Private Sector Participation in Low Cost Water Well Drilling

Knowledge and Research (KAR) Project R7126

Compilation of Work on Siting Methodology and Hydrogeological Potential of the Pounder Rig

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- the numerous individuals who have acted as consultants or assistants to the project,
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It is our hope that the work which we have started in this short project can continue and build on the foundation provided by the many partners and stakeholders involved.

2 BACKGROUND

This report contributes to the findings, implications, and future plans of a project, initiated by Cranfield University (Silsoe, UK) entitled "Private Sector Participation in Low Cost Water Well Drilling". The project was funded by DFID from July 1998 to June 2001, with additional funding partners (Government of Uganda, DANIDA, SIDA, UNICEF, Water Aid, and an anonymous donor) joining at various stages throughout this three-year period.

The three-year Project had two overall aims:

- to develop, and transfer to the private sector, technology suitable for affordable shallow well construction
- to research the process of technology transfer and the conditions necessary for its success, in the context of rural water source construction

The first aim of the project was addressed through three main objectives or outputs:

- the design, field testing, and evaluation of a new human-powered drilling rig (the "Pounder rig")
- the uptake of the technology by a small number of contractors, and their use of the rig in commercial contracts
- the establishment of a sustainable means by which the rig and subsequent spare parts will be made available in country

The research aspect of the project used the technology transfer and uptake process as a gateway to action research. The process of developing the technology and introducing it into the private sector, and the concurrent investigation and learning process, were intertwined in such a way that the project informed the research, and the research informed the project. Both benefited.

The overall research question was:
"what enabling conditions and external actions are necessary to stimulate and strengthen effective rural water supply service delivery by the private sector?"

Introduction

This report is made up of four separate reports:

1. Development of a Siting Methodology for Pounder Rig Well Drilling in Uganda, January 2000. By Callist Tindimugaya.

This was a short consultancy to explore the likely content of a siting methodology for shallow Pounder wells.

2. Shallow Well Siting in Mukono District Using the Pounder Well Siting Methodology, November 2000. By Callist Tindimugaya.

This involved more detailed field surveys at the locations of previously drilled Pounder wells in Katabi sub-county. It allowed the development of initial ideas from the first report.

3. Shallow Well Siting in Mukono District using the Pounder Well siting Methodology, November 2000. By Callist Tindimugaya.

Here the methodology is used to investigate eight locations in Mukono District and select four suitable sites for drilling.

4. A review of the Siting Methods for the Pounder Rig in Uganda, June 2001. By A. Luutu

An independent overview of previous siting work in an attempt to extend hydrogological assessment more widely over the districts of Uganda

3 DEVELOPMENT OF A SITING METHODOLOGY FOR POUNDER RIG WELL DRILLING IN UGANDA, JANUARY 2000

By Callist Tindimugaya

3.1 Introduction

Groundwater is the main source of potable water in rural areas of Uganda. The current national rural safe water supply coverage is estimated at around 46 %. The traditional source of drinking water has been deep boreholes, which currently number approximately 15,000 in the whole country. These are however very expensive to construct and have very high operation and maintenance costs.

Efforts have been put into improving access to safe drinking water through funding from both the Government and external support agencies. These involve development of simple and low cost technologies that are easy to maintain by the user communities such as shallow hand dug and drilled wells and spring protection.

Shallow well construction is a new technology in Uganda and only a few projects/programmes have embarked on large-scale shallow well construction activities.
One big project that has constructed shallow wells on a large scale is Rural Water and Sanitation Project (RUWASA) which mainly concentrated on hand augering as an alternative to deep well drilling. This technology was considered as one of the cost-effective methods of providing potable water to rural communities, where the technology is best suited geographically, hydrogeologically and logistically.

Hand augering was found feasible in soft formations of unconsolidated sedimentary deposits such as clay and sand with very little boulders. The area should also have no significant laterite horizons and the aquifer should have high transmissivity. The shallow groundwater is mainly found within weathered soils. Such water has been found to be less expensive to develop than bedrock aquifers, has a softer taste and the operation and maintenance (O&M) cost of the handpump are lower. Previous studies in the country have also indicated that high yielding water sources can be obtained from the shallow aquifer (Howard et al. 1994).
In Uganda, shallow hand augered wells have been constructed up to a maximum depth of about 20 meters.

Although the technology has been employed for approximately ten years now, it has not fully gained the required acceptance by both the community and the policy makers. The cause of this has been low success rate resulting from the following:

(a) Collapsing formation which inhibits deeper drilling and proper well completion
(b) Hard laterite horizons that are difficult to penetrate by augering equipment

To make the technology acceptable, any low cost shallow well drilling will have to overcome the above limitations. The development of Pounder well drilling technology is thus aimed at overcoming the current problems while at the same time providing low cost wells thereby improving the coverage. For Pounder well drilling to be successful, it will have to employ a siting methodology that is appropriate and cost effective in order to keep the costs as low as possible while at the same time improving its acceptability to communities. There is a spectrum of siting possibilities available varying both in complexity and cost. Conventional deep boreholes use a wide range of techniques which are quite complex and expensive while hand auger wells use very low-input approaches such as identification of valley bottom surface water, open water holes etc. Hand auger well siting is however not based on prevailing hydrogeological conditions and this has in most cases affected its success. To obtain the best results shallow well siting should thus use low input approaches that take into consideration prevailing hydrogeological conditions. Development of a Pounder rig well siting methodology therefore aims at filling up that gap. It is for this reason that the Cranfield Low Cost Water Well Drilling Project has commissioned this study. The aims of the study are:

(a) To review the current shallow and deep well siting methodologies.
(b) To identify possible techniques for shallow well siting, in the context of the likely economic and capabilities of the Pounder rig technology.
(c) To produce a first draft of a methodology for Pounder rig well siting.
(d) To produce an outline plan for developing the ideas in (c) above.
(e) To consider the possible role which the Pounder rig might itself have as a technique for siting hand dug wells, hand augered wells and Pounder wells.
(f) To present a written report covering items a – e above.

3.2 Current Shallow And Deep Well Siting Methodologies

As mentioned earlier, shallow well drilling is a new technology and hence siting methodologies employed by the different organisations have not been harmonised to produce a standard methodology. Each organisation has tended to do it the way it feels ensuring that reasonable results are obtained at the minimum cost possible.
Organisations that are very actively involved in shallow well drilling and employing some form of siting have been grouped into three categories for purposes of discussing their siting methodologies. These organisations are RUWASA, Non governmental organisations and district water offices. Private companies involved in shallow well drilling normally get contracts from one of these organisations and thus have to follow the methodologies set by those organisations. Before a review of shallow well siting methodologies is made, a brief discussion of the deep well siting methodologies employed in the country will be made.

3.2.1 Deep well siting methodology

This methodology varies from organisation to organisation depending on the available human and financial resources and time. Siting is normally done by hydrogeologists who are either employed directly by the organization or hired to provide that service. They normally have a BSc degree in Geology with at least one-year experience in borehole siting. The quality of work produced is quite good and improves with experience. On average, with siting done by a hydrogeologist, a success rate of 60 % up from around 20 % has been achieved in most of the country.

The methodology discussed below represents the common steps involved in deep well siting as promoted by the Directorate of Water Development.

Deep well siting is normally done through 4 different steps as follows:

(i) Desk study

This involves study of all the available hydrogeological and general data relevant to the area of interest such as borehole drilling logs, water quality data, topographic and geological maps, aerial photographs and any previous reports. This results in delineation of areas with hydrogeological potential to be subjected to detailed hydrogeological investigations.

(ii) Field reconnaissance and water source mapping

This is done for purposes of verifying the findings of the desk study and for assessing the current water supply situation in an area. This involves mapping and plotting of all water sources on a base map using a GPS, and studying vegetation changes, topography and geomorphology of the area with respect to findings of the desk study in order to correlate the results.

(iii) Detailed hydrogeological investigations

This involves carrying out Geoelectrical line profiles. Geoelectrical profiling is usually done with resistivity equipment and sometimes with electromagnetic equipment. The profiles are run perpendicular to the geological body or structure of interest, usually a vertical joint or fracture, in order to identify anomalies. Once the anomalies have been identified, they are subjected to Vertical Electrical Soundings (VES) to assess the vertical groundwater potential at that site. Preliminary interpretation is done in the field for purposes of deciding whether additional work is needed or not.

(iv) Data analysis and interpretation

Once the geophysical investigations have been completed, all the gathered data is analysed and interpreted in order to select sites for drilling. Use is made of computer programs such as RESIXP, RESOUND, and GEWIN to analyse the sounding data. Borehole records and any other available data such as geophysical logging are utilised in order to obtain the best interpretation. Based on the interpretation, a drilling site is recommended.

3.2.2 Shallow well siting methodology

As mentioned before organisations involved in shallow well drilling will be discussed under 3 categories as follows:

(a) RUWASA

RUWASA's shallow well siting methodology follows the deep well methodology with minor differences. Siting is done by hydrogeologists employed by the project. Implementation of siting procedures aims at production of a localised technical map and a Participatory Rural Appraisal (PRA) village map on which areas having hydrogeological potential are denoted. This is done for purposes of facilitating the communities to decide where detailed hydrogeological investigations should be carried out, thus offering several alternatives of sites having hydrogeological potential.

Siting is done in nine different steps as follows:

(i) Establishment of District Water Resource File

This is done in order to evaluate if the resources can sustain the requirements. The information included in the file comes from existing databases and groundwater resources assessment reports.

The following information is included in the file:

- Forecast population demand adopting the 1991 National census and a consumption of 20 l/c/d
- Assessment of return periods of annual effective rainfall.
- Assessment of return periods of length of nil groundwater recharge
- Water point distribution (established by the District and Project).
- Other relevant information.

(ii) Establishment of Sub-county Water Resource File

The file includes all existing relevant information found in the office database and a sub- county map indicating the location of all known protected sources.

The following information is included in the file:

- Assessment of areas with shallow water table (from maps, aerial photos, existing records, etc) indicated on the sub –county map.
- Assessment of all known protected sources also to be included on the sub-county map.
- Assessment of annual groundwater fluctuation from monitoring wells in the district if any.
- Assessment of any areas with an elevated water consumption (small towns water supply, industrial water supply, etc).
- Other relevant information (summary review of the sub-county hydrogeological environment/ condition plus appropriate technology options).

(iii) Introductory meeting at Sub-county level

The purpose of this meeting is to brief the local council III about hygiene education, sanitation, water programmes, and allocated water point sources by the district.
The LC III members are briefed about the criteria for new water sources distribution, available water supply technologies in their sub-county and the cost implications for choosing any of the technologies, and the siting procedures and reasons why site selection must be based on prevailing hydrogeological conditions.

(iv) Meeting LCIII Council on Water Source Allocation

The purpose is to inform / determine and explain the number of sources allocated to each parish, the technologies that may be used, and the role of the communities.

(v) Village /User identification and verification

This is done by touring the whole area and visiting all the existing sources for purposes of recording water sources related information and identifying potential sources of pollution. The information recorded during this stage of siting includes water source number, type, location (using GPS), water quality, yield, reliability, acceptability, accessibility and present condition. The information gathered during reconnaissance is cross-checked with what is available in the district water resources assessment database.
Similarly, information on pit latrines such as location, time of construction, whether the groundwater table was struck during construction etc is record in addition to existence of any septic tanks, cemeteries or any other potential source of pollution.

(vi) Identification of areas having hydrogeological potential locations

This is a more detailed desk study comprising use of aerial photos, topographical maps, census (inventory) maps, and already existing information in the district water resources assessment reports and project database.

The activities carried out include:

- Water source distribution according to parish decisions taking into account the existing distribution of functioning/ used protected sources.
- Preparation of a technical base map on the 1:50,000 scale, which should include all the relevant information from all the siting steps.
- Study of aerial photos, topographical and hydrogeological maps to identify any features that might indicate potential areas in and around the selected village.
- Analysis of existing data from the project database, the district water resources assessment reports and also from related detailed studies.

(vii) Village selection of areas for detailed investigations.

The purpose of this step is to select 3 areas for detailed hydrogeological investigations on the basis of the PRA and technical maps.
The hydrogeolgical potential as indicated on the technical map is transferred to ground locations using a peg. The ground locations are then transferred to the PRA map with the assistance of the community.

The community is then divided into groups with each group selecting three preferred areas after which the groups reconvene to select the final three areas for detailed hydrogeological investigations.

(viii) Detailed hydrogeological investigations of selected areas

The purpose of this step is to investigate the three areas identified in the previous step using geophysical methods.
This involves carrying out both Very Low Frequency (VLF) profiles and Geoelectrical line profiles. The VLF profiling has always been done using a WADI but its use has tremendously reduced because of problems of acquiring satellites at certain periods of the day and also because geoelectrical profiling can serve the purpose. Geoelectrical profiling is usually done with resistivity equipment. The profiles are run perpendicular to the geological body or structure of interest, usually a vertical joint or fracture, in order to identify anomalies. Once the anomalies have been identified, they are subjected to Vertical Electrical Soundings (VES) to assess the vertical groundwater potential at that site. The VES are done in the same way as for deep wells only that they are shallower in the case of shallow wells. Preliminary interpretation is done in the field for purposes of deciding whether additional geophysical work is needed or not. Once the VES results have been interpreted and found promising, a penetration test is done using a test hand auger on the site where the survey was carried out. This is done with 25-50 mm diameter auger to a minimum depth of 7 meters for purposes of confirming the VES interpretation. Once penetration test results are good, a production well is constructed next to the test hole.

(ix) Finalisation of village files and sub-county water resources report

Upon completion of the source, the technical data and findings are updated in the project database and the village file is completed.
The activities that are carried out are:

- correlation of VES model and actual geology
- correlation of hydrogeological features such as structure, overburden thickness etc with yield.
- Correlation of other features with water quality, etc.

(b) Non Governmental Organisations.

Some of the non-governmental organisations involved in hand auger well drilling are Accord, ActionAid, CPAR(Canadian Physicians for Aid and Relief), Soroti Diocese and
CAP(Community Action Program).
Siting by these organisations does not follow a clearly set out methodology but is based on a few guidelines regarding identification of some features which indicate availability of shallow groundwater. These include presence of open

water holes, thick and green vegetation, certain types of trees known to thrive on shallow water, nearby surface water bodies, valley bottoms etc.
Once these features have been identified, a decision as to whether test drilling should be done using a small diameter auger (25 – 50 mm) is made. If open water sources are available, test drilling is not normally done but a well is drilled a few metres (5-20 m) upstream with the hope that water will be available. In a number of situations it has not been possible to drill such sites because of either presence of boulders or laterite or collapsing formation which could not be discerned from the open water holes.

In situations where other features have been relied on to indicate presence of shallow water, test drilling is done at randomly selected locations to assess the underlying formation and the depth to which water is struck. As earlier mentioned, this is done using a small diameter auger (25 – 50 mm) until the water is encountered or to a maximum depth of 10 m. Lithology encountered during augering is however not normally recorded. Once a sandy formation with water has been encountered, drilling continues for about 2 meters into the aquifer after which test pumping is done using a manual pump (jolly jumper or hand pump) to assess the aquifer yield. Once the test drilling has been successful and the aquifer yield is enough for a handpump, a production well is constructed just a small distance (0.5-1 m) from the test hole. These wells are usually successful. Because of the fear of failure such test drillings are done in fairly obvious areas which most times are very far from the users.
Test drilling is however done by a few organisations while others embark on actual drilling on a trial and error approach.

In cases where test drilling is not done, sites are selected on the basis of community preference but only after their potential based on presence of groundwater indicators has been assessed by the drilling crew.

(c) District Water Offices

Similar to the non-governmental organisations, district water offices do not have a clearly set out siting methodology but rely on identification in the field of a few features that may indicate presence of shallow groundwater. They rely on availability of open water sources, thick and very green vegetation, valley bottoms, swamp areas, etc.
Once these features have been identified, a shallow well is constructed as close as possible with the hope that water will be struck. Construction is done without any knowledge of the underlying formation and this is believed to be the main cause of the problems mentioned earlier. Once a hard formation is encountered or the hole starts collapsing, the site is abandoned and drilling is attempted on another site. With the community providing the labor for drilling, this situation becomes discouraging and reduces interest in shallow wells as compared to deep wells where drilling is done by motorised machines. There is no attempt to assess in detail the causes of failure and how they can be avoided. The drilling

teams just abandon the village and move to another one with the hope of success during their next trials.

From the above review, the following can be noted:

- The shallow well siting methodology employed by RUWASA is similar to that for deep wells with minor differences. It is too elaborate, expensive and time consuming and can only be implemented by highly qualified personnel with quite specialised equipment. Some of the steps are deemed not to be very necessary and sometimes are seen as a repetition of previous steps. For low cost shallow well drilling this is considered not to be appropriate.
- The other organisations don't have formal and appropriate siting methodologies. Siting is based on the understanding of the individual as to what indicates presence of shallow groundwater. The result is that wells are sited very far from the beneficiaries, usually as close as possible to open water sources, swamps, valley bottoms, etc in order to reduce chances of failure. Where they are successful they offer improved water quality but not necessarily improved access to water.

Although there may be chances of getting water very close to the communities, there is no attempt to site wells in those locations because of lack of a siting methodology.

Development of an appropriate shallow well siting methodology whether for Pounder well drilling or any other type of wells is thus a necessity if improved access to good quality low cost water is to become a reality.

3.3 Possible Methodologies Of Shallow Well Siting For Pounder Drilling

There are many methods of exploring shallow groundwater, although they vary widely in investment, operational and maintenance costs, degree of difficulty of interpretation, skilled manpower requirements and effectiveness**.**
Some of the available methods include:

- Seismic refraction
- Geo – electrical resistivity
- Geophysical well logging
- Electromagnetic
- Test drilling
- Study of existing information (maps, well records, aerial photos etc.)
- Field reconnaissance and mapping

All the above methods are limited in their effectiveness if they are employed on their own. To obtain the best results a combination of all the above methods would be the best approach but the cost of siting would be exorbitant and in some cases uncalled for. In any case, siting should always involve study of existing information and field reconnaissance and mapping because they provide very valuable information at reasonable cost. For Pounder well drilling, the preferred method to be combined with the above methods is test drilling. Apart from the fact that it can provide absolute certainty about the quantity and quality of water, which none of the other methods can, test drilling is also a very cheap method, if carried out with hand operated equipment. The equipment can be operated byany one after a short period of training and it can easily be transported.

3.4 Methodology For Pounder Rig Well Siting

Before any methodology for Pounder rig well siting is elaborated on, a brief summary of the capabilities of the rig will be reviewed as follows:

- Can drill to 30 m, but preferred completion depth is around 15-20m.
- Requires a water table deeper than 3m below ground, in order for hydrostatic pressure to support the hole, but alternative of full temporary casing is being addressed in the design review.
- Strongly preferred option is to drill at maximum 100mm diameter, allowing direct installation of a handpump (i.e. rising main doubles as casing, and well screen attaches to the bottom of cylinder as a tail pipe).
- Drilling is fast in clay and soft materials.
- Rig is capable of penetrating laterite and rock, but time and cost prevent more than a few metres of such materials being drilled.

A siting methodology for Pounder rig wells will have to identify a range of conditions that conform to the capabilities of the rig as mentioned above. The methodology will not only have to be appropriate but also cost effective in order to keep the cost of the shallow wells as low as possible. The cost of siting is expected not to exceed 5 % of the cost of the well. Since the cost of construction of a Pounder rig well is expected to be between 1 and 2 million Uganda shillings, siting would be in the range of Shs 50,000 to 100,000.

The proposed siting methodology has thus been based on the capabilities of the rig and the cost element of siting as already discussed above. While the siting methodology will aim at identifying areas with suitable conditions for Pounder rig well drilling, it is anticipated at the moment that it will not be easy to meet the criterion regarding the depth to water table in order to utilise hydrostatic pressure to support the wells. In some parts of the country where the topography is completely flat, this criterion may not be met thus limiting the use of this technology. Once the planned alternative of full temporary casing is implemented, this will cease to be a problem.

The proposed siting methodology is composed of three different stages as follows:

a) Detailed Desk Study

This involves analysis and interpretation of all the available hydrogeological and general data such as borehole drilling logs, water quality data, topographic and geological maps, aerial photographs and any previous reports. This could be done on a county or sub-county level. The purpose of this study is to understand the hydrogeological situation of the whole area, which would aid in planning of further investigations. The result is a map delineating areas with shallow well potential that could be considered for further investigations.

The information that is derived from each of the above data is as follows:

i Borehole records and water quality data

These generally provide a picture of the hydrogeology of the area in terms of the depths to water, underlying geology/ lithology, well yields, groundwater levels and fluctuations, quality of water and general information on possibilities for future water supplies.

ii Topographical maps

These provide information on surface level features such as rivers, valleys, plains, vegetation and water sources that may give a clue to the availability of shallow groundwater.

iii Geological maps

These give useful information on the characteristics of deeper layers and possible weathering products.

iv Aerial photographs

These give some clues about presence of shallow groundwater from the type of vegetation, topography, lineaments and other characteristics of the landscape.

The above information is analysed, interpreted, correlated and presented on maps and the final result is a zonation map showing areas with shallow well potential.
Once the above data is carefully and comprehensively analysed and interpreted, it provides a reliable prediction of groundwater occurrence and would greatly guide further well siting. The delineated shallow well potential areas would then be a centre of focus during further well siting.

The above information is readily available from the Ministry of Water, Lands and Environment under the departments of Water Resources Management, Mapping and Surveys and Geological Survey all located in Entebbe. Although the available data for some areas is not up to date and the quality may not be so good, the amount of useful information that can be extracted is reasonably much. Apart from aerial photo interpretation, desk study can be done by field officers at district level or working with non governmental organisations after some initial training by a hydrogeologist. Field officers normally have a diploma in Civil or Water Engineering related courses and are thus capable of learning those skills fairly quickly.

Aerial photo interpretation could be done at once by a hydrogeologist for a big area and results for specific areas could then be extracted and given to relevant people for use in their siting activities.
The number of man days required for desk study depend on the size of the area, amount of available data and the experience of the person doing the study, but on average 3 - 6 days should be enough per district.

b) Field reconnaissance and Water Sources Mapping

This involves making an orientation tour of the area in order to collect relevant information about the present water supply conditions, the hydrogeology and the areal layout and also to verify the findings of the desk study. This includes mapping and plotting of all water sources on a base map and studying vegetation changes, topography and geomorphology of the area and comparing these with results of the desk study.
The areas that were earlier zoned as having a potential for shallow wells are re-assessed and where necessary modifications made in the field.

Existing wells, hand dug holes and springs if present may reveal aquifers suitable for shallow well construction. Interviews should be conducted with the community regarding the construction history and the reliability of these sources in order to get an idea about the depth of the aquifer, possible difficulties encountered and whether the wells can provide water throughout the year. Water levels in the wells should be measured to get an idea about the depth to water table.

Landscape features such as rivers, streams, valleys, swamps, mountains, etc should be studied in order to get information about hydrogeological conditions of the area. Special attention should be given to certain types of vegetation, which indicate presence of shallow groundwater such as papyrus, date palm, sugar canes, yams and bananas.

All the above findings of reconnaissance tour should be plotted on the map to indicate shallow well potential zones which is later compared with that earlier prepared during desk studies. A final map is prepared with some explanatory notes on the possibilities of obtaining water as close as possible to the beneficiaries. Based on the results of the reconnaissance tour, further well siting activities involving test drilling should be carried out.

Step a and b above, can effectively be done by some one with some experience and training in well siting and groundwater development. As mentioned earlier, apart from aerial photo interpretation, all the other activities can be done by a field officer at the district level with basic training to at least a diploma level in Civil or Water Engineering related course after some initial training.

c) Test Drilling

Although a fairly good indication of presence of shallow groundwater can be obtained through the above mentioned steps, one can never know what kind of soil he is going to encounter, the problems it is likely to cause, and the amount of water the aquifer can yield. This information can only be obtained through test drilling using small diameter (25-30mm) drilling equipment.

Test drilling should if possible be done by a small diameter Pounder rig, which has similar components with the main rig but varying only in diameter/size of the tools. Alternatively, a Pounder rig with possibilities of attaching different sizes of tools could be used with small diameter tools used for test drilling after which large diameter tools are used for construction of the production well. The hole would be drilled to the required depth and left unlined.

Test drilling should start at the shallow well potential locations preferred by the users and progress at increasing distances from the users in case good results have not been obtained. It is anticipated that a maximum of three test holes will be required if sites for drilling are selected carefully. The drilling should be as deep as possible (<30 m) depending on the depth of the aquifer, and all the lithology encountered during drilling should be recorded. Once a promising aquifer has been encountered during drilling, continuous test pumping, using a drill pipe, with a foot valve attached, and a pump rod and plunger inserted, should be done for at least 30 minutes to assess the water yielding capacity of the aquifer. Well yield, water level and water quality should be measured during this test.

On the basis of the test results a decision should be made as to whether the aquifer can supply water of sufficient quantity and quality. If for example, a yield of more than 700 l/h is maintained with a small drop (< 1 m) in water level after more that 30 minutes of pumping, then the aquifer has a good potential for yielding enough water.

The test drilling team should move well ahead of the construction team in order to get enough time to evaluate the test drilling results.

After test drilling has been completed, an evaluation of the results from the desk studies to completion of test drilling should be done, whether the test has been successful or not. If all the test holes are found dry, the result would be important in the sense that the village would start planning for alternative water supply.

This step can be handled by one of the drilling crew members after some initial practical training. If work involves construction of community wells, the community would assist in test drilling. If an average of three test holes are to be drilled per village, it is expected that one village will be investigated per day if the conditions are not so adverse and the drilling depth is approximately 10m.

If the results of test drilling are not favorable for Pounder rig drilling, the site can be considered for either a hand augered or hand dug well. For example, if the water table is shallower than 3 meters, Pounder drilling may not be undertaken at that site in which case it could be considered for hand augering if the conditions are favorable. Similarly, if the yield is not enough for a Pounder rig well, the site could be considered for a hand dug well.
This situation implies that a Pounder rig siting methodology if implemented can be useful to other technologies even if the results are not good for Pounder drilling.

Based on the test drilling results, a well design indicating the depth to which screens, gravel pack, clay seal, etc should be placed will then be prepared and passed on to the drilling crew by the test drilling team. This will enable the drilling crew to know before hand how deep they have to drill and what the completion procedures will be in order to make the necessary adjustments. To avoid encountering any unfavorable conditions, actual drilling should be done on top of the test hole or as close as possible. This will ensure that the conditions that will be encountered will be as similar as possible to those encountered during test drilling.
The above siting methodology is considered appropriate for areas where the number of wells is many thus off setting the siting costs. If however only a few wells are required in a small locality, the detail and the amount of desk study could be limited and special attention could then be given to field observations. In all situations, test drilling should be done before actual drilling is done.

3.5 Proposal For Developing The Above Ideas

The above ideas are based on the present experience with shallow well drilling by hand augering, which has many similarities with Pounder rig drilling.

The ideas presented above will have to be tested in order to evaluate their potential and cost before they are considered appropriate for use as Pounder rig well siting procedures.

It is thus proposed that the above idea be developed as follows:

a) An area with a size of a typical county or sub-county (200 – 500 Square kilometres) where at least 10 Pounder rig wells could be constructed should be selected. This area should be varied in geology.
b) All the available information such as borehole records, aerial photographs, topographical and geological maps and any other relevant data and reports should be gathered and comprehensively studied. The cost of these materials and the number of days required to complete this desk study should be clearly record. This should result in the assessment and delineation of potential shallow well zones.
c) Once the desk study is completed, field reconnaissance should then be made to correlate field observations with results of desk study. The cost involved in doing that and the usefulness of each activity should be evaluated.
d) Once locations that are as close to the users as possible have been identified, test drilling should be done with the assistance of the community. Again, correlation of the results of test drilling, desk study and reconnaissance should be done to find out whether there are similarities. An evaluation of the usefulness of each method with regard to the results of test drilling should be made.
e) Based on the above an assessment of the usefulness of each of the steps of the proposed siting methodology should be made to aid future modification.
f) Funds allowing a similar exercise could be tried out in another geologically and topographically different area in order to compare the results.
g) Based on the two practical trials the siting methodology could be modified to produce a more meaningful and cost effective one.

3.6 References

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4 DEVELOPMENT OF THE IDEAS IN THE DRAFT POUNDER RIG WELL SITING METHODOLOGY, JUNE 2000

By Callist Tindimugaya

4.1 Summary

A draft methodology for Pounder rig well siting was prepared based on existing procedure of shallow well siting employed by different organisations in Uganda. The methodology, geared to identifying a range of conditions that conform to the capabilities of the rig had not only to be appropriate but also cost effective in order to keep the cost of the shallow wells as low as possible.

The draft siting methodology composed of three different stages contains many ideas which needed to be developed in order to determine the applicability of each of the stages of the methodology. The assessment was done in Katabi Sub-County of Mpigi District in an area of approximately 3 square kilometers where five wells were constructed during the trial phase of the Pounder rig.

Although the study faced a number of limitations such as small size of study area, limited data and very hard laterite, the potential of each of the stages of the siting methodology was reasonably assessed. Information obtained from study of data on existing Pounder rig wells, field observations, interviews with the community regarding pit latrine construction and test drilling all indicate that the draft siting methodology is applicable with minor adjustments.

Although the amount of existing data may be limited for a particular area, a lot of valuable information can be obtained during desk studies if data analysis and interpretation are carried out bearing in mind the expected outputs from each data set.

Reconnaissance has been found to be very important and very useful in verifying the results of the desk study and in providing additional information that is essential for further siting activities. It can yield very useful information at a relatively small cost and should thus be given much attention during siting.

Although the potential of test drilling was not fully assessed because of limitations with hand augering, it is an invaluable tool in Pounder rig well siting. It is however quite expensive especially in hard formations but the number of test drillings can be reduced through careful and detailed reconnaissance. Since hand augering will be used as a first attempt at finding the most promising Pounder well site it should not be used as a basis for rejecting sites for Pounder well drilling in case difficulties with hand augering have been experienced. An opportunity exists to improve the results of test drilling through exploratory Pounder drilling using small diameter equipment.

A step by step draft procedure for well siting has thus been prepared based on the results of this study and the known potential of some of the component of the siting methodology that could not be assessed.

4.2 Background

4.2.1 Introduction

At the request of the Low-Cost shallow Well drilling project, a draft methodology for Pounder rig well siting was prepared in January 2000. The methodology was based on existing procedure of shallow well siting employed by different organisations in Uganda. The methodology was geared to identifying a range of conditions that conform to the capabilities of the rig. The methodology had not only to be appropriate but also cost effective in order to keep the cost of the shallow wells as low as possible.

The proposed siting methodology composed of three different stages is briefly reviewed in the following section.

4.2.2 Review Of Draft Siting Methodology

a) Detailed desk study

This involves analysis and interpretation of all the available hydrogeological and general data such as borehole drilling logs, water quality data, topographic and geological maps, aerial photographs and any previous reports. The purpose of this study is to understand the hydrogeological situation of the whole area, which would aid in planning of further investigations. The result is a map delineating areas with shallow well potential that could be considered for further investigations.

If desk study is carried out properly it provides a reliable prediction of groundwater occurrence and greatly guides further well siting. The delineated shallow well potential areas would then be a centre of focus during further well siting.

b) Field reconnaissance and water sources mapping

This involves making an orientation tour of the area in order to collect relevant information about the present water supply conditions, the hydrogeology and the area layout and also to verify the findings of the desk study. This includes mapping and plotting of all water sources on a base map and studying vegetation changes, topography and geomorphology of the area and comparing these with results of the desk study.

The areas that were earlier zoned as having a potential for shallow wells are re-assessed and where necessary modifications made in the field.
Based on the results of the reconnaissance tour, further well siting activities involving test drilling are carried out.

c) Test Drilling

This provides information on what kind of soil one is going to encounter, the problems it is likely to cause, and the amount of water the aquifer can yield.

According to the draft siting methodology test drilling should start at the shallow well potential locations preferred by the users and progress at increasing distances from the users in case good results have not been obtained. The drilling should be as deep as possible (<30 m) depending on the depth of the aquifer, and all the lithology encountered during drilling should be recorded. On the basis of the test results a decision should be made as to whether the aquifer can supply water of sufficient quantity and quality.

After test drilling has been completed, an evaluation of the results from the desk studies to completion of test drilling should be done, whether the test has been successful or not.

The draft siting methodology was considered appropriate for areas where the number of wells to be constructed is many thus off setting the siting costs. If however only a few wells are required in a small locality, the detail and the amount of desk study would be limited and special attention would then be given to field observations. In all situations, test drilling was considered to be necessary before actual drilling is done.

4.2.3 Proposal For Developing The Ideas In The Siting Methodology

As mentioned before, the draft siting methodology was prepared based on the present experience with shallow well drilling by hand augering, which has many similarities with Pounder rig well drilling.

The proposed ideas therefore required development in order to evaluate their potential and cost before they are considered appropriate for use as Pounder rig well siting procedures.

It was thus proposed that the ideas be developed as follows:

a) An area with a size of a typical county or sub-county (200 – 500 Square kilometers) where at least 10 Pounder rig wells could be constructed be selected. This area should be varied in geology.

b) All the available information such as borehole records, aerial photographs, topographical and geological maps and any other relevant data and reports be gathered and comprehensively studied. The cost of these materials and the number of days required to complete this desk study should be clearly record. This should result in the assessment and delineation of potential shallow well zones.
c) Once the desk study is completed, field reconnaissance should then be made to correlate field observations with results of desk study. The cost involved in doing that and the usefulness of each activity should be evaluated.
d) Once locations that are as close to the users as possible have been identified, test drilling should be done with the assistance of the community. Again, correlation of the results of test drilling, desk study and reconnaissance should be done to find out whether there are similarities. An evaluation of the usefulness of each method with regard to the results of test drilling should be made.
e) Based on the above, an assessment of the usefulness of each of the steps of the proposed siting methodo logy should be made to aid future modification.
f) Funds allowing a similar exercise could be tried out in another geologically and topographically different area in order to compare the results.
g) Based on the two practical trials the siting methodology could be modified to produce a more meaningful and cost effective one.

4.2.4 Terms Of Reference

The current study therefore is a follow up of the draft siting methodology and its main terms of reference were:

to practically develop the different stages of the proposed siting methodology with a view of determining their applicability

to evaluate the usefulness and cost of each of the components of the proposed stages of the siting methodology

to recommend possible modifications to the siting methodology

4.3 Activities Carried Out And The Findings

4.3.1 Introduction

This study was carried out in an area of approximately 3 square kilometres located in Katabi Sub-county , Mpigi District. This is an area where five wells were constructed during the trial phase of the Pounder rig with fairly good results. The purpose of selecting this area was to take advantage of the existing information regarding the abilities and potential of the rig to construct successful water wells. Most of the data utilised in this study therefore was a result of trial drilling under the project.

The activities were carried out in the order as presented in the draft siting methodology so as to assess the extent to which initial stages are useful for the later stages of the methodology. This was however not always possible because the area is limited in extent and little data is available. It was for example found that it was not very useful to study aerial photographs, topographic and geological maps. Desk studies were thus based mainly on existing data for the trial Pounder rig wells. However, it had earlier been anticipated and documented in the draft siting methodology that the amount of desk study work would reduce with the size of area of study.
Despite the above limitations the study fully employed field reconnaissance and water source mapping stage of the siting methodology and was found to be very useful and cost effective.

This was followed by test drilling in different locations from the valley towards the communities. Test drilling was done in this way because most of the areas close to settlements are underlain by very hard laterite which is exposed at the surface and thus could not allow drilling to be done.

The details of the activities carried out and the results obtained are discussed below.

4.3.2 Activities and findings

a) Desk studies

This involved analysis and interpretation of all available information such as topographic and geological maps, reports relevant to the study area and drilling logs of the existing Pounder rig wells. Topographic maps were used to identify surface level features such as rivers, valleys, swamps and vegetation, which provide clues about availability of shallow groundwater. Geological maps were used to obtain information on the characteristics of deep lithological layers and possible weathering products, while drilling logs were used to obtain a picture of the hydrogeology of the area in terms of the underlying lithology and depths to water.

From the topographic map, it was found that the study area is located on a hill which slants steeply towards Nambigirwa swamp. The topography is however cut by small and shallow valleys covered by fairly thick vegetation. Areas along the swamp and the valleys were therefore identified as having a potential for shallow groundwater. The geology of the area is formed by Buganda – Toro rocks which are characterised by phyllites and schists that normally weather to fine grained material.

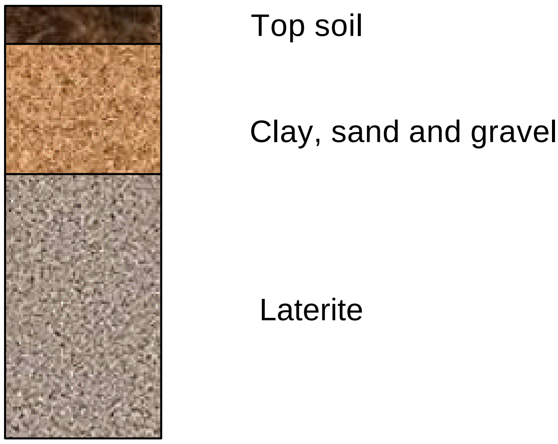
However, due to the small size of the study area, little information could be obtained from the topographic and geological maps. Desk studies were thus based mainly on records of the five Pounder rig wells constructed during the trial phase of the project. Data on each of the wells was individually studied in order to get an idea about the vertical distribution and the groundwater yielding potential of the lithological units at those locations. Data for the different wells was compared in order to identify lithological similarities and differences. This made it possible to assess the spatial distribution of the lithological units.

The details of the wells are summarised in section 4.6.

Based on desk studies, the following observations could be made:

- Areas along the swamp and valleys covered by fairly thick vegetation have a potential for shallow groundwater
- The lithology underlying the study area is dominated by fine grained material due to the nature of the parent rock
- All sites are underlain by hard laterite at fairly shallow depths ranging between 1 and 3 metres and was difficult to penetrate with the Pounder rig.
- A mixed zone of clay and sand/silt occurs above the laterite layer and seems to give rise to laterite when it is leached.
- An aquifer seems to occur above a hard laterite layer and is formed by the so called weathered murrum made of a mixture of clay, sand and gravel size material.
- The lithological units are almost similar across the area both vertically and areally with minor differences in thickness.

The generalised representative vertical section across the study area is presented below.



The above information was useful in planning and execution of field investigations. It was for example clear at the outset that test drilling was not going to be easy and deep because of hard laterite. It was also evident that the conditions at each of the sites and across the area would almost be similar with very minor differences. The productive aquifer was found at shallow depths above the hard laterite and in most cases yielded enough water for a hand pump.

The results of desk studies were used to delineate shallow well potential zones as presented in figure 2.1 in Section 4.8.

b) Field reconnaissance and Water source mapping

This involved traversing the area for purposes of collecting information on topographic conditions, geology, vegetation pattern and changes, present water supply situation, hydrogeological conditions, the general layout of the study area and mapping of existing water sources. This activity also involved verifying findings of desk studies.
The topography of the area was found to be characterised by a steeply slanting hill that is cut by small shallow valleys all ending in Nambigirwa swamp. The landscape features such as valleys and swamps provided clues about the hydrogeological conditions and locations where further detailed investigations could be carried out.
The geology of the area was assessed from pit latrine constructions and brick making pits. It was found to be made up of top soil below which is clay mixed with sand and gravel overlying laterite. This information confirmed findings of desk studies.

Vegetation changes and pattern were observed in order to link them to the availability of shallow groundwater. Attention was given to presence of palm trees and very thick bushes especially in gently sloping areas and most of these were associated with anthills. These locations were considered as targets for test drilling. Some of the identified landscape features were presented on a sketch map as indicated on figure 2.2 in section 4.8.

The Pounder rig wells and other water sources were mapped and plotted on a base map in order to asess the water supply situation in the area. This also made it possible to compare the lithological data of the different Pounder wells so as to identify possible causes of the small differences in lithology and water yielding potential. The distribution of the existing water sources is presented in figure 2.3 in section 4.8.

During this phase of siting a lot of interviews were conducted with the community regarding the construction history of their pit latrines in order to obtain information the underlying lithology and whether and how deep the water was encountered. This proved very useful as the whole area is fully built up with many pit latrines. It was even possible to observe pit latrines under construction thereby clearly identifying the lithological layers penetrated. In some areas where latrines had already been completed it was possible to observe the cuttings excavated during construction.
The interviews also involved collection of information on the reliability of the open water sources and the constructed Pounder rig wells.

From the findings of this stage especially information gathered from pit latrine constructions, it was established that it is possible to obtain water very close to the homesteads although there was hard laterite to penetrate. It was however found that beyond certain elevations it was not possible to obtain any water. The maximum depth of pit latrines in this area is 13m. Based on the results of this stage, it was decide not to attempt any test drilling in some higher locations because there would be no water and also because the laterite would be too hard to penetrate.

The shallow well potential map earlier prepared during desk studies was thus modified as presented in figure 2.4 in section 4.8. The map shows that the shallow well potential zone is bigger than that earlier identified during desk studies.

Test drilling was thus carried out within the zoned shallow well potential area, progressively from the valley bottom above the existing Pounder rig wells upstream until it was not possible to penetrate the laterite.

c) Test Drilling

Test drilling was carried out using a hand auger set capable of drilling holes with a diameter of approximately 30mm. Test drilling was employed in order to assess its potential as a component of the Pounder rig well siting methodology.

Most of the locations considered for test drilling were close to either palm trees, thick bushes or anthills and were upstream the existing Pounder rig wells. A few other locations located between the Pounder rig wells were considered for test drilling for purposes of filling in the data gaps. The major aim of test drilling was to assess the hydrogeological conditions at various locations within the zoned shallow well potential area progressively from the swamp uphill towards homesteads. This was necessary in order to find out whether it would have been possible to drill productive Pounder rig wells closer to users. As mentioned before, because of availability of very hard laterite all over the place, the potential of test drilling could not be fully explored. However as earlier indicated, observations made at pit latrine constructions and interviews conducted with the community enabled assessment of the potential of test drilling if equipment that is capable of penetrating hard laterite is employed.

Test drilling carried out close to the valley bottoms was usually successful although laterite was also encountered. As drilling progressed upstream, it became increasingly difficult to drill because of the hard laterite. Drilling was abandoned at many locations when very hard laterite was encountered.

Test drilling was carried out at 20 locations distributed across the area as indicated on figure 2.5 in section 4.8. The depths of drilling ranged between 0.2 and 3.1 metres but water was only encountered at 4 locations found either close to the swamp or in a clear cut lineament valley. Close to 4 upstream test drilling locations where water was not encountered, pit latrines were either under construction or had just been completed. Water was encountered during construction of the latrines and was found at depths ranging between 5 and 13 metres usually below hard laterite. This indicates that had it been possible to penetrate the hard formation during test drilling, water would have been encountered. This suggests that since the Pounder rig well is capable of crushing the laterite, productive Pounder wells could have been constructed closer to water users. The average distance from the Pounder rig well to these locations is 100m.

Hard laterite further made it difficult to concretely assess the benefits of some field observations such as vegetation pattern and changes and other potential shallow groundwater indicators such as anthills. However all test drilling sites located close to the valleys, and near these features yielded water although a direct relationship could not be obtained since other sites where these features do not occur also produced water.

The results of test drilling are presented in section 4.7.

Locations of the test drilling sites around each of the Pounder rig wells are presented in figures 2.6 to 3.0 in section 4.8.

Assessment of the results of test drilling indicates that the generalised vertical lithological section across the study area is composed of top soil, clay with sand

and gravel and laterite, as earlier identified from desk studies and reconnaissance. This confirms that the first stages of the siting methodology are important for planning and successful execution of the later stages.

4.4 EVALUATION OF THE COMPONENTS OF THE DRAFT SITING METHODOLOGY

The different stages of the siting methodology have been tried out in a rather small area with varying results. A number of limitations have made it difficult to fully assess the potential and usefulness of each of the stages. These are, the small size of the study area, limited data both in quantity and distribution and very hard laterite. However, it has been possible to get an indication of the potential of each of the stages through inferences such as observation at pit latrines constructions and interviews with the community.

Based on the results of this study, the following evaluation can be made:

a) Desk Study

This activity is very important in Pounder rig well siting because it provides an idea about the conditions expected in the field and the possibilities of constructing successful Pounder rig wells. This involves study of topographic and geological maps, aerial photographs, existing hydrogeological data such as borehole records and water quality data, and any available reports relevant to the study area.

Topographic maps normally show surface level features such as rivers, valleys, plains, vegetation and water sources (springs, open holes and boreholes) in addition to the topographic contours. The available maps for most of the country were printed around 1974 and thus show only water sources that existed at that time. Aerial photographs show certain features such as lineaments, vegetation and topography. The available photographs were taken in the 1960s and may thus not clearly present the current conditions. The quality of the photographs is also not very good. Attempts are however being made by the government through funding from the Japanese government to obtain up to date aerial photographs for the whole country. The scale of suitable topographic maps and aerial photographs should be at most 1: 50,000 and 1: 60,000 respectively and these are available from the Lands and Surveys Department located in Entebbe. Each topographic map costs ten thousand shillings while the aerial photographs cost five thousand shillings each.

Geological maps provide information on the nature of the rocks in an area and the characteristics of the deeper layers and possible weathering products which may provide an indication of the groundwater potential. The available geological maps were printed in 1967 and have not been updated and may thus not be accurate. However, the most useful geological maps should be at a scale of 1: 60,000 and are available from the Geological Survey and Mines Department located in Entebbe, at a cost of ten thousand shillings each.

Hydrogeological data and reports provide information on the hydrogeological conditions of an area in terms of depth to water, underlying lithology, well yields, groundwater levels, quality of water and general information on possibilities of future water supplies.
The quality of this data varies depending on the qualifications of the individuals collecting it but useful information can still be derived from any available hydrogeological data. Most of this data and information can be obtained from the Directorate of Water Development's Groundwater database located in Entebbe and from the Information Centre located in Luzira. Most of the data on springs and shallow wells is however still in the possession of the district water offices and other organizations involved in groundwater development. The data from the Groundwater database costs five hundred shillings per complete water source record.

The final result of this activity is map showing areas with shallow well potential as presented in figure 2.1 in section 4.8.

Although the amount of data may be limited for a particular area, a lot of valuable information can be obtained if data analysis and interpretation are carried out bearing in mind the expected outputs from each data set as presented above. If a reasonable amount of good quality water source data is available, the rest of the data can be given minimum consideration during desk studies.
This activity is rather cheap to carry out as it is done in the office. Under this assignment, approximately one-man day was spent on this activity and only twenty thousands shillings was spent on purchase of a topographic and geological map.

b) Field reconnaissance and water source mapping

This activity involves making an orientation tour of the area in order to collect information on water supply conditions, the hydrogeology of the area, and to verify findings of the desk studies.

This activity should start with a quick reconnaissance tour to obtain an overview of the area in terms of lay out, possible variations in geological and hydrogeological conditions, distribution of settlements and water sources and availability of potential groundwater indicators such as vegetation and other landscape features etc.
This can be done while travelling in a vehicle and making stops where necessary in case interesting features are identified.
After the quick tour is completed and an overview of the area has been obtained, detailed reconnaissance should be carried out to collect all the information

necessary for obtaining a good picture of the hydrogeological conditions of the area. This should be done on foot and will involve study of topography, geomorphology and distribution of landscape features such as streams, valleys, swamps and vegetation changes. Topographically low lying areas which are close to streams, swamps, valleys and very thick vegetation will have a good potential for shallow groundwater. The activity should also involve mapping geological features from outcrops and excavations to obtain information on the underlying lithology. Similarly, mapping and plotting of water sources on a base map should be carried out in order to assess the water supply situation and the distribution of potential aquifers.

Landscape features identified during this activity should be presented on a sketch map for purposes of clearly visualizing and relating them to each other. An example of such a map is presented in figure 2.2 in section 4.8.

While carrying out this activity, interviews should be conducted with the community regarding the construction history and reliability of water sources, underlying lithological layers, their hardness and depth to water that can be obtained from existing pit latrines constructions and building sites. Information from these interviews can provide ideas about general hydrogeological conditions in the area.

The final result of this activity is a shallow well potential zone map as presented in figure 2.4 in section 4.8.
Based on the discussions with the community regarding preferred well sites, test drilling sites should be selected in the zoned shallow well potential area and pegged .

In order to get contrasting observations in the field, the size of the area to be covered should be at least one square kilometre. The actual size will however depend on the variations in natural conditions such as topography and geology, and also on existence of the features that are useful in groundwater potential assessment as earlier highlighted. The area should also be manageable since detailed reconnaissance will be done on foot.

This activity has been found to be very important and should be given serious attention and consideration. It has been found to be very useful in verifying the results of the desk study and in providing additional information that is essential for further siting activities. It has been observed that a lot of information can be obtained from this stage alone which could reduce the amount of work required for the later stages. Even though desk studies are limited by inadequate data, detailed reconnaissance could greatly improve their findings. Under this study it was found that information on the vertical lithological layers could be obtained from brick pits and pit latrine constructions making is unnecessary to carry out test drilling in those locations. Similarly interviews with the community with regard to pit latrine construction generated information on the vertical lithological layers, their hardness, depth to water and general hydrogeological conditions. This activity is considered to be a very important stage of the siting methodology and can be quite cheap.

During this study approximately one-man day was spent on this activity with approximately ten thousand shillings spent on field assistance.

c) Test drilling

This activity is carried out using small diameter hand auger test drilling equipment (25 – 30mm) in order to get information on the kind of soil to be encountered, the problems it is likely to cause, the depth to water and the amount of water an aquifer can yield.
Test drilling should be carried out at the pegged sites within the identified shallow well potential zones and should if possible start at the site most preferred by the users and progress at increasing distances from the users in case good results have not been obtained.
A maximum of three test holes should be drilled in each location while recording the lithology encountered in order to choose the best site for a Pounder rig well. The drilling should be as deep as possible (< 30m) depending on the depth of aquifer. Once a promising aquifer has been encountered during drilling a pumping test of at least 30 minutes should be carried out to assess the aquifer potential.

The potential of test drilling in this study could not be fully explored because of the presence of hard laterite all over the place which could not be penetrated by a hand auger. However, in the few locations where test drilling was successful, it proved a very useful tool in confirming the hydrogeological conditions at particular locations. Similarly, information obtained from pit latrine constructions indirectly proved the potential of test drilling if appropriate equipment capable of crushing hard laterite is employed.
Because of the hard laterite, this stage of siting proved to be laborious and expensive.
During this study approximately 3 man-days were spent on this activity. An average of 5 assistants were used per day both for drilling and retrieving the tools whenever they would get stuck. Approximately one hundred thousand shillings was spent on paying field assistants.

Hand augering will be used as a first attempt at finding the most promising Pounder well site but difficulties with hand augering will not be used as a basis for rejecting sites for Pounder well drilling. Implementation of Pounder well drilling contracts envisage three stages involving siting, exploratory Pounder drilling and actual Pounder drilling. An opportunity therefore exists to improve the results of test drilling if hand augering has encountered problems, through exploratory Pounder drilling using small diameter equipment.

In case the water is not encountered, the site will be abandoned. However, if the amount of water is not enough for a Pounder well, a hand dug well will be recommended for construction. If the amount of water is sufficient, the hole will be reamed and a handpump installed.

In conclusion therefore the proposed siting methodology seems to be applicable with only minor adjustments required. It has been found that the amount of useful information that can be obtained from desk studies even with limited data is incredible. The amount of desk study work can thus be brought to a minimum with fairly good results being obtained. Special consideration should be given to reconnaissance stage of siting as a lot of valuable information can be obtained in a relatively cheap way. Test drilling should be employed in all cases using a hand auger as a first step at selecting sites for Pounder well drilling. In cases where drilling difficulties are encountered while using a hand auger, an opportunity exists to explore the sites during exploratory drilling using a Pounder rig. The study has further found that results of all the three stages of siting have similarities. The first two stages do not only provide good background information for test drilling but also give an indication of what conditions to expect and where test drilling should or should not be carried out.

4.5 STEP BY STEP PROCEDURE FOR WELL SITING

This study aimed at developing the ideas in the draft siting methodology with a view of assessing their potential and applicability. However, some of the components of the draft siting methodology could not be addressed due to some limitations as discussed earlier. This section therefore presents a step by step draft procedure for well siting based on the results of the study and the known potential of some of the component of the siting methodology that could not be assessed.

The draft procedure composed of three stages as in the draft siting methodology is presented below.

a) Desk Studies

- Gather all information on the study area such as topographic maps, geological maps, aerial photographs, existing hydrogeological data (borehole records and water quality data), and any available reports.

- Carry out detailed study of the above data in order to obtain information on the topographic and hydrogeological conditions of an area in terms of relief, potential locations of shallow groundwater, depth to water, underlying lithology, well yields, groundwater levels, quality of water and general information on possibilities of future water supplies.

- Based on the results of the above study prepare a map indicating zones having a potential for shallow well construction. An example of such a map is presented in figure 2.1 in section 4.8.

b) Field reconnaissance and water source mapping

- Make a quick reconnaissance tour around the area to obtain an overview of the area in terms of lay out, possible variations in geological and hydrogeological conditions, distribution of settlements and water sources and availability of potential groundwater indicators such as vegetation and other landscape features etc.

- Carry out detailed reconnaissance to collect all the information necessary for obtaining a good picture of the hydrogeological conditions of the area. This will involve study of topography, geomorphology and distribution of landscape features such as streams, valleys, swamps and vegetation. It should also involve mapping geological features from outcrops and excavations to obtain ideas on the underlying lithology. Similarly, it should involve mapping and plotting of water sources on a base map in order to assess the water supply situation and the distribution of potential aquifers.
- Compare results of desk studies with findings of reconnaissance as this activity progresses in order to identify differences and similarities.

- Present the information gathered during this activity on sketch maps for purposes of clearly visualizing and relating them to each other. Examples of such maps are presented in figures 2.2 and 2.3 in section 4.8.

- Conducted interviews with the community while carrying out this activity, regarding the construction history and reliability of water sources, underlying lithological layers, their hardness and depth to water.

- Present the final results of this activity in form of a map showing shallow well potential zones, as an improvement of that earlier prepared during desk studies. An example of such a map is presented in figure 2.4 in Annex 3.

- Based on the discussions with the community regarding preferred well sites, select test drilling sites in the shallow well potential zones and peg them.

c) Test drilling

- Carry out this activity using a small diameter hand auger test drilling equipment (25 – 30mm)

- Carry out test drilling at the pegged sites within the identified shallow well potential zones. Start at the site most preferred by the users and progress at increasing distances from the users in case good results have not been obtained.

- Drill a maximum of three test holes in each location while recording the lithology encountered in order to choose the best site for a Pounder rig well. The drilling should be as deep as possible (< 30m) depending on the depth of aquifer. Once a promising aquifer has been encountered during drilling a pumping test of at least 30 minutes should be carried out to assess the aquifer potential.

- Since hand augering will be used as a first attempt at finding the most promising Pounder well site, it should not be used as a basis for rejecting sites for Pounder well drilling in case difficulties with hand augering have been experienced. An opportunity exists to improve the results of test through exploratory Pounder drilling using small diameter equipment.

4.6 Details of Pounder Rig Wells Drilled in Katabi Sub-County, Mpigi District

i Kajubi

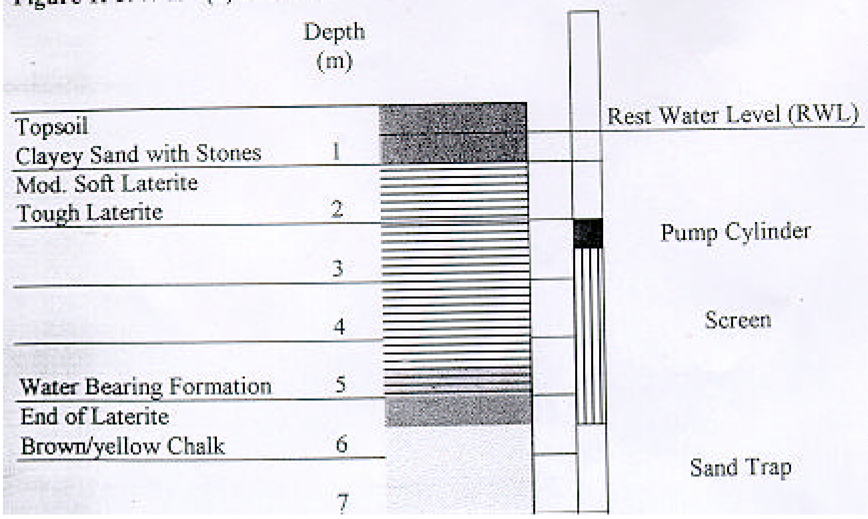
Well number: P/W 2/6
Site name: Kajubi
Village: Kawuku
Parish: Kisubi
GPS Co-ordinates: N 00 08.104 E 032.31.942
Depth drilled: 6m
Lithology: Clay, hard laterite
Comments : Site located on slope of a fairly shallow valley

ii Valley Zone

Well number: P/W 2/7[1] (2)
Site name: Valley Zone
Village: Kawuku
Parish: Kisubi
GPS Co-ordinates: N 00 08.498 E 032.32.159
Depth drilled: 7m
Lithology: Top soil, clayey sand with stones, soft laterite, hard laterite
Comments: Site on slope of a fairly steep valley

The design to which the well was completed is presented below.

Figure 1: P/W 2/7 (2) Profile

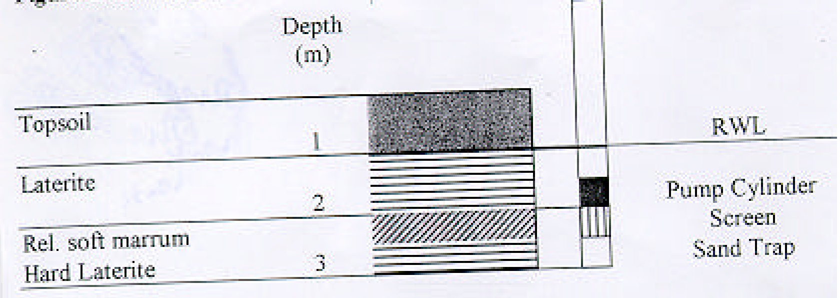


iii Ndaula

Well number: P/W 2/8
Site name: Ndaula
Village: Zzika
Parish: Kisubi
GPS Co-ordinates: N 00 07.950 E 032.31.869
Depth drilled: 3m
Lithology: Top soil, laterite, soft murrum, hard laterite
Comments: Site at bottom of a fairly steep valley

The design to which the well was completed is presented below.

Figure 2: P/W 2/8 Profile

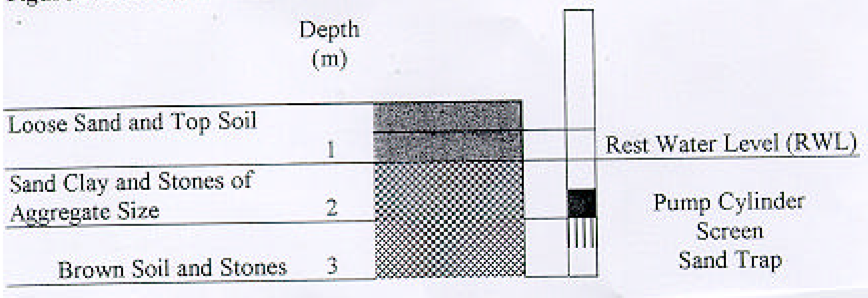


iv Zzika Zone

Well number: P/W 2/9
Site name: Zzika
Village: Zzika
Parish: Kisubi
GPS Co-ordinates: N 00 07.179 E 032.31.647
Depth drilled: 3m
Aquifer depth: 2.5m
Rest water level: 0.9m
Lithology: Top soil with loose sand, sandy clay, brown soil and stones
Comments: Site at bottom of a very steep valley

The design to which the well was completed is presented below.

Figure 3: P/W 2/9 Profile



v Bukadekade

Well number: P/W 2/11
Site name: Kitala
Village: Zzika
Parish: Kisubi
GPS Co-ordinates: N 00 07.222 E 032.31.407
Depth drilled: 3m
Aquifer depth: 2.8m
Rest water level: 0.4m
Lithology: Sand with loam soil, clay sand with murrum, soft murrum, hard laterite
Comments: Site at bottom of a very steep valley

4.7 Results of test drilling

i Site No: T/W 2/1 Ndaula (first trial)

Co-ordinates: N 00.07.927
E 032.31.879

Depth (m)	**Lithology**
0 – 1	Brown silty clay
1 – 1.5	Clay with gravel (moist)
1.5 – 2.1	Laterite (soft)
2.1 – 2.3	Hard Laterite

Comments: Site located approximately 20 m above a Pounder rig well but no water was encountered. Formation was too hard to penetrate.

ii Site No: T/W 2/2 Ndaula (second trial)

Co-ordinates: N 00.07.917
E 032.31.900

Depth (m)	**Lithology**
0 – 0.5	Brown clay
0.5 – 1.1	Clay with gravel (moist)
1.1 – 1.3	Hard Laterite

Comments: Site located uphill above T/W 2/1. Formation was too hard to allow further drilling and thus no water was encountered.

iii Site No: T/W 2/3 Ndaula (third trial)

Co-ordinates: N 00.07.917
E 032.31.900

Depth (m)	**Lithology**
0 – 0.5	Brown clay
0.5 – 1.2	Clay with gravel (little water)
1.2 – 1.3	Very hard Laterite

Comments: Site located just 3m below T/W 2/2. Some little water was encountered but is too little for a handpump.

iv Site No: T/W 2/4 Ndaula (fourth trial)

Co-ordinates: N 00.07.920
E 032.31.924

Depth (m)	**Lithology**
0 – 0.5	Top soil
0.5 – 1.0	Silty clay
1.0 – 1.1	Very hard laterite

Comments: Site located near an anthill upstream all the previous sites. No water was encountered.

v Site No: T/W 2/5 Kajubi (first trial)

Co-ordinates: N 00.08.112
E 032.31.966

Depth (m)	**Lithology**
0 – 0.5	Brown clay soil
0.5 – 1.0	Very hard clay

Comments: Site abandoned because it was too hard to drill deeper.

vi Site No: T/W 2/6 Kajubi (second trial)

Co-ordinates: N 00.08.120
E 032.31.975

Depth (m)	**Lithology**
0 – 0.3	Top soil
0.3 – 1.0	Clay with gravel (soft)
1.0 – 1.5	Clay with gravel (very hard)

Comments: Site located near an anthill. No water was encountered

vii Site N0: T/W 2/7 Valley Zone (first trial)

Co-ordinates: N 00.08.495
E 032.32.149

Depth (m)	Lithology
0 – 0.6	Clayey soil
0.6 – 1.0	Sandy clay
1.0 – 1.3	Soft laterite
1.3 – 1.8	Moist but hard Laterite

Comments: Site located approximately 15m above a Pounder rig well. Test stopped because the equipment got stuck in the hole.

viii Site No: T/W 2/8 Valley Zone (second trial)

Co-ordinates: N 00.08.497
E 032.31.166

Depth (m)	Lithology
0 – 0.3	Top soil
0.3 – 0.6	Reddish sandy clay
0.6 – 1.0	Soft laterite
1.0 – 1.1	Hard Laterite

Comments: Site located approximately 50m upstream Pounder rig well.

ix Site No: T/W 2/9 Zzika (first trial)

Co-ordinates: N 00.07.172
E 032.31.639

Depth (m)	Lithology
0 – 0.39	Very hard laterite

Comments: Site located approximately 15m upstream of Pounder rig well. The valley is very steep with bare laterite outcrops.

x Site No: T/W 2/10 Zzika(second trial)

Co-ordinates: N 00.07.191
E 032.31.643

Depth (m)	Lithology
0 – 0.1	Top soil
0.1 – 0.2	Very hard laterite

Comments: Site located approximately 30m from Pounder rig well and is surrounded by laterite outcrops.

xi Site No: T/W 2/11 Bukadekade (first trial)

Co-ordinates: N 00.07.211
E 032.31.409

Depth (m)	**Lithology**
0 – 0.4	Reddish clay soil
0.4 – 1.0	Sandy clay
1.0 – 1.8	Soft murrum/laterite
1.8 – 2.0	Very hard laterite (impenetrable)

Comments: Site located approximately 15m upstream the Pounder rig well on a fairly steep slope. No water was encountered.

xii Site No: T/W 2/12 Bukadekade (second trial)

Co-ordinates: N 00.07.184
E 032.31.425

Depth (m)	**Lithology**
0 – 0.6	Reddish top soil
0.6 – 1.0	Laterite with pebbles (very hard)

Comments: Site located approximately 50m upstream Pounder rig well. No water was encountered.

xiii Site N0: T/W 2/13 Between Zzika and Bukadekade (first trial)

Co-ordinates: N 00.07.029
E 032.31.684

Depth (m)	**Lithology**
0 – 0.2	Top soil
0.2 – 0.8	Clay with gravel
0.8 – 1.2	Hard Laterite

Comments: Site located approximately 17m upstream open water source. No water was encountered.

xiv Site No: T/W 2/14 Between Zzika and Bukadekade (second trial)

Co-ordinates: N 00.07.014
E 032.31.678

Depth (m)	**Lithology**
0 – 0.3	Top soil
0.3 – 1.5	Brown sandy clay
1.5 – 3.1	Sandy clay with gravel (moist)

Comments: Site located along lineament forming the valley. Water was struck at 2.3m.

xv Site No: T/W 2/15 Kiryankuyege (first trial)

Co-ordinates: N 00.07.812
E 032.31.720

Depth (m)	**Lithology**
0 – 0.7	Loam soil
0.7 – 1.1	Clay with gravel
1.1 – 1.3	Hard Laterite

Comments: Site located close to a swamp. Observations made at brick making pits and information from the brick makers indicate that water is approximately 3m below ground level.

xvi Site No: T/W 2/16 Kiryankuyege (second trial)

Co-ordinates: N 00.07.704
E 032.31.787

Depth (m)	Lithology
0 – 0.3	Top soil
0.3 – 0.8	Clay with gravel
0.8 – 1.1	Hard Laterite

Comments: Site located approximately 200m upstream brick pits and is covered with fairly thick vegetation. No water was encountered.

xvii Site No: T/W 2/17 Kiryankuyege (third trial)

Co-ordinates: N 00.07.861
E 032.31.729

Depth (m)	Lithology
0 – 0.3	Black loam
0.3 – 1.1	Silty clay
1.1 – 1.3	Greyish – reddish laterite

Comments: Site located close to brick making pits and has a lot of water below laterite according to brick makers.

xviii Site No: T/W 2/18 Kololo (first trial)

Co-ordinates: N 00.08.243
E 032.31.954

Depth (m)	**Lithology**
0 – 0.6	Clay
0.6 – 1.0	Clay with gravel
1.0 – 1.3	Clayey sand with gravel
1.3 – 1.7	Sand with gravel

Comments: Site located approximately 20m upstream of a shallow well which is similar to Pounder rig wells. A lot of water struck at 1.6m.

Site No: T/W 2/19 Kololo (second trial)

Co-ordinates: N 00.08.320
E 032.31.970

Depth (m)	Lithology
0 – 0.8	Gravel (very hard)

Comments: Site located approximately 80m upstream shallow well. Could not drill deeper because of hard gravel. A near by pit dug approximately to 7 feet never encountered any water but a pit latrine located 20m away and constructed to 15 feet struck water, according to residents.

xix Site No: T/W 2/20 Lubumba (first trial)

Co-ordinates: N 00.08.378
E 032.32.040

Depth (m)	**Lithology**
0 – 0.9	Clay with silt
0.9– 1.5	Fine sand

Comments: Site located in a valley close to a motorised hand dug well which is used to supply piped water to Kawuku Trading centre.Water was struck at 1.3m.

xx Site No: T/W 2/21 Zzika (pit latrine logging)

Co-ordinates: N 00.07.256
E 032.31.712

Depth (m)	**Lithology**
0 – 0.6	Top soil
0.6 – 2.3	Laterite
2.3 – 5.0	Weathered phyllite

Comments: Site located on a topographically high area underlain by very hard laterite. All latrines constructed in the area reportedly encountered very hard laterite and no water was encountered as construction progressed deeper.

4.8 Figures

FIG 2.1 SHALLOW WELL POTENTIAL ZONE MAP (FROM DESK STUDY) FOR KAWUKU KATABI SUB-COUNTY.

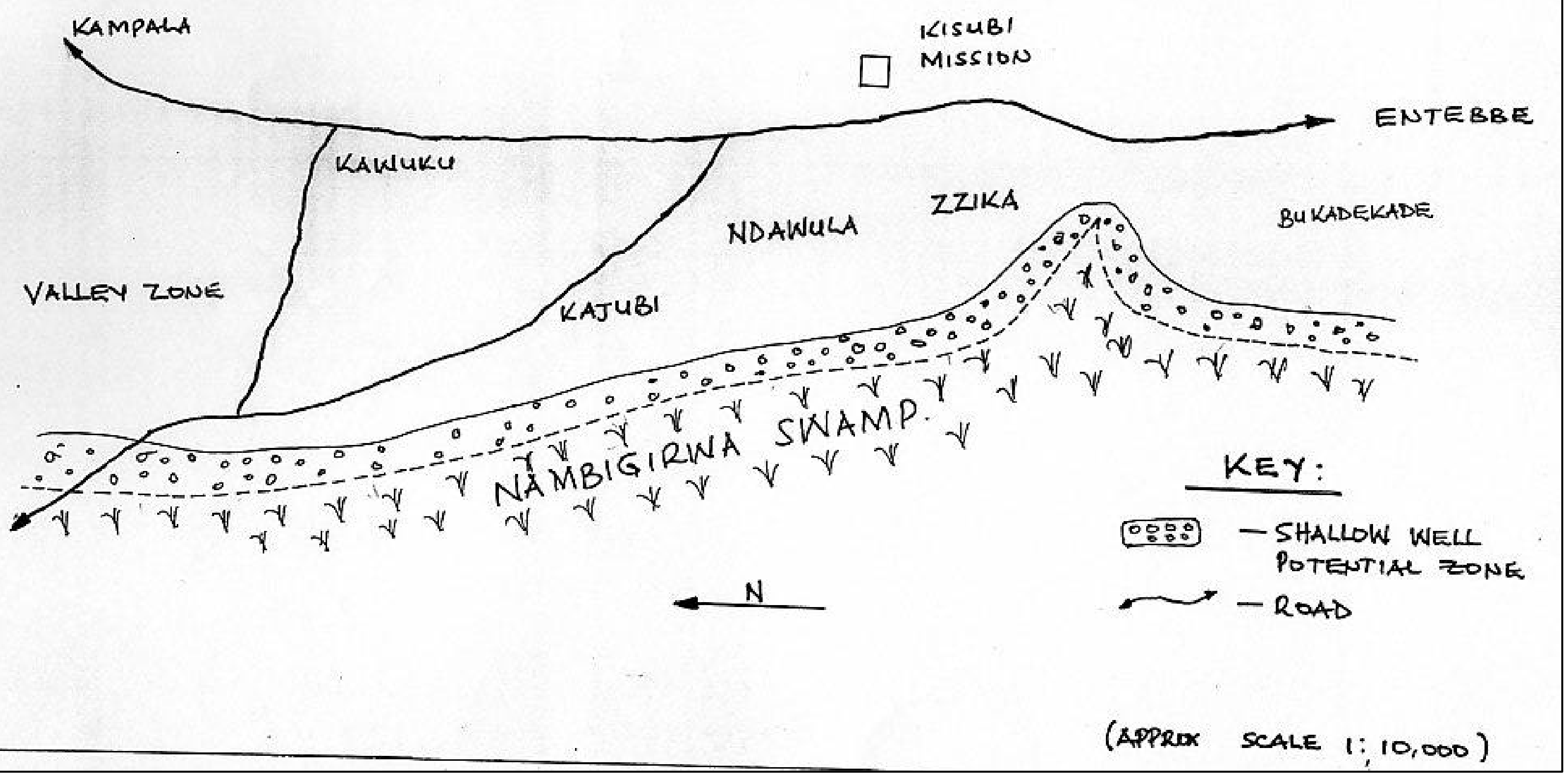
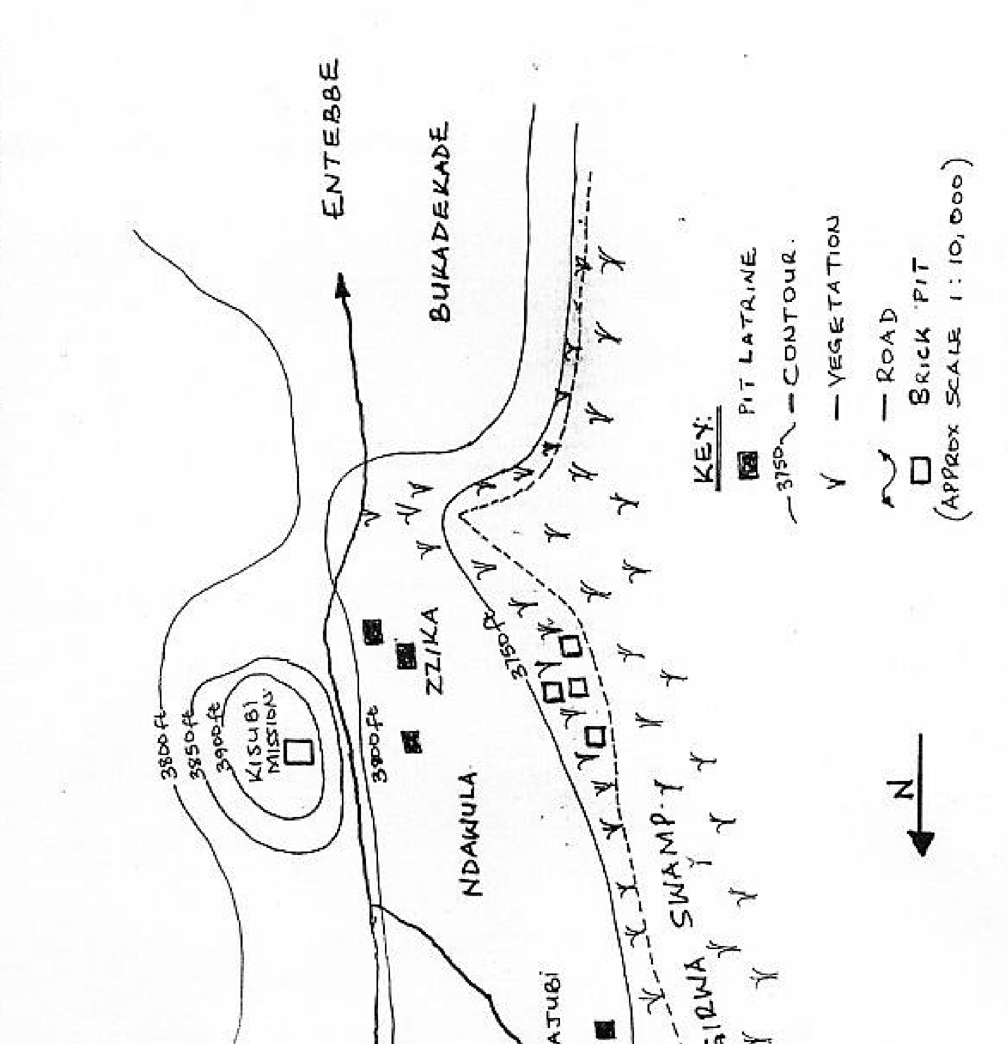


FIG 2.2 LOCATION OF SOME LANDSCAPE FEATURES IN KAWUKU, KATABI SUB COUNTY.



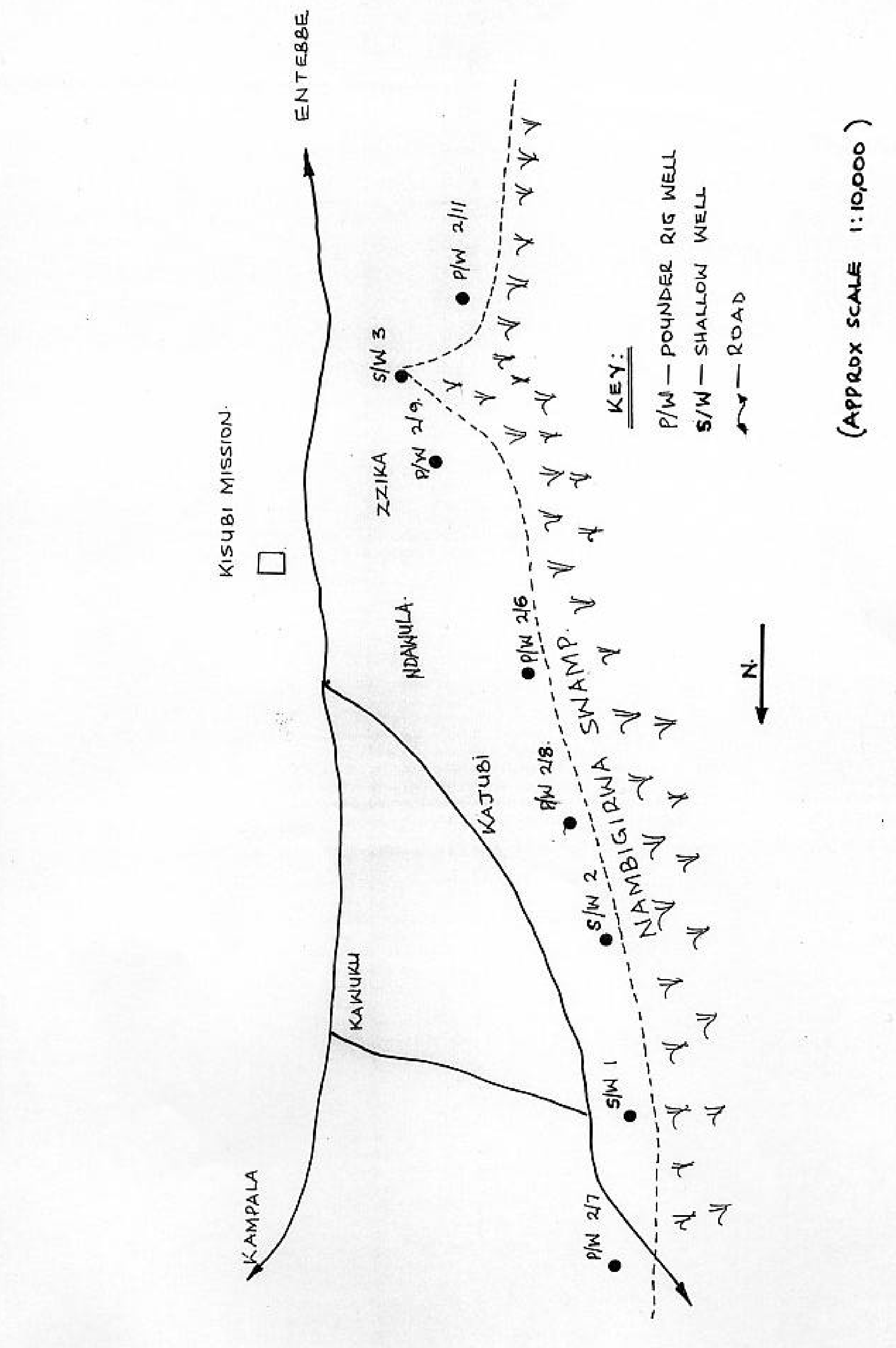


FIG 2.3 DISTRIBUTION OF WATER SOURCES IN KAWUKU, KATABI SUB COUNTY MPIGI DISTRICT.

FIG 2.4 SHALLOW WELL POTENTIAL ZONE MAP (AFTER RECONNAISSANCE) FOR KAWUKU, KATABI SUB COUNTY.

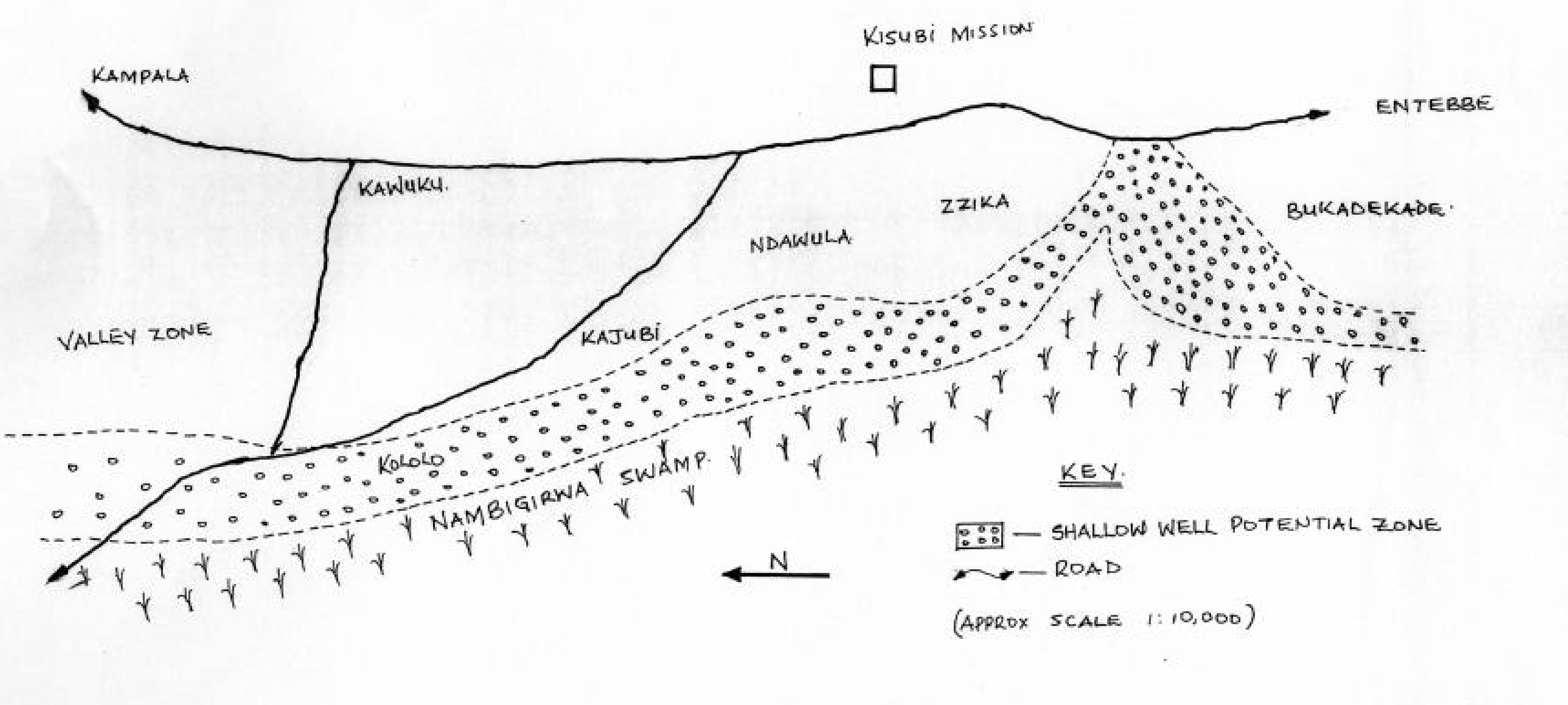


FIG 2.5 LOCATION OF POUNDER RIG WELLS AND TEST DRILLING SITES IN KAWUKU, KATABI S/COUNTY.

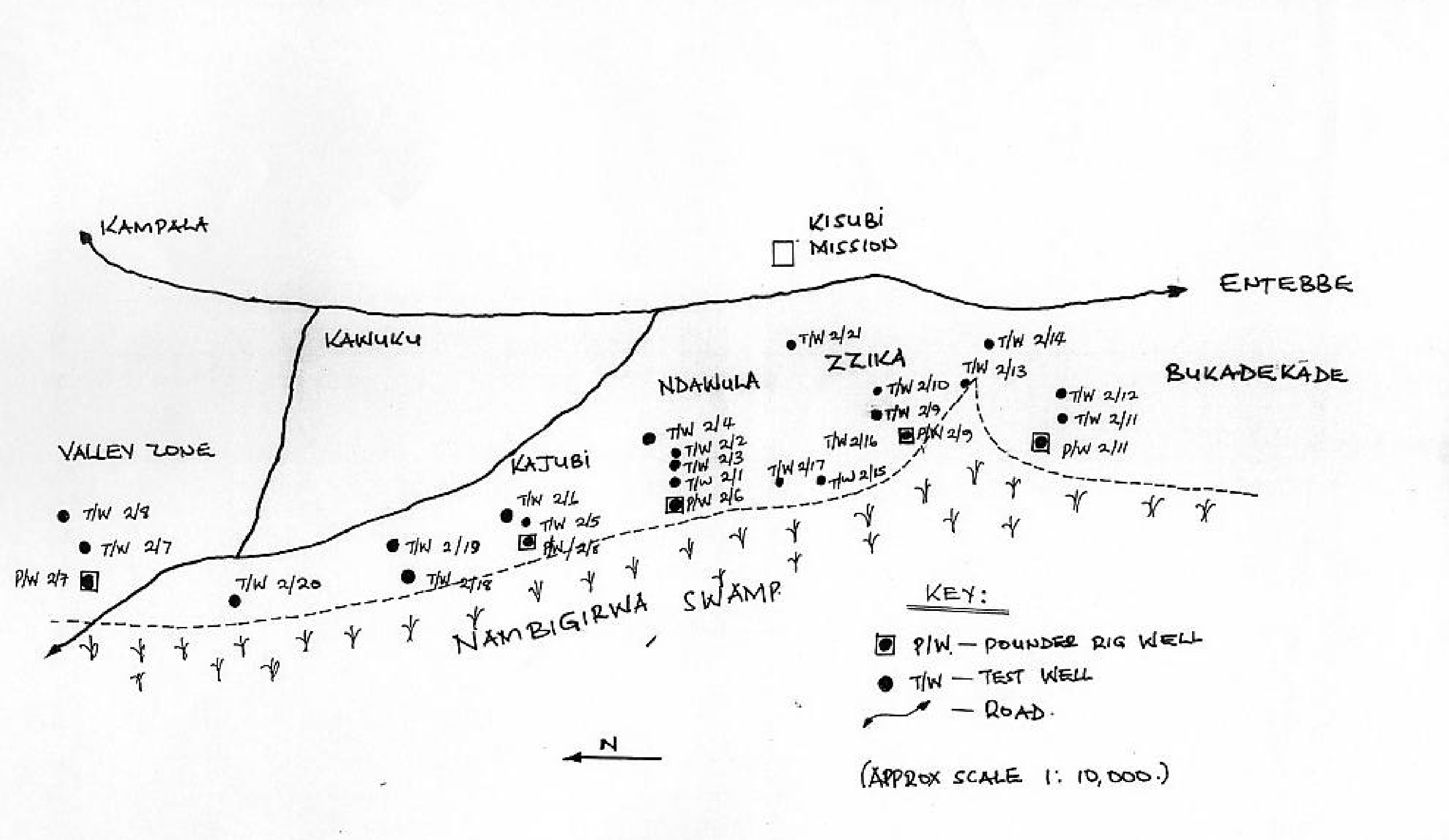
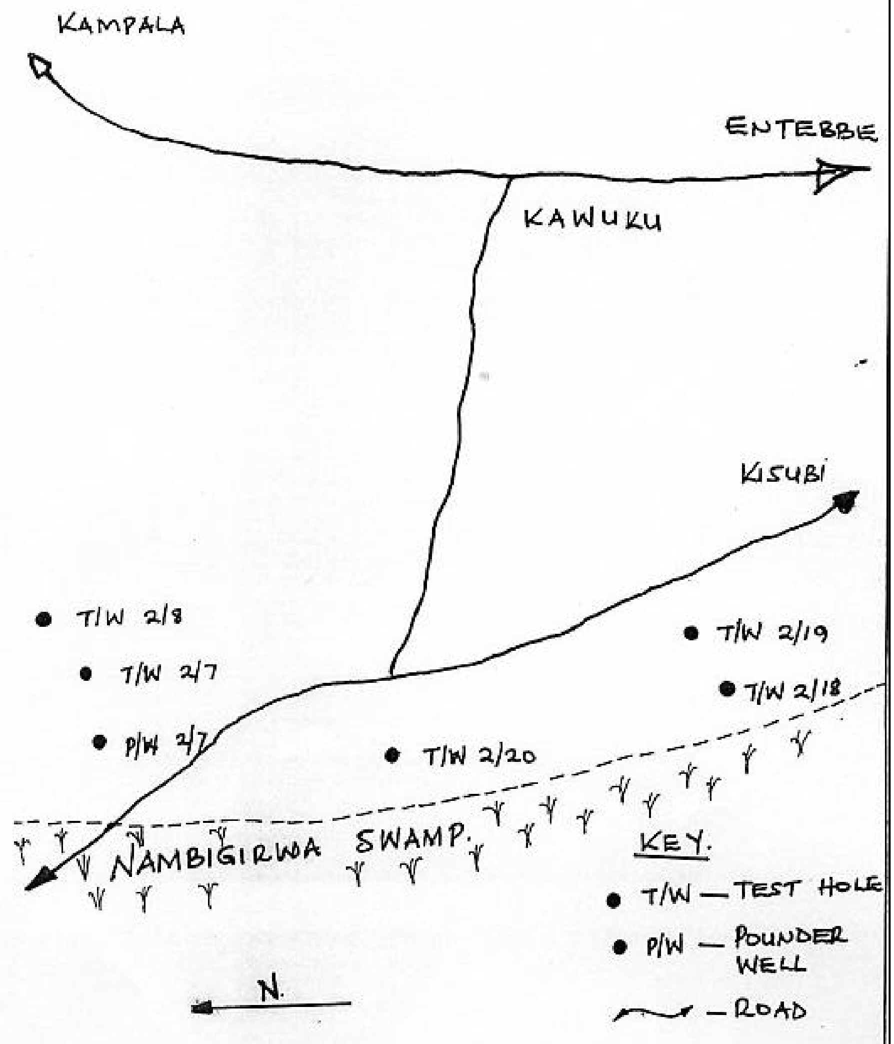


FIG 2.6 LOCATION OF TEST HOLES IN RELATION TO POUNDER WELL IN VALLEY ZONE.



(NOT TO SCALE)

FIG 2.7 LOCATION OF TEST HOLES IN RELATION TO POUNDER WELL IN BUKADEKADE

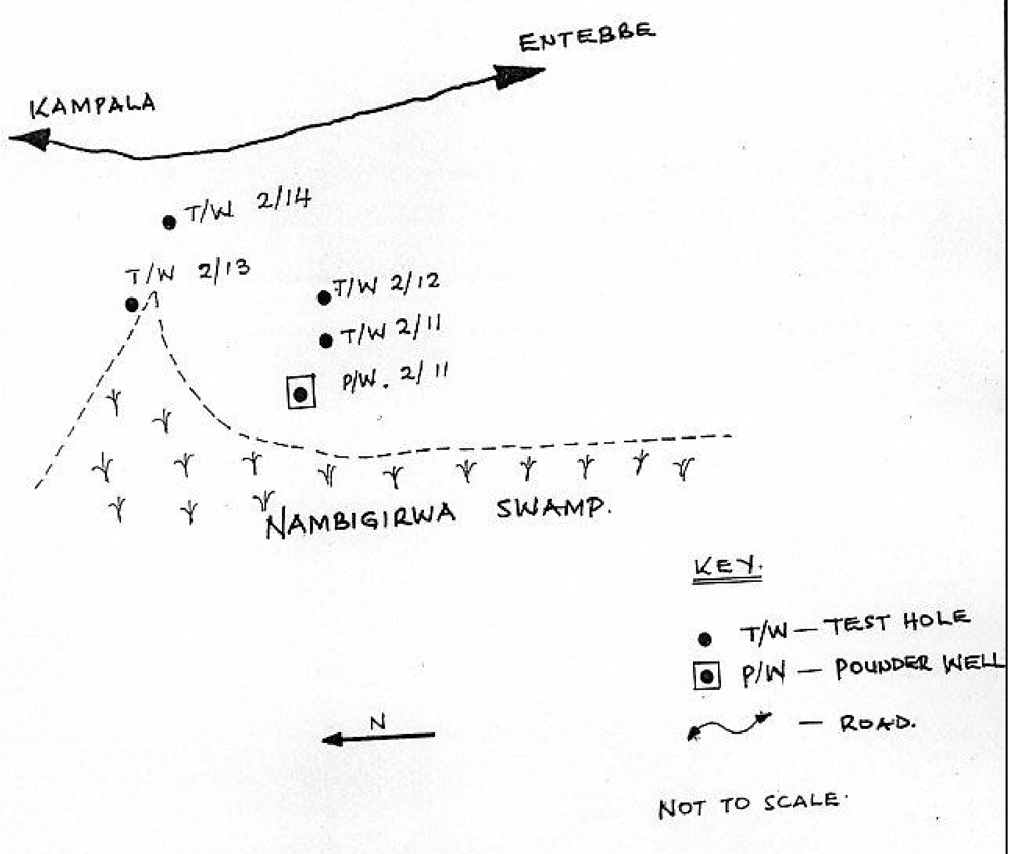


FIG 2.8. LOCATION OF TEST HOLES IN RELATION TO POUNDER WELL IN KAJUBI

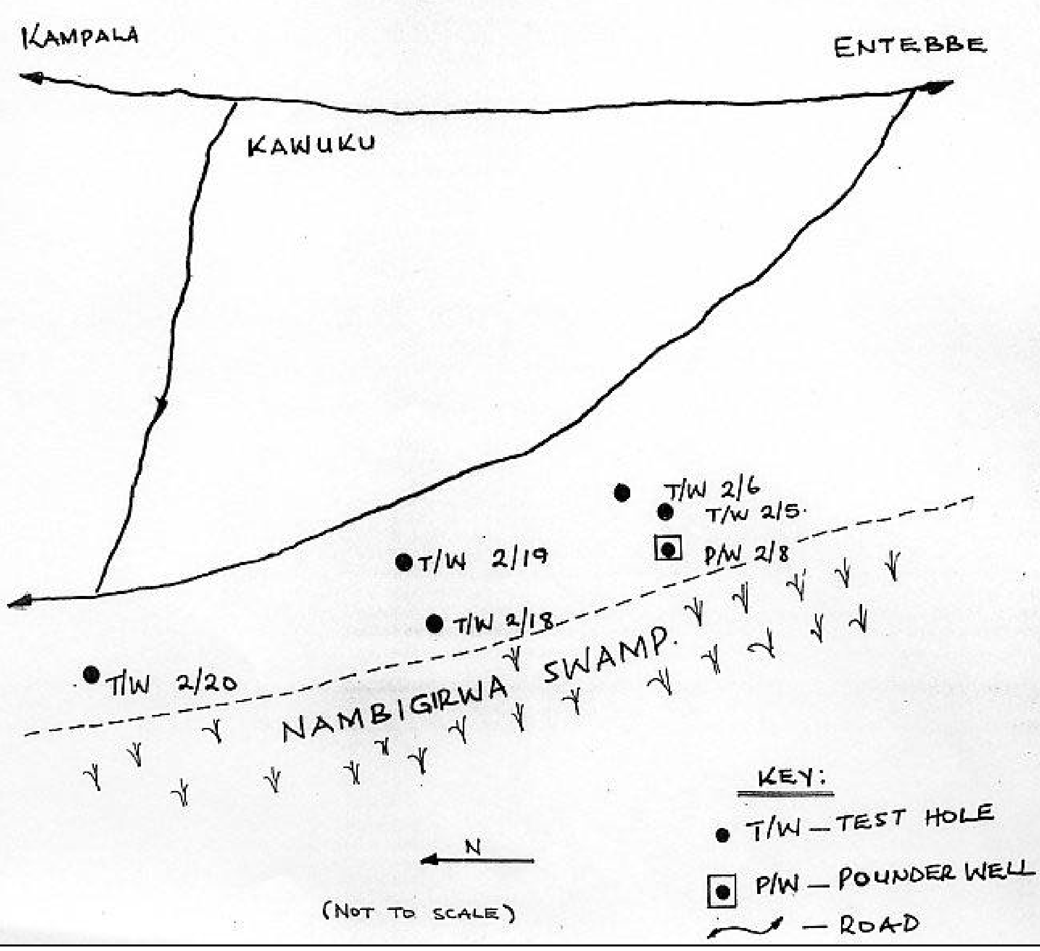
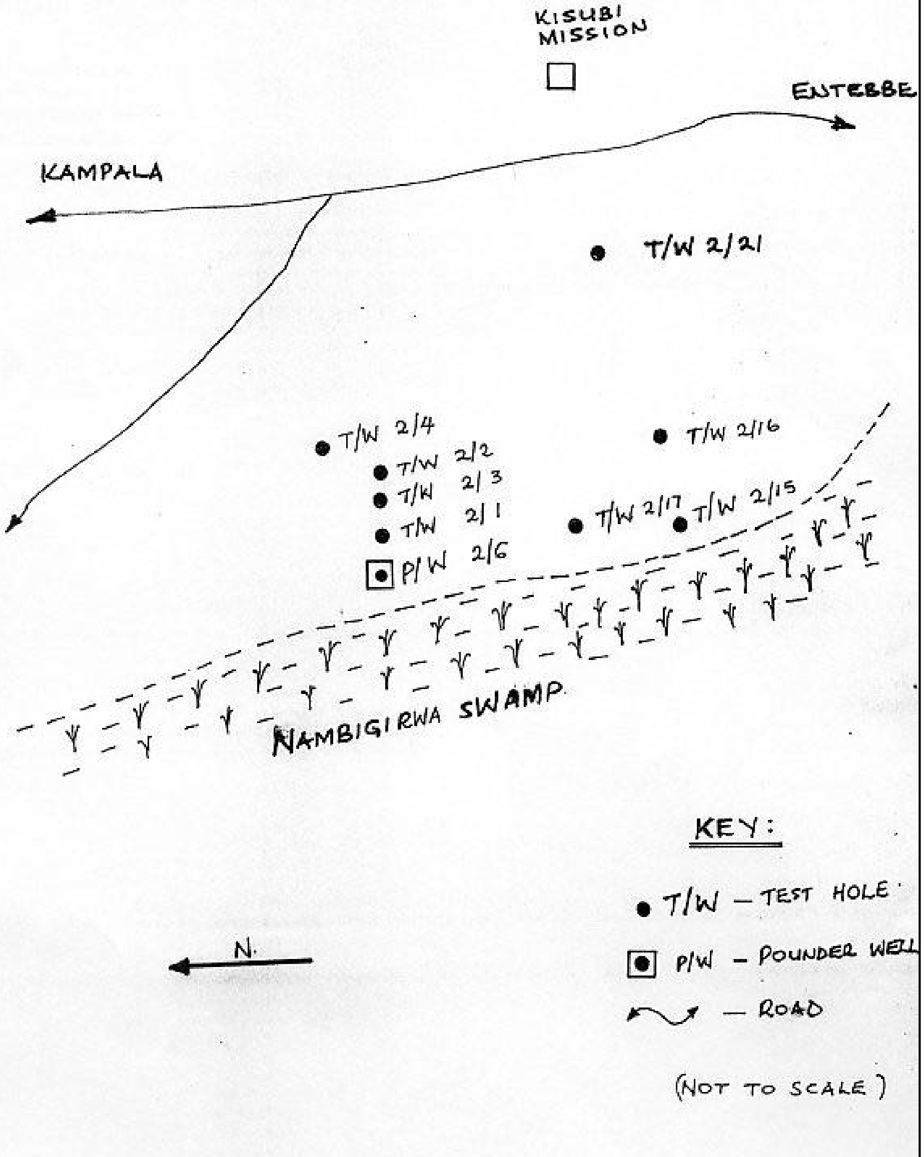


FIG 2.10 LOCATION OF TEST HOLES IN RELATION TO POUNDER WELL IN NDAULA ZONE.



4.9 References

Low Cost Shallow Well Drilling Project, Uganda Field Trials report : Report covering Pounder rig Experimental Drilling in Mpigi District.

Tindimugaya, C., 2000: Draft methodology for Pounder rig well siting: Report to the Low Cost Shallow Well Drilling Project, Cranfield University, U.K.

5 SHALLOW WELL SITING IN MUKONO DISTRICT USING THE POUNDER WELL SITING METHODOLOGY, NOVEMBER 2000

By Callist Tindimugaya

5.1 Summary

This study aimed at employing the draft siting methodology in the siting of Pounder wells in Mukono district. A total of 8 locations distributed across the district were investigated using the draft siting methodology with the objective of selecting 4 sites that are suitable for Pounder well drilling. The rest of the sites were to be considered for hand dug well construction. A total of 7 sites were investigated as the eighth location had a dug well already under construction by the time the siting was carried out.
Based on the siting activities carried out four sites for Pounder well drilling were selected in the villages of Nakasajja, Kasozi, Ntunda and Budyandi.

The sparse distribution of the sites could however not allow full employment of all the different stages of the siting methodology. As had been earlier anticipated the activities relied heavily on field reconnaissance and test drilling with little benefit being derived from desk studies. There were also limitations with test drilling with a hand auger because of presence of hard formations that were difficult to penetrate
The sites for well construction were confirmed through test drilling although it was generally difficult to penetrate gravel/ sand aquifer with the test auger. The thickness of the aquifers at all the four locations could thus not be determined because of difficulties with penetrating the sand/gravels. Permeability of the formations was inferred from grain size distribution because of the failure to penetrate the aquifer fully. Test drilling should in future be carried out using equipment having the same properties as the Pounder rig in order to be able to crash the hard formations.
The depths of the Pounder wells will therefore be determined when enough water has been obtained. The minimum depth of the holes should however be 3 metres below the depth where the main water was encountered. Similarly since the aquifer was identified at lower locations it is thus recommended that the final sites be shifted upstream to obtain the head required for Pounder well drilling.

The capacity building element of this assignment was highly appreciated by the district staff and the contractors as could be seen from their keen involvement in the different activities. Although it is difficult to gauge how much each individual leant it can be stated that there was a general appreciation of the need to carry out some investigations before actual well construction is carried out.

5.2 Background

5.2.1 Introduction

A draft methodology for Pounder well siting was prepared in January 2000 and was further developed in June 2000 through field-testing. The methodology is geared to identifying a range of conditions that conform to the capabilities of the rig. The methodology was meant to be not only appropriate but also cost effective in order to keep the cost of the shallow wells as low as possible. The siting methodology is composed of three different stages namely detailed desk studies, field reconnaissance and water source mapping, and test drilling. Mukono district was target by the Low Cost Shallow Well Drilling Project as one of the districts in which the methodology should be used in siting for both Pounder and hand dug shallow wells. The district has engaged a number of contractors for shallow well construction but sites needed to be selected before construction could start. A total of 8 shallow well sites including four for Pounder wells needed to be selected. However hand dug well construction was going on in one of the areas by the time siting started and thus no siting work was done in this area. The four Pounder wells will be constructed by two contractors. Preferred sites had already been identified by the community but siting was done in order to select the four sites suitable for Pounder well drilling and also to identify suitable locations for hand dug wells. From the siting it was possible to make relevant recommendations regarding drilling depth, expected lithology, depth to water and well construction and completion with regard to both Pounder and hand-dug wells. A brief review of what was expected to be carried out as presented in the draft siting methodology is presented below.

5.2.2 Review of the components of the draft siting methodology

a) Detailed desk study

This involves analysis and interpretation of all the available hydrogeological and general data such as borehole drilling logs, water quality data, topographic and geological maps, aerial photographs and any previous reports. This is done for purposes of understanding the hydrogeological conditions in the areas of interest. The result is normally a map delineating areas with shallow well potential that should be considered for further investigations. These areas thus become centers of focus during further well siting activities.

b) Field reconnaissance and water sources mapping

This involves making an orientation tour of the area in order to collect relevant information about the present water supply conditions, the hydrogeology and the areal layout and also to verify the findings of the desk study. This includes mapping and plotting of all water sources on a base map and studying vegetation changes, topography and geomorphology of the area and comparing these with results of the desk study.
Based on the results of the reconnaissance tour, further well siting activities involving test drilling are carried out.

c) Test drilling

This provides information on what kind of soil one is going to encounter, the problems it is likely to cause, the depth to water table and the amount of water the aquifer can yield.

According to the draft siting methodology test drilling should start at the shallow well potential locations preferred by the users and progress at increasing distances from the users in case good results have not been obtained. The drilling should be as deep as possible (<30 m) depending on the depth of the aquifer, and all the lithology encountered during drilling should be recorded. On the basis of the test results a decision should be made as to whether the aquifer can supply water of sufficient quantity and quality.

After test drilling has been completed, an evaluation of the results from the desk studies to completion of test drilling should be done, whether the test has been successful or not.

The draft siting methodology was considered appropriate for areas where the number of wells to be constructed is many thus off setting the siting costs. If however only a few wells are required in a small locality, the detail and the amount of desk study would be limited and special attention would then be given to field observations. In all situations, test drilling was considered to be necessary before actual drilling is done.

The seven areas investigated are sparsely distributed in the district and are located in three different sub-counties. This issue combined with the situation that the preferred locations had already been identified limited full utilisation of all the stages of the draft siting methodology.

5.2.3 Terms of reference

The terms of reference for this assignment were to:

- Investigate all the identified sites using the draft siting methodology with a view of selecting any four sites that are suitable for Pounder well drilling.

- Involve the district staff in siting activities in order to build their capacity to utilise the Pounder well siting methodology in future.

5.3 ACTIVITIES CARRIED OUT AND THE FINDINGS

5.3.1 Introduction

As mentioned before, this study was carried out in the district of Mukono in three sub-counties of Kyampisi, Kayunga and Ntunda. There were three sites in Kyampisi in the villages of Nakassajja, Kyabakade and Kasozi. Two sites were located in Kayunga in the villages of Buyobe and Kyamimbi while two sites were located in Ntunda in the villages of Ntunda and Budyandi. As mentioned before the eighth site located in Ntunda was already under construction by the time this study was undertaken and was thus not investigated. The seven sites investigated were so far apart that the studies carried out were specific to each site. This had a bearing on the amount of time and resources spent on this activity.
The activities in each location were carried out in the order as presented in the draft siting methodology. It was however not always possible to fully utilise all the stages of the methodology because the areas were limited in extent and little data was available. It was for example found that it was not very useful to study aerial photographs for such limited areas. Desk studies were thus limited mainly to study of topographic and geological maps, and existing data for boreholes drilled in nearby areas. As had earlier been anticipated and documented in the draft siting methodology the amount of desk study work reduced with the size of area of study.
The study however fully utilised field reconnaissance stage of the siting methodology and was found to be very useful and cost effective.

This was followed by test drilling in different locations from the valleys towards the communities. Test drilling was done in this way because the locations close to the communities were usually underlain by hard soils which could not easily be penetrated by the test auger. In some cases these locations were underlain by laterite and hard rocks. Test drilling was thus carried out progressively from the identified locations towards the communities with the aim of obtaining the required depth to water of 3m which is essential for stabilisation of the hole during Pounder well drilling. In areas where the aquifer was found to be having a very low permeability and thus unsuitable for Pounder wells, test drilling was limited to areas where the water table is notso deep. These sites would be suitable for hand dug wells and thus the water table needs to be shallow to make hand digging fairly easy.

The details of the activities carried out in each location and the results obtained are discussed below.

5.4 Activities and findings

5.4.1 Siting Activities

1) Nakasajja – Kyampisi Sub-county

Desk studies

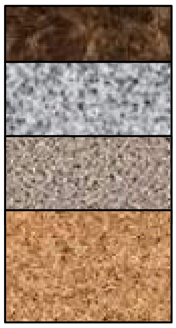
From the topographic map, it was found that the target area is located on a small ridge that slants gently towards a swamp. Areas along the swamp and the slope were therefore identified as having a potential for shallow groundwater. The geology of the area is formed by Basement complex rocks that are characterised by undifferentiated gneisses that normally weather to fine - medium grained material.

Borehole data for surrounding areas was studied. The boreholes studied are WDD5811, WDD5613, WDD5614, WDD4888, and WDD5618 all found in Ntonto parish. The records of these boreholes indicate that the underlying overburden, lithology is made up of topsoil, murrum, clay and sand mixed with clay.
The detailed of the wells are summarised in Annex 1.

Based on desk studies, the following observations could be made:

- Areas along the swamp, valley and slope covered by fairly thick vegetation have a potential for shallow groundwater.
- The lithology underlying the study area will be dominated by fine-medium grained material due to the nature of the parent rock.
- The site is likely to be underlain by murrum, which may cause difficulties during test drilling.
- A mixed zone of clay and sand found in the overburden may form a fairly good aquifer.
- The lithological units are almost similar across the area both vertically and areally with minor differences in thickness.

The generalised representative vertical section of the site is presented below:



The results of desk studies guided further activities and gave a clue of the conditions to expect in the field.

Field Reconnaissance.

This involved moving around the area with the guidance of the community to collect information on the topographic conditions, the geology of the area, vegetation pattern and changes, present water supply situation, existing water sources, hydrogeological conditions and the general layout of the target area. This was achieved by means of field observations and interviews with the community members.
The topography of the area is characterised by a small hill that slants gently towards a valley covered by papyrus. The area is underlain by clay mixed with silt and sand as observed from pit latrine constructions and from reports by pit latrine diggers. This information was fairly consistent with findings of desk studies.

Areas along the swamp and on the slope had quite thick and fresh vegetation such as palm trees indicating presence of shallow ground water.
The people in the area collect water from the swamp while others get it from neighbouring villages.
Interviews conducted with the community regarding the construction history of their pit latrines indicate that underlying lithology is made up of clay mixed with sand and becomes very hard to dig when water is encountered. The depth of water at the highest point of this area was reported to range between 8 and 12m as commonly observed during pit latrine construction.

From the findings of reconnaissance it was established that it is possible to obtain very close to the target community. However considering that the area is a fast growing trading centre it was decided to select a site, which can easily be protected from pollution. It was thus decided to carry out test drilling as close as possible to the community while bearing in mind the pollution concerns. The site would also be able to meet the requirements for Pounder well drilling. A site located approximately 30mupstream ofthe swamp and approximately 300m from the trading centre was thus selected for test drilling to confirm the existing hydrogeological conditions.

Test drilling

Test drilling was carried out using a hand auger with an outside diameter of approximately 30mm. As mentioned before test drilling was carried out approximately 30m from the swamp and 300m from the trading center in order to verify and confirm the hydrogeological conditions in and around the identified site.

Due to difficulties with drilling using the hand auger set only one test hole was drilled in the area. It took almost six hours to drill this hole.

The results of the test drilling are presented below.

Site co-ordinates: N 00 28' 45.1" and E 032 40' 50.5"

Depth (m)	Lithology	Comments
0 – 0.6	Brown top soil	Dry
0.6 – 1.5	Brown clay	Dry
1.5 – 2.5	Reddish laterite soil	Soft
2.5 – 3.0	Grey clay with little sand	Moist, water struck at 2.6m
3.0 – 4.0	Brown laterite soil	Soft
4.0 – 6.0	Brown silty soil	Soft
6.0 – 6.3	Brown soil with sand particles	Dry
6.3 – 6.8	Sand with gravel	Saturated, water struck at 6.5. Drilling stopped at 6.8 because of hard gravel

Comments and Conclusions

Assessment of the results of test drilling indicates that the generalised vertical lithological section in the area is composed of top soil, clay, laterite, clay with sand and sand with gravel. This is consistent with results of previous stages of the siting methodology.

Main sand / gravel aquifers starts at 6.5m but its thickness could not be determined because of the difficulty in penetrating the gravel with hand auger. There is a possibility of tapping the shallower and deeper aquifers together in case the yield from the deeper aquifer is not enough.

Based on activities carried out it is possible to drill a productive Pounder well at this site since the Pounder rig is expected to drill through the hard sand / gravel formation. Drilling should go as deep as possible until enough water to sustain a hand pump has been obtained.
Location map of the site with the relevant features mapped is presented in section 5.7

2) Kyabakadde – Kyampisi Sub-County

Desk Studies.

From the topographic map, it was found that the target area is located in a valley below a steep hill. The geology of the area is formed by Basement complex rocks that are characterised by undifferentiated gneiss's that normally weather to fine and medium grained material.

The are no boreholes available in the area but borehole data for surrounding areas was studied. The boreholes studied are WDD5811, WDD5613, WDD4888 and WDD5618. The records of these boreholes indicate that the underlying overburden, lithology is made up of topsoil, murrum, clay and sand mixed with clay. The details of the wells are summarised in section 4.6.

Based on desk studies, the following observations could be made:

- The lithology underlying the study are will be dominated by fine – medium grained material due to the nature of the parent rock.
- The site is likely to be underlain by murrum, which may cause difficulties during test drilling.
- A mixed zone of clay and sand found in the overburden may form a fairly good aquifer.
- The lithological units are almost similar across the area both vertically and areally with minor differences in thickness.

The generalised representative vertical section of the site is similar to that for Nakasajja as presented earlier:

The results of desk studies were used as a basis for further field activities.

Field Reconnaissance

Reconnaissance of the area involved field observations and interviews with the community members.
From field observations the topography of the area was found to be characterised by a steep hill below which there is a fairly wide valley. An open water hole is found in this valley and is being used for water supply to the community. From observations made at the existing open water hole the area is

underlain by clay mixed with silt and fine sand. This information was quite different from findings of desk studies regarding lithology. This is not very surprising because the available data used was from a far off village. This finding indicates that the underlying lithology varies even within the same geological environment possibility to variations in weathering conditions.

Interviews with the community regarding the reliability of the open water source indicated that it is perennial although the yield reduces tremendously in the dry period. The depth to water around this area is quite shallow and ranges between 0.5 and 1.2m.

It was decided to carry out test drilling in the vicinity of the open water in order to assess the underlying lithology and their water yielding potential.

Test Drilling

Test drilling was carried out approximately 5m from the open water source. Since test drilling was carried out for assessing the site conditions only one test hole was drilled in the area.

The results of the test drilling are presented below:

Site co-ordinates: N00 30’ 08.8” and E 032 43’ 44.9”

Depth (m)	Lithology	Comments
0 – 1.2	Dark silty top soil	Dry
1.2 – 2.4	Dark clayey fine sand	Moist, water struck at 1.6m
2.4 – 3.0	White fine sand	Saturated
3.0 – 4.0	Greyish fine sand	Moist, water struck at 2.6m
40. – 5.0	Brown laterite soil	Moist, little water

Comments and Conclusions

Assessments of the results of test drilling indicates that the generalised vertical lithological section in the area is composed of fine grained material which leads to low permeability conditions.
Based on activities carried out it is not possible to drill a productive Pounder well at this site but the site should be considered for a hand dug well. Digging could go down to 5m to provide enough storage.
Location map of the site with the relevant features mapped is presented in section 5.7

3) Kasozi Village, Bulijjo.

Desk Studies

From the topographic map, it was found that the target area is located in a valley formed by a lineament below a gently sloping hill. The geology of the area is formed by Basement complex rocks that are characterised by undifferentiated gneisses that normally weather to fine – medium grained material.

There is one borehole, WDD 10472 available in the area at Bulijjo Primary School whose data was studied to get an idea about the sub-surface geological conditions. Data for this borehole indicates that the underlying overburden lithology is made up of topsoil, clay mixed with silt and sand.

The details of the well are summarised in section 4.6

Based on desk studies, the following observations could be made:

The lithology underlying the study area will be dominated by fine – medium grained material.
A zone made up of sand found in the overburden may form a fairly good aquifer.
There may be preferential flow of water along the lineament forming the valley.

The generalised representative vertical section of the site is presented below:

The results of desk studies were utilised in further field activities.

Field Reconnaissance

As in the other areas reconnaissance of the area involved field observations and interviews with the community members.
From field observations the topography of the area was found to be characterised by a gently sloping hill below which there is a fairly narrow valley formed by a lineament. An open water hole is found in this valley and is being

used for water supply to the community. From observations made at the existing open water hole the area is underlain by clay mixed with silt, fine sand and medium grained sand.
Interviews conducted with the community regarding the reliability of the open water source indicated that it is perennial and the yield does not reduce in the dry period. The depth to water around this area is quite shallow and ranges between 1.4 and 3.5m.
Results of field reconnaissance thus indicated that the permeability of the formation is medium and the site may be suitable for a Pounder well.

It was decided to carry out test drilling at different locations to assess the underlying lithology and their water yielding potential.

Test Drilling

Test drilling was carried out at three different locations as indicated on the site sketch map.
All the test drilling sites showed similar lithology with only variation occurring on the depth to water due to differences in topographic conditions.

The results of test drilling at one of the sites are presented below.

Site co-ordinates: N 00 28’ 25.5’’ and E 032 46’ 44.7’’

Depth (m)	Lithology	Comments
0 – 2.0	Brown soil	Dry
2.0 – 3.0	Greyish - Brown silty clay	Dry
3.0 – 3.4	Greyish fine sand	Dry
3.4 – 3.8	Greyish medium sand	Saturated, water struck at 3.5m. Drilling stopped because of collapsing sand

Comments and conclusions

Assessment of the results of test drilling indicates that the generalised vertical lithological section in the area is composed of topsoil, silty clay, fine sand and medium sand. This agrees fairly well with results obtained from previous stages of the siting methodology.

Sand aquifer starts at 3.5m but its thickness could not be determined because the sand was collapsing due to saturation.
Based on activities carried out it is possible to drill a productive Pounder well at this site since collapsing of the sand is expected to be controlled by the water pressure during drilling. Drilling should go as deep as possible until enough water to sustain a handpump has been obtained.

Location map of the site with the relevant features mapped is presented in section 5.7.

4) Buyobe Village, Kayunga Sub-County

Desk studies

From the topographic map, it was found that the target area is located on a wide ridge that slants gently towards a swamp. The geology of the area is formed by Basement complex rocks that are characterised by undifferentiated gneiss's that normally weather to fine - medium grained material.

There is one borehole, WDD 2683 available in the area whose data was studied to get an idea about the sub-surface geological conditions. Data for this borehole indicates that the underlying overburden lithology is made up of topsoil, clay and clayey sand.

Details of the well are summarised in section 4.6.

Based on desk studies, the following observations could be made:

- Areas along the swamp and slope covered by fairly thick vegetation have a potential for shallow groundwater
- The lithology underlying the study area will be dominated by fine grained material due to the nature of the parent rock.
- A mixed zone of clayey sand found in the overburden may form an aquifer.

The generalised representative vertical section of the site is presented below:

The results of desk studies were very useful in guiding further siting activities and gave a clue on the conditions to expect in the field.

Field Reconnaissance

Reconnaissance of the area involved field observations and interviews with the community members as was done in other areas.
From field observations, the topography is characterised by a wide ridge that slants gently towards a swamp. Areas along the swamp and the slope were therefore identified as having a potential for shallow groundwater. These areas have quite thick vegetation constituted by banana and coffee plantations and palm trees. An open water hole is found at the edge of the swamp is being used for water supply to a big community. From observations made at the existing open water hole the area is underlain by silty clay and fine sand.
Information obtained from the community indicated tha t the water hole is perennial but the yield reduces in the dry period.
Within the same village but at a higher elevation a shadoof was constructed in 1996 down to a depth of 23ft. It was reportedly constructed in the rainy season and was used for 3 years after which it completely dried up. Pit latrines constructed in the area but at a slightly lower elevation encounter water at around 22ft.
Results of field reconnaissance thus indicated that the permeability of the formation is low and the site may only be suitable for a dug well.

It was thus decided to carry out test drilling at different locations to assess the underlying lithology and their water yielding potential in order to recommend a maximum depth for well digging. Only one hole was drilled at this location.

Test Drilling

Test drilling was carried out at one location just 3m from the open water hole as indicated on the site sketch map.

The results of test drilling are presented below.

Site co-ordinates: N 00 45’ 15.3’’ and E 032 51’ 44.5’’

Depth (m)	Lithology	Comments
0 – 1.1	Clay	Moist
1.1 – 1.8	Sandy clay	Moist, water struck at 1.2m
1.8 – 5.2	Clay with little sand	Dry

Comments and conclusions

Assessment of the results of test drilling indicates that the generalised vertical lithological section in the area is composed of fine grained material which leads to low permeability conditions.

Based on activities carried out it is not possible to drill a productive Pounder well at this site but the site should be considered for a hand dug well. Digging could go down to 4m to provide enough storage.
Location map of the site with the relevant features mapped is presented in section 5.7.

5) Kyamimbi Village, Kayunga Sub-County

Desk studies

From the topographic map, it was found that the target area is located on a wide ridge that slants gently towards a valley. The geology of the area is formed by Basement complex rocks as the case in other areas investigated.
There is one borehole, WDD 2683 available in the vicinity of the area whose data was studied to get an idea about the sub-surface geological conditions. Data for this borehole indicates that the underlying overburden lithology is made up of topsoil, clay and clayey sand.

Details of the well are summarised in section 4.6.

Based on desk studies, the following observations could be made:

- Areas along the valley have a potential for shallow groundwater
- The lithology underlying the study area will be dominated by fine grained material.
- A zone of clayey sand found in the overburden may form an aquifer.

The generalised representative vertical section of the site is similar to that for Buyobe as presented earlier.

The results of desk studies were very useful in guiding further siting activities as earlier mentioned.

Field Reconnaissance

Reconnaissance of the area involved field observations and interviews with the community members as was done in other areas.
From field observations, the topography is characterised by a wide ridge that slants gently towards a valley. This valley seems to be following a lineament and was therefore identified as having a potential for shallow groundwater. There are so many sand pits in the area surrounded by papyrus. A number of water holes have been constructed in the area by the local community in an effort to get water. One of them is a shadoof constructed in 1995 down to 22feet but was dry

at the time of the visit. The people interviewed indicated that alot of water was encountered at around 15ft but was cased off during construction. The people get only 2 jellycans from this shadoof before it completely dries up. Similarly it was reported that a well was constructed at a lower elevation down to a maximum depth of 12ft. Water was reportedly encountered at 7ft. As the well was not lined it collapsed after a few months of use. A similar well was under construction at the time of the visit. It had reached a depth of 12ft but had not yet encountered water. The owner was planning to continue digging until the water is got. Other reports received regarding pit latrine construction indicated that wate is normally encountered around 15ft. From observations made at the well that was under construction the area is underlain by silty clay and fine to medium grained sand.

Results of field reconnaissance thus indicated that the permeability of the formation is low to medium and the site may only be suitable for a dug well.

It was thus decided to carry out test drilling at different locations to assess the underlying lithology and their water yielding potential.

Test Drilling

Test drilling was carried out at three locations all showing almost similar lithology. Their locations are as indicated on the site sketch map.

The results of test drilling at one of the sites are presented below.

Site co-ordinates: N 00 46’ 08.8’’ and E 032 53’ 45.1’’

Depth (m)	Lithology	Comments
0 – 1.2	Brown sand with little clay	Dry
1.2 – 3.0	Greyish brown sand	Dry
3.0 – 3.2	Sand with gravels	Dry, stopped because sand was collapsing and augering was very difficult.

Comments and Conclusions

Assessment of the results of test drilling indicates that the generalised vertical lithological section in the area is composed of fine to medium sandy material which leads to low permeability conditions.
Based on activities carried out it is not possible to drill a productive Pounder well at this site but the site could be considered for a hand dug well. Digging could go

down to not less than 7m since water is reported to occur at around 5m in this area.
Location map of the site with the relevant features mapped is presented in section 5.7.

6) Ntunda Village (Gopari Source), Ntunda Sub – County

Desk studies

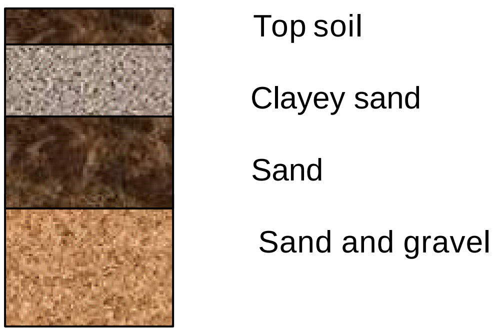
From the topographic map, it was found that the target area is located in a valley formed by a lineament below a steeply sloping hill. The geology of the area is formed by Basement complex rocks that are characterised by undifferentiated gneiss's that normally weather to fine - medium grained material.

There are two boreholes, WDD 11142 and WDD 10388 available in the area at Ntunda Trading centre whose data was studied to get an idea about the sub-surface geological conditions. Data for these boreholes indicates that the underlying overburden lithology is made up of topsoil, clay mixed with silt, sand and gravel.
The details of the wells are summarised in section 4.6.

Based on desk studies, the following observations could be made:

The lithology underlying the study area will be dominated by fine-medium grained material.
A zone made up of sand and gravel found in the overburden may form a fairly good aquifer.
There may be preferential flow of water along the lineament forming the valley.

The generalised representative vertical section of the site is presented below:



The results of desk studies guided further siting activities as they provided a clue on the conditions to expect in the field.

Field reconnaissance

As in the other areas reconnaissance of the area involved field observations and interviews with the community members.
From field observations the topography of the area was found to be characterised by a steeply sloping hill below which there is a fairly narrow valley formed by a lineament. An open water hole is found in this valley and is being used for water supply to the community. From observations made at the existing open water hole the area is underlain by clay mixed with fine and medium grained sand.
Interviews conducted with the community regarding the reliability of the open water source indicated that it is perennial and the yield does not reduce in the dry period. The community indicated that the well has the highest amount of water in the whole parish and were proud of it.
Results of field reconnaissance thus indicated that the permeability of the formation is medium and the site may be suitable for a Pounder well.

It was decided to carry out test drilling at different locations to assess the underlying lithology and their water yielding potential.

Test Drilling

Test drilling was carried out at three different locations as indicated on the site sketch map.
All the test drilling sites showed similar lithology with only variation occurring on the depth to water due to differences in topographic conditions.

The results of test drilling at one of the sites are presented below.

Site co-ordinates: N 00 34’ 45.7’’ and E 032 55’ 17.2’’

Depth (m)	Lithology	Comments
0 – 1.2	Brown soil	Dry
1.2 – 2.0	Sandy soil	Moist, water struck at 1.6m
2.0 – 2.5	Gravely sand	Saturated, water struck at 2.1m. Drilling stopped at 2.5m

Comments and Conclusions

Assessment of the results of test drilling indicates that the generalised vertical lithological section in the area is composed of topsoil, clay with sand and sand with gravel. This is consistent with results of previous stages of the siting methodology.

The main aquifer is formed by sand with gravel and starts at 2.1m. Its thickness could not be determined because the test auger could not go deeper due to hard gravel. To achieve the required head for Pounder well the site could be shifted slightly higher.
Based on activities carried out it is possible to drill a productive Pounder well at this site since the Pounder rig is expected to drill through the hard sand/gravel formation. Drilling should go as deep as possible until enough water to sustain a handpump has been obtained. Minimum drilling depth should be 3m below the depth at which water is struck.
Location map of the site with the relevant features mapped is presented in section 5.7

7) Budyandi, Ntunda Sub-County

Desk studies

From the topographic map, it was found that the target area is located on a wide ridge that slants gently towards a swamp. Areas along the swamp and the slope were therefore identified as having a potential for shallow groundwater. The geology of the area is formed by Basement complex rocks that are characterised by undifferentiated gneiss's that normally weather to medium to coarse-grained material.

There are two boreholes, WDD 11142 and WDD 10388 available in the area at Ntunda Trading centre whose data was studied to get an idea about the sub-surface geological conditions. Data for these boreholes indicates that the underlying overburden lithology is made up of topsoil, clay mixed with silt, sand and gravel.
The details of the wells are summarised in section 4.6.

Based on desk studies, the following observations could be made:

The lithology underlying the study area will be dominated by fine-medium grained material.
Areas along the swamp and slope covered by fairly thick vegetation have a potential for shallow groundwater
A zone made up of sand and gravel found in the overburden may form a fairly good aquifer.

The generalised representative vertical section of the site is similar to that for Ntunda village as earlier presented.

The results of desk studies were very useful in further siting activities as they provided a clue on the conditions to expect in the field.

Field reconnaissance

As in the other areas reconnaissance of the area involved field observations and interviews with the community members.
From field observations the topography of the area was found to be characterised by a gently sloping hill towards a swamp. An open water hole is found at the edge of the swamp and is being used for water supply to the community. From observations made at the existing open water hole the area is underlain by clay mixed with fine and medium grained sand.
Interviews conducted with the community regarding the reliability of the open water source indicated that it is perennial and the yield does not reduce in the dry period.
The pit latrines constructed upstream the open water source encountered water at around 15ft.
Results of field reconnaissance thus indicated that the permeability of the formation is medium and the site may be suitable for a Pounder well.
It was decided to carry out test drilling at different locations to assess the underlying lithology and their water yielding potential.

Test Drilling

Test drilling was carried out at two different locations as indicated on the site sketch map.
All the test drilling sites showed similar lithology. One of the sites located at a higher elevation stopped at 2m without encountering water. Drilling stopped because the formation was very hard.

The results of test drilling at one of the sites located 15m upstream the open water source are presented below.

Site co-ordinates: N 00 36’ 40.6’’ and E 032 56’ 51.3’’

Depth (m)	**Lithology**	**Comments**
0 – 0.5	Black top soil	Dry
0.5 – 2.1	Brown silty clay	Soft, little water struck at 1.2m
2.1 – 3.0	Gravely sand with little laterite	Saturated, water struck at 2.6m. Drilling stopped at 3.0m

Comments and Conclusions

Assessment of the results of test drilling indicates that the generalised vertical lithological section in the area is composed of topsoil, clay, sand and sand with little gravel. This is almost similar to results of previous stages of the siting methodology.

The main aquifer is formed by gravely sand which starts at 2.6m. Its thickness could however not be determined because of the difficulties with penetrating the gravely material. To achieve the required head for Pounder well the site could be shifted slightly higher.

Based on activities carried out it is possible to drill a productive Pounder well at this site since the Pounder rig is expected to drill through the hard gravelly sand formation. Drilling should go as deep as possible until enough water to sustain a handpump has been obtained. The minimum depth of the hole should be 3m below the depth where water is encountered.
Location map of the site with the relevant features mapped is presented in section 5.7.

5.4.2 Training of district staff and contractors

One of the terms of reference for this assignment was to train the district staff in the use of the Pounder well siting methodology as a way of improving shallow well siting activities in the district. In addition to the district staff the contractors who were going to use the Pounder well drilling equipment were expected to participate in the siting activities in order to appreciate their benefits while at the same time getting familiar with shallow well drilling activities. The district staff comprised of a community mobiliser and water officer while the two contractors were represented by at least one person each. These people were involved in reconnaissance and test drilling activities at all the seven sites. The training involved explaining the activities carried out at each site and the benefits of such activities. Similarly, they were also involved in the practical activities at each site such as drawing sketch maps and test drilling. The capacity building element of this assignment was highly appreciated by the people involved as could be seen from their keen involvement in the different activities even when work had to be done over the weekends. Although it is difficult to gauge how much each individual leant it can be stated that there was a general appreciation of the need to carry out some investigations before actual well construction is carried out. With continued practice in the use of the siting methodology in the district, it is expected that it will become a routine in shallow construction activities especially once benefits are realised.

5.5 Conclusions And Recommendations

The draft siting methodology has been employed in Mukono district to select sites for Pounder well drilling. A total of 8 locations distributed across the district were investigated with the objective of selecting 4 sites that are suitable for Pounder well drilling. A total of 7 sites were investigated as the eighth location had a dug well already under construction by the time the siting was carried out. Based on the siting activities carried out four sites for Pounder well drilling were selected in the villages of Nakasajja, Kasozi, Ntunda and Budyandi. Due to the sparse distribution of the sites it was not possible to fully employ all the different stages of the siting methodology. As had been earlier anticipated the activities relied heavily on field reconnaissance and test drilling with little benefit being derived from desk studies. There were also limitations with test drilling with a hand auger because of presence of hard formations that were difficult to penetrate

Based on the activities carried out the following conclusions and recommendations can be made:

- All the site conditions were confirmed through test drilling although it was generally difficult to penetrate gravel/ sand aquifer with the test auger. Most times the auger would get stuck due to collapsing of the saturated formation and retrieving the tools was usually difficult and required so many people.
- The thickness of the aquifers at all the four locations could not be determined because of difficulties with penetrating the sand/gravel's. Test drilling should in future be carried out using equipment having the same properties as the Pounder rig in order to be able to crash the hard formations.
- The depths of the production holes will be determined when enough water has been obtained. The minimum depth of the holes should however be 3 metres below the depth where water was encountered.
- Permeability of the formations was inferred from grain size distribution.
- Since the aquifer was identified at lower locations it was assumed that the required head could be obtained if one drills the production hole upstream. It is thus recommended that the final sites be shifted upstream to obtain the head required for Pounder well drilling.
- The district staff and the contractors were involved in the siting activities in order to build their capacity. The capacity building element of this assignment was highly appreciated by the people involved as could be seen from their keen involvement in the different activities even when work had to be done over the weekends.
- Although it is difficult to gauge how much each individual leant it can be stated that there was a general appreciation of the need to carry out some investigations before actual well construction is carried out.

5.6 TERMS OF REFERENCE FOR A HYDROGEOLOGICAL CONSULTANCY INPUT TO THE SITING OF POUNDER WELLS IN MUKONO AND MPIGI DISTRICTS

Background

New low-cost water well drilling technology (the Pounder Rig) has been through prototype design, field testing, and further development, and is about to be transferred to small contractors in Mukono and Mpigi Districts. Sites for drilling are to be selected, initially in two sub-counties of Mukono, and subsequently in Mpigi. Initially (before end 2000) it is expected that four wells will be drilled in Mukono, and up to six in Mpigi.

The initial arrangements between Mukono District and the contractors will be fixed price contracts, based on average costings for hand-dug wells. This is not our ideal arrangement, since we are aware that every well or borehole is different (in terms of lithology and ease of drilling), and therefore variable in cost. In order to enable these first contracts to be performed within budget, we wish to find sites which are not too deep, and not involving too great a thickness (if any) of laterite or rock. Later, more “difficult” sites can be attempted.

In Mukono community mobilisation will be undertaken in more than four communities, to allow some choice of drilling locations (communities which do not receive Pounder wells will receive hand dug wells). The precise sites for Pounder wells need to be decided through agreement between the communities, the District/Sub-Counties, the Project Team, and the Consultant Hydrogeologist.

Note, in this paper the word *“location”* is used to mean the general locality of a proposed well (ie the community or village where the precise drilling *“site”* is to be chosen).

General Requirements of the Consultancy

Building on the previous two assignments undertaken by this Consultant, we wish him to provide hydrogeological advice on a total of up to 15 locations identified by the Districts/Sub-Counties. We would expect to see results from using the draft siting protocol which was developed in the second assignment, including all relevant documented data, as well as detailed information gathered from site surveys.

In general, the site requirements for a successful Pounder well are:

1. fairly level terrain for rig
2. access by pickup to say 500m from site (rig has wheeled trolley approx 800mm wide for site access)
3. water table depth at least 3m

4. total depth 20m maximum (including allowance for drawdown, seasonal variation, and 3-6m of screen). This figure may change as experience of rig performance develops. Implication at present is that maximum allowable depth to dry season pumping water level is 14-17m (depending on screen length used)
5. unconsolidated/uncemented formations are acceptable, although running sands may require casing
6. limited amounts of laterite and consolidated/cemented rock are acceptable, although speed of drilling will be reduced in hard formations
7. losing (eg heavily fractured) formations are best avoided

For the first contractor-drilled wells conditions 1-3 stand, but we are seeking profiles with very limited amounts of (or no) hard rock, with sufficient permeable formation below a shallow water table to allow completion at a total depth of around 10m. The ideal would be a water table at 3-5m depth, with 3-6m of fairly permeable formation below.

Specific Terms of Reference

In consultation with Team Leader Uganda (Kerstin), Community Water Supply Specialist (Ronnie) and District Staff (District Water Officer and Community Development Officer):

1. visit and assess each of the identified locations in Mukono, and later Mpigi Districts
2. produce sketch maps and descriptions, providing all possible information about the nature of the formations, depth to water, and likely drilling conditions to be encountered
3. supply logs and descriptions of all relevant nearby wells, boreholes, or other excavations
4. produce a report setting out all the information gathered, and drawing conclusions about Pounder drilling conditions at each location; recommend specific sites to be drilled
5. prior to drilling, liaise with the individuals already listed, and the Drilling Consultant (Peter) and Contractors to finalise the actual sites to be drilled.

5.7 Figures

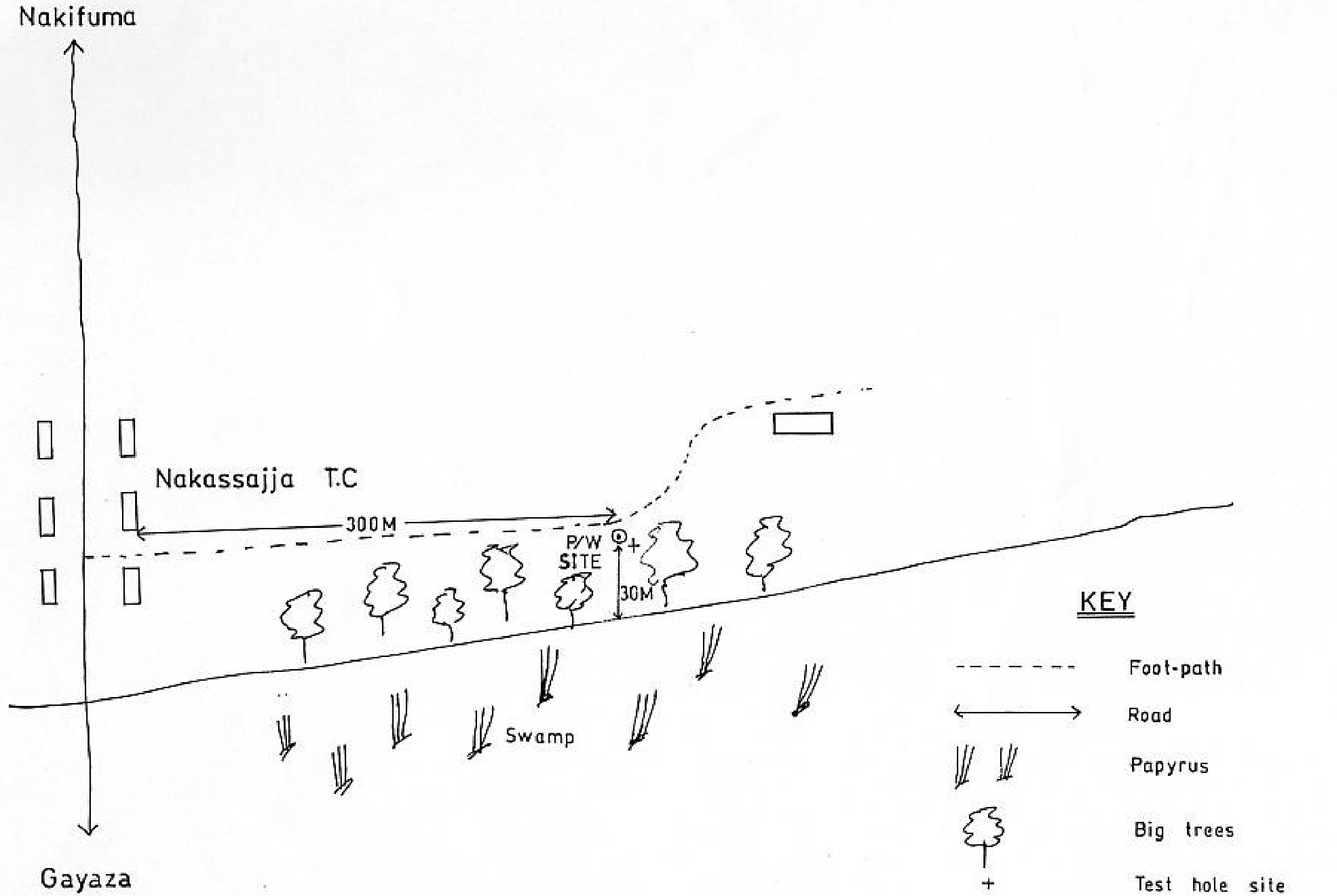


Figure 2.1
Location of landscape features and proposed pounder Well site in Nakassajja village

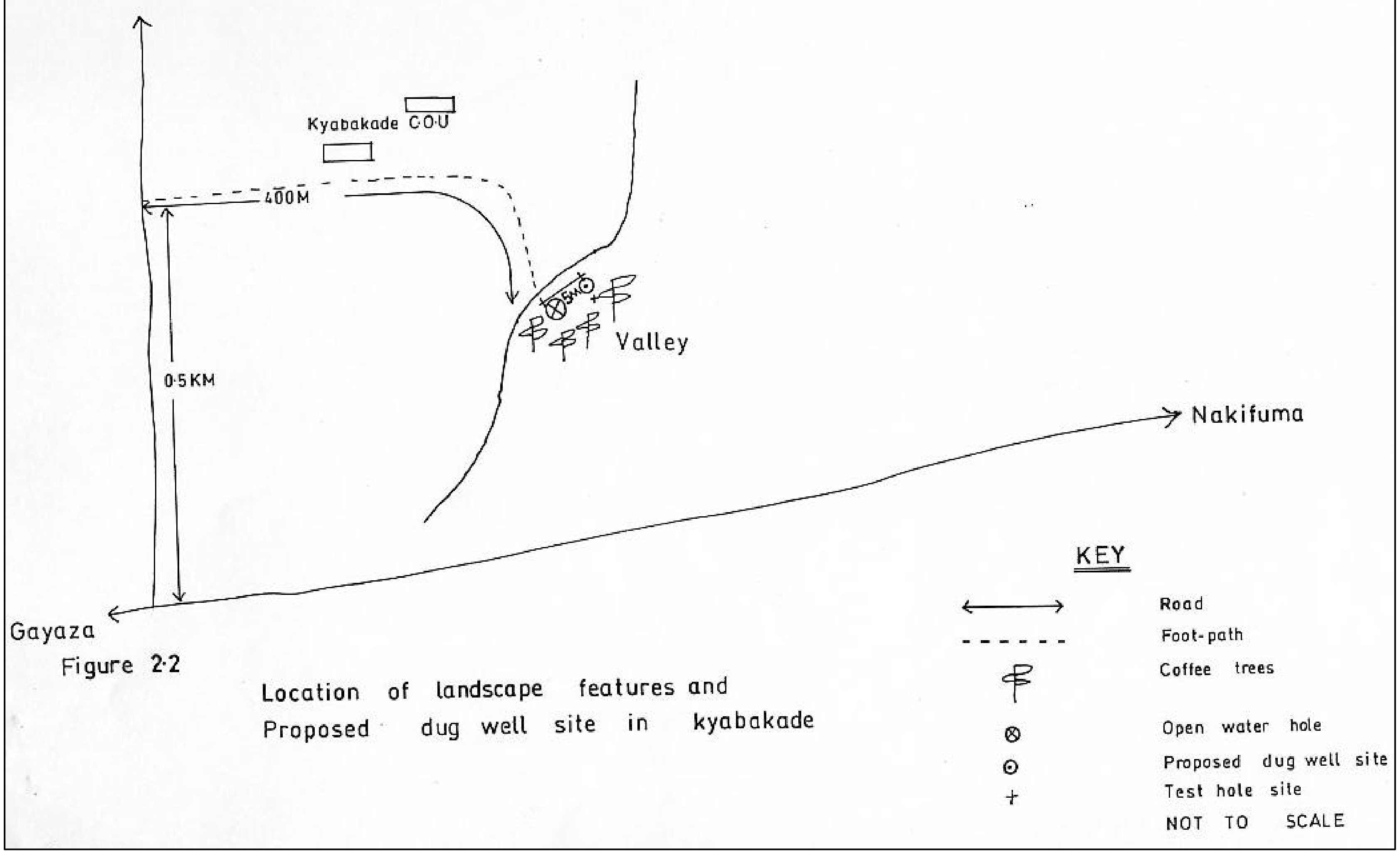


Figure 2.2

Location of landscape features and Proposed dug well site in kyabakade

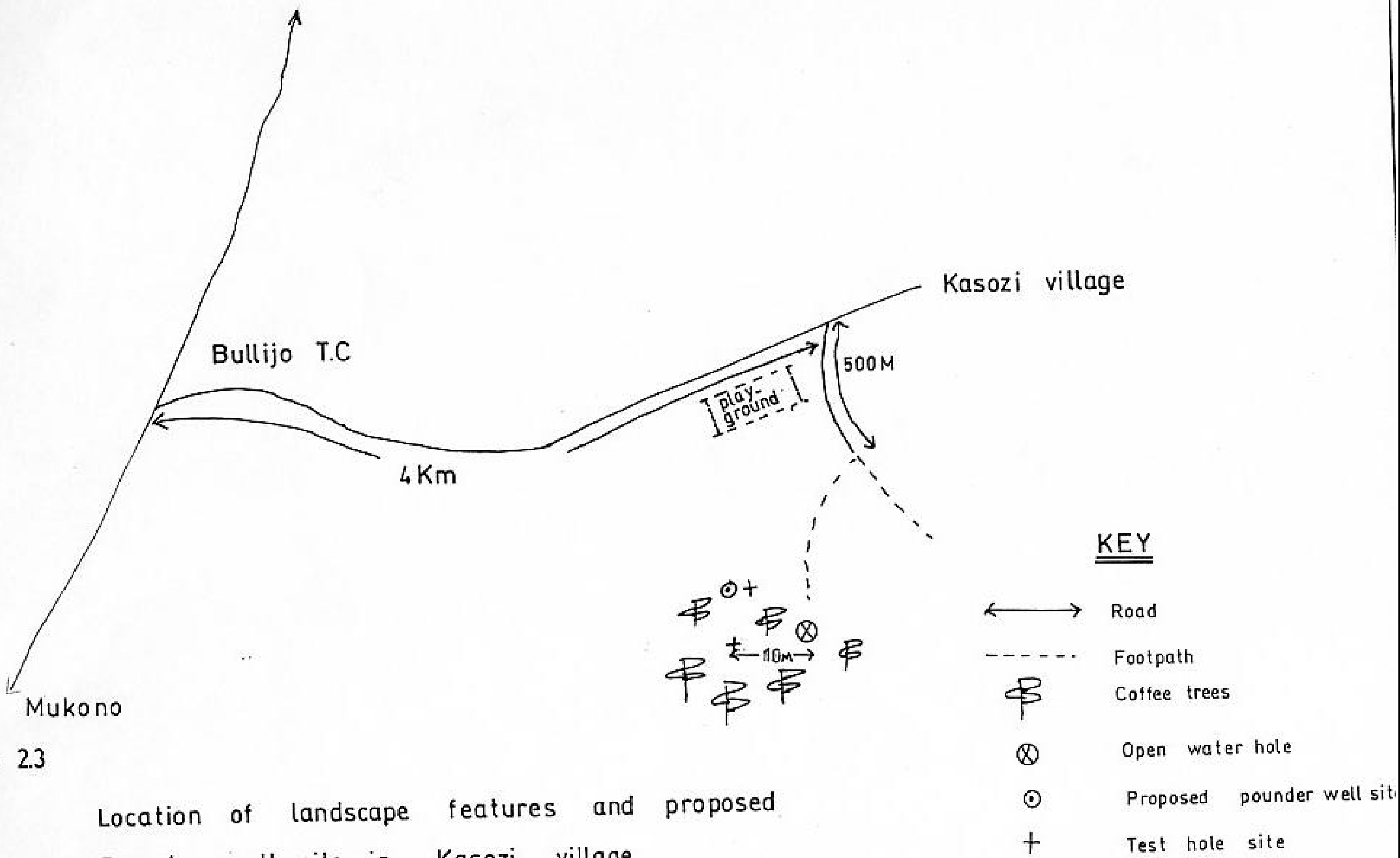
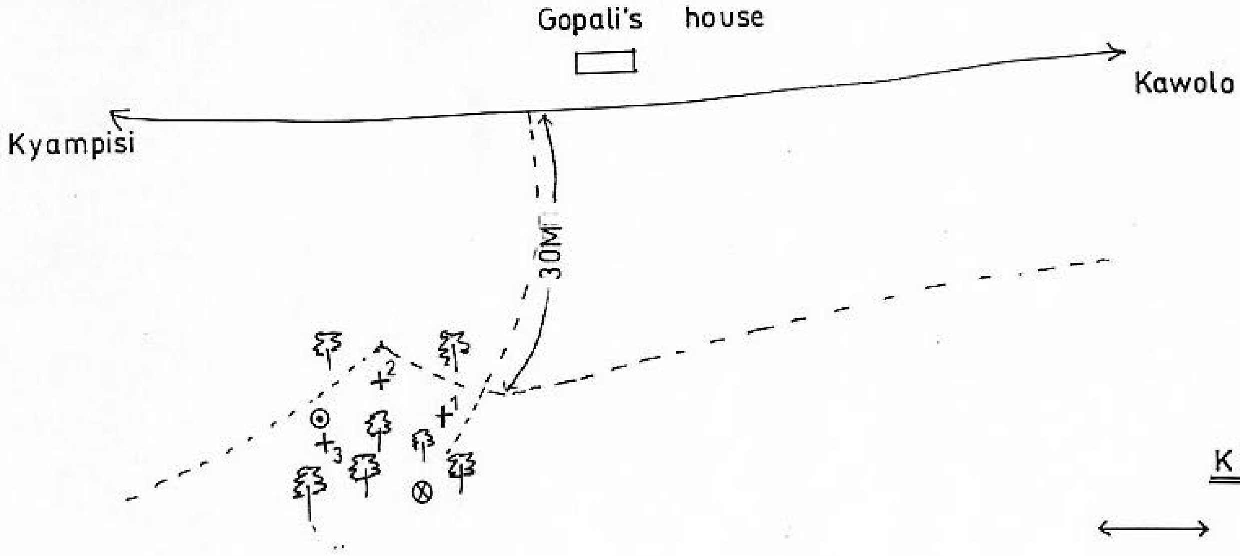


Figure 2.3

Location of landscape features and proposed Pounder well site in Kasozi village



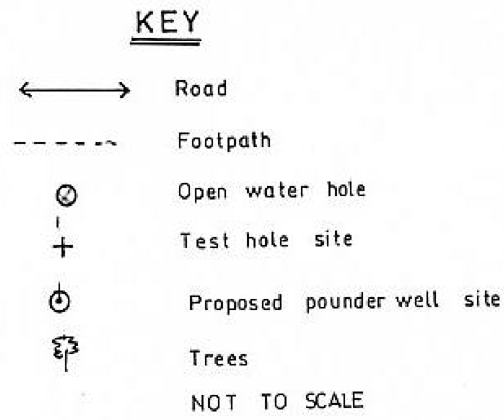


Figure 2.4

Location of landscape features, test hole sites And proposed pounder well sites in Ntunda village

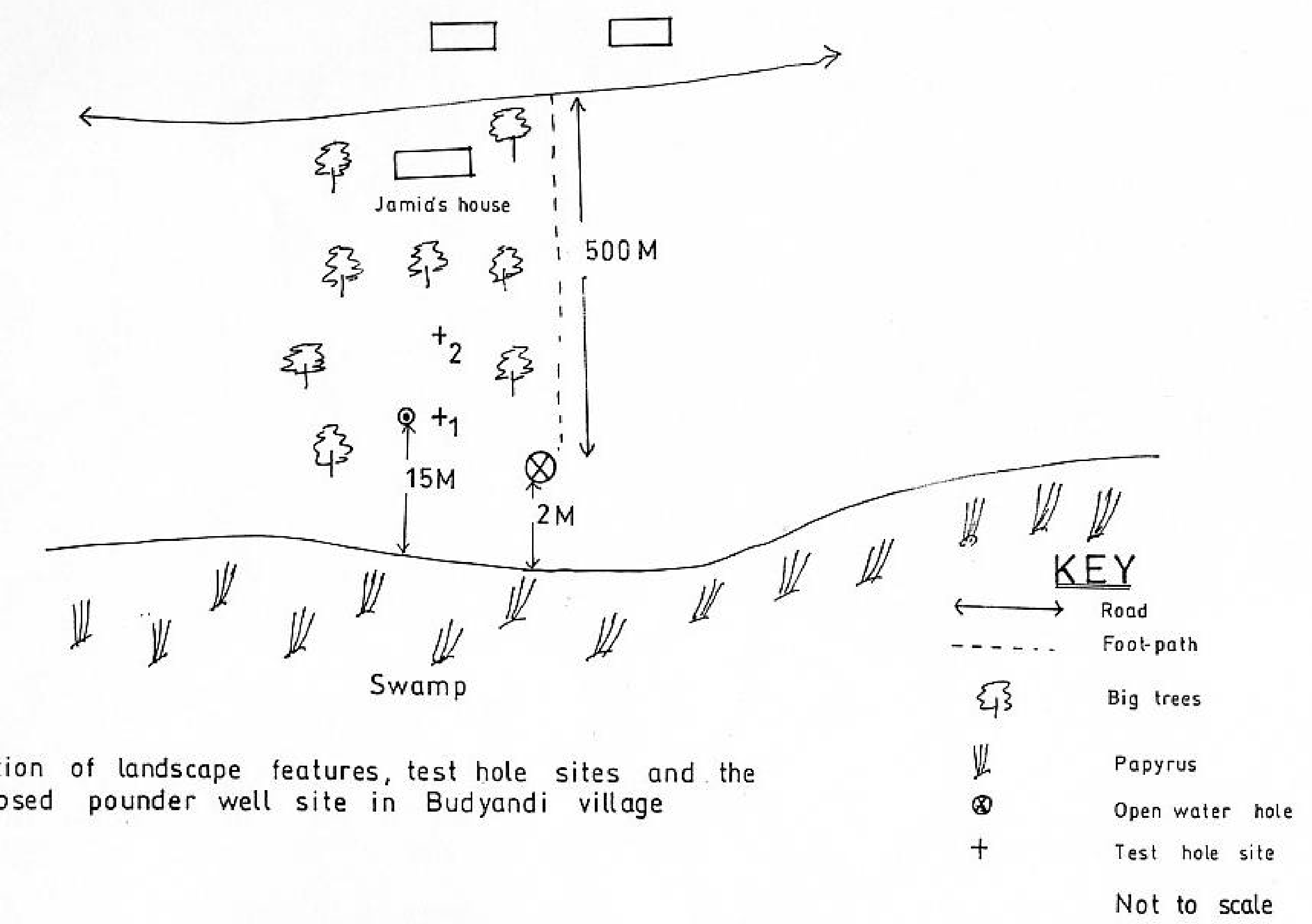


Figure 2.5

Location of landscape features, test hole sites and the Proposed pounder well site in Budyandi village

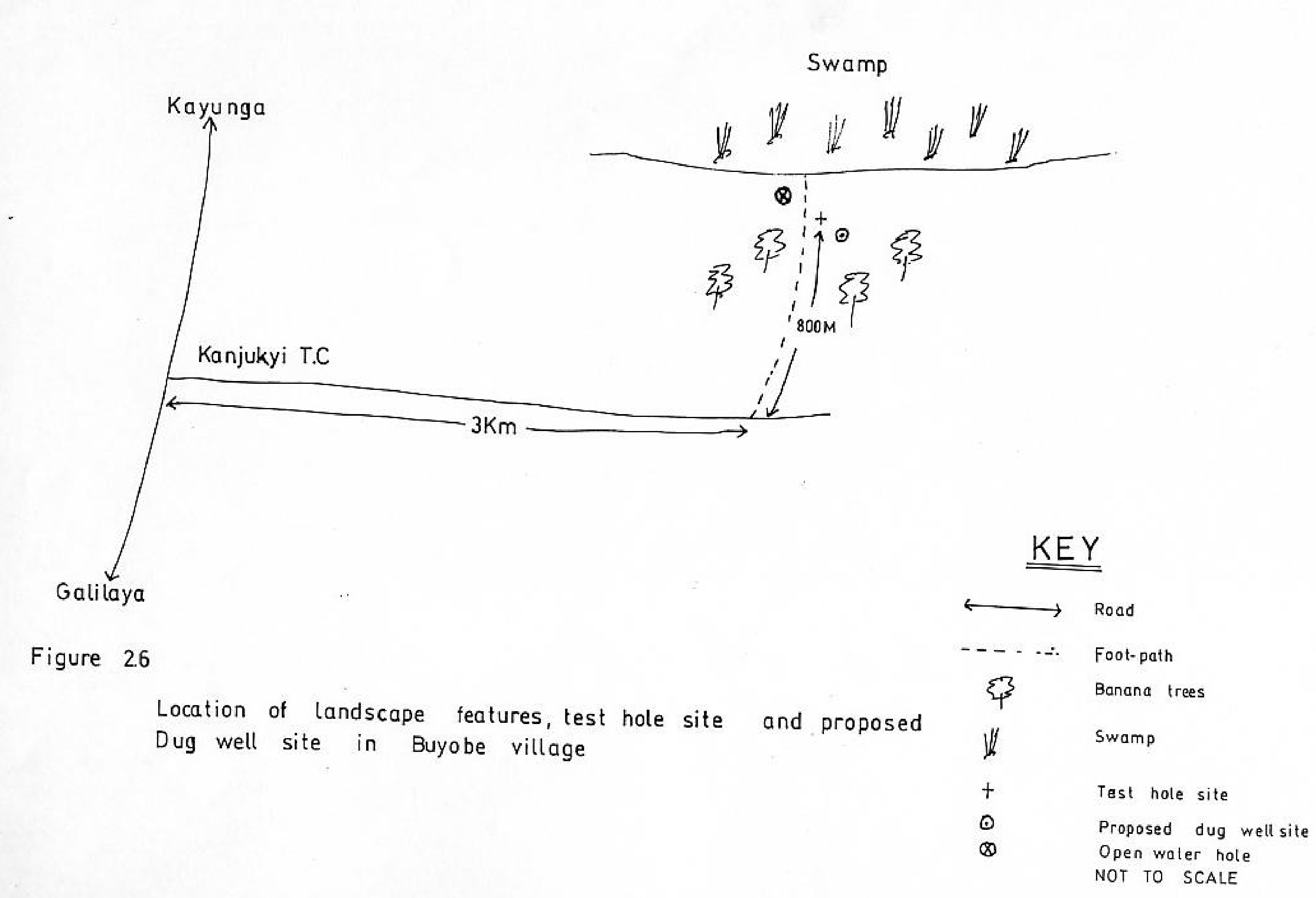


Figure 2.6

Location of landscape features, test hole site and proposed Dug well site in Buyobe village

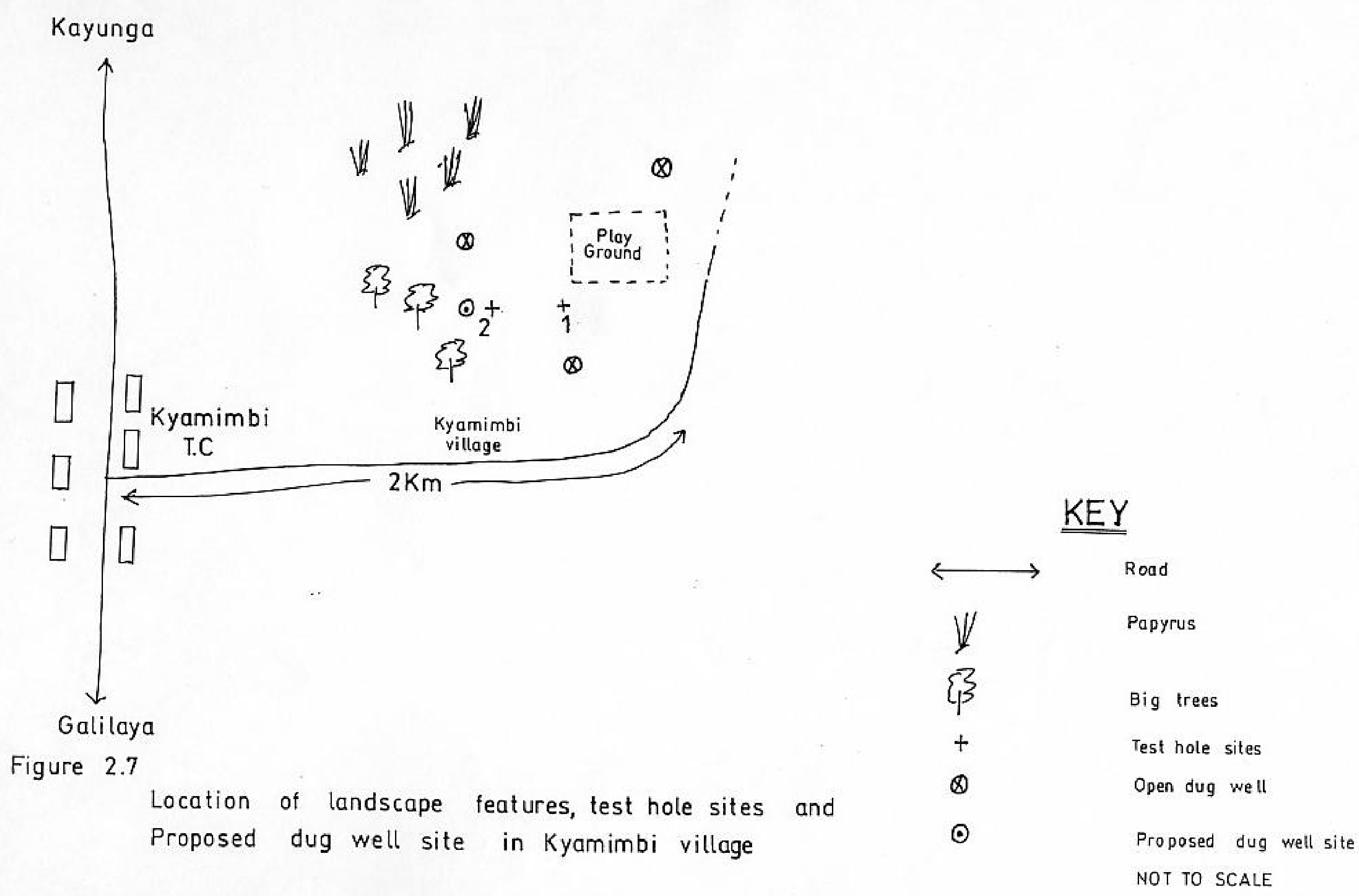


Figure 2.7
Location of landscape features, test hole sites and Proposed dug well site in Kyamimbi village

5.8 References

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6 A REVIEW OF THE SITING METHODS FOR THE POUNDER RIG IN UGANDA, JUNE 2001

By A. Luutu

6.1 Introduction

Groundwater is the main source of potable water in rural areas of Uganda. The current national rural safe water supply coverage is estimated at around 46%. Provision of ground water through traditional methods of drilling deep boreholes is very expensive and cannot be afforded by the local communities unless funding is done by either the central government or external funding. Efforts involving development of simple and low cost technologies such as hand dug wells, auger well and spring protection have been carried out in the last few years by government and various external support agencies and NGO's. However, these low cost technologies have not fully gained the required acceptance by both communities and the policy makers due to the low success rate. The success rate for shallow wells depends on a number of factors, which include the following:

- siting method applied,
- ability of the rig to penetrate hard laterite horizons,
- knowing whether there is water or not, having enough water,
- stopping water supply loss and
- Ability of the method to stabilise collapsing formation to achieve proper well construction.

In order to improve the shallow well technology and make it acceptable, a low cost water well drilling project was started in 1998. The project is implemented by the Institute of Water and Environment Cranfield University Silsoe. The project is funded by UK government Department for International Development (DFID), with supplementary funding from Danish International Development Agency (DANIDA). As a result of the project a prototype low cost-drilling rig (Pounder rig) was imported in Uganda in 1999 to start field trials. The Pounder rig is capable of penetrating hard laterite formations. This gives it advantage over other shallow well drilling technologies, and with appropriate siting methodology the rig can improve the water coverage in the country.

The success of any drilling technology is only feasible when the site is suitable hydrogeologically (permeable regolith/fractured bedrock with enough water), geographically (acceptability to the community, suitable water quality for human consumption), and logistically (being able to reach the site with the drilling equipment). Inappropriate siting of water wells coupled with high expectation of successful water sources due to general lack of understanding of hydrogeological principles can result in loss of faith in the capability of the drilling equipment. This will lead to morals among communities, contractors and clients. The development of an appropriate siting methodology for Pounder wells has been one of the major challenges for the Low Cost Drilling Project. The project has developed and tested siting methodology based on the existing methodologies in Uganda. The aim of this report is therefore to review the siting methodology developed in light of the drilling experience and recommend suitable drilling regions/districts for the Pounder rig.

6.1.1 Terms of reference

The terms of reference of this study are:

- Review Pounder drilling experiences and identify the hydrogeological capabilities and limitations of the method

- To review the Pounder siting methods undertaken to date, compare them with the siting methods undertaken nationally for other sources, draw out lessons learnt and make recommendations for an appropriate siting methodology for Pounder wells.

- Relate Pounder capability and limitations to known hydrogeological regions of Uganda

6.1.2 Experiences and Limitations of the Pounder rig

The Pounder rig has been tested in Mpigi, Mukono,Jinja and Katakwi with varying success. The experience gained with the rig indicates that it is much faster than hand augering. Generally hand augering takes atleast 5 days to complete one well, while the speed varies from 2 days to 5 days. In some instances it has drilled 13m in a single day, this implies that the rig drills very fast in clay and soft material. The rig also has the ability to penetrate hard formations. If drilling is carried out with 100mm diameter bit (largest ponder rig bit), it allows direct installation of a handpump (i.e. rising mains doubles as casing, and well screen attaches to the bottom of cylinder as a tail pipe) If hydrogeologically suitable site (shallow water table and permeable regolith) are selected, the rig can therefore give good success. The results of water quality monitoring at five sites in Mpigi district show that the Pounder wells have slightly better bacteriological water quality that the auger wells. Although the rig has the advantages mentioned above, it has some limitations as observed from the Mpigi field trials and the commercial drillings in Mukono, Jinja and Katakwi.

Limitations of the Pounder rig

- The penetration rate in the hard laterite horizons is rather low, and in some cases gravel is also difficult to penetrate. During the hard rock test, the rig was only able to drill 2 m in a day. This means that a lot of time would be spent on one hole. Therefore time and cost prevent more than a few metres of such material being drilled.

- Most of the wells constructed during the Mpigi field trials and the commercial drilling are rather shallow 3 – 7m. This may cause a problem of water quality once the sanitation within the neighbourhood is not good. Very shallow wells may also allow infiltration of rainwater, which makes water turbid after rain. Such a problem has been observed in hand augered wells.

- The work in the four districts shows very few cases where the holes exceed 20m. It is probable there may be significant problems to drill beyond 20m. This because in all cases reaming of the wells has not even reached the drilled depth. However it is not clear whether greater depth were not achieved due to the hydrogeological conditions of the selected sites. there is therefore no experience gained if the water at a site is deeper than 20m, and the likely problems such as stabilisation have not been dealt with in trials.

- The drilling equipment requires a hydrostatic head (3m above the rest water level) to support the walls of the hole. This may be very difficult to achieve in a drilling program at all the sites, and a modification needs to be sought. An alternative of temporary casings could be assessed. The temporary casings for the rig were imported in the country but have not been used during the filed trials due to availability of funds. Their use could possibly help in finding a solution to dealing with very fine formations containing micas and also the turbidity problem. The bailer flaps which could be used to stabilise the hole during drilling have also never been tested.

- The rig action appears to put a high suction force at the drill bit face, which is very likely to pull in both the walls and the flow. To prevent the collapsing of the drill hole, keep the required head, avoid water loss and create low circulation of water, polymer was used. When the formation is too porous fibre is added to assist in the blocking of the very porous zones. There may be a problem in that the fibre may permanently block water production and effectively block any well screen.

- As the rig uses water during the drilling, it requires good hydrogeological experience and knowledge of the aquifers in Uganda to be able to identify productive zones. While it is difficult to understand the productive zones, the knowledge to point out such zones is lacking in the drillers. In addition there is no information about the regolith permeability in Uganda. If the cuttings are not properly described, a good production well may be declared low yield or dry due to poor well design. The aquifer zones such as sandy clay, silty clay, and gravely clay needs to be properly identified.

- Some of the sites drilled by the Pounder rig were selected using hand auger test drilling equipment. Since the equipment cannot penetrate hard laterite, potential site may be discarded. In addition many test drillings may need to be carried out, increasing the siting costs. Since the test hole site is a few metres from the actual Pounder site, the problem of encountering large boulders/hard gravel during drilling remains a major concern. There are also problems of knowing whether the formation is very hard and, whether there is water.

- The test pumping method using the suction pump and measuring recovery is not well laid out and it's not clear how close are the estimates to the actual yield of the Pounder wells. If the formation is not very stable, the hole may collapse and the drilling string and other drilling equipment may be lost. The in-situ test pumping method has the same problems but has been neither tried in the Mpigi field trials nor in commercial drillings. There is also a problem of installing wells with no/very little water since the results of test pumping cannot be trusted, and this means loss of the pump.

- The ponder rig was used as testing rig in Katakwi two out of the three holes were too difficult to penetrate. The third hole was very shallow and was turned into a dug well. Although the costs of testing using the Pounder well may be between 10-15% of the cost of a successful well, the cost of the wells is likely to be high if many trials/tests are carried out. The question of how many tests should be tried before the site is abandoned is critical in keeping the Pounder wells at a low cost.

6.2 Review of the siting methodology

6.2.1 Introduction

As mentioned earlier, development of an appropriate siting methodology for any type of drilling is very important and crucial to the success of any drilling project. In view of this, the low cost drilling project engaged Mr. Callist Tindimugaya to develop, a siting methodology for the Pounder rig. In his report, (development of a siting methodology for Pounder rig well drilling in Uganda January 2000), a review was done on the current shallow and deep well siting methodologies being used in the country. Shallow well technology being relatively new in Uganda the methodology employed by different organisations were different, and had minor differences from the one used for deep well siting. The Directorate of water development methodology involves 4 steps, namely; desk studies, field reconnaissance and water source mapping, detailed hydrogeological investigations, and data analysis and interpretation.

The Ruwasa methodology involves a participatory rural appraisal (PRA) leading to development of village maps where areas of hydrogeological potential are denoted. The actual siting is done in nine steps, including;

i Establishment of the District Water Resources File in order to evaluate if the resources can sustain the requirements.

ii Establishment of sub-county water resources file -, which includes relevant information in the database and the sub -county map of all known protected sources.

iii Introductory meeting at sub-county level- to brief the local councils about hygiene education, sanitation, water programmes, and allocated water point sources by the district.

iv Meeting the LCIII Council on water source allocation- to inform/determine and explain the number of sources per parish, the technologies that may be used and the role of the communities.

v Village/User identification and verification- identification of all the water sources in the village.

vi Identification of areas having hydrogeological potential locations.

vii Village selection of areas for detailed investigations.

viii Detailed hydrogeological investigations of selected areas.- using geophysical methods, mainly resistivity surveys.

ix Finalisation of village files and sub-county water resources report

For details of these steps reference should be made to the report "Development of a siting methodology for Pounder rig well drill in Uganda. (Callist Tindimugaya, January 2000)". The Non government organisations were found not to follow up any clearly set out methodologies, but based their shallow well locations on identification of features, which indicate availability of shallow groundwater. Some were found to use test drilling in site selection. The district water offices were found to follow the similar methods like the Non government organisations.

The nine step shallow well methodology employed by RUWASA seems elaborate, rather expensive and need time to accomplish all the steps. Therefore, highly qualified personnel with quite specified equipment can only implement it. The RUWASA methodology however creates a sense of ownership in the communities from the beginning, as the community makes the village map. For low cost drilling it seem rather inappropriate. The other organisations, due to lack of proper guidelines for siting, sometimes put water sources very far from the people, and in some cases in swamps and valley bottoms to reduce failure. It is against this background that the low cost-drilling project engaged Mr. Callist Tindimugaya to develop an appropriate shallow well siting methodology for a Pounder well.

6.2.2 Main aspects of the methodology developed for Pounder rig

The siting methodology for the rig was aimed at achieving high success rate, while at the same time keeping the siting costs low. The methodology developed had three different stages, namely;

- Detailed desk studies- to understand the hydrogeological situation of the area of interest and plan further investigations.
- Field reconnaissance and water source mapping - collect relevant information about present water supply conditions, field observations and interviews with the community about the shallow water sources, to get idea about the depth of aquifers, possible difficulties encountered, and whether wells are perennial.
- Test drilling- to get idea about the soils and the lithologies to be encountered during drilling and the depth to water table.

6.2.3 Results obtained using the siting methodology above

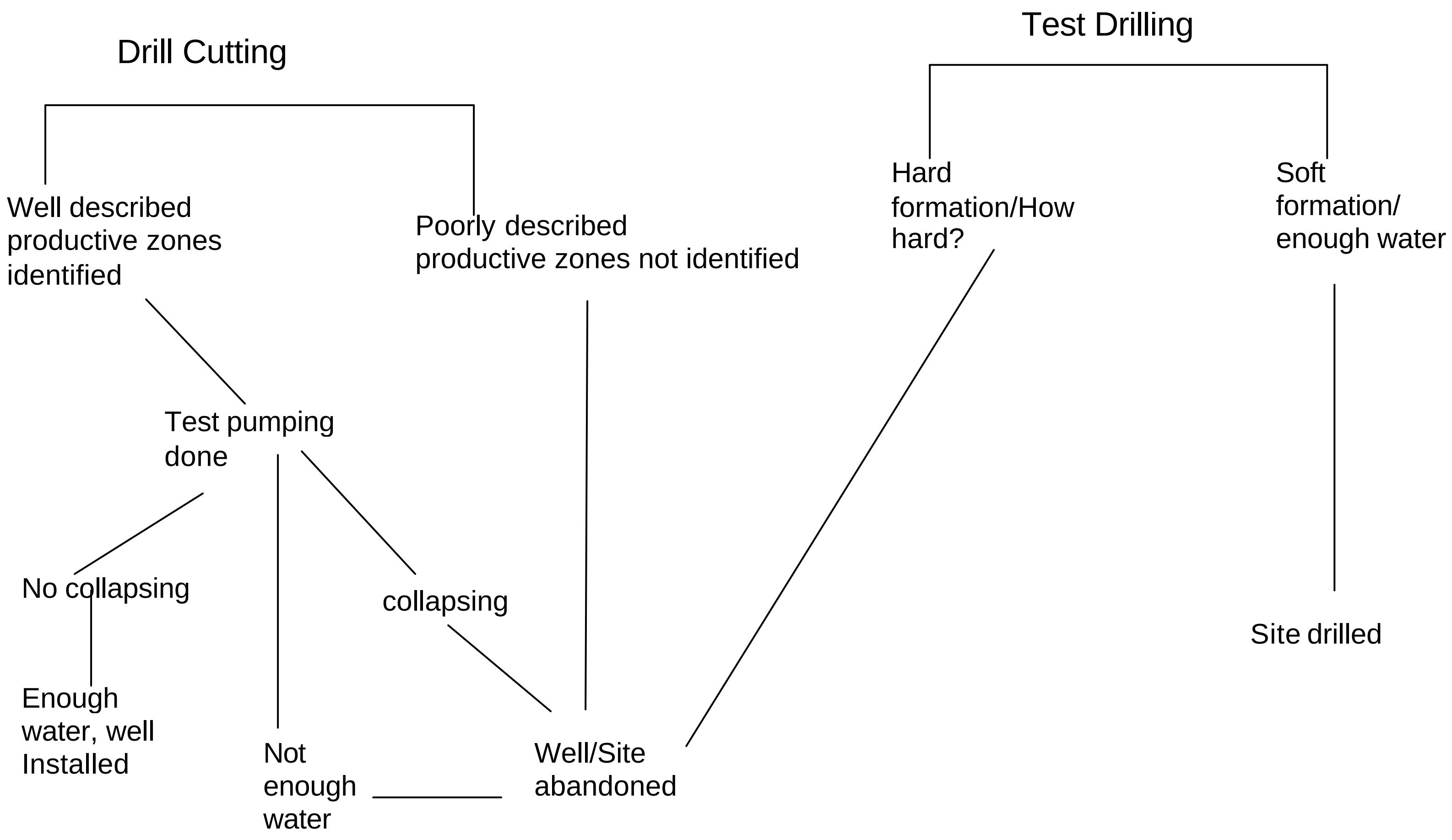
In Mpigi district, 7 trials were made, with fairly good success before the siting methodology was developed. Out of the seven, five wells were successfully completed. It should be noted that the crew was still learning the new technology. The water quality of these wells is being monitored, and the results obtained so far indicate that the water quality is fit for human consumption. Five hand augered wells within the same location have also been monitored and the results show slightly high bacteriological content. The separate report titled: Water Quality Data for Five Pounder Well and Five Hand-Augured Wells in Katabi Sub County, Mpigi District, Uganda shows comparison of the bacteriological water quality for Pounder and auger wells for a period of one year.

Using the above methodology 4 sites out of eight locations were suitable for the Pounder rig. Unfortunately only 2 sites were drilled and one was successfully completed. Therefore no conclusions can be drawn from these two attempts.

In Jinja, one hole out of three was successfully completed. The selection of the sites was mainly based on reconnaissance, RUWASA database and resistivity. It similarly difficult top to draw sound conclusion from only three sites.
In Katakwi the Pounder rig was used as a test rig for locating places to make dug wells. At all the three attempts, hard formation (bedrock and Gravel), that was difficult to penetrate, was encountered at varying depth. The first two holes were abandoned and the third was successful, but the owner preferred to have it as a dug well since it was very shallow (2.7m).

Although no firm conclusions can be drawn from the results of the drillings using the proposed siting method, as the drillings were very few, it methodology could possibly yield good results, and needs to be further tested. As mentioned before, that the success of any drilling depends not only on good siting methodology but also on appropriate well design. There is no reference in any of the reports about the well design being used. Probably better success could have been obtained with a properly set out design. Part of the decision making process during drilling is shown in Figure 1 below.

Figure 1: Part of the decision making process in shallow well drilling



6.3 Pounder rig and hydrogeological regions of Uganda

Information about shallow wells in Uganda is scanty, and is not available in the national database in Entebbe. The potential for shallow wells is therefore very difficult to assess and the summary of information where shallow technology is feasible has been obtained through the following means:

- Available literature on water sources in Uganda
- Interview with people who have worked/ visited the various districts.
- Taking to District water officers
- Discussions with Non government organisations who have worked in some of the districts.
- Personal experience while working in some of the districts

Table 1 gives a general overview of the shallow well potential in Uganda. In areas where more data is available and shallow well drilling has been done in the past, particular sub-counties within a particular district have been specified. This means that the other sub-counties have not been found very suitable by the past shallow well drilling projects or have shallow wells have not been tried there. Again it is important to stress that these are only for guidance as there may also be other areas in the district where shallow well technology is feasible but has never been tested. Where little information is available, regions of the district have been sited where shallow well technology can be implemented. This has been mainly based on consultant's experience in those areas and the discussions with the informants.

The General comments about the potential have been based on the criteria mentioned below and the information obtained from various people and non-governmental organisations who have worked in those districts. By the time of writing this report more new districts have been formed, where those are not mentioned, they are counted together with the old districts, as the information available is based on the old districts. Generally, shallow well potential is highest in the basement complex rocks compared to the rest of the geological formations in Uganda. These due to the fact that the basement rocks are the oldest and therefore weathered and fractured. The description of the shallow well potential has been based on the following criteria;

- High water levels and regolith permeability at shallow depth.
- High water levels (saturated zones) may occur frequently at the margins of depressions and in valleys, where springs are also found. The permeability is generally highest where the bedrock is fairly coarse grained
- Weathering products/ where no very fine materials such as micas are expected.
- Relatively thick permeable regolith
- Thickness of laterite layer- believed to be formed due to infiltration.

- Table 1: Suitable shallow well regions/districts (source: Uganda Water Action Plan, Rapid Water Resources Assessment, RUWASA Project Water Resources Assessment Surveys Reports and interview with individuals)

District	Region/sub-county	Source of information	General Comments
Mukono	Kayunga,Ntunda, Kasawo, Kangulumira, Kauga,Goma,Nakisunga, Ngogwe, Seeta-Namuganga,Nyenga	Ruwasa Water Resources Assessment Report/Angella Bwiza/Deliverance Church Kampala	Medium potential – most of the southern part of the district, has fairly thick and permeable regolith. The northern part of the district and parts near lake Kyoga lie in the dry belt.
Jinja	Buwenge,Butagaya, Mafubira,Budondo, Busedde, buyengo	Ruwasa Water Assessment Reports/Angella Bwiza	Medium potential- Most parts of the district have fairly permeable regolith, and shallow water table. Some parts near Kakira, have highly weathered fine materials and are unsuitable
Mpigi	Most parts of the district. Mutuba 1 Mpigi, Katabi, Bunjako	District water office/DWD-Drilling supervisor/World Vision International	High potential- most parts of the district have permeable regolith and shallow water table. The topography is well pronounced and its easy to identify areas for shallow well drilling. However there are some parts of the district such as Entebbe where, the regolith has very low permeability.
Luwero	Southern part of the district	District Water officer/DWD-Drilling supervisor/World Vision International/Deliverance Church Kampala	Medium potential- fairly permeable regolith and shallow water table in low lying areas. The northern part lies in the dry belt.
Nakasongola		District water officer/DWD-Drilling supervisor/DWD-Principal hydrogeologist	Nil –low potential- the district falls in the dry belt.

Kamuli	Buzaya County; Nawanyago, Kitayunjwa, Wankole, Bugulumbya, Butansi, Kisozi.	RUWASA Reports/Assistant District water officer/DWD- Drilling supervisor.	Low to medium potential- most parts of the district are covered by laterite and in some areas the bedrock is shallow. Where shallow wells have been tried, the regolith is fairly permeable. The northern part of the district along Lake Kyoga falls in the dry belt.
Iganga		Ruwasa Reports/Angella Bwiza/DWD-Drilling supervisor	Low potential- most parts of the district are covered by laterite, and in some areas the bedrock is very shallow.
Bugiri	Buswale, Kapyanga, Sigulu	Ruwasa reports	Low potential- shallow bedrock. Most parts of the district are covered by laterite
Pallisa	Bulangira,Agule,Pallisa, Puti-puti,Kaderuna,Butebo, Kibale	Ruwasa Reports/ District water office	Medium potential- the regolith is relatively permeable. Some of the northern parts of the district lie in the dry belt. Most parts of the district are covered by laterite
Tororo	Lumino,Buhehe,Wasafu, Dabani,Buteba,Mulanda, Kwapa, Mukuju, Rubongi,Kisoko, molo,Kirewa	Ruwasa Water Resources Assessment Reports/Angella bwiza	Medium potential- big part of the district covered by laterite, where shallow wells have been tried, the water table is rather shallow and the regolith is permeable.
Mbale	Bulambuli, Bungokho, Bugobero, Bumwoni, Buhugu,Butandiga	RUWASA Water resources Assessment reports/DWD-Drilling supervisor/Deliverance Church Kampala	Medium potential- fairly permeable regolith with shallow water table, most parts of the district covered by laterite.

Busia	Buteba,Masafu,Masaba Busitema	DWD-Drilling supervisor/Angella Bwiza/Deliverance Church Kampala.	High potential- shallow water table and high regolith permeability
Kumi	Eastern Part of the district, Bukedea area.	Based on Geological information and climatic conditions, DWD-Drilling Supervisor	Low potential- part lies in the dry belt
Kapchwora	Ngenge, Namalu	Based on Geological and climatic information/DWD-Drilling supervisor	Low potential- only along river beds in the south. Other areas topographically unsuitable. Hill sources such as gravity flow schemes and springs are prefered.
Soroti	Some parts of the district	Rapid water assessment report/DWD-Drilling supervisor	Medium potential- shallow water table and fairly permeable regolith. Laterite covers most parts of the district.
Katakwi	Most parts of the district	Water Aid/District Water officer/DWD-Drilling supervisor	Medium potential- shallow water table. Laterite cover in many parts of the district,
Moroto	South-near Mbale,namalu area	DWD-Drilling supervisor	Low potential, part of the district is in the dry belt, possible along river beds
Kotido	Along river beds/extreme North west and extreme south east near Rwamuge, Abim Area	DWD-Drilling supervisor	Low potential-water levels deeper than 30m

Apach	All district	District water officer/DWD Drilling supervisor/Manager Aquatech/Patric Nyeko/ Deliverance Church Kampala	Medium potential- shallow water table and highly permeable formation
Lira	South and Eastern part of district	DWD-Drilling supervisor/Manager Aquatech/World Vision International/Patric Nyeko/Deliverance church Kampala	Medium potential- Laterite cover, shallow water table and good permeability of the regolith
Gulu	Southern Parts of Gulu	DWD-Drilling Supervisor/World Vision International/Deliverance Church Kampala	Medium potential- Laterite cover, fairly good permeability of the regolith
Bundibugyo	Lower parts of the district	DWD-Drilling supervisor/HEWASA	low potential –low permeability of the regolith/ large part is National Park
Kitgum	Southern part of the district	DWD-Drilling supervisor/Manager Aquatech	Medium potential- laterite cover, high permeability of the regolith.
Moyo	Near river banks/extreme south boarder with Gulu	DWD-Drilling supervisor	Low potential- laterite cover,low permeability of regolith
Arua	South and western part of the district	DWD-Drilling supervisor/Patrick Nyeko	Medium potential- laterite cover, shallow water table.
Nebbi	Parts of the district	DWD-Drilling supervisor/World Vision international/Patric Nyeko	Medium potential, laterite cover, shallow water table.

Masindi	Biiso,Bwijanga, Masindi Town council, Kimengo, Pakanyi Miirya,Kigumba, Kiryandongo,	Masindi Water master plan/District water officer/DWD-Drilling supervisor	Medium potential- shallow water table and high permeability of the regolith in the district except rift valley and dry areas around Mutunda.
Hoima	Most parts of the district	District water officer/DWD-Drilling supervisor	Medium potential-areas covered by laterite. The areas near Kiboga,-poor regolith permeability, the Kafu belt and the rift valley areas are unsuitable. Generally deep groundwater within the rift valley.
Kiboga	Small areas near Mpigi	Based on Geological and climatic information/DWD Drilling supervisor	Low – Medium potential- areas towards Hoima lie in the dry belt and shallow well is not a feasible option.
Kibaale	Areas near Hoima and Mubende	Based on geological and climatic information/DWD-Drilling supervisor	Low potential- fair permeability of the regolith. Areas near the rift valley are unsuitable. The sediments have very low permeability.
Mubende	Some Parts of the district	Based on geology and climatic information/DWD-Drilling supervisor	Low –Medium potential- well pronounced topography, shallow water table. Some parts of the district lie in the dry belt and are unsuitable.
Kabale		DWD-Drilling supervisor/DWD-Principal Hydrogeologist	Low potential, most of the areas are topographically unsuitable, topographically low areas have springs.
Kabarole	Parts of the district	Water AID/DWD-Drilling Supervisor	Medium potential- shallow water table, fairly good permeability of the regolith
Mbarara	Muzizi catchment, Kashari area and Rukinga	Accord /DWD-Drilling supervisor	Low –Medium potential –areas which are topographically low, success has been achieved in Rukinga and Kashari

Bushenyi		District water officer/DWD-Drilling supervisor/DWD-Principal Hydrogeologist	Low potential- topographically unsuitable/iron content high in the shallow waters
Rukungiri	South and central part of the district	DWD-Drilling Supervisor	Low potential- topographically unfavourable. Hilly sources springs and gravity flow schemes are preferred.
Masaka	Parts of Sembabule and Kalungu area	Based on geological and climatic information/DWD Drilling supervisor/DWD Principal Hydrogeologist /Deliverance Church Kampala	Low potential-poor permeability of the fine grained regolith
Rakai	Some parts of the district with non-uniform sediments.	Based on geological and climatic information/DWD-Drilling supervisor/Deliverance Church Kampala	Low potential-poor permeability of the fine grained regolith
Kisoro	Western and north-western parts.	DWD-Drilling supervisor	Low potential- due to topography –hilly sources- gravity flow schemes and springs prefered. Presence of volcanic rocks (possibly with low permeability?).
Adjumani	Most parts of the district	DWD-Drilling supervisor	Medium potential-shallow water table and permeable regolith.

General comments

As mentioned above, various sources have been used to compile this information, and in some districts/regions, the information is very scarce. The terms low, medium and high potential are explained as follows:

Nil to low potential-Districts most parts of the district lie in the dry belt/ the regolith has low permeability/ the topographic conditions are not favourable.

Medium potential- districts with large areas suitable for shallow wells. With fairly good permeability of the regolith and shallows have been constructed with fairly good success in that district.

High potential- Districts with large areas having shallow well potential and shallow water table and a regolith with high permeability. Shallow wells have been constructed with good success.

The potential for shallow wells is influenced to a large degree by the geological, climatic and topographic conditions of the district. The districts in the Buganda-Toro and Karagwe-Ankolean , due to the low grade metamorphism ,the weathering of the rocks produces very fine regolith with poor permeability. The areas close to the rift valley have sediments, which are similarly fine and have poor permeability and the water levels in most cases are deeper than 30m.

Some areas such as Nakasongola, northern Mukono, part of Kiboga and Hoima, part of Luwero and Mubende, part of Kumi and Moroto and part of Mukono lie in the dry belt and there is nil- very low shallow well potential. The success rate for deep boreholes in dry belt is also low compared to other parts of these districts. These areas (dry belt) will soon be studies and defined clearly by the water department. The low potential of these areas is possibly due to the low permeability of the thick regolith, low recharge, and deep water levels. In parts of Masaka and Rakai, due to non-uniformity of the sediments, some areas covered with sediments have good shallow well potential. In topographically unsuitable areas, hilly sources-gravity flow schemes and springs are preferred.

6.4 Conclusions and recommendations

The development of the low cost drilling Pounder rig has had success. Based on the work done so far, the following comment conclusions and recommendations can be made;

- The rig has the capacity to drill fast in clay and soft materials, and has been able to drill up to 20m deep. It is faster and can drill deeper than hand augering. Since the rig is expected to drill up to 30m, it is recommended that some tests be carried out to that depth, to determine the rig's full potential and capacity.

- The rig is capable of penetrating laterite and rock, but time and cost prevent more than a few metres of such materials being drilled. In addition the human power capacity limits drilling in hard formation.

- The requirement of hydrostatic pressure of 3 m above the water table makes it difficult to for the rig to operate in areas, which have shallow well potential but are rather flat with shallow water table. The modification of the equipment to use temporary casings could solve this problem. It is therefore recommended that further tests be carried out using the already available temporal casings.

- The siting methodology developed for the Pounder rig is sufficient and can yield good results, however, the following needs to be emphasised;

- The reconnaissance should be given more time in siting and as much as possible information gathered from the communities. This makes it possible to integrate the data from desk studies improving the chances of selecting the most potential sites. if sites with very hard formation can be avoided through information gathering, then the technology will have very high success.

- The communities should be involved not only at the site selection stage but also during drilling, they could do some of the activities such as providing water etc. This will enhance the sense of ownership.

- Well success does not only depend on proper siting but also well construction. Unless proper sample description is carried out and appropriate well designs are prepared and implemented, potential site may be declared low yielding or dry due to failure to identify the aquifer zones.

- While the use of the hand auger testing equipment gives an idea of the formations and the water table at the site, its inability to penetrate the hard laterite horizons makes it unsuitable where such horizons exists. Unfortunately, there is wide distribution of laterite in most parts of the country. Since it is not a feasible option to develop a test Pounder rig, as it would also not be able to penetrate deep due to the small size of the drill pipe, the Pounder rig should be used for the testing. It is recommended that the number of testing should be limited to three to avoid increasing costs.

- The site selection should be done by a qualified person, who should also supervise the drilling activities. During this process the drilling crew should be fully involved to enable transfer of knowledge.

- The conclusions especially on siting are rather preliminary since little testing has been carried out. It is further recommended that more sites are identified, and further testing be done.

- The tests done in the districts of Mpigi, Mukono, Jinja and Katakwi reveal that once hydrogeologically suitable sites are selected, and proper logging is carried out, the rig will improve the clean and safe water coverage in Uganda.

- It is further recommended that the water quality monitoring of the water sources be continued to truly establish the water quality of the Pounder wells as compared to augered wells.

- A procedure for estimating the yields of the Pounder wells should be prepared and implemented for the proper assessment of the well success. The problem of collapsing of the drill hole during test pumping should be addressed otherwise good wells and tools may be lost in case the well collapses.

6.5 TERMS OF REFERENCE FOR REVIEW OF SITING METHODOLOGY AND RECOMMENDATIONS FOR SUITABLE DRILLING REGIONS/DISTRICTS

BACKGROUND

Inappropriate siting of water wells, coupled with high expectation of successful water sources and a general lack of understanding of hydrogeological principles can lead to loss of faith in the capability of drilling equipment, and reduced moral among communities, contractors and clients. In addition, the current environment of non-payment for dry wells, and payment of a fixed sum for successful water sources, can result in financial loss for the private contractors if too many wells are dry or involve difficult or lengthy drilling. The capabilities of the Pounder Rig are such that the machine is capable of drilling in a wide range of formations, with the result that the variation in cost of drilling is significant. Significant financial losses are likely to reduce the interest of the private sector in water source provision.

The development of an appropriate siting methodology for Pounder Wells is thus one of the major challenges faced by the Low Cost Drilling Project. The Project has undertaken a significant amount of work in this area, which is covered in the following reports:

- Baseline Study in hydrogeology - February 1999
- Development of a Siting Methodology for Pounder Drilling in Uganda - Jan. 2000
- Development of the Draft Pounder Rig Well Siting Methodology - June 2000
- Shallow Well Siting in Mukono District using the Draft Siting Methodology - November 2000

In addition, other siting methods have been utilised for Pounder Wells, as contained in the following reports:

- Safewater Technical Services Siting Methodology - January 2001
- Report on Hydrogeological Investigations for Four Shallow Wells in Butagaya, Budondo, Buwenge and Mafubira Sub-counties, Jinja District - January 2001
- Summary of Rig Use in Katakwi - May 2001

The outcome of the Pounder Well Drilling is contained in the report:

- Uganda Field Trials - November 1999
- Uganda Commercial Drilling: December 2000 to May 2001 - May 2001

The siting methods have included desk studies, field reconnaissance, hand augering, resistivity and Pounder Drilling.

Knowledge Required

The Pounder Rig has drilled wells in four districts, with varying success rates. The Project would like to draw the lessons learnt out of the various siting and drilling recommendations and experiences in order to be able to put forward a recommended siting methodology for Pounder Wells.

Further, with the intention of drilling in other parts of Uganda in the future and to enable the added value of the Pounder over Hand augering and hand digging to be explored (i.e. ability to penetrate laterite), the Project would like to be able to select the most suitable regions/districts in Uganda for Pounder Wells. Informants have indicated that there are some areas in Uganda which are particularly well suited to Pounder drilling. The Project would like to have such appropriate Pounder Well regions/districts identified, documented and detailed to enable it to plan future Pounder Rig activity.

Specific Terms of Reference

1. Review Pounder drilling experience and identify the hydrogeological capabilities and limitations of the method.
2. To review the Pounder siting methods undertaken to date, compare with siting methods undertaken nationally for other sources, draw out the lessons learnt and make recommendations for an appropriate siting methodology for Pounder Wells.
3. Relate Pounder capability and limitations to known hydrogeological regions of Uganda.

6.6 References

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Rural water supply and sanitation project feasibility study Luwero and Masindi districts. Final Report. Volume 1, may 1993. Halcrow rural management liverpool associates in tropical health.

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Masindi water master plan, August 1997.

RUWASA- Water point inventory survey for Pallisa district final report July 1996

RUWASA- Water resources assessment survey Mbale District Final report may 1997

RUWASA- Water resources assessment survey Tororo District Final report may 1997

6.7 Persons contacted during this evaluation

1. Patrick Nyeko – Directorate of water development Luzira
2. George Otaka-Aquatech Enterprises (U) Ltd.
3. John Mabira-District Water officer, Luwero
4. Angela Bwiza- Hydrogeology specialist, Rural Water and Sanitation Project (RUWASA)
5. Callist Tindimugaya- Principal Hydrogeologist, Directorate of water development Luzira
6. Samuel Ogutu- Ass. District Water officer Kamuli
7. Chris Tumusiime- Senior Engineer Directorate of water Development Luzira.
8. Moses Omunyakori- District Water officer Pallisa.
9. Stephen Kagaba- Hydrogeologist Eastern centres, Directorate of Water Development.
10. Paito Obote- Program Engineer Water Aid
11. Ali Nsamba- Accountant , Health Through Water and Sanitation Programme (HEWASA)
12. Roseline – Adminstrative Assistant – Accord.
13. Mirima- District water officer Bushenyi.
14. Simon Wakooli- Assistant District Water officer Hoima.
15. Albert Oleja-Acting Water officer Katakwi.
16. Moses OPio- Acting District Water officer Apach.
17. Nicholous Byantalo-District Water Officer Mpigi
18. Vally Wabwire- Assistant District Water officer-Masindi

19. Elisha Mutyaba- Water and Sanitation Specialist- World Vision International.
20. Edward Kiwanuka-Deliverance Church-Kampal