<u>INTRODUCTION TO GROUND WATER EXTRACTION TECHNOLOGIES:</u>
BOREHOLE, SHALLOW WELL AND TUBE WELL
Shallow wells are also called Traditional Wells

1.0 <u>INTRODUCTION</u>

Rural Communities in developing countries use their own initiatives to acquire drinking water from either surface water sources (rivers, dams etc) or ground water sources. For surface water, water is fetched by the use of buckets. For the ground water sources, shallow holes are dug, in which water is fetched using buckets tied to ropes.

Unfortunately, human activities (both domestic and industrial) have polluted a lot of the natural water sources. Many are even drying up due to deforestation (for firewood, farming and building) and poor land husbandly. Consequently, the use of surface water has greatly reduced, unless treated. High levels of poverty make water treatment virtually impossible (even boiling is not assured with scarcity of firewood). On the other hand, hand-dug wells have major problems with respect to quality and periodic drying up (see Appendix I & II).

Appropriate technologies have been developed for both the sources such as gravity-fed water supply technologies for surface water and tube-well for ground water. This write-up is only dealing with the technologies for extracting ground water, which are tube-well based.

2.0 <u>DEFINITIONS</u>

No	SUBJECT	DEFINITION
1	Well/ Tube-well	A hole drilled in the ground for the purpose of extracting ground water. Some tend to limit the term to shallow wells.
2	Borehole	A deep well/ tube-well; over 50 feet (about 15m) depth. Although the construction technology is similar to a machine drilled shallow well, the type of pump is different since water has to be pumped from a deeper level (Appendix I & III).
3	Shallow Well:	A shallow well/ tube-well; bellow 50 feet depth. This technology is applicable in shallow water tables, hence often in soft soil/ sandy formations. Due to their shallowness, shallow wells are prone to pollution from seepage of polluted water and drying up during dry season. However, with proper siting, these problems (and those below) can be eliminated. Actually, in some areas, shallow wells tap into fresh water than deep wells, while the opposite is also true. Their biggest advantage is their relatively low cost (Appendices II-IV).

3.1	- Hand dug	A shallow well dug by hand held tools (eg hoe, shovel etc). It sometimes has got problems with pollution due to often unprotected state and wide-diameter which is prone to collapsing of the walls (a common hazard for women and girls, who traditional draw water for house-holds).
3.2	- Machine dug	A shallow well drilled by a mechanized or manually operated machine (drilling rig) with a small diameter. This is easily protected and fitted with a hand or submersible pump. There is virtually no collapsing and relatively low chances of pollution with respect to the hand dug shallow well (Appendices II-IV).

3.0 TECHNOLOGY CHOICE

The various technologies above have their advantages and disadvantages. Some of the determinants for choosing the technology to use are as follows;

3.1 Local environment; type and depth of water bearing rocks (aquifers), accessibility of the area (eg with big drilling rigs).
3.2 Community capacity in acquiring spare parts for maintenance of the well.
3.3 The capital investment available for well installation (cost).
3.4 Availability of materials required to install the pump (including availability of a suitable water pump).
3.5 Water quality in the shallow and deep aquifers.
3.6 Availability of the drilling technologies.

4.0 CONCLUSION

Considering various factors such as; the level of technical services in most of rural areas of Africa, the usual protracted dry seasons and even droughts, a gift of a borehole would assure sustainable adequate potable water supply to a Community throughout a year and for many years than a shallow well. It also opens then an opportunity of piping to a bigger area (and closer to their houses through a network of taps) if pumped into an elevated tank by solar or wind operated submersible pump.

APPENDIX I

BOREHOLE WATER SUPPLY COSTING

Featuring inputs that determine costing

1.0 INTRODUCTION

The provision of potable water to communities in a sustainable manner is apparently costly. However, considering what goes into it, the output and the expected impact, it is cost effective. All World Vision boreholes that were installed with support from World Vision aim at providing potable water supply sustainably to communities, together with its associated sanitation and hygiene. To achieve this, the following three major activities are done; i) Community mobilization, ii) Borehole drilling and iii) Borehole maintenance, Sanitation and hygiene capacity building. The details are as follows;

2.0 MAJOR COMPONETS OF A BOREHOLE PROJECT

The following are the details of the above three major activities;

2.1 COMMUNITY MOBILISATION

i) PRE-DRILLING COMMUNITY AWARENESS AND ACTIVITIES;

When a Community has requested for a borehole, WV Water and Sanitation Specialist visit them, discussing all the details of borehole installation and future management demands. This is the initial component of Community ownership of the borehole to-be, and a critical element of sustainability. The Community selects a Borehole Committee as its representative in the preceding activities. Secondly, the Community is facilitated in site selection of the borehole site (eg far from latrines; a hydrogeologically highest potential areas for hitting a wet borehole; centrally positioned site to all users). This stage averages one month.

ii) DURING BOREHOLE DRILLING

Before the borehole drilling commences, WV orients the Community in the coming activities. The Communities are therefore able to carry out some form of monitoring the driller's activities, as well as get familiarized to the drilling process. This stage averages one week.

iii) POST-BOREHOLE DRILLING

WV trains the Community in the proper management of the borehole to ensure sustainability. This process includes the proper operation and maintenance of the borehole pump and its sanitation facilities (concrete apron, waste water drainage channel and washing slab). Management of waste-water is also explored (eg gardening or soaking into the ground). Communities are therefore able to repair the hand pump if it breaks-down. This stage averages one month.

2.2 BOREHOLE SITE SELECTION

The borehole Community borehole siting is supported by a private Geophysical Siting contractor. Using very high technology, the contractor identifies the site with the highest potential site for getting a wet/ productive borehole. This is a necessity to reduce chances of striking a dry hole, hence wasting a lot of money. If it does not match the Community's original site, compromises are made, especially where culture is strong (eg near a grave yard is culturally not accepted by some communities). This activity averages one day.

2.3 BOREHOLE INSTALLATION

With the site selected, a private contractor is engaged to drill the borehole. WV technicians support the Community in supervising the driller. This ensures that the right procedures and materials are used in the construction of the borehole, as well as the installation of the hand pump and its sanitation civil/ concrete works. Sometimes, the Drilling Contractor is different from the Civil Works Contractor as a means of cross checking the data/ information the Driller provided. In water scarce areas, borehole depths average 50m (150feet). This is often the most expensive stage, and can take an average of one month to implement.

2.4 BOREHOLE MAINTENANCE, SANITATION AND HYGIENE COMMUNITY CAPACITY BUILDING

Upon successful borehole installation, the Community, through the Committee, is trained in the proper operation and maintenance of the water supply pump. This is a vital component for sustaining the pump. On the other hand, in order to ensure potability of the water, the Community is trained in sanitation and hygiene (how to keep their water point clean; water collecting vessels/ containers clean; personal and domestic cleanliness; clean water storage; waste disposal eg latrines and rubbish pits respectively). This stage averages one month.

APPENDIX II

SHALLOW WELLS

1.0 INTRODUCTION

Shallow wells are normally the means of accessing ground water of shallow depths (Shallow ground water table). In this water supply system, skilled people dig into the soft ground formations (sandy to clay) until they strike the water table. A shallow well is called "unprotected" when its top is not properly covered (because dirty blown by wind or carried by surface flowing water or even the pails from the ground it rests on can enter and pollute the well. before going in the well). When fitted with a proper lid on top, it is called a protected well. In some cases, a hand-pump is also fitted to increase the protection.

2.0 TECHNOLOGIES

The following two technologies are often used;

2.1 Shallow well siting;

A site to dig a shallow well is often identified by its hydrogeological setting; being along low-lying areas with thick soils and the type of vegetation favoring shallow water table. At times, traditional devining methods are used (eg a small branch of a special tree which breaks at the right site). In many cases, they know from history that the area has shallow-water table, and even the taste of the water (eg areas with or without salty water).

2.2 Shallow well digging;

i) Hand Dug Shallow wells

Normally, a hand dug shallow-well is about one to two meters (1 to 1.5yards) in diameter, depending on the size of tools used. A hand-held hoe is the commonest tool used. A small bucket, tied to a rope, is used to remove the dug soil from the hole. This process requires a team size of two or so experts. As they dig deeper, they make notches along the walls, where they step (hence a small diameter is advantageous). At times, they use locally made wooden ladders. If they reach a hard formation (eg rock) before striking the water, they abandon the well.

As the depth increases, oxygen decreases in the hole. At depths of over two meters, some put fresh leaves beside the digger (although they normally may not explain the technology; the leaves actually use the carbon dioxide from the digger to produce oxygen within the hole!). While 5 meters depth, are often considered maximum, some go beyond. It takes an average of a week to finish a hand-dug shallow-well.

ii) Machine dug

Some communities have appropriate technologies which assist them dig the well faster in the same soft formations. Many communities use a tripod auger (also called the Vonder Rig). It goes up to 15meters depth. Its diameter is the borehole size. This process requires an average of ten people for 2 to three days. If a mechanized drilling machine is used, a maximum of one day would be required to complete a well.

2.2 Performance and Protection of Shallow wells

Shallow wells in clay formation are good for stability of their walls, but recharge is usually slow if many people draw water from it. The result is a common long queue of people awaiting water recharge in the well. On the other hand, shallow-wells in sandy formations tend to be hazardous as they collapse easily, but their recharge is usually fast due to much higher porosity compared to the clay formations. This problem is usually managed by lining the well's walls with locally made materials such as bricks or baskets. A concrete slab is often put on top to prevent pollution. Where resources allow, a pulley system or better still, a hand-pump is installed to lift the water to the surface.

3.0 WHY OPT FOR SHALLOW WELL TECHNOLOGY

In most cases, communities will go for shallow wells because of the following reasons;

- 3.1 They can acquire a well using their own resources (low cost and locally available technology compared to borehole or piped water technologies).
- 3.2 Some Areas needing water supplies are not accessibility by big drilling machines.
- 3.3 Some areas have naturally polluted deep water (eg too salty for human consumption), while shallow water is of better quality).
- 3.4 When external support is relatively low, compared to the magnitude of need, some communities opt for digging many shallow wells for the same amount of money, which would have gone into much fewer boreholes.

4.0 LIMITATIONS OF SHALLOW WELLS

Despite the above advantages of shallow wells, the following are some of their typical limitations;

- 4.1 Shallow wells dry quickly in protracted dry season since the water table of the annually recharged perched water aquifer in the superficial deposits (eg the sand, clay formation etc) goes down fast.
- 4.2 Easy water pollution due to poor disposal of human and industrial waste on the ground.
- 4.3 The large diameter wells are hazardous to people when they collapse.
- 4.4 If unprotected, animals can also cause pollution when they drink from it.

5.0 CONCLUSION

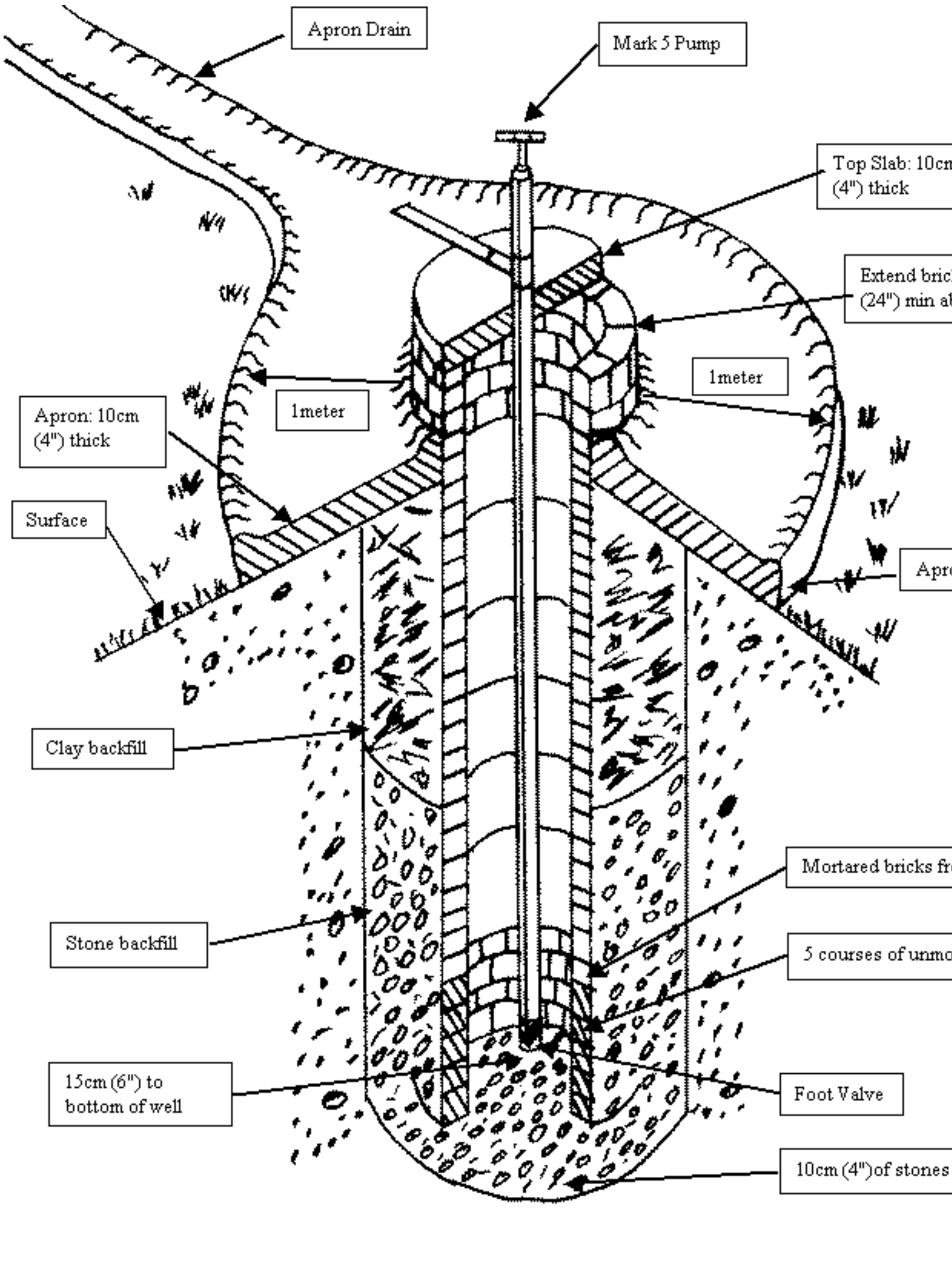
In many areas of the world, shallow wells have proven very effective due to their locally available technology and low cost. Where well constructed and fitted with hand-pumps, they have proven sustainable in supplying potable water. Therefore, with proper consideration for local hydrogeology (ground water quality, fluctuations levels and potential for pollution), the shallow wells will effectively provide potable water to many people.

APPENDIX III

A typical protected shallow well fitted with a hand pump:

Dissected to show the internal components

(http://www.marionmedical.org/Manual/complete.htm)



APPENDIX IV

SOME FREQUENTLY ASKED QUESTIONS

(http://www.metrokc.gov/HEALTH/water/wells.htm#what)

What is a shallow well?

A hole which has been dug, bored, driven or drilled into the ground for the purpose of extracting water is a well. A well is considered to be shallow if it is less than 50 feet deep. The source of a well is an aquifer. An aquifer is an underground layer of permeable soil (such as sand or gravel) that contains water and allows the passage of water.

Aquifers are replenished as rainfall seeps down through the soil. Ground water travels through permeable soil on top of hard or impermeable layers. Shallow wells usually are only deep enough to intercept the uppermost (or most easily reached) perched water table.

There are two main types of wells:

1. **Water table wells** are those that penetrate into aquifers in which the water is not confined by an overlying impermeable layer. The level at which the soil is saturated is the water table. Pumping the well lowers the water table near it. These wells are particularly sensitive to seasonal changes and may dwindle during dry periods.
2. **Artesian wells** penetrate into ground water having confining layers above and below the aquifer. Rainfall enters into the aquifer through permeable layers at high elevations causing the ground water to be under pressure at lower elevations. Because of this pressure, the water level in the well is higher than the aquifer. A well that yields water by artesian pressure at the ground surface is a "flowing" artesian well.

How are wells constructed?

Wells can be constructed in a number of ways. The simplest and least expensive of all wells is the driven well. It is constructed by driving a well-drive point into the ground that is fitted to the end of a series of pipe sections. A driven well is usually 2 inches in diameter.
Most wells, however, are drilled by either cable tool, percussion or hydraulic rotary, creating a 4 - 8 inch diameter hole. A casing or pipe sleeve is extended into the hole to prevent the sides from caving in. The annular space outside of the casing is sealed with cement grout or puddling clay.
Water can be pumped to the surface by a variety of methods. Very shallow wells (less than 20 feet) can use a suction pump at the ground surface. Deeper wells must use a submersible pump to push the water to the surface. Ground water is allowed to enter the casing by either an open end pipe, perforated pipe or a well screen, depending on the size of the aquifer soil particles. If the holes in the pipe or screen are too large, then the well may pump sand with the water. If the holes are too small, they may become plugged and reduce the overall yield of the well.

Dug wells

In the past, holes or pits were dug by hand or machines into the ground to tap the water table. Dug wells are usually 3 to 10 feet in diameter, 10 to 40 feet deep and lined with brick, stone, tile, wood cribbing or steel rings to prevent the walls from caving in. They depend entirely on the natural seepage from the penetrated portions of water table aquifers.
Dug wells have disadvantages to driven or drilled wells. They are more difficult to protect from contamination, and their yields are also very low because they do not penetrate into the reliable, productive water table aquifer. A dug well can be made much safer and more productive by driving a well point with a screen into the water-bearing formation, thus converting it into a driven well.

This resource is courtesy World Vision International.