WATER FOR RURAL COMMUNITIES IN GHANA: AN OVERVIEW OF PROVISION OF BOREHOLES

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ABSTRACT

A rapidly growing interest in groundwater abstraction, for rural communities, is occurring throughout Ghana with much attention on the development of boreholes. The limited financial resources available and skilled-manpower required in large-scale projects, suggests that groundwater development can be costly and difficult without the proper understanding of hydrogeological principles and practice and the appreciation of the socio-cultural dimensions of the beneficiary communities. A general overview of borehole provision has been outlined in this paper supported with data derived from borehole development in poorly-permeable areas of the Ashanti Region. The importance of the use of geophysical techniques in well-siting is also emphasized as an invaluable tool in terrains where groundwater development could be difficult and complex.

INTRODUCTION

Ghana, in recent times, has focused much attention on the need to provide potable water and adequate sanitation facilities to rural communities, which constitute over sixty percent of the population (Ghana vision 2020). As a result of constraints on the availability of water-resources and finance and the need for technically simple and easily implemented water-supply schemes, underground water resources are being developed. This involves constructing dug and drilled wells and equipping them with simple manually operated hand-pumps. In pursuance of this objective, the government has directly and indirectly, through encouragement to Non-Governmental Organisations (NGOs) and of late through traditional authorities (on pilot basis), improved access to water supply in rural communities. In fact within a span of ten years, (1974-1984), about 6000 hand-operated boreholes had been drilled in the Northern, Central and Southern parts of Ghana, with assistance of bilateral donors, such as Canadian International Development Agency (CIDA), Japanese International Development Agency (JICA), Danish International Development Agency (DANIDA), etc. (GWSC, 1987). Most of the programmes are funded with direct disbursement and contractor/consultant execution.

There are, however, many technical and financial problems in constructing and maintaining these boreholes. The assumption that little attention needs to be given to the siting, design and construction of boreholes, as the yield requirements are small, are countered by the argument that the neglect of hydrogeological principles and practices, can result in much higher cost and the whole programme of meeting the needs of deprived communities could be in jeopardy. A new thinking is required if the limited financial and trained-manpower resources are to be used effectively in providing reasonably low-cost but adequate and reliable groundwater supplies to the deprived communities. In this paper, the technical processes for groundwater development are discussed, illustrated by results and experiences from deprived communities in Ashanti Region underlain by rocks of the Birimian System and the Voltaiain Formations, from which abstraction of groundwater is complex and difficult due to the presence of crystalline and sedimentary rocks. The need for hydrogeological principles in the design and construction of wells is also highlighted.

1.1 Historical Background to Groundwater Development in Ghana: Over much of Ghana and Sub-Sahara Africa in general, the existence of readily accessible water has always been a very important criterion for settlement. The seasonality of rainfall, its effect on the presence of water and pasture, has resulted in fixed settlement occurring only close to perennial surface water or shallow groundwater. Across most of the rural communities in Ghana, groundwater use was until more recently, restricted to abstraction from shallow hand-dug wells and open holes on river banks or in dry river beds.

Formal development of groundwater resources for domestic supply was commenced by colonial governments in about 1900 generally, on a small scale with very limited budgets and was often carried out in a piecemeal fashion. Water-well drilling programmes was mainly the responsibility of the Geological Survey Department (Bates, 1962). The geological input to the provision of groundwater supplies was often restricted to routine well-siting, commonly carried out by field-survey geologists with little or no formal training in hydrogeology. One of the important outcomes of this was an interest

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Table - 1: Comparison of Drilling Methods and Equipment

Items	Hand operated rig	Cable tool rig	Small – air flush rotary rig	Large multi purpose rotary rig
Capital Cost	very low	low- medium	medium	very high
Running cost	very low	low	medium	very high
Training needs for operation	low	low- medium	medium	very high
Repair skills	very low	low- medium	medium	very high
Back up support	low	low- medium	medium	very high
200mm holes to 15m in unconsolidated formation	fast	fast	feasible but difficult	very fast*
200mm holes to 50m in unconsolidated formation	very slow and difficult	fairly fast	feasible but difficult	very fast*
200mm holes to 15/50mm semi – consolidated formation	impossible	fairly fast	feasible but difficult	very fast*
100mm holes to 15/50m in consolidated (hard) formation.	impossible	very slow	fast	very fast*

in, but often uncritical use of geophysical techniques, especially resistivity for routine well siting, irrespective of hydrogeological conditions or water requirement with the neglect of other aspects of the provision of supplies.

One of the outcomes of increased interest in water supply at the national political level, is the strengthening of Government organisations responsible for water development. The establishment of Community Water and Sanitation Agency (CWSA) with the responsibility of co-ordinating national rural water and sanitation programmes, have provided the institutional framework for closer coordination between the various sectors engaged in rural water resources development across the country. During the past few years, there have been concerted efforts in Ghana to identify water resources development options that are suitable to serve widespread rural population, since large scale surface water development is often constrained by the need for expensive reticulation and treatment, and may be further affected by markedly seasonal nature of many surface water resources. Current thinking is tending to favour boreholes, which provide a primary protected source where people can collect clean water. The hand-pump is replacing the bucket, and with improved design, local community maintenance of its mechanism should be feasible.

1.2 Feasibility Studies and Master Planning: Groundwater resources are generally more difficult to quantify than surface water, particularly when dealing with geologically complex aquifers, and when account must be taken of potential advantages of widespread

Table - 2: Summary of Drilling Results Weathered/Crystalline Basement Aquifer

Project Identification/Location	Number of Boreholes Drilled (Dec, 2004)			Borehole Records			
PPTAP/Ashanti Region	Total	Successful	Dry	Aver. Drill Depth (m)	Aver. Depth of aquifer (m)	Aver. SWL (m)	Aver. Yield (L/min)
	38	34	4*	65	45	14.6	35

* Dry wells drilled in the Voltaian sandstones and shale beds of the Sekyere East and West Districts of Ashanti Region

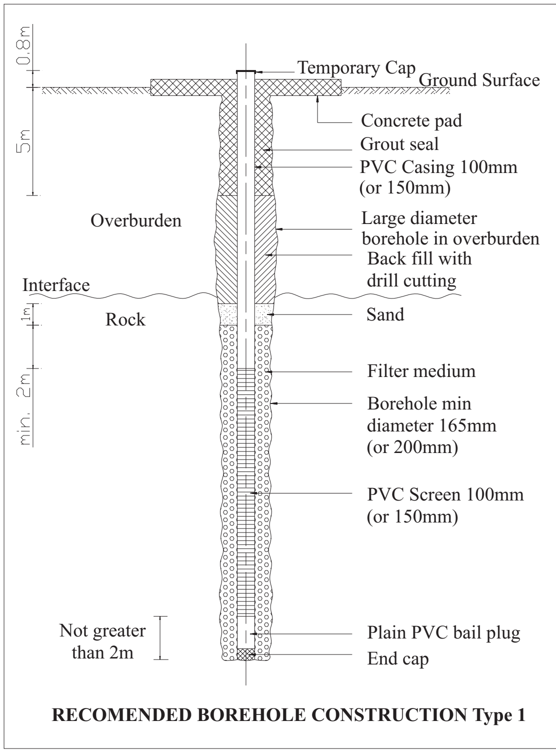


Figure - 1: Borehole design type "A" for sedimentary formation

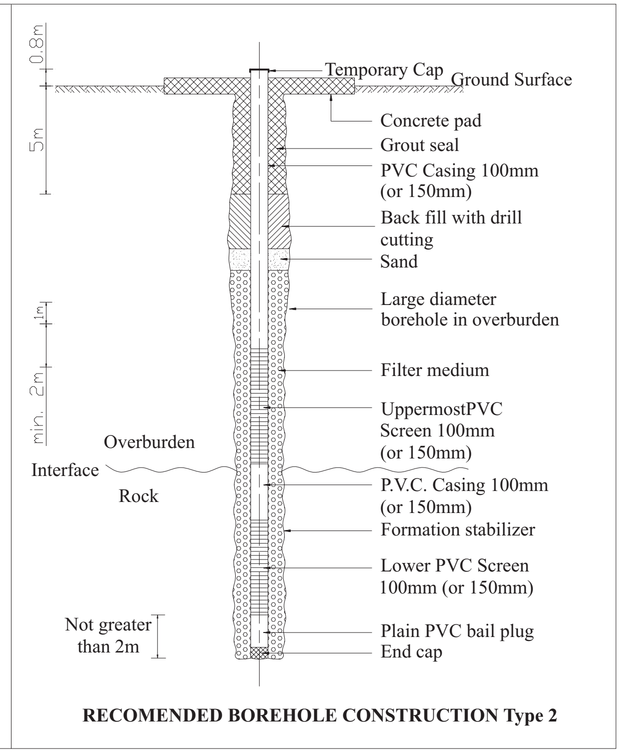


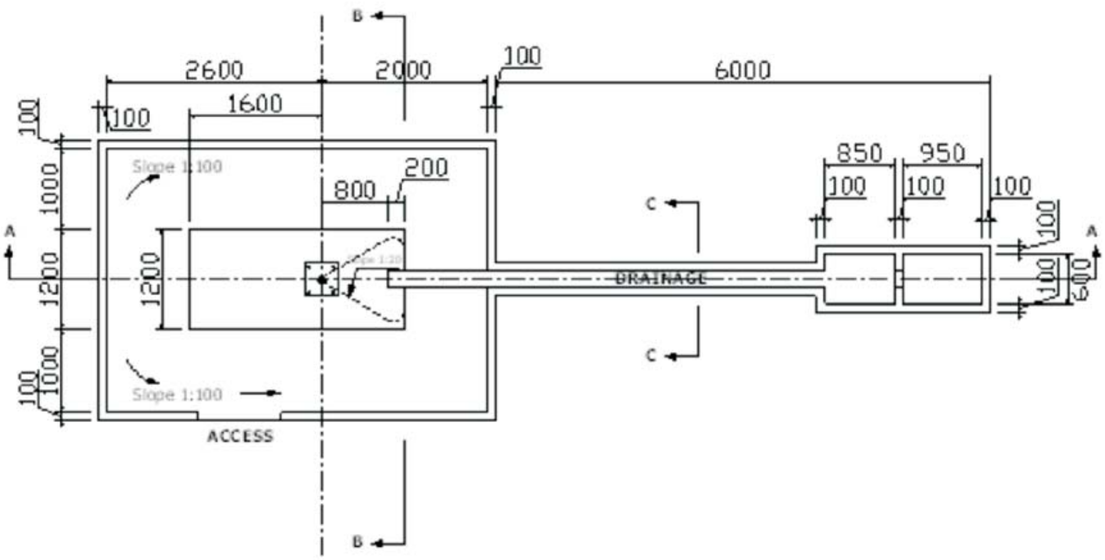
Figure - 2: Borehole design type "B" for hard formation

occurrence, lower environment impact and cost effectiveness. An important component of a Master Plan, therefore, should be to identify the occurrence of available water sources, whether ground or surface water, and to provide cost-comparisons of development options. This could be carried out by a multi–disciplinary team, probably headed by a hydrogeologist or water engineer, who by nature of his training appreciates and comprehends the complexities of groundwater development. The teams' overall responsibility could be looking critically at accumulation of information, including well construction, water-quality and geophysical data. Additional information by investigative drilling, is necessary in an attempt to identify hydrogeological conditions on regional or national basis. Updating and modification of the Master plans, should frequently be carried out as the project implementation progresses, and should not be regarded as final statements. This is particularly true, where groundwater supply programmes elsewhere is increasing the available hydrogeological information.

Many factors must be balanced including water demand, the hydrogeological environment, water quality, optimum drilling and abstraction methods, the availability and suitability of local construction materials and the feasibility of community involvement.

In planning a project of groundwater abstraction with hand-pumps, decisions or information on the following design factors will be needed.

a. Per-capital water consumption and the maximum acceptable walking distance for collection
b. Total number of people to be served (by extrapolation to a planning horizon usually 5 – 10 years ahead) and their distribution, required numbers of water points can be calculated.
c. Types of water points, whether dug, or a drilled well in accordance with hydrogeological conditions.
d. Optimum pump-design for easy maintenance
e. Plan for maintenance, operational procedure and funding.
f. Recommended level of community involvement.



DESIGN OF PLATFORM FOR HAND PUMP BOREHOLES (PLAN)

Figure - 3: Standard Design of Aprons and drain pit type A

Projects involve a wide range of activities from field survey to community organization, and in certain areas a small scale pilot project in advance of a major scheme may be merited.

1.3 Equipment: Drilling rigs currently used for groundwater exploration in Ghana range from small – air flush rigs, which can drill a few meters to large multi-purpose rotary rigs capable of drilling to more than 500m. Low-cost hand operated rigs and cable-tool rigs are less employed as drill-depth is to a few meters below ground surface, and are limited to servicing private homes. In Ghana deep groundwater generally available to boreholes occurs in three types of environments: (a) in zones of deep weathering in hard crystalline rocks; (b) in fractured and jointed fresh rocks of several kinds and (c) in porous stratified sedimentary rocks. Ideally a rig should, therefore, be fast and efficient, simple as possible and cheap to operate, robust and reliable, as well as easy to move and maintain. It should also be capable of drilling through any type of formation both unconsolidated and hard formations. Table-1 shows the relative merits of various types of drilling rigs.

Drilled-wells for hand-pump installation, require a minimum internal diameter of approximately 100mm to accommodate a hand pump cylinder. The wells will often not be less than 30m deep, but average around 60m deep and in some cases reach or exceed 80m (beyond which pumping by hand is not feasible). Borehole mechanization requires large diameter holes which could be 150m – 175mm. Rigs must be able to drill together both hard and soft rocks in the same hole. Direct circulation rotary rigs with mud facilities are commonly used in Ghana, but occasionally small rotary rigs without hammer facilities are employed for drilling unconsolidated formations in areas where accessibility for machinery is not possible.

Drilled formations will range from unconsolidated (and caving) sediments through semi-consolidated formations (such as weathered crystalline rocks) to hard consolidated rocks. If it is planned to screen unconsolidated to semi-consolidated formations, a 50 – 75mm thick gravel pack is desirable, requiring a hole diameter of 200 – 250mm. Open hole completion of 100mm diameter may be adequate in hard rocks.

Most suitable drilling methods will depend on local circumstances but as drilling technology improves, rigs could be produced which could

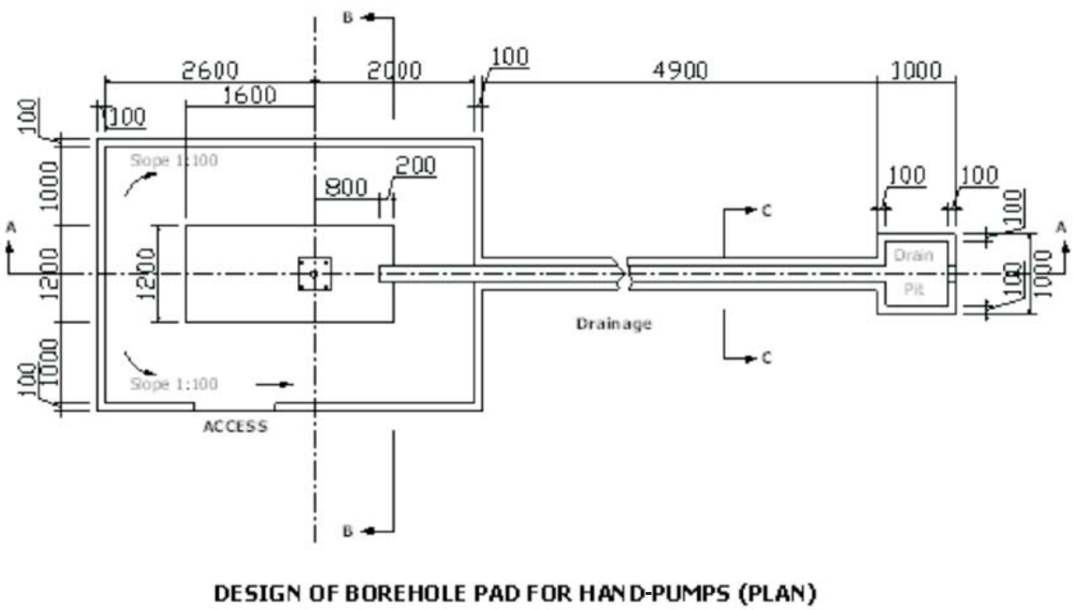


Figure - 4: Standard Design of Aprons and drain-pit type B

be suited for drilling wells in remote areas with semi skilled crews. Similar attention needs to be given to other items of rural water-supply hardware such as down the hole hammer bits, caisons, well screens (slotted and plain). Well-screen commonly in use in Ghana are the locally extruded and slotted PVC pipes. The advantages of using PVC pipes for well construction lie in the relatively low-cost, ease of installations and range of slot sizes, caisons for installation in unconsolidated upper formation to prevent cave in range from 200m – 250m. A maximum caison length of 40m is suitable for most drilling operations in Ashanti Region. The wide distribution of crystalline rocks in Ashanti Region also calls for the application of emerging technologies for obtaining maximum yields from low permeable rocks. Hydro fracturing has become an invaluable method in this regard, enabling marginal boreholes to be redeveloped to increase yield. This could be a back up support for drilling equipment mobilization on a project.

2. WELL-SITING

Hydrogeological conditions and user-convenience must both be considered in well-siting. A sense of community ownership is desirable and critical in the overall project success and may be achieved by allowing the community as much involvement as possible in the selection of the well-sites. The degree to which this is feasible will depend on the hydrogeological environment where the supply aquifer is within fractured bedrock, the need for detailed geophysical surveys will limit community site selection. Where aquifer occurs in extensive weathered formations at moderate depth the community's choice could be paramount, bearing in mind the need for protection from pollution and ensuring proper drainage at the well-site.

The well-site should be chosen so that an adequate and sustained yield of water of acceptable quality is to be anticipated. For a hand-pump, the minimum requirement as specified by CWSA should not be less than 13.5 l/min. The well should be situated so that it can serve a rural population of 500-1000 people within the design maximum walking distance, which is usually between 0.3 and 1.0 km. If the water level is shallow and the near surface formation is relatively soft, a dug well will probably be more economic, with deep water wells and hard formations, a drilled well is likely to be preferable.

The use of geophysical techniques, mainly the electrical resistivity method, is gaining acceptability as an invaluable tool for successful detection of potential aquifer zones, which would have been overlooked in groundwater exploration programme. Applications are more justified when determination of weathering thickness is a critical factor or in a search for localized fracture zones in bedrock. Unsuccessful boreholes are expensive and the need to minimize the number is clear. The over 80% achievement of successful boreholes in Ashanti Region justifies its application in well-siting (Table 2). Improved correlation with hydrogeological conditions of lower-cost geophysical techniques such as electromagnetic and perhaps more effective use of satellite imagery in conjunction with air photographs would have obvious advantages in low–cost rural water supply programmes. A more extensive use of sophisticated geophysical techniques would in many cases be constrained by the general scarcity of equipment and trained geophysicists in the country.

3. WELL-DESIGN, CONSTRUCTION AND COMPLETION

A good well-design is fundamental to long-term project success, because of the greatly reduced need for hand-pump maintenance due to reduction in sand pumping. A series of standard designs shown in figures 1 and 2, may suffice but close supervision should ensure that the designs are correctly implemented. Close supervision of a drilling programme is likely to reduce costs. All too frequently, a well is drilled to 60m when an adequate yield would and lower draw down could be obtained from shallow well, screened in unconsolidated surface weathered layers than from a deeper hole in which it is cased out. A drilled well draws on storage in the aquifer, in order to ensure a reliable supply, the relationship between pumping regime, storage requirement and rate of inflow must be carefully understood so that a general design parameter of target depth of excavation below dry season static water-level can be established. Further the amplitude of seasonal and long-term water level fluctuations needs to be considered. Such neglect could put out of action several boreholes. An important requirement of well-construction is that it should ensure proper sanitary protection to reduce pollution risks. Current designs being implemented in most groundwater projects are given in figures. 3 and 4.

In practice any of the designs could be adopted to suit the topographic and terrain condition. Provision should be made by means of an apron and drain for removal of waste water from the wells' head. Recommended drains could, therefore, be modified to ensure that the well-site is clean. This is particularly important when the borehole is located close to residential areas with poor drainage facilities.

4. WATER-QUALITY

Boreholes drilled in Ghana are more often than not drilled to provide potable water for all-purpose use. It would be expected that the quality of water should meet WHO international standards. Chemical analyses are expected to provide results of iron, chloride, nitrate and other mineral logical contents of the water within acceptable limits. Bacteriological tests to determine the extent of contamination with pathogenic substances, are crucial to avoid users drilling contaminated water. The availability of chemicals on the market makes possible for the disinfection of contaminated boreholes to make usable without health hazards.

5. HAND-PUMPS

The critical issue in selecting a hand-pump, for installation at the community level, is its potential for sustainability. The hand-pump itself is still a weak link in development programmes, due to difficulties of maintenance. Village Level Operating Maintenance (VLOM) hand-pumps, are generally understood to possess attributes of robustness, high-discharge at relatively shallow depths, and ease of maintenance as well as cost-effectiveness.

Hand-pumps are designed to have most of the maintenance work to be done at the community level, and require few tools and interchangeable wearing parts. One of the major risks to the sustainability of hand-pumps is the availability of spare parts for the community to purchase locally. The chance of spare parts' availability is increased when there is standardization on a small number of hand-pumps throughout the community. This standardization makes it easier for the private sector, to procure hand-pumps and spare parts, as well as to set up retail networks. Hand-pumps' standardization also facilitates the training requirements for community-level caretakers and area mechanics.

Based on the national sector policies initiated in 1992, Ghana standardized on the use of the following VLOM hand-pumps at the national level:

- Afridev SKAT/HTN Specification Revision 3 –1998 (Suitable for 10 – 45m depths)
- Nira AF – 85 Direct – Action hand pump. (Suitable up to 15m depths)
- Vergnet HPV – 60 Vergnet pump (Suitable for 10 – 45 depths)
- IM2 Ghana modified India Mark II. (Suitable

above 10m depths)

Final selection of the pump may be modified after completion of the borehole, when the dynamic water-level is known. Experience in Ashanti Region indicated that hand-pump failure can most frequently be attributed to sand-pumping consequent upon poorly-designed gravel packs or incorrect well-screened slot size. Major savings are to be anticipated from improved borehole design in respect to this single issue.

6. COMMUNITY PARTICIPATION

The importance of community participation must be stressed. Projects which have not involved the local communities during the planning and implementation phase, often break down because of the lack of commitment by the villagers. Construction is only the beginning of the life of a water-supply point. Operations will hopefully continue for many years afterwards, but it is during construction that a sound basis of effective maintenance must be established. It is only in this way, that a sense of commitment and feeling of ownership by the community can be built up to allow a successful establishment of a maintenance system, in which the villagers themselves play a large part.

7. OPERATION AND MAINTENANCE

A major cause of failure of rural water-supply projects all over the world, is the inadequate attention to organisation and funding of maintenance. (Grey et.al. 1985). The experience of projects in Ghana, has shown that a centralized government maintenance organisation is rarely able to provide adequate service, because of high-costs of operation and bureaucracy. This can result in pumps being out of action for long periods of time. Villagers may become disillusioned with an improved, but unreliable supply and return to traditional, polluted sources. By their nature, rural water supplies are widely dispersed in remote areas and provide for poor in the community, in such circumstances, more effective maintenance may be possible in which responsibility is developed wholly or in part to the community using the well. If community responsibilities are to be extended to routine replacement of below-ground components these too must be simple and easily removed from the wells. Successive tiers of area mechanics and maintenance assistances leading up to district teams could provide the capability to carryout more difficult repairs, a supply of spare parts and supervise each tier below. Different solutions are possible. There is, therefore, the need for socio-cultural studies on an effective maintenance system which takes not only the technical factors into consideration but also the social and administrative structures, economic factors and the general degree of self reliance of the people in the deprived communities.

8. CONCLUSION AND RECOMMENDATIONS

Groundwater development can be difficult and costly without proper understanding of the hydrogeological principles and practice involved. The recent experience in Ashanti Region of Ghana, attests to the benefits that can follow from the appreciation of groundwater-abstraction from basement complex, in terms of the successful number of boreholes achieved and reduction in cost. It is clear that groundwater is likely to be the most preferred option of supplies to most deprived communities in Ghana for the future. Consequently there is need to occasionally review groundwater abstraction and exploitation techniques, in order to be better suited to the limited skills available and the large-scale of many programmes.

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