pump Hydraulic motor Hydraulic cylinder	3hours

12 BUDGET PLAN

The annual budget of the equipment maintenance shall be calculated based on the necessary spare parts and consumables for each equipment. As described in Chapter 8, the maintenance cost for a drilling rig was calculated to be 3.5 % of the CIP price of a drilling rig. The maintenance cost for the other hiring equipment was calculated using this ratio of 3.5 %, as shown in ***Table 13***. Total cost is Tsh 155,323,200. The annual maintenance cost calculated by the maintenance section shall be reported to the hiring business unit for them to include it in the hiring tariff with other items such as management cost, risk for exchange rate, SGA (selling, general & administrative expenses), profit etc. The maintenance budget shall be annually reviewed and modified according to the results of the operation of the hiring business.

Table 13 Maintenance Budget for the 1st Year's Use of Hiring Equipment

Equipment	Unit	Qty	Unit Price CIP (US$)	Amount CIP (US$)	Maintenance Cost (3.5% per annum)		Remarks
					US$	Tsh	
Truck Mounted Drilling rig 150 m	units	6	260,894	1,565,364	54,788	87,660,800	Service & Maintenance
Trailer Mounted Air Compressor	units	5	39,081	195,405	6,839	10,942,400	Service & Maintenance
Trailer Mounted Mud pump	units	5	30,740	153,700	5,380	8,608,000	Service & Maintenance
Trailer Mounted Pumping Test Unit	units	5	94,247	471,235	16,493	26,388,800	Service & Maintenance
Rig Accessories	sets	6	216,428	1,298,569	8,308	13,292,800	3.5 % of only necessary items
Casing tools	sets	6	12,573	75,440	2,220	3,552,000	3.5 % of only necessary items
Fishing Tools	sets	6	2,538	15,230	209	334,400	3.5 % of only necessary items
Direct Mud Circulation Drilling Tools & Accessories	sets	6	16,488	98,927	2,840	4,544,000	3.5 % of only necessary items
Total				3,965,467	97,077	155,323,200	

Ministry of Water (MoW)
Drilling and Dam Construction Agency (DDCA)
Japan International Cooperation Agency (JICA)

DDCAP

Maintenance Manual for OWNER (DDCA)

Maintenance System for Hiring Equipment

Version 1

March 2013

Groundwater Development and Management Capacity Development (DDCAP) Project

Contents

Appendices

[Form A-1] Hiring Equipment Condition Check Sheet for Truck-mounted Drilling Rig

[Form A-2] Hiring Equipment Condition Check Sheet for Support Truck

[Form A-3] Hiring Equipment Condition Check Sheet
for Trailer-mounted Air Compressor / Mud Pump / Pumping Test Unit

[Form B-1] Periodic Service Check Sheet for Truck-mounted Drilling Rig

[Form B-2] Periodic Service Check Sheet for Support Truck

[Form B-3] Periodic Service Check Sheet
for Trailer-mounted Air Compressor / Mud Pump / Pumping Test Unit

1 DOCUMENTS FOR THE MAINTENANCE SYSTEM

The documents, namely maintenance guideline, maintenance plan and maintenance manual for the hiring equipment were prepared by the Groundwater Development and Management Capacity Development (DDCAP) Project, in order to manage the maintenance system for the hiring equipment. The roles and the contents of each document are summarized as follows.

This is Document 3: Maintenance Manual for the Owner for the maintenance works for hiring equipment.

Document 1: Maintenance Guidlene

The guidline stipulates the roles and responsibility of both lessee (DDCA) and lesser (private drilling company). The gidline is a principle for the operation of the maintenance system. The guidline is derected to a system to hire drilling equipment and machinery. The guideline aims to maintain the equipment and machinery for hiaring as good working condition in order to accommodate demand of the private drilling companies.

Document 2: Maintenance Plan

The maintenance plan demonstrates the plans for the periodical service, sparparts, consumable parts, tools, procurement, staff assignment, training and budjet. The maintenance works for the hiring equipment should be carried out according to the maintenance plan.

Document 3: Maintenance Manual

The separate maintenance manuals for Owner (DDCA) and Hirer (private drilling company) were provided. The manuals indicate the method and procedures of the maintenance works.

2 PURPOSE OF MAINTENANCE MANUAL OF HIRING EQUIPMENT

The maintenance manual of hiring equipment indicates the methods and procedures of actually conducting the maintenance and management of hiring equipment, as stipulated in the guideline for hiring management. This manual will be revised according to the conditions of the hiring equipment, and the revision will be conducted by the the maintenance section of DDCA.

3 CONDITION CHECK OF HIRING EQUIPMENT BEFORE AND AFTER HIRING

When inspecting hiring equipment, the condition of the equipment is checked following the daily service manual and by filling in the items on the “hiring equipment condition check sheet” concerning the condition of the equipment before and after use.

3.1 HIRING EQUIPMENT CONDITION CHECK SHEET

The hiring equipment condition check sheet will be used for the following equipment:

- [Form A-1] Truck Mounted Drilling Rig
- [Form A-2] Support trucks (Cargo trucks, Cargo truck with crane and Water tank truck)
- [Form A-3] Trailer Mounted Air Compressor
- [Form A-3] Trailer Mounted Mud Pump
- [Form A-3] Trailer Mounted Pumping Test Unit

3.2 CONTENTS OF THE HIRING EQUIPMENTCONDITION CHECK SHEET

The following contents will be filled in the daily service check sheet before and after the operation of the hired equipment:

- Date
- Type and model of equipment
- Mileage (operated hours) before operation, mileage (operated hours) after operation
- Name of the person who conducted the condition check
- The condition will be judged in two categories: good and bad
- Any comments on the condition of the equipment will be filled in the "Comments" column.
- After confirming the condition of the equipment, the HMWS of the DDCA and the person in charge of the hirer who hired the equipment sign the paper.
- Photograph of the equipment taken before and after operation is attached to the check sheet

Table 1 shows an example of how to fill in the check sheet is presented below, using the following case of a vehicle problem as an example.

- The fuel tank was not full when the equipment was returned
- Oil leakage was detected from the oil pressure pipe
- No other problems were found

Table 1 Example of the Hiring Equipment Condition Check Sheet

Hiring equipment condition check sheet　　Truck Rig

Model :IVECO		Type: Rig	Reg. No.: STK XXXX		
Mileage: 15,500km			Checked by: Uzawa		
Date (Before) 1/6/2012			Date(After) 10/9/2012		
Place	No.	Check	Condition	Before	After
Engine	1	Fuel	full tank	✔	✕
	2	Engine general	start, running sound, smoke	✔	✔
	3	Engine oil	amount, condition	✔	✔
Out side	4	Body, Cabin	tightening, damage	✔	✔
	5	wiper and side mirror	tightening, damage	✔	✔
	6	Tire	damage	✔	✔
Electric	7	lighting device	tightening, damage	✔	✔
	8	Switch, meter, wiring	working, damage	✔	✔
Running	9	Clutch	working sound, smoking	✔	✔
	10	Brake	working sound, smoking	✔	✔
	11	Parking brake	working sound, smoking	✔	✔
	12	Chassis	working, damage	✔	✔
Rig	13	Engine condition	start, running sound, smoke	✔	✔
	14	Fuel	full tank	✔	✔
	15	Hydraulic oil	amount, leakage	✔	✔
	16	Hydraulic hose, pipe	damage	✔	✕
	17	Rotation gear box	Oil level	✔	✔
Mud pump	18	Mud pump condition	damage	✔	✔
	19	Condition	damage	✔	✔

Photo

Front		
Right		
Left		
Back		

Coments: Fuel is NOT full.
Hydraulic pipe leakage

DDCA HMWS : Mr. George B

Private company: Mr. XXXXXX

4 PERIODIC SERVICE

When conducting periodic service according to the mileage of the vehicle or the operation hours of the equipment, "periodic service check sheet" shall be used. By following this check sheet, the service can be kept in the same quality, regardless of the ability or the experience of the persons in charge. Detecting any machine problems at early stage by periodic services is important so that the suitable conditions of the equipment for the hiring will be kept.

4.1 PERIODIC SERVICE CHECK SHEET

The periodic service check sheet will be used for the following hiring equipment:

- [Form B-1] Truck Mounted Drilling Rig
- [Form B-2] Support trucks (Cargo trucks, Cargo truck with crane and Water tank truck)
- [Form B-3] Trailer Mounted Air Compressor
- [Form B-4] Trailer Mounted Mud Pump
- [Form B-5] Trailer Mounted Pumping Test Unit

4.2 CONTENTS OF THE PERIODIC SERVICE CHECK SHEET

The following contents will be filled in the periodic service check sheet before and after the operation of the hired equipment:

- Date
- Type and model of the equipment
- Mileage (operated hours) before operation, mileage (operated hours) after operation
- Name of the person who conducted the periodic inspection
- The condition will be judged in these six categories: ok, change, adjust, clean up, tighten and lubricant
- Any comments on the condition of the equipment will be filled in the "remarks" column.

Table 2 shows an example of how to fill in the check sheet is presented below, using the following case of a vehicle problem as an example.

- 20L of engine oil and engine oil filter is replaced
- 10L of hydraulic oil refilled
- 2L of differential oil refilled
- Adjustment of the fan belt
- Adjustment of the front, back and parking brake
- Tightening of the clip nut
- Comment in the remarks column: the consumption of the brake lining

Table 2 Example of how to fill in the periodic service check sheet

Periodic service check sheet

Date	Type	Model	Reg. No.	Mileage	Checked by
11/9/2012	Survice truck	IVECO	STK XXXXX	19,892km	Mr. UZAWA

✔	OK	×	Change	A	Adjust	C	Clean up	T	Tighten	L	Lubricant

Service truck

Oil, Filter and water

	Item	Qty.
×	Engine oil (amount, leakage)	20 L
×	Engine oil filter (leakage)	1
✔	Fuel filter (leakage)	-
C	Air cleaner (blocking)	-
L	Hydraulic oil (amount, leakage)	10 L
✔	Hydraulic oil filter (leakage)	-
✔	Power steering (amount, leakage)	-
✔	Brake oil (amount, leakage)	-
✔	Clutch oil (amount, leakage)	-
✔	Transmission (amount, leakage)	-
L	Differential (amount, leakage)	2 L
✔	Radiator, coolant (amount, leakage)	-
✔	Battery (amount, loosening)	-

Engine room

A	Fan belt (damage, loosening)
✔	Fan (damage, loosening)
✔	Injector pump, Nozzle (leakage)
✔	Generator (damage, condition)
✔	Starter (damage, condition)

Outside

✔	Brake air tank, piping (leakage, condition)
✔	Brake air tank Drain (leakage, condition)
✔	Front Brake hose, pipe (leakage, damage)
A	Brake lining front (leakage, damage, wear-out)
✔	Rear Brake hose, pipe (leakage, damage)
A	Brake lining rear (leakage, damage, wear-out)
A	Parking brake (condition, damage, wear-out)
✔	Hydraulic pump, cylinder(leakage, condition)
✔	Tire (depth of ditch, damage)
T	Wheel nut bolt (damage, loosening)
✔	Frame, body (tightening, damage)
✔	Lights / Miller (tightening, damage)
–	Attachment (Crane, Water tank)

Driving

✔	Engine general (start, running sound, smoking)
✔	Foot brake
✔	Hand brake
✔	Clutch / Transmission
✔	Steering
✔	Noise

Comments: Good condition Brake lining ya mbele Zimeanza kulika

Appendices

[Form A-1] Hiring Equipment Condition Check Sheet for Truck-mounted Drilling Rig
[Form A-2] Hiring Equipment Condition Check Sheet for Support Truck
[Form A-3] Hiring Equipment Condition Check Sheet
for Trailer-mounted Air Compressor / Mud Pump / Pumping Test Unit
[Form B-1] Periodic Service Check Sheet for Truck-mounted Drilling Rig
[Form B-2] Periodic Service Check Sheet for Support Truck
[Form B-3] Periodic Service Check Sheet
for Trailer-mounted Air Compressor / Mud Pump / Pumping Test Unit

Hiring equipment condition check sheet Truck-mounted Rig

Photo **[Form A-1]**

Date:	Model:	Reg. No.:
Mileage:	km	Checked by:

Place	No.	Check	Condition	Before	After
Engine	1	Fuel	full tank		
	2	Engine general	start, running sound, smoke		
	3	Engine oil	amount, condition		
Out side	4	Body, Cabin	tightening, damage		
	5	wiper and side mirror	tightening, damage		
	6	Tire	damage		
Electric	7	lighting device	tightening, damage		
	8	Switch, meter, wiring	working, damage		
Running	9	Clutch	working sound, smoking		
	10	Brake	working sound, smoking		
	11	Parking brake	working sound, smoking		
	12	Chassis	working, damage		
Rig	13	Engine condition	start, running sound, smoke		
	14	Fuel	full tank		
	15	Hydraulic oil	amount, leakage		
	16	Hydraulic hose, pipe	damage		
	17	Rotation gear box	Oil level		
Mud pump	18	Drilling condition	damage		
	19	Condition	damage		

Front		
Right		
Left		
Back		

Coments:

DDCA HMWS :

Private company:

Hiring equipment condition check sheet Support truck

[Form A-2]

Date:	Model:	Reg. No.:
Mileage: km		Checked by:

Place	No.	Check	Condition	Before	After
Engine	1	Fuel	full tank		
	2	Engine general	start, running sound, smoke		
	3	Engine oil	amount, condition		
Out side	4	Body, Cabin	tightening, damage		
	5	wiper and side mirror	tightening, damage		
	6	Tire	damage		
Electric	7	lighting device	tightening, damage		
	8	Switch, meter, wiring	working, damage		
Running	9	Clutch	working sound, smoking		
	10	Brake	working sound, smoking		
	11	Parking brake	working sound, smoking		
	12	Chassis	working, damage		
Optional divice	13	Operation	start, running sound, smoke		
	14	Hydraulic oil	amount, leakage		
Crain Water tank	15	Hydraulic hose, pipe	damage		
	16	Control lever	working, damage		
Total	17	Condition	Good or Bad		

Photo

Front		
Right		
Left		
Back		

Coments:

DDCA HMWS :

Private company:

Hiring equipment condition check sheet Trailer Comp/Mud P/PT unit

Date:	Model:	Reg. No.:
Mileage: km		Checked by:

Place	No.	Check	Condition	Before	After
Engine	1	Fuel	full tank		
	2	Engine general	start, running sound, smoke		
	3	Engine oil	amount, condition		
Out side	4	Body, Cabin	tightening, damage		
	5	wiper and side mirror	tightening, damage		
	6	Tire	damage		
Electric	7	lighting device	tightening, damage		
	8	Switch, meter, wiring	working, damage		
Running	9	Clutch	working sound, smoking		
	10	Brake	working sound, smoking		
	11	Parking brake	working sound, smoking		
	12	Chassis	working, damage		
Compressor	13	Engine condition	start, running sound, smoke		
	14	Fuel	full tank		
	15	Hydraulic oil	amount, leakage		
	16	Hydraulic hose, pipe	damage		
	17	Hydraulic motor	0il level		
Air tank	18	Drilling condition	damage		
	19	Condition	damage		

Photo **[Form A-3]**

Front		
Right		
Left		
Back		

Coments:

DDCA HMWS :

Private company:

Periodic service check sheet **Truck-mounted Rig** **[Form B-1]**

Date	Type	Model	Reg. No.	Mileage	Checked by
				km	

✔	OK	×	Change	A	Adjust	C	Clean up	T	Tighten	L	Lubricant

Truck

Oil, Filter and water

	Item	Qty.
	Engine oil (amount, leakage)	
	Engine oil filter (leakage)	
	Fuel filter (leakage)	
	Air cleaner (blocking)	
	Hydraulic oil (amount, leakage)	
	Hydraulic oil filter (leakage)	
	Power steering (amount, leakage)	
	Brake oil (amount, leakage)	
	Clutch oil (amount, leakage)	
	Transmission (amount, leakage)	
	Differential (amount, leakage)	
	Radiator, coolant (amount, leakage)	
	Battery (amount, loosening)	

Engine room

- [ ] Fan belt (damage, loosening)
- [ ] Fan (damage, loosening)
- [ ] Injector pump, Nozzle (leakage)
- [ ] Generator (damage, condition)
- [ ] Starter (damage, condition)

Outside

- [ ] Brake air tank, piping (leakage, condition)
- [ ] Brake air tank Drain (leakage, condition)
- [ ] Front Brake hose, pipe (leakage, damage)
- [ ] Brake lining front (leakage, damage, wear-out)
- [ ] Rear Brake hose, pipe (leakage, damage)
- [ ] Brake lining rear (leakage, damage, wear-out)
- [ ] Parking brake (condition, damage, wear-out)
- [ ] Hydraulic pump, cylinder(leakage, condition)
- [ ] Tire (depth of ditch, damage)
- [ ] Wheel nut bolt (damage, loosening)
- [ ] Frame, body (tightening, damage)
- [ ] Lights / Miller (tightening, damage)
- [ ] Attachment (Crane, Water tank)

Driving

- [ ] Engine general (start, running sound, smoking)
- [ ] Foot brake
- [ ] Hand brake
- [ ] Clutch / Transmission
- [ ] Steering
- [ ] Noise

Rig

Oil, Filter and water

	Item	Qty.
	Engine oil (amount, leakage)	
	Engine oil filter (leakage)	
	Fuel filter (leakage)	
	Air cleaner (blocking)	
	Hydraulic oil (amount, leakage)	
	Hydraulic oil filter (leakage)	
	Radiator, coolant (amount, leakage)	
	Fan belt (damage, loosening)	
	Battery (amount, loosening)	

- [ ] Fan (damage, loosening)
- [ ] Injector pump, Nozzle (leakage)
- [ ] Generator (damage, condition)
- [ ] Starter (damage, condition)

Control panel

- [ ] Hydraulic oil (leakage)
- [ ] Control switch (condition)
- [ ] Control meter (condition)

Hydraulic pump

- [ ] Hydraulic pump (condition)
- [ ] Hydraulic hose and pipe
- [ ] Hydraulic oil (leakage)
- [ ] Hydraulic oil (level)

Mud pump

- [ ] Mud pump (condition)
- [ ] Hydraulic hose and pipe (leakage)
- [ ] Cylinder (condition)
- [ ] Gear oil (level)
- [ ] Greasing

Mast

- [ ] Wire rope (condition)
- [ ] Hydraulic motor (condition)
- [ ] Hydraulic hose and pipe (leakage)

Rotation gear

- [ ] Gear oil (level)
- [ ] Hydraulic oil (leakage)

comments: ______________________________

Periodic service check sheet **Support Truck** **[Form B-2]**

Date	Type	Model	Reg. No.	Mileage	Checked by
				km	

✔	OK	×	Change	A	Adjust	C	Clean up	T	Tighten	L	Lubricant

Support truck

Oil, Filter and water

	Item	Qty.
☐	Engine oil (amount, leakage)	
☐	Engine oil filter (leakage)	
☐	Fuel filter (leakage)	
☐	Air cleaner (blocking)	
☐	Hydraulic oil (amount, leakage)	
☐	Hydraulic oil filter (leakage)	
☐	Power steering (amount, leakage)	
☐	Brake oil (amount, leakage)	
☐	Clutch oil (amount, leakage)	
☐	Transmission (amount, leakage)	
☐	Differential (amount, leakage)	
☐	Radiator, coolant (amount, leakage)	
☐	Battery (amount, loosening)	

Engine room

- ☐ Fan belt (damage, loosening)
- ☐ Fan (damage, loosening)
- ☐ Injector pump, Nozzle (leakage)
- ☐ Generator (damage, condition)
- ☐ Starter (damage, condition)

Outside

- ☐ Brake air tank, piping (leakage, condition)
- ☐ Brake air tank Drain (leakage, condition)
- ☐ Front Brake hose, pipe (leakage, damage)
- ☐ Brake lining front (leakage, damage, wear-out)
- ☐ Rear Brake hose, pipe (leakage, damage)
- ☐ Brake lining rear (leakage, damage, wear-out)
- ☐ Parking brake (condition, damage, wear-out)
- ☐ Hydraulic pump, cylinder(leakage, condition)
- ☐ Tire (depth of ditch, damage)
- ☐ Wheel nut bolt (damage, loosening)
- ☐ Frame, body (tightening, damage)
- ☐ Lights / Miller (tightening, damage)
- ☐ Attachment (Crane, Water tank)

Driving

- ☐ Engine general (start, running sound, smoking)
- ☐ Foot brake
- ☐ Hand brake
- ☐ Clutch / Transmission
- ☐ Steering
- ☐ Noise

Comments:

____

____

____

Periodic service check sheet **Trailler mounted Compressor, Mud P, PT Unit** **[Form B-3]**

Date	Type	Model	Reg. No.	Working hour	Checked by
				H	

✔	OK	×	Change	A	Adjust	C	Clean up	T	Tighten	L	Lubricant

Trailler compressor, Mud pump, Pump test unit

Oil, Filter and water		Qty.
	Engine oil (amount, leakage)	
	Engine oil filter (leakage)	
	Fuel filter (leakage)	
	Air cleaner (blocking)	
	Hydraulic oil (amount, leakage)	
	Hydraulic oil filter (leakage)	
	Radiator, coolant (amount, leakage)	
	Fan belt (damage, loosening)	
	Battery (amount, loosening)	
	Fan (damage, loosening)	
	Injector pump, Nozzle (leakage)	
	Generator (damage, condition)	
	Starter (damage, condition)	

Trailler

	Tire
	Leaf spring (condition)
	Parking brake (condition)

Control panel

	Hydraulic oil (leakage)
	Control switch (condition)
	Control meter (condition)

Hydraulic pump

	Hydraulic pump (condition)
	Hydraulic hose and pipe
	Hydraulic oil (leakage)
	Hydraulic oil (level)

Hydraulic motor

	Hydraulic motor (condition)
	Hydraulic hose and pipe
	Hydraulic oil (leakage)
	Hydraulic oil (level)

comments:

Ministry of Water (MoW)
Drilling and Dam Construction Agency (DDCA)
Japan International Cooperation Agency (JICA)

DDCAP

Maintenance Manual for HIRER (Private Drilling Company)

Maintenance System for Hiring Equipment

Version 1

March 2013

Groundwater Development and Management Capacity Development (DDCAP) Project

Contents

Appendices

1 DOCUMENTS FOR THE MAINTENANCE SYSTEM

The documents, namely maintenance guideline, maintenance plan and maintenance manual for the hiring equipment were prepared by the Groundwater Development and Management Capacity Development (DDCAP) Project, in order to manage the maintenance system for the hiring equipment. The roles and the contents of each document are summarized as follows.

This is Document 3: Maintenance Manual for the Hirer for the maintenance works for hiring equipment.

Document 1: Maintenance Guidlene

The guidline stipulates the roles and responsibility of both lessee (DDCA) and lesser (private drilling company). The gidline is a principle for the operation of the maintenance system. The guidline is derected to a system to hire drilling equipment and machinery. The guideline aims to maintain the equipment and machinery for hiaring as good working condition in order to accommodate demand of the private drilling companies.

Document 2: Maintenance Plan

The maintenance plan demonstrates the plans for the periodical service, sparparts, consumable parts, tools, procurement, staff assignment, training and budjet. The maintenance works for the hiring equipment should be carried out according to the maintenance plan.

Document 3: Maintenance Manual

The separate maintenance manuals for Owner (DDCA) and Hirer (private drilling company) were provided. The manuals indicate the method and procedures of the maintenance works.

2 PURPOSE OF THE MAINTENANCE MANUAL OF HIRING EQUIPMENT

The maintenance manual of hiring equipment indicates the methods and procedures of actually conducting the maintenance and management of hiring equipment, as stipulated in the guideline for hiring management. This manual will be revised according to the conditions of the hiring equipment, and the revision will be conducted by the the maintenance section of DDCA.

3 DAILY MAINTENANCE OF HIRING EQUIPMENT BY HIRER

The hirer (private drilling company) is required, following the daily service manual, to fill in the items on the "daily service check sheet" concerning the condition of the equipment before and after use. The private drilling companies are required to accurately fill in the sheet as the record indicates the daily condition of the equipment as well as relevant information for detecting the cause of problems.

3.1 DAILY SERVICE CHECK SHEET

The daily service check sheet will be used for the following hiring equipment:

- [Form B-1] Truck Mounted Drilling Rig
- [Form B-2] Support trucks (Cargo trucks, Cargo truck with crane and Water tank truck)
- [Form B-3] Trailer Mounted Air Compressor
- [Form B-4] Trailer Mounted Mud Pump
- [Form B-5] Trailer Mounted Pumping Test Unit

3.2 CONTENTS OF DAILY SERVICE CHECK SHEET

The following contents will be filled in the daily service check sheet before and after the operation of the hired equipment:

- Date
- Mileage (operated hours) before operation, mileage (operated hours) after operation
- Time at the start and end of operation
- The condition will be judged in these four categories: good, not good, bad, no relevance
- When the condition is confirmed to be "not good", the private company must swiftly report to the DDCA's Head of maintenance workshop, and the equipment must be closely monitored when in use.
- When the condition is confirmed to be "bad", the private company must swiftly report to the DDCA's Head of maintenance workshop.
- Any comments on the condition of the equipment will be filled in the "remarks" column.

Table 1 shows an example of how to fill in the check sheet is presented below, using the following case of a vehicle problem as an example:

- No problems were found with the vehicle during operation on Sept. 1, 2012
- Oil leakage from the hydraulic system was detected after the operation. On receiving this report from the user, the DDCA mechanical workshop instructed to continue operation while paying attention to the amount of the oil, as the oil leak was small, and would not interfere with the operation.
- Water leakage from the radiator was detected after operation on Sept. 2.
- The DDCA mechanical workshop conducted repairs of the oil leakage of the oil pressure system and the water leakage of the radiator on the Sept. 3, by dispatching a mechanic to the drilling site. The vehicle was not operated on the 3rd.
- On the 4th, the repair was complete and the vehicle was confirmed to be in good condition.

Table 1 Example of Daily Service Check Sheet

Daily service check sheet (Truck) ✔: Good △: Not good X: Bad —: No relevance

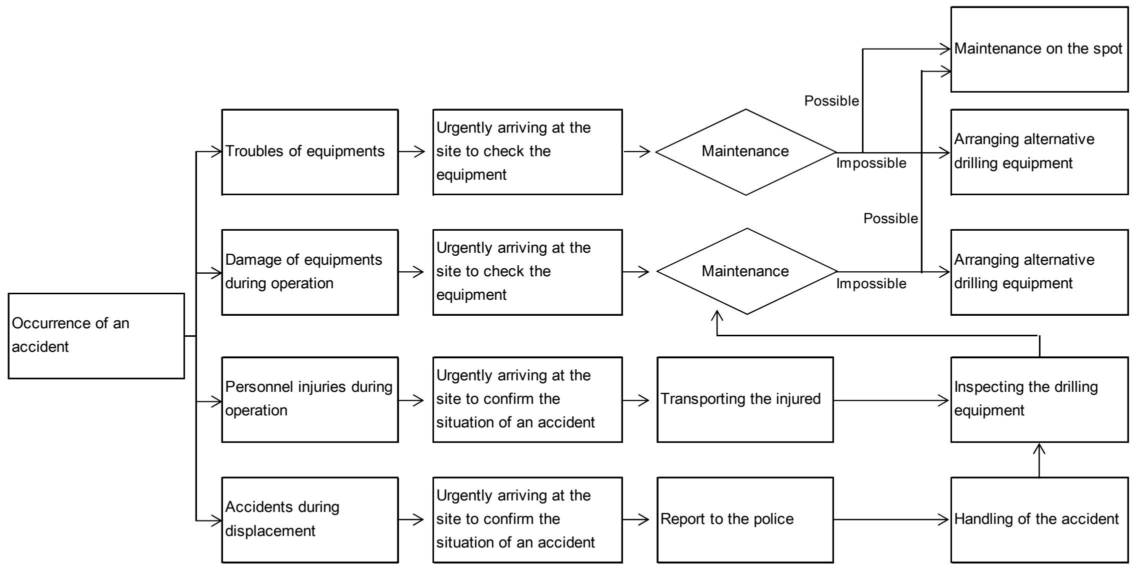
Model:		IVECO	Date	1/9/2012		2/9/2012		3/9/2012		4/9/2012	
Type:		Service truck		Start	End	Start	End	Start	End	Start	End
Reg. No.:		STK XXXX	Mileage	12,300	12,450	12,450	12,560	—	—	12,560	12,770
Checked by:		XXXXXX	Time	8:10	17:30	8:30	16:30	:	:	7:30	17:50
Place	Check item	Contents		Check		Check		Check		Check	
Front	Front	Lighting device (condition)		✔	✔	✔	✔	—	—	✔	✔
		Glass, wiper and side mirror (condition)		✔	✔	✔	✔	—	—	✔	✔
		Clutch oil (level)		✔	✔	✔	✔	—	—	✔	✔
		Radiator coolant water (level)		✔	✔	✔	✕	—	—	✔	✔
	Bottom	Engine oil (leakage)		✔	✔	✔	✔	—	—	✔	✔
		Radiator water (leakage)		✔	✔	✔	✔	—	—	✔	✔
Side	Left & Right	Front tire (condition)		✔	✔	✔	✔	—	—	✔	✔
		Hydraulic oil (level)		✔	△	△	△	—	—	✔	✔
		Brake oil (level, leakage)		✔	✔	✔	✔	—	—	✔	✔
		Air cleaner (indicator, blocking)		✔	✔	✔	✔	—	—	✔	✔
		Fuel water separator (condition)		✔	✔	✔	✔	—	—	✔	✔

3.3 EVALUATION OF DAILY SERVICES

The hirer shall submit the daily service check sheet to the owner (the maintenance section of DDCA) when returning the hiring equipment and the maintenance section confirms whether the daily service has been properly conducted. The maintenance section utilizes the daily service check sheet for the confirmation of the condition of the hiring equipment after its operation.

4 SAFETY MEASURES MANUAL

Safety must be the utmost priority during operation and relocation of drilling equipment. In case of accidents and problems, measures must be swiftly taken following the safety measures flow chart in ***Figure 1***.



Telephone number							
POLICE	112	UMBURANCE	XXX	DDCA DPM	0XXX-XXX-XXX	DDCA TCO	0XXX-XXX-XXX
FIRE	XXX	DDCA CEO	0XXX-XXX-XXX	DDCA HMWS	0XXX-XXX-XXX		

Figure1 Safty Measures Flow Chart

Appendices

[Form B-1] Daily Service Check Sheet for Truck Mounted Rig

[Form B-2] Daily Service Check Sheet for Support Truck

[Form B-3] Daily Service Check Sheet for Trailer Mounted Air Compressor

[Form B-4] Daily Service Check Sheet for Trailer Mounted Mud Pump

[Form B-5] Daily Service Check Sheet for Trailer Mounted Pumping Test Unit

Daily service check sheet ✔: Good X: Not good –: Nothing [Form B-1]

Type: Truck mounted rig		Date														
Model:			Start	End	Start	End	Start	End	Start	End	Start	End	Start	End	Start	End
Reg. No.:		Hours														
Checked by:		Time	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Place	Contents		Check		Check		Check		Check		Check		Check		Check	
Engine	Engine oil (amount, leakage)															
	Fuel (amount, leakage)															
	Air filter (blocking)															
	Radiator (coolant water leakage)															
	Fan belt (condition)															
Hydraulic pump	Hydraulic pump (condition)															
	Hydraulic hose and pipe															
	Hydraulic oil (leakage)															
	Hydraulic oil (level)															
Hydraulic oil cooler	Hydraulic oil (leakage)															
	Fan (condition)															
Mud pump	Mud pump (condition)															
	Hydraulic hose and pipe (leakage)															
	Cylinder (condition)															
	Gear oil (level)															
	Greasing															
Control panel	Hydraulic oil (leakage)															
	Control switch (condition)															
	Control meter (condition)															
Rotation gear box	Gear oil (level)															
	Hydraulic oil (leakage)															
Mast	Wire rope (condition)															
	Hydraulic motor (condition)															
	Hydraulic hose and pipe (leakage)															

Remarks

Daily service check sheet (Support Truck) ✔: Good X: Not good —: Nothing [Form B-2]

Type:		Date														
Model:			Start	End	Start	End	Start	End	Start	End	Start	End	Start	End	Start	End
Reg. No.:		Mileage														
Checked by:		Time	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Place	Check item	Contents	Check		Check		Check		Check		Check		Check		Check	
Front	Front	Lighting device (condition)														
		Glass, wiper and side mirror (condition)														
		Clutch oil (level)														
		Radiator coolant water (level)														
	Bottom	Engine oil (leakage)														
		Radiator water (leakage)														
Side	Left & Right	Front tire (condition)														
		Hydraulic oil (level)														
		Brake oil (level, leakage)														
		Air cleaner (indicator, blocking)														
		Fuel water separator (condition)														
		Engine oil (level, condition)														
		Air tanks (draining)														
		Battery (condition)														
		Transmission oil (leakage)														
		Hydraulic cylinder (condition)														
		Rear tire (condition)														
Back	Back	Lighting device (condition)														
		Number plate (condition)														
	Bottom	Differential oil (leakage)														
Engine room	Engine	Radiator coolant water (leakage)														
		Oil leakage (engine, power steering oil)														
		Fan belt (condition)														
		Power steering oil (level)														

Remarks

Daily service check sheet ✔: Good X: Not good —: Nothing [Form B-3]

Type: Trailer mounted compressor		Date														
Model:			Start	End	Start	End	Start	End	Start	End	Start	End	Start	End	Start	End
Reg. No.:		Hours														
Checked by:		Time	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Place	Contents		Check		Check		Check		Check		Check		Check		Check	
Engine	Engine oil (amount, leakage)															
	Fuel (amount, leakage)															
	Air filter (blocking)															
	Radiator (coolant water leakage)															
	Fan belt (condition)															
	Battery (amount, cleaning)															
Hydraulic pump	Hydraulic pump (condition)															
	Hydraulic hose and pipe															
	Hydraulic oil (leakage)															
	Hydraulic oil (level)															
Hydraulic oil cooler	Hydraulic oil (leakage)															
	Fan (condition)															
Comp. unit	Air filter (blocking)															
	Air tank (leakage, damage)															
	Air hose and pipe (leakage)															
Control panel	Control switch (condition)															
	Control meter (condition)															
	wiring (condition)															
Trailer	Tire (condition)															
	Leaf spring (condition)															
	Frame (condition)															

Remarks

Daily service check sheet ✔: Good X: Not good −: Nothing [Form B-4]

Type: Trailer mounted mud pump	Date														
Model:		Start	End	Start	End	Start	End	Start	End	Start	End	Start	End	Start	End
Reg. No.:	Hours														
Checked by:	Time	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Place	Contents	Check		Check		Check		Check		Check		Check		Check	
Engine	Engine oil (amount, leakage)														
	Fuel (amount, leakage)														
	Air filter (blocking)														
	Radiator (coolant water leakage)														
	Fan belt (condition)														
	Battery (amount, cleaning)														
Hydraulic pump	Hydraulic pump (condition)														
	Hydraulic hose and pipe														
	Hydraulic oil (leakage)														
	Hydraulic oil (level)														
Mud pump	Mud pump (condition)														
	Hydraulic hose and pipe (leakage)														
	Cylinder (condition)														
	Gear oil (level)														
	Greasing														
Control panel	Control switch (condition)														
	Control meter (condition)														
	wiring (condition)														
Trailer	Tire (condition)														
	Leaf spring (condition)														
	Frame (condition)														

Remarks

Daily service check sheet ✔: Good X: Not good −: Nothing [Form B-5]

Type: Trailer mounted pump test unit	Date														
Model:		Start	End	Start	End	Start	End	Start	End	Start	End	Start	End	Start	End
Reg. No.:	Hours														
Checked by:	Time	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Place	Contents	Check		Check		Check		Check		Check		Check		Check	
Generator engine	Engine oil (amount, leakage)														
	Fuel (amount, leakage)														
	Air filter (blocking)														
	Radiator (coolant water leakage)														
	Fan belt (condition)														
	Battery (amount, cleaning)														
Hydraulic engine	Engine oil (amount, leakage)														
	Fuel (amount, leakage)														
	Air filter (blocking)														
	Radiator (coolant water leakage)														
	Fan belt (condition)														
	Battery (amount, cleaning)														
Hydraulic pump	Hydraulic pump (condition)														
	Hydraulic hose and pipe														
	Hydraulic oil (leakage)														
	Hydraulic oil (level)														
Control panel	Control switch (condition)														
	Control meter (condition)														
	wiring (condition)														
Trailer	Tire (condition)														
	Leaf spring (condition)														
	Frame (condition)														

Remarks

収 集 資 料 リ ス ト

		プロジェクトID		調査団番号			
地域	アフリカ	調査団名	地下水開発セクター能力向上プロジェクト	調査の種類	技術協力プロジェクト	担当部課	地球環境部 JICAタンザニア事務所
国名	タンザニア	配属機関名	井戸ダム建設公社（ＤＤＣＡ）	現地調査期間	12/9/7 - 13/2/15		中村　覚 大林　孝典

番号	資料の名称	形態	収集資料	専門家作成資料	JICA作成資料	テキスト	発行機関	取り扱い区分	図書館記入欄	備考
1	List of DDCA employees (English ver.)	デジタル	＊				Drilling Dam and Construction Agency (DDCA)			
2	List of DDCA employees (Swahili ver.)	デジタル	＊				Drilling Dam and Construction Agency (DDCA)			
3	Manufacturers of PVC-U and HDPE Pipes	コピー	＊				Plasco Ltd.			
4	Criteria for issuing a water well drilling permit	コピー	＊				Ministry of Water (MoW)			
5	Private drilling company list	コピー	＊				Ministry of Water (MoW)			
6	Government specifications and regulations applicable to water well drilling and institution in Tanzania mainland	コピー	＊				Ministry of Water (MoW)			
7	Environmental Management Act, 2004	コピー	＊				The United Republic of Tanzania			
8	Water Resource Management Act, 2009	コピー	＊				Ministry of Water and Irrigation (MoWI)			
9	Regulations of Water Supply and Sanitation Act, 2009	コピー	＊				Ministry of Water and Irrigation (MoWI)			
10	Water Supply and Sanitation Act, 2009	コピー	＊				The United Republic of Tanzania			
11	The Constructors Registration Act, 1997	コピー	＊				The United Republic of Tanzania			
12	College of Engineering and technology (CoET)	デジタル	＊				University of Dar es Salaam			

番号	資料の名称	形態	収集資料	専門家作成資料	JICA作成資料	テキスト	発行機関	取り扱い区分	図書館記入欄	備考
	Bureau for industrial cooperation (BICO)									
13	UCU Rolling Strategic Plan for the year 2002/03 - 2006/07	コピー	*				University College of Lands and Architectural Studies (USLAS) Consultancy Unit			
14	Sector Needs and Effective Demands Assessment	デジタル	*				Gtz			
15	The Executive Agencies (Drilling and Dam Construction Agency) (Establishment) Order	デジタル	*				Ministry of Water (MoW)			
16	Subsidiary legislation, the executive agencies act, 1997 (Order)	デジタル	*				Ministry of Water (MoW)			
17	Rationalization of Drilling Operation in Tanzania Review of the Borehole Drilling Sector in Tanzania	デジタル	*				Erich Baumann, Peter Ball, Alebachew Beyene			
18	Investment Strategy 2007	デジタル	*				Drilling Dam and Construction Agency (DDCA)			
19	Study on Impact Assessment of Executive Agencies Part2: Agencies' Assessment Report	デジタル	*				Economic and Social Research Foundation (ESRF)			
20	Business Plan 2010-2013 (Draft)	コピー	*				Drilling Dam and Construction Agency (DDCA)			
21	Hotuna ya waziri wa maji 2006/2007	コピー	*				Ministry of Water (MoW)			
22	Hotuna ya waziri wa maji 2007/2008	コピー	*				Ministry of Water (MoW)			
23	Hotuna ya waziri wa maji 2008/2009	コピー	*				Ministry of Water (MoW)			
24	Hotuna ya waziri wa maji 2009/2010	コピー	*				Ministry of Water (MoW)			
25	Hotuna ya waziri wa maji 2010/2011	コピー	*				Ministry of Water (MoW)			
26	Hotuna ya waziri wa maji 2011/2012	コピー	*				Ministry of Water (MoW)			
27	Hotuna ya waziri wa maji 2012/2013	コピー&デジタル					Ministry of Water (MoW)			
28	DDCA Strategic Plan 2005 - 2010	デジタル	*				Drilling Dam and Construction Agency (DDCA)			

番号	資料の名称	形態	収集資料	専門家作成資料	JICA作成資料	テキスト	発行機関	取り扱い区分	図書館記入欄	備考
29	Water Sector Development Programme 2006 - 2025	デジタル	＊				Ministry of Water (MoW)			
30	Water Sector Development Programme Restructuring Plan for Phase 1	デジタル	＊				Ministry of Water (MoW)			
31	Tender Document with DDCA (No. LGA/100/W/16)	コピー	＊				Nkasi district Council			
32	Construction Document	コピー	＊				Ilala Minicipal Council			
33	Contract Document with DDCA	コピー	＊				Sumbawanga District Council			
34	Tender document with DDCA	コピー	＊				Maswa District Council			
35	Water Sector Status Report 2011	デジタル	＊				Ministry of Water (MoW)			
36	Minute of Component 2 TWG Meeting Held at Maji Ubungo on 19th April, 2012	デジタル	＊				Ministry of Water (MoW)			
37	Minute of cpomponent 2 TWG meeting held at Maji Ubungo on 19th April, 2012	コピー	＊				Ministry of Water (MoW)			
38	National Environmental Standards Compendium	コピー	＊				Tanzania Bureau of Standard			
39	Design Manual for Water Supply and Wastewater Disposal, 3rd ed.	コピー&デジタル	＊				Ministry of Water (MoW)			
40	Drilling and Dam Construction Agency Trial Balance for the Twelve Months Ending June 30 2009, 2008	コピー	＊				Drilling and Dam Construction Agency (DDCA)			
41	Magari na Mitambo ya Serikali iliyopo DDCA, April, 2012	コピー	＊				Drilling and Dam Construction Agency (DDCA)			
42	Taarifa Ya Utekelezaji Mpango wa Bajeti wa Wakala wa Mwaka 2011/2012, Juni 2012	コピー	＊				Drilling and Dam Construction Agency (DDCA)			
43	Mantrac CAT Rental activity 17/07/2012	コピー	＊				Drilling and Dam Construction Agency (DDCA)			
44	Water Sector Development Programme (WSDP) Programme Implementation Manual For 2007/08, November 2006	コピー	＊				Ministry of Water (MoW)			
45	Annual Operational Plan 2002-2003	コピー	＊				Drilling and Dam Construction Agency (DDCA)			

番号	資料の名称	形態	収集資料	専門家作成資料	JICA作成資料	テキスト	発行機関	取り扱い区分	図書館記入欄	備考
46	Drilling and Dam Construction Agency Annual Budget 2011-2012	コピー	*				Drilling and Dam Construction Agency (DDCA)			
47	General Ledger Report by: Segment 4-Account Code DRILLING AND DAM CONSTRUCTION AGENCY 07/01/2008 Thur 06/30/2009, Detail, Non-Zero Accounts, Posted Transactions, 2008	コピー	*				Drilling and Dam Construction Agency (DDCA)			
48	General Ledger Report by: Segment 4-Account Code DRILLING AND DAM CONSTRUCTION AGENCY 07/01/2008 Thur 06/30/2009, Detail, Non-Zero Accounts, Posted Transactions, 2010	コピー	*				Drilling and Dam Construction Agency (DDCA)			
49	General Ledger Report by: Segment 4-Account Code DRILLING AND DAM CONSTRUCTION AGENCY 07/01/2008 Thur 06/30/2009, Detail, Non-Zero Accounts, Posted Transactions, 2009	コピー	*				Drilling and Dam Construction Agency (DDCA)			
50	General Ledger Report by: Segment 4-Account Code DRILLING AND DAM CONSTRUCTION AGENCY 07/01/2008 Thur 06/30/2009,Detail, Non-Zero Accounts, Posted Transactions, 2010	コピー	*				Drilling and Dam Construction Agency (DDCA)			
51	General Ledger Report by: Segment 4-Account Code DRILLING AND DAM CONSTRUCTION AGENCY 07/01/2008 Thur 06/30/2009, Detail, Non-Zero Accounts, Posted Transactions, 2008	コピー	*				Drilling and Dam Construction Agency (DDCA)			
52	General Ledger Report by: Segment 4-Account Code DRILLING AND DAM CONSTRUCTION AGENCY 07/01/2008 Thur 06/30/2009, Detail, Non-Zero Accounts, Posted Transactions, 2010	コピー	*				Drilling and Dam Construction Agency (DDCA)			
53	General Ledger Report by: Segment 4-Account Code DRILLING AND DAM CONSTRUCTION AGENCY 07/01/2008 Thur	コピー	*				Drilling and Dam Construction Agency (DDCA)			

番号	資料の名称	形態	収集資料	専門家作成資料	JICA作成資料	テキスト	発行機関	取り扱い区分	図書館記入欄	備考
	06/30/2009, Detail, Non-Zero Accounts, Posted Transactions, 2010									
54	Borehole List : Drilled by DDCA (1997-2011)	コピー&デジタル	*				Drilling and Dam Construction Agency (DDCA)			
55	Curriculum Information Report for Basic Technician Certificate (NTA Level 4) in Hydrogeology and Water Well Drilling, August 2011	コピー&デジタル	*				Water Development and Management Institute (WDMI)			
56	Curriculum Information Report for Technician Certificate (NTA Level 5) in Hydrogeology and Water Well Drilling, October 2011	コピー&デジタル	*				Water Development and Management Institute (WDMI)			
57	Curriculum Information Report for Ordinary Diploma certificate (NTA Level 06) in Hydrogeology and Water Well Drilling, August 2011	コピー&デジタル	*				Water Development and Management Institute (WDMI)			
58	Working Instruction	コピー&デジタル	*				Drilling and Dam Construction Agency (DDCA)			
59	Present and Future Activities in Water Sector Visima vilivyochimbwa katika Halmashauri 84, 2012	コピー&デジタル	*				Ministry of Water (MoW)			
60	Annual Budget 2011-2012	コピー&デジタル	*				Drilling and Dam Construction Agency			
61	Annual Budget 2012-2013	コピー&デジタル	*				Drilling and Dam Construction Agency			
62	The Financial Statements of the Water Development and Management Institute for the Year ended 30th June, 2011	コピー&デジタル	*				Drilling and Dam Construction Agency			
63	Drilling - the Manual of Methods, Application, and Management.	コピー&	*				Australian Drilling Industry Training Committee			

番号	資料の名称	形態	収集資料	専門家作成資料	JICA作成資料	テキスト	発行機関	取り扱い区分	図書館記入欄	備考
		デジタル					Limited			
64	Drillers Training and Reference Manual	コピー&デジタル	*				National Waterwell & Drilling Association of Australia			
65	User Guide Procurement of Smaller Works National Competitive Bidding, July 2007	コピー&デジタル	*				Public Procurement Regulatory Authority			
66	User Guide Procurement of Non-Consultant Services, July 2007	コピー&デジタル	*				Public Procurement Regulatory Authority			
67	User Guide Procurement of Medium and Large Works National Competitive Bidding, July 2007	コピー&デジタル	*				Public Procurement Regulatory Authority			
68	The Public Procurement (Goods, Works, Non-consultant Services and Disposal of Public Assets by Tender) Regulations, 2005	コピー&デジタル	*				The United Republic of Tanzania			
69	The Public Procurement Act, December 2011	コピー&デジタル	*				The United Republic of Tanzania			
70	The Vocational Education and Training Act Chapter 82, revised Edition 2006	コピー&デジタル	*				The United Republic of Tanzania			
71	Vocational Education and Training by Government in Tanzania The Example of Community Oriented Vocational Training in Folk Development Colleges, May 2000	コピー&デジタル	*				Vocational Educational Training Authority (VETA) / GTZ			
72	National TVET Monitoring Report for Tanzania	コピー&デジタル	*				SADC & UNESCO Assessment and Review of Technical and Vocational and Training (TVET) in the SADC Region			
73	The National Council for Technical Education Act, 1997	コピー&	*				The United Republic of			

番号	資料の名称	形態	収集資料	専門家作成資料	JICA作成資料	テキスト	発行機関	取り扱い区分	図書館記入欄	備考
	(NO. 9 of 1997)	デジタル					Tanzania			
74	The Companies Act, 2002	コピー&デジタル	*				The United Republic of Tanzania			
75	Business Activities Registration Act, 2005	コピー&デジタル	*				The United Republic of Tanzania			
76	The Business Licensing Act, 1972	コピー&デジタル	*				The United Republic of Tanzania			
77	Craft Syllabus	コピー	*				Water Development and Management Institute (WDMI)			
78	Water Development and Management Institute Prospectus 2011/12	コピー					Water Development and Management Institute (WDMI)			
79	Water Development and Management Institute Prospectus 2012/13	コピー					Water Development and Management Institute (WDMI)			