United Republic of Tanzania

Ministry of Water, Energy and Minerals

Morogoro Conference on Wells

Proceedings of the Morogoro Conference on Wells
held at Mikumi Wildlife Lodge
18 – 22 August 1980

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PREFACE

The annual Regional Water Engineers Conference in Tanga this year passed a resolution that may have great bearing on water development in Tanzania:

> "The Conference discussed the financial requirement of the 1991 rural water development implementation target, and aware of the limited financial resources available to develop, operate and maintain water schemes, it was resolved that an appropriate technological mix emphazising on the shallow well technology as a least cost alternative be worked out and used as a means of realizing the objectives of the programme where possible. Further, the Ministry should institute a machinery for the shallow wells projects".

Any water development activity involving large scale application of any specific technology mix will greatly influence the water master planning in the country, and the Water Master Planning Coordination Unit (WMPCU) in the Ministry of Water, Energy and Minerals therefore initiated a countrywide conference on well technology.

In close cooperation with the Morogoro Wells Construction Project (MWCP) and by kind financial support from the Netherlands (DGIS), Finland, Sweden (SIDA), Denmark (DANIDA) and Norway (NORAD), the conference was arranged at the Mikumi Wildlife Lodge from 18th through 22nd August 1980.

The MWCP made their professional shallow well construction establishment available to the conference participants, and through full-scale demonstrations we all were given first-hand information on most aspects of this technology.

It is our wish that decision makers in Tanzanian water development now feel more familiar with least cost technology, and that the conference has brought Tanzania closer to the 1991 target.

Ragnar Schonborg
Conference Secretary

1. OPENING SPEECH BY NDUGU H. BAKARI MWAPACHU, PRINCIPAL SECRETARY, MINISTRY OF WATER, ENERGY AND MINERALS

Ndugu Chairman, Ladies and Gentlemen,

It is a great pleasure for me to get this opportunity to address you here at the Mikumi Conference on Shallow Wells, and I have reasons to believe that this conference will prove to be worth while in more than one sense. The conference is a direct spin-off from the Annual Regional Water Engineers Conference held in Tanga this year, where the Ministry met with all the RWEs in order to assess the present situation of the management of the water resources in our country, with particular reference to institutional framework. That conference was a rewarding one, and the Ministry very happily and greatfully noted that all participants did their utmost to unwrap shortcomings and constraints characterizing Tanzanian water management at the moment. The conference made several resolutions aimed at guiding present and future water development, and one of these resolutions serves as the foundation and the basis for our conference here in Mikumi today: "In order to reach the target set forth by the Government and the Party that all Tanzanians shall have potable water within 400 m, by 1991, the shallow well technology should be used whenever possible and feasible".

A resolution as such, of course, brings us nowhere. It takes a strategy and it takes resources to implement the adopted resolution and this is why we are gathered here: to try and arrive at reasonable and appropriate measures to see that Tanzanian water development is guided according to the resolution made and adopted in the Tanga Conference. After the Mikumi conference a meeting is scheduled to be held where Maji will meet with development agencies to outline a strategy, and during the conference itself all parties involved in the decision making will have an opportunity to learn about the technology resource that we all are occupied and concerned with at this moment: Shallow Wells.

To build a suitable horizon for our discussion, I find it appropriate to have a broad look at rural water supply in general, and to see how it has developed through the years from way back in colonial times till the present.
Until 1920 hardly any attention was given to rural water supply by the colonial government and only simple gravity systems and some hand dug wells with bucket and rope, and in some cases imported cast iron hand pumps existed in a few settlements and at some mission ports.
After the first World War the diesel and the electric motor was introduced. From then on two different systems were developed, easily distinguishable as:

a. the motor-driven pump systems, and
b. non motor-driven pump systems

The motor-driven system was primarily used for concentrated populated areas as well as for farms, estates and industries. These systems were self-supporting in the sense that there was some kind of paid revenue. This generated money, making it necessary to develop an organization to govern and control the system as well as to maintain the system. It also necessitated and made it possible to develop better equipment, beter constructions and better materials. The non motor-driven systems served scattered populated areas and small farms. The technology employed was rudimentary gravity systems with hand dug wells and in some cases with hand pumps that had undergone no development after the First World War. This system has almost virtually remained the same all the way.

In 1946 the Water Development Department was given the responsibility for rural water supply, and the Public Works Department remained with the task of providing water to urban areas. This was the institutional situation at Independence. A main change took place in 1971 when the Government was directed by the Party to give priority to national development for education, health and water, and very soon the Government was therefore badly in need of equipment, construction materials and transport facilities. This could all be obtained abroad, where in the meantime considerable development was taking place in water supply technology. But prices were rising all the time, and improvements were introduced every year in both materials and equipment.

Tanzania has, over the past years, been in the lucky situation that foreign development agencies have felt the responsibility for participating in water development; but this obviously is a coin with a back side. Every donor or agency has its own ideas and its own approach to cope with development problems, and we ourselves are not always in the position to choose or to guide. Our economical, technological or organizational set-up is not able to absorb such a diversity of support, either in time, space or volume, and I honestly should like to see the society who would be able to fully utilize and support the way it is best suited to Tanzania today.

In 1980 the situation appears to be one of non-coordinated support and non-coordinated machinery to receive this support. And the irony about this picture is that all efforts are made with good will and with the best of intentions. Yet the fact remains: Less people are getting water this year than last year or the year before last, counted by percentage! I said it in the Tanga conference and I say it here again: we cannot accept that by 1991 20 million of our inhabitants have no water! We cannot sit and watch newly developed schemes rendered inoperative! If the will, toughness and devotion is there, most of the constraints we are experiencing may be eliminated! Giving water to the people cannot and should not be done without total, undivided participation by the people themselves.
It should not be expected that a handful of Tanzanians, foreign agencies and some people should supply millions of our countrymen with water without full support and involvement by the beneficiaries, i.e. by the people. I hope this is not a strange and distant thought to the Tanzanian people; after all, "Self-reliance" has been our guiding principle for many years! In the end, each one of the 20 million individuals drinking potable water in 1991 should with pride have the right to say: "We made it"!

To involve the villagers, one shall have to employ a technology at this stage of our development easily comprehensible and adoptable, and one which is not too unlike the one already in use. The people should develop confidence and faith in the technology serving them. After all, it is an integrated part of their life and every day living. The best way to achieve this is through participation in all facets from the beginning to the end. And what technology meets this requirement? The simplest and the most labour intensive one. Pumped schemes, schemes with elaborate distribution systems and water quality improvement plants are too distant and too unfamiliar and too difficult to understand. Moreover, they are too difficult to keep up and too difficult to operate. Water by the people for the people would seem a natural future goal. To day, however, this is hardly conceivable and we shall have to assist the people still for many years to come. But their participation is demanded!

In evaluating alternative water supply systems, there are several possibilities to choose from, and there are several criteria to base the selection on:

- availability of and quality of water resources
- availability of materials and equipment
- cost
- expected life of water supply scheme
- population development

to mention a few. The types of supply usually considered are:

- gravity supply
- pumped surface water
- borehole
- shallow well

In general, surface water contains heavy seasonal sediment loads and is bacteriologically unsafe. Surface water, therefore, very often requires water treatment resulting in high investment and operation cost and a high demand for skilled manpower.
Ground water may not always be of a quality suitable for drinking water, but as a rule it is safe compared to surface water. Aside for springs, occasionally found in hilly areas, shallow wells and boreholes represent the most reliable ground water source. The construction of boreholes or narrow diameter wells of greater depths, requires machine-powered equipment.
Even the simplest type of drilling equipment, the percussion rig, requires high initial cost and skilled personnel, and its operation is entirely dependent on the availability of spare parts and fuel. Shallow wells do not have these requirements, and their construction is done with a minimum of skill, and wells down to 29 m. have been successfully made without the use of mechanized equipment. As a rule, the shallow well furthermore is satisfactorily operated manually. It can be an altogether labour-intensive technology.

I would like to ask you to make a scientific cost comparison between the various water supply options, revealing the advantageous position, if any, of the shallow well. Some educated sources say that the position comes out with an average development cost of approximately 1:10 (one-tenth) of that of optional alternatives; as indicated by the table hereunder:

TYPE OF SUPPLY	% OF POPULATION SUPPLIED	UNIT COST PER CAPITA T.Shs.	TOTAL DEVELOPMENT COST Mill. T.Shs.
Gravity supply	15%	900	2,700
Pumped surface water	23%	700	3,220
Borehole	12%	700	1,680
Shallow well	50%	80	800
			8,400

Assuming 20 million people served with this particular technology mix, the total cost will be 8,4 billion T.Shs. or approximately 900 million T.Shs. per year. Knowing that the contribution from foreign development agencies and other donors amounts to about 1/5 - 1/3 of this it should be quite obvious that Tanzania is not going to be able to reach the target in time.

The numbers given may be highly uncertain, and among others, the technology mix will vary considerably from region to region, and the overall national average may in the end come out differently. Yet I have reasons to believe that shallow wells, if really put in focus, may cover an even higher part of the total and two thirds has been quoted by reliable sources. One point of interest that we will have to consider whether we like it or not, is the possibility of relocating villages in cases where water supply will prove beyond economical reasonable limits. This is a solution we will be very reluctant to put to use, but nevertheless it should be kept in mind.

The technology mix will depend on the distribution of surface/ground water potential in each region, and the compilation of our national master plan, where all regional water master plans will be incorporated and made conform with Government policy, will give us the final answer.

At present several shallow well projects are under way. I shall not reveal the latest findings as far as success or failure goes, but restrict myself to point out that in Shinyanga there is a shallow well project being implemented, where Tanzanian management and staff, in spite of all the constraints that exist in Tanzanian water development to-day, have achieved an amazingly high production of close to 200 wells within one year. This, I think, may serve as the best example of our own adaptability and ability, and I hope that this conference will prove that this is replicable throughout the country. And what do the experts say? Over the last 5-6 years a variety of water master plans has been prepared for most of our regions. Each donor and each consultant has employed his own mode and model. Hardly any of those plans have emphatically stressed the low-cost technology; and those plans are the basis for water development in the regions today. It is to counteract this, among others, that MAJI has re-established a Coordinatun Unit within the Project Preparation Division: the Water Master Planning Coordination Unit (WMPCU). And I am happy to see that this unit in a matter of fact way, and without delay, has initiated this Conference on least cost technology. Through this Conference we shall all open-mindedly and without prejudice listen to each other and learn. We should first of all listen to those who already have accumulated the knowledge and know-how in this particular field in our country - the representatives from Morogoro, from Mtwara and Lindi, from Shinyanga, from Tanga, Arusha and from Mwanza. These people will tell us what they have achieved, what they succeeded in and what went wrong, so that the rest of us may learn. Together with our own knowledge and experiences, we shall make a wholehearted effort to pave the way toward portable water to every Tanzanian.

I am not yet quite convinced that shallow wells in their present state of development give the final solution. I think, however, that together we shall be able to reach the best solution. This is to be our goal: the best solution.
My personal opinion, which any of you is invited to argue for or against, is that we shall need a standardised organizational pattern, a standard system and standard equipment in the years to come after the donors have left our country.
Let us spend time here at Mikumi wisely, and let us see, talk, think and speak in a manner that serves us all credit.

Mr. Chairman, Ladies and Gentlemen,

Asante Sana.

2. RESOLUTIONS PASSED AT THE MOROGORO CONFERENCE ON WELLS

1. Noting that shallow well technology offers a low-cost alternative, a high self-help component and a manageable technology at village level, and furthermore observing that the implementation of shallow wells has so far partly been based on capital intensive methods, the conference resolves that shallow well construction as one of the least-cost technologies should be given priority by involving beneficiaries' participation.

2. To facilitate the development of shallow wells wherever feasible, the conference resolves that the Government adopts the following mode of operation:

   a. Ownership

   To enforce the existing policy whereby the village governments shall be deemed to own their own water supply schemes, shallow wells inclusive, and be fully responsible for their development.

   b. Responsibilities

   The organization should be based on the following distribution of responsibilities:

Village Government	-	Ownership, clearing, hand digging or drilling, lining, maintenance, protection and mobilization.
RWE/RDD	-	Mobilization, implementation, planning and coordination and finding village contractors. Survey and siting of well locations, supervision of construction work, installation of hand pumps, maintenance inspection and assistance, quality control.
Shallow Well Development Centre	-	Production, standardization, procurement and distribution of materials, tools, equipment to the village. Monitoring and evaluation.
MAJI Headquarters/ WRI	-	Coordination with donors, PMO, Maji and other institutions. Administration of programme funds. Overall control and administration. Manpower training.

3. Recognizing the desireability of village self-help, we resolve that all efforts should be made to ensure village participation during construction, and transfer of technology to the villagers for construction, operation and maintenace of shallow wells, with the full technical and material support of the ministry to that level and those areas required by individual villages.

4. The conference has with appreciation noted the assistance received by the Government of various donor agencies in the effort to undertake shallow well development wherever feasible throughout the country, and hence resolved that these agencies are requested to continue support. To secure the maximum benefit of the assistance the conference resolves that
   a. the donors and the Tanzanian Government are urged to establish a pattern of regular meetings for mutual consultation and coordination of water development strategies, and
   b. that the donors are urged to establish a regular technical coordination committee to cooperate with Tanzanian authorities in matters related to
      - the standardization of materials, tools and equipment
      - the standardization of technology
      - supplies
      - maintenance, etc.

5. Recognizing the ultimate goal that the villagers maintain their water supply system, the conference resolves that, wherever possible, methods, materials and equipment resulting in minimal maintenance requirements should be applied and that efforts should be made to encourage local production.

6. The water quality monitoring/analysis of water schemes, shallow wells inclusive, shall be done through a network of zonal water laboratories under the Maji Central Water Laboratory.

3.1. SHALLOW WELLS IN TANZANIA, INTRODUCTION AND DISCUSSION POINTS

Papers presented by C.J. Bonnier, Project Director Morogoro Wells Construction Project

A. INTRODUCTION

1. The 1991 target

Everybody should have the possibility to obtain clean and sufficient water at a reasonable distance.

2. The situation in 1980

At the moment roughly 3 million people of the rural population have access to a source of clean drinking water.

As the total rural population of Tanzania in 1991 will amount to 23 million people, new water sources have to be constructed for another 20 million people during the next 10 years.

This means a production of systems for 2 million people per year from now onwards, provided that none of the systems go out of order in the meantime.

In 1979 new supplies were constructed for 400,000 people only.

It is obvious that new ways have to be found in order to reach the 1991 target.

3. Costs

The following division of supply systems has been proposed:

system	population %	population million	investment per head (Shs.)	costs total (Shs.x10^6)	O+M costs per h/y	costs per year (Shs.x10^6)
gravity	10	2	900	1800	10	20
surface	20	4	700	2800	20	80
deep well	20	4	600	2400	15	60
shallow well	50	10	100	1000	4	40
sub total	100	20		8000		200
per year				800		800
Total costs/year in million Shs. =						1000

The available donor funds are roughly Shs. 250 million per year.

4. What is financially feasible?

system	population %	population million	investment per head (Shs.)	costs total (Shs.x10^6)	O+M costs per h/y	costs per year (Shs.x10^6)
shallow wells	80	16	100	1600	1	16
deep wells with handpump	20	4	150	600	1	4
sub total	100	20		2200		20
per year				220		220
Total costs/year in million Shs. =						240

5. Experience with shallow wells in Tanzania

General

During the resettlement period, around 1970, a lot of shallow wells were constructed. Up to now shallow wells are still being made by Maji.
In general the results are poor:
1. due to lack of dewatering pumps, the wells cannot be made deep enough
2. good hand pumps are not available in Tanzania
3. the wells are open and polluted
4. the diameter of the constructed wells is too large, the set-up too complicated, and the costs, therefore, too high (Shs. 40,000.-/well)

Shinyanga

Since March 1975 a total of 1000 wells have been constructed by the SSWP.
Most of these wells are hand dug and all were provided with the wooden Shinyanga pump. This pump requires a lot of maintenance. Within a few years all pumps have to be replaced by other maintenance-free constructions.

Lindi/Mtwara

In a period of 2 years 600 shallow wells have been drilled by Finnwater Consulting Engineers. All wells are provided with a Finnish-made hand pump.

Morogoro

The Morogoro Wells Construction Project is organized as:
1. a contractor, for the construction of 250 wells per year in the Morogoro Region
2. a training institute, for the training of survey and construction groups from other regions
3. a production and supply organization of materials and equipment for the construction of shallow wells in other regions

In most other regions, like Mwanza, Tabora, Tanga and Arusha, shallow well projects have started.

At the moment appr. 2500 wells have been constructed, supplying water to some 750,000 people.

As, due to all kind of shortages, approx. 75% of all piped supply systems are out of order, the total number of people served by piped supply systems is even less than that served by shallow wells (0.25 x 20 x 40 x 3000 = 600,000).

6. What will be the future?

If we are going on as we did during the last 5 years:

1. constructing schemes that are too expensive, costing up to Shs. 8000/head
2. constructing schemes, pumping equipment and treatment plants that are too complicated
3. procuring equipment that is too sophisticated, or of very poor quality

failing any coordination or standardization, 20 out of the 23 million people of the rural population of Tanzania will be without a source of clean drinking water by 1991.

That will be the result of our billions of shillings spent for rural water supply in Tanzania during the last decade.

However,

- if we look at the whole problem once again
- if we examine what is feasible
- if we are really prepared to coordinate our efforts in order to reach the 1991 target

we are convinced that, on the basis of all information we shall get during these days spent together, a reasonable solution can be found for Tanzania.

B. DISCUSSION POINTS

1. In order to reach the 1991 water supply target for the rural areas in Tanzania, the maximum investment costs for a water supply system may not exceed the amount of Shs. 100/- per head

20 million x Shs. 100	= Shs. 2000,000,000
25% Maji overhead	= Shs. 500,000,000
in 10 years	= Shs. 2500,000,000
per year	= Shs. 250,000,000

2. All water supply systems should be built as "maintenance-free" constructions and should not involve any operation costs.

   no motors, no pumping equipment, no treatment plants, no spares, no fuel, no chemicals, no operators, no watchmen

3. Until 1991 all efforts should be directed towards implementation of the lowest cost solution, i.e. shallow wells only.

   If 75% of the rural population can be supplied with shallow wells, and this has been carried out, then the remaining 25% of the population will voluntarily move to those areas where shallow wells have already been constructed.

Thus it is not necessary to plan supply systems for 100% of the population, certainly not before the possibilities for shallow wells have been thoroughly examined.

4. Since a shallow well is the lowest cost supply system, a total of 60,000 shallow wells have to be constructed during the next 10 years.

to be served by 1991	: 20 million people
served by one well	: 250-400 people
number required	: 60,000 wells
per region in 10 years	: 3,000 wells
per region per year	: 300 wells
per district per year	: 75 wells

This number applies for a district unit with 2 survey/construction groups each with a capacity of 40 wells of year.

5. Until the required number of wells has been constructed, execution must be carried out on a contract basis in Regional Shallow Wells Projects, directly financed by the donors.

not as part of the RWE organization
not under government regulations
no voting of funds by Maji/Treasury

6. The survey/construction system, the materials and the equipment must be standardized.

In 1991 Tanzania should be left with one survey/construction system, one type of well and one type of pump.

7. Until 1991 there will be an organization which:
a. tests systems, materials and equipment
b. provides guidelines for all regions
c. procures and distributes all materials and equipment

The Morogoro Wells Construction Project can undertake this for the time being. Gradually, but before 1991, a Tanzanian organization has to take over this job.

8. On the national level the implementation of shallow well programmes should be supervised and coordinated by PMO/Maji.

The supervising authority will organize at least one donor meeting per year, the resolutions of which will be binding for all parties.

3.2. PAPERS ON THE MOROGORO WELLS CONSTRUCTION PROJECT

3.2.1. Organization and maintenance
3.2.2. Survey for shallow wells
3.2.3. Construction of hand-drilled shallow wells
3.2.4. Supply
3.2.5. Training for shallow wells

3.2.1. ORGANIZATION AND MAINTENANCE

Paper presented by F.H.J. van de Laak, Project Manager MWCP

A. ORGANIZATION

Construction

The organization of the Morogoro project originally was based on the organization as it was during the first half of 1978 in the Shinyanga Shallow Wells Project.
This included the setting up of a mechanical well-drilling unit, as well as provisions for a hand-dug well unit.
However, as in the first six months equipment for neither hand-dug nor mechanical drilled wells was available, the project started out in December 1978 with one group of well sinkers equipped with hand-drilling equipment. As a result, wells considered having a too low yield were left to be constructed at a later date. Pretty soon, a second group could be equipped which together with the first group formed a so-called unit. By a unit is meant a number of groups of well sinkers that can be supplied by one lorry and are supervised by a unit leader.

Each group consists of three well sinkers employed by the project and who, temporarily, employ around four people from the village to help in the work.
A unit therefore consists of eight trained people being:

- one unit leader
- one driver
- six well sinkers

By June 1979 a third group of double strength could be formed, which after some time split up and formed a second unit of two groups.
During the second half of July 1979, a machine-drilling group was set up, intended to survey and drill wells in more consolidated material through which hand-drilling equipment cannot penetrate. At first it was intended that this group would only survey for wells and, if sites were found, a percussion rig was to follow and complete the well. As, however, the AXBE percussion rigs from Dodoma were in a far state of disrepair, it was tried to use the B80 rig for both purposes of survey and construction.

Generally, it can be said that in the Morogoro circumstances the B80 machine was not obtaining sufficiently positive results to warrant the expense of operation and the use of this machine was discontinued.
The main reasons were:

1. low mobility, causing low productivity in relation to the expense involved
2. the types of aquifers prevalent in Morogoro need the use of casing pipe which gave problems in regard of the equipment available with the rig
3. in most cases the heavy hand-drill could also do the job

As a result, the project now has a construction strength of two units, of two groups each, working with hand equipment, that take care of the wells construction. It is the intention to form a fifth, separate group, that will take care of special construction problems, that will experiment with new or improved equipment, and that takes care of special requests for wells which normally cannot be handled by the regular construction units without disrupting their programme.
There has been no need yet to form groups for constructing hand-dug wells, although this may be done in the near future.

Survey

Although the construction is the main productive section in the project, its productivity depends for a major part on the results of the survey section.
The importance of the survey section cannot be stressed enough, and although its results are hidden behind the construction section, the quality of the wells in terms of water quality and quantity is decided here.
Several times the project has tried, in Shinyanga as well as in Morogoro, to incorporate the surveyors into the well sinking teams.

In other words, a surveyor goes ahead of the team and finds the well sites for the construction group but is with them in the camp.
They work in the same village or one village further on. The idea was to improve the feedback between construction and survey, and to diminish transport problems as the surveyor can make use of the same transport facilities as the construction team, i.e. a lorry.
For field use he has a trolley on which he puts his equipment.
Especially at the start of the Morogoro project this system has been tried, and because of the relatively small production capacity at that time, it did work. However, as soon as the rainy season started and immediate shifts were necessary due to inaccessibility of areas, and later because of the increase in productivity, it became again necessary to survey in areas far away from the areas where construction was continuing. The need for a stockpile of approved sites and the occurrence of areas where the yield and water quality of a well demand siting at the end of the dry season, were reasons to disengage the survey from the construction team. For that reason the survey now works as an independent section, headed by a hydrogeologist and an assistant hydrogeologist, and consisting of seven surveyors who, each with his own set of equipment and with help of villagers on a daily paid basis, do the site finding for the project.
Next to the seven surveyors the project employs several others who are either being trained or are engaged with special surveying tasks, e.g. finding out if in a particular area wells can be made at all.
A very positive point in the Morogoro survey set-up has been, also due to the initial absence of hand-dug well construction equipment, that till now it has not been necessary to construct hand-dug wells.
The hydrogeological situation may have played a significant part here, but the main reason has been that the surveyor specifically looked for yields high enough for drilled wells and did not stop if a low-yield aquifer was found. Thus wells have increased in depth as well as yield.
A problem of organization of survey and construction is the considerable shift in personnel because of trained personnel leaving the project for a variety of reasons, a large proportion going for further studies.

Production, Supply and Workshop Facilitites

In order to provide the productive units in the field with the required materials and equipment, the project has created a section, headed by a Production and Supply Manager, which forms the backbone of the project. The production and supply manager coordinates the following departments:
1. garage and mechanical equipment
2. stores
3. factory
4. yard
5. supplies

Ad 1

The garage and mechanical equipment department takes care of all vehicle maintenance and repairs and is also responsible for repair, maintenance and operation of mechanical equipment such as motor pumps, the B80 drilling rig, and percussion rigs. Due to the incompleteness of the percussion rigs and the consequent difficulties of repairing or rehabilitating these rigs, and because of the decision made in regard of the B80 as mentioned before, the department is at present confined to the vehicle maintenance and repair whereby it also takes care of several more vehicles belonging to associated Netherlands-funded projects. It is the intention to attempt again to bring an AXBE percussion rig into operation in the near future.
The department is headed by two mechanical engineers.

Ad 2

The stores is the central department of the project where all other departments, and the above mentioned associated projects, obtain their supply. The stores are headed by a stores officer.

Ad 3

The factory takes care of repair, replacement, modification, and production of equipment used by the project. Wherever possible it supplies to the stores items that are suitable for local manufacture, for issue to the various departments.
Apart from this it manufactures these same items for delivery to third parties. This will be elaborated upon under the section Supply. The factory is headed by two mechanical engineers.

Ad 4

Any other activities present on the project yard are brought together under the name "Yard Department" and comprise all other works inclusive of: 1) manufacture of tents; 2) carpentry; 3) concrete factory; 4) canteen; etc.
Except for the canteen, these are under the direct charge of the Production Manager. The canteen has its own committee from amongst the workers.

Ad 5

The supply department takes care of all supplies, be it from internal production on the yard or from outside sources which can be Morogoro or Dar es Salaam as well as overseas. It also takes care of supply to third parties.

As the job combination Production and Supply Manager has become too large to be handled by one person, the function has been split whereby now the responsibility for the supply from outside the yard has been placed with the Chief Administrator, who is presently aided by a supplies assistant.

A central function in the project is held by the accounts and administrative section, headed by a Chief Administrator and an Accountant. This section deals with day to day financial and administrative matters, including accounts, administration, supply and personnel.

Lastly, the project includes a training section wherein personnel of other regions is being trained in survey and construction. The training programme was started in July 1979 when personnel from the Regional Water Engineer in Morogoro was trained. After this, personnel was trained from Tanga, Cost Region, Dar es Salaam Rural, Dodoma, Iringa and Arusha.
Since the Regional Water Engineers' meeting in Tanga it has been agreed with the Water Resources Institute at Ubungo that, in view of the expected large demand for training of personnel, the Institute will take over the training for survey and construction in future. For the next course in September part of the staff, equipment, materials and vehicles of the Morogoro project will be available to the Institute. After this last participation, the project will confine itself to training its own staff and staff of other Netherlands projects, but is willing to give advice and guidance through mutual agreement to other regions and projects in Tanzania.

General

The project, in contrast to the Shinyanga project, has a decentralized set-up, whereby each section is separately administered. In principle, therefore, each section buys from or sells to other sections.
The general idea behind this is to enable each section to work as an independent unit within the project with the possibility, at a later date, to completely seperate the sections so that they could work as economically viable units. Thus, a complete project take-over by the Regional Water Engineer, as was done in Shinyanga, would not be necessary.
The reasons are:

1. The wells construction project is a project for Morogoro Region only, whereas the backing-up organization has a much wider scope and can serve a good part of Tanzania, if need be. Apart from this, it is, at present, also serving other Netherlands-funded projects in Morogoro Region.

2. To burden a Regional Water Engineers' organization with tasks that are partly nationally oriented, did not seem to be a good idea. Moreover, expansion of the Regional organization with a Region-oriented wells construction project only, without its back-up, would considerably simplify a future take-over.

3. A reduced scope of well construction projects would make it easier for other regions to set up and maintain their own projects.

4. In case all sections, including the wells construction section, are made independent (e.g. under an umbrella organization) a system can be worked out whereby the Regional Water Engineers' staff is the principal and supervisor, and the wells are surveyed and constructed against contract. This would lift the wells construction effort out of the civil service atmosphere in which it is stuck now. As such it would no longer be severely hampered by civil service regulations, such as salary scales, promotion, and benefits, etc., and could make way for a set-up where increased effort and efficiency pays off directly to those creating it.

B. WELL AND PUMP MAINTENANCE

To have a project construct wells that provide villages with water at minimum cost is one thing.
To maintain the constructed system in the years following is another problem and one that is not so easy to solve.
When, in order to reach the 1991 target in Tanzania, the country chooses to adopt the low-cost system of constructing shallow wells wherever possible and gives this priority over other types of supplies it is absolutely necessary to realize from the start the magnitude of the maintenance of these systems and to adopt a realistic solution that is applicable wherever these systems are built, before the construction of the wells is actually started. For, if we do not do so, wells will become non-operative at the same rate as they are built and the whole exercise will be very expensive and very disappointing to the population of Tanzania, whatever the enthusiasm may have been with which the programme was started. Accepting this, I propose to give the meeting my views on the problem and what could be a solution.
Others, I presume, will do the same. It is my sincere hope that this conference will be able to adopt solutions for a reliable maintenance organization that are practical and feasible within the context of the Tanzanian situation.
I propose to put my views forward divided into three parts:

1. The magnitude of the work.
2. The work itself.
3. The organization of the work.

Ad 1

The magnitude of the work.

- If only 50% of the Tanzanian population will be served by shallow wells, and taking the population per region around one million, then each region will, in the next ten years, build some 1500 wells, each serving around 350 people, or roughly 150 wells per year.
- If a production target of 150 wells per year is built up and maintained, this results in a stepped-up maintenance requirement of 150 wells per year, starting one year after the first wells are made.
- These wells will not be near the urban centres but will be spread all over the country, often in areas that are inaccessible for a part of the year.
- To keep these wells operative, and to minimize the cost of spares necessary to repair them, a well check should be made at least twice a year and preferably monthly.

In terms of the Shinyanga project, where around 1000 wells have been made, checking each well twice a year means that two thousand wells have to be visited per year, at an average distance of 100 km from the Regional headquarters.

Ad 2

The work itself.
In Annex 1 to this paper the necessary detailed checks are given, based on the Morogoro situation.
Roughly the work is divided in two parts:

1. village maintenance, which can be done by the villagers themselves without any technical training
2. technical maintenance to be done by trained personnel

The list is comprehensive but the actual work is routine work and requires little skill.

Ad 3

The organization of the work.
The Shinyanga organization:
Let us again use the Shinyanga project as an example. In the terms of reference of the project was written that the project would maintain the wells until then end of the project period. Full stop. Who would take care of the wells was not specified. Later it became clear that Maji had to take care of this. During the project a maintenance organization was set up, geared to effective and efficient maintenance of the wells. Already during the second year it became evident that this method would involve such high costs of personnel and transport that the Regional Water Engineer of Shinyanga did not consider it possible to continue after the Dutch participation would have ended.

Finally a form was chosen whereby the maintenance was incorporated into the Regional Water Engineer's organization. This involves one Regional Maintenance Officer and four (presently five) District Maintenance Officers. Since May 1980 each District Maintenance Officer has an assistant in each Division. In each village there were two village pump attendants whose duty was to do preventive maintenance and report the needs for repair to the DMO.

Morogoro:
The terms of reference of the Morogoro project stipulate that the Regional Water Engineer takes care of the maintenance of the wells starting three months after completion of the wells, and beginning on the 1st July 1979. In July 1979, for this purpose, two District Maintenance Officers were trained for the Regional Water Engineer and in subsequent discussions in the Region the following was agreed upon:

1. The maintenance of pumps is the responsibility of the Regional Water Engineer.
2. The maintenance of wells can be split into two parts:
   a. the maintenance in the village which mainly concerns the well surroundings
   b. the technical maintenance and repairs
3. The Regional Water Engineer would organize this maintenance. It would be supervised by technical staff, that would be decentralized till ward level, under the responsibility of the District Water Engineer.
4. In the villages the responsibility would lie with the village water committees.

So far no definite maintenance organization has been set up.

C. EXPERIENCE WITH MAINTENANCE

Shinyanga

When visiting Shinyanga last month I found that the system in Shinyanga works well in that the maintenance personnel is very active and I was able to meet at random several of the Divisional Maintenance Officers at work.
Nevertheless, from my visit I found that the practical results in Shinyanga are that 30% of the wells are out of order. This figure is not bad seen in the light that most of the pumps were not out of order for a long time and the organization copes with the repairs somehow.
What is worse is that an estimated 60% of the working wells are in need of some repair, some if which is extensive. The indication is that until recently reports do reach the District Maintenance Officer on breakdowns of wells, but preventive maintenance is virtually absent. Consequently, breakdowns are frequent and severe, needing much repair at a relatively high cost, estimated at T.Shs. 500/- per well per year.

Many of Shinyanga's problems derive from the quality of the pump cylinder, and from the vulnerability of the pumphead. The first is an inheritance of the Dutch project and the cylinder valves need to be replaced by the presently used type. The second is a result of the type of pump head used as there are too many bolts and nuts and clamps that can be used for oxploughs and oxcarts, and because the handle of the pump is made of wood. Very clearly Shinyanga experience shows the fact that generally men have little regard for the pump that the women need for their water and that they see no bones in making a pump inoperative of it can help their oxcart.
It is my opinion that the Shinyanga pump in the circumstances should be abandoned and replaced by a less vulnerable pump.

Morogoro

A check on 100 wells in Morogoro made in June 1980 established that all pumps are working, be it that some of the earlier type of kangaroo pumps have broken springs. Nevertheless people do draw water from those wells. Many complaints were received about the early type kangaroo pump, which is on the list to be replaced by the present type. None of the new type gave rise to complaints.

The Morogoro pumps and wells thus appear to be more reliable than those in Shinyanga: the wells have rather guaranteed safe yields and the pumps remain operative for a considerably longer time.

Apart from the need to replace the early type of kangaroo pump and to check on new pumps after some 3 months of operation, there appear to be no real technical maintenance problems, so far, and there are very few complaints. This probably accounts for the fact that no maintenance organization has been established yet.

On the other hand, when visiting the wells, one is often struck by their surroundings, which are often very badly kept, if at all. Spill water, sometimes bad smelling, is standing near the well, gutters are clogged, the grass grows man-high along the well, etc.
It is obvious that the village maintenance system does not work well yet, if it does at all.
Fortunately, the understanding that well surroundings have to be kept clean, is spreading. This is attributed to a better information of the villagers by the project staff. In Kilosa one of our surveyors has roused the interest in and has explained the problem of well maintenance to the participants of a seminar of village chairmen and ward secretaries, which proved quite effective. Moreover, a series of posters illustrating the importance of well-kept shallow wells is given to and displayed in each new village where wells are to be constructed. These posters, a reproduction of which can be found on the center page of the fourth progress report, appear to greatly influence the attitude of the villagers towards the wells and well surroundings. In the future even more emphasis will be put on this kind of educative information.

Conclusions

Maintenance costs can be very high as was proven in Shinyanga. A marked reduction in these costs can be obtained by reducing the need for maintenance through the use of better techniques and the installation of well-constructed, rugged and "maintenance free" pumps.

Even if the latter are more expensive to purchase or produce, as a rule the decrease in maintenance costs more than offsets the additional expenditure.

A further, very important, influence can be the preventive maintenance of well, pump and well surroundings by the local population. Every effort must be made to increase village participation in this respect.

ANNEX I - MOROGORO WELLS CONSTRUCTION PROJECT INSTRUCTIONS WELL MAINTENANCE

1. VILLAGE MAINTENANCE

Village maintenance training can be done on the spot in the villages. Suggestion: the Maji maintenance officer with the village well attendants does a full maintenance round of all wells in the village and explains at each well what should be done daily and what monthly. At the same time this work is carried out under his supervision.

The work to be done is:

Check and rectify where not in order:

Daily

1. Check operation of pump. Notice specifically what happens at first stroke when pump has not been in use for more than one hour. If water does not come immediately, foot valve is leaking and failure should be reported.
   Other points:
   - loose nuts on anchorbolts
   - loose anchorbolts in concrete
   - spill-water leakage under footplate back into the well (check seal for tightness)
   - action pump (pump should easily be depressed for at least half the stroke and return by itself to initial position)

   If any of these points are not in order - rectify or report to Maji maintenance officer.
2. Clean concrete slab.
3. Clean the spill water gutter. Check for standing water in gutter and rectify by filling with clay.
4. Surround the well with suitable hedge to prevent cattle and other animals to come near the well.
5. Keep surroundings within the hedge clean and fill holes where water can gather. Let ground slope away from well.
6. Instruct users in use of well. Well slab should not be used to wash clothes. Washing clothes should not be done within twenty steps from the well.
7. Instruct villagers to use spill water to irrigate vegetable etc. field at end of spill gutter. Let them regulate flow of water to different parts of field via ditches and small dikes: Field not nearer to well than 20 meters! There should be no standing water in the field either!
   Reason: Mosquito breeding, spreading of cholera, and other diseases. No children should use the well as a playground.

Montly
------

1. Trim hedge in order that it stays tight. Repair openings in hedge where necessary.
2. Check concrete slab and gutter for cracks. If cracks occur cut these out wide and fill with mortar mixture 1 cement : 2 sand. If no cement available fill cracks with clay and report damage.
3. Check action pump for changes and report if serious.

2. MAINTENANCE BY MAJI OFFICER

Periodical only

1. Check each well and pump at least every three months for technical points. If in order leave as it is.

Check list

- Check action pump: Pay attention to:
  a. first stroke should give water even after whole night standing
  b. action should be easy. Stroke, if pump is operated by adult, should be at least half the total stroke possible (15 cm) and pump must return to original position
  c. check all bolts and nuts for tightness
  d. check seal of foot plate so that no spill water can enter the well

If pump action is not in order

1. Pump does not give water at all.
2. Action is too heavy.
3. Pump does not return except by pulling it up by hand.

Remove pump completely

Procedure
----

1. Remove the four nuts off anchor bolts. Press pump down and place block between strip on outlet and foot plate.
2. Lift pump for ± 50 cm.
3. Place wood block under foot plate and let foot plate rest on block.
4. Attach clamp for rising main to riser and tighten.
5. Turn pump head anti-clockwise keeping it straight up, till pump head is loose from rising main, at the same time preventing rising main from turning by holding clamp in position (block can be removed if clamp is tight).

6. Lift pump head till first joint of pump rod comes free. Place spanners on two pump rod nuts (do not use pipe wrenches as these spoil the nuts) and open joint. When loose, turn pump head anti-clockwise while holding bottom part of pump rod with pipe wrench till pump rods separate. Keep pump head perfectly straight or either pump rod will bend, or thread will spoil! Remove spring washer from pump rod.
7. Place pump head aside horizontally. Be careful not to damage it! Take care no dirt comes in pump rod.
   Attach pump rod hanger.
   Pull pump rod and check if water level does not drop.
   Push pump rod and check if it works o.k. (smooth).
8. Lift clamp with rising main. Hold rising main by hand, remove clamp and bring out approximately 6 m length of riser, till joint becomes visible. If too heavy use pipe wrenches to hold pipe. Make sure pipe does not slip back into well! Replace clamp on rising main and tighten properly below joint.
9. Loosen joint in rising main with pipe wrench.
10. Lift rising main till pump rod joint becomes visible. Loosen pump rod joint with spanners taking care to keep rising main straight. When loose, remove rising main with pump rod. Take care that pump rod and rising main do not drop into the well.
11. Repeat 8-9 and 10 till pump cylinder is reached and removed.
12. Cover well hole temporarily with metal cover plate.
13. Carefully remove rising main and pump rod from cylinder.
14. Check by looking into cylinder from the upper side if pump cylinder contains sand or other dirt. Note if these are present.
15. Carefully remove caps from cylinder. Remove piston. Use pump rod puller if necessary.
16. Check piston and cylinder for foreign matter, such as sand, gravel, mud, twigs, etc. If present try to dermine cause (why and how these come into pump cylinder). For sand and gravel that is similar to gravel pack, you must suspect that PVC screen is damaged. Assemble pump rod and measure exact depth of well. Look on well record for depth at installation. If sand or gravel has filled into well till the pump cylinder, well needs to be cleaned with membrane pump. If sand or gravel keeps coming in, well screen is damaged. Well can be repaired with placing smaller dia screen, or may have to be abandoned.
17. When foreign matter is not present, or does not indicate a broken or burst screen, clean pump cylinder, foot valve and piston with valve, check for wear or faults that cause leakage and rectify where necessary. Reassemble cylinder. Take care that no dirt can enter during re-installation.
18. Check rising main and pump rod for cracks, rust and worn threads and wear due to friction. Clean both, clean rust patches with steel brush and paint with bituminous paint (pipes should be dry). Paint should be completely dry before re-installation.

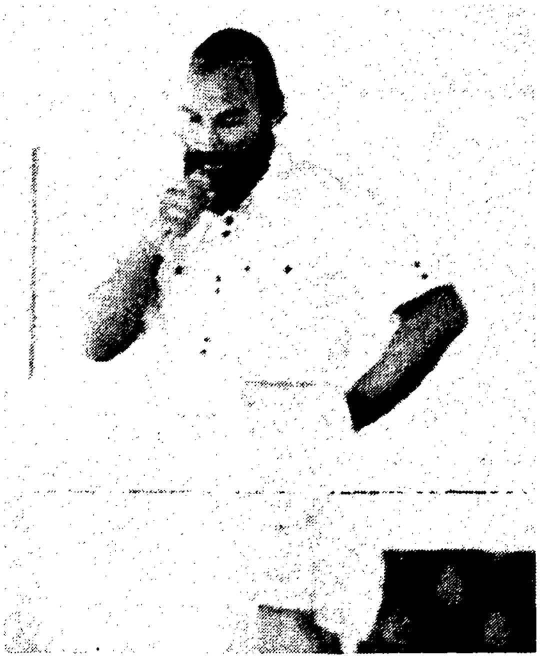
19. Inspect pump head for wear. Inspect action of spring. Try action by placing pump head on well without rising main etc. If satisfactory, do not disassemble.
    If unsatisfactory, depress pump slightly and keep in place with rope or wire tied between handles and foot plate. Remove weld on the two nuts at outlet, remove nuts and strip.
    Release rope or wire slowly to take off spring tension.
    Lay pump head flat and remove hood and pump rod together. Remove spring, clean and check spring for rust and/or excessive wear, clean and check all other parts for excessive wear. Reassemble, greasing spring thoroughly with, if possible, waterproof grease.
20. Reassemble pump cylinder and rising main, lowering assembly in well. Take care to place new spring washers in pump rod connections. Put some bituminous paint on threaded ends. Wipe off carefully all excess paint after thoroughly tightening joints.
21. Reassemble all parts and lower into well in reverse order as described in 8 to 4 above. Make sure threads are entered properly into female ends and keep pump head perfectly straight whilst assembling to pump rod and riser.
22. Put seal, newly impregnated with bituminous paint, below foot plate, lower pump head over bolts and put and tighten the four nuts. Paint thread ends and nuts.
23. Try out pumping action. Pump for at least half an hour continuously with two people and full strokes, to remove water present in well at the time of checking.
24. Fill in check/repair details for filing in well file. Do not forget to mention well number, date, name of checking officer and details of parts renewed of repaired with reference to possible cause.

Tool list village attendants

1. One combination spanner for M 16 nuts.
2. Jembe.
3. Shovel.

Tool list Maji maintenance officer

1. Two combination spanners for M 16 nuts.
2. Two pipe wrenches 18".
3. Two clamps for holding rising main.
4. One/two spanners for M 10 nuts.
5. Tin with bituminous paint.
6. One wooden block for foot plate.
7. One paint brush 1".
8. One steel brush 4 row.
9. Tin with waterproof grease.
10. Spring washers M16.
11. M16 nuts.



3.2.2. SURVEY FOR SHALLOW WELLS

Paper presented by R.V. van Lissa, Hydrogeologist MWCP

A. WHAT IS SURVEY FOR SHALLOW WELLS

A survey for shallow wells comprises all activities, aimed at the selection of sites where successful shallow wells can be constructed.

This logically leads us to the Morogoro Wells Construction Project's definition of a successful shallow well.
A successful shallow well is a well:

- which gives water throughout the year, even during extremely dry periods
- with a yield sufficiently high to meet the daily water consumption needs of at least 250 people
- with a water quality that meets the Tanzanian standards
- which is located within walking distance (1 km) from the consumers
- which is accessible on foot throughout the year
- which is by its location as well as its construction protected from any form of chemical or bacteriological contamination

Generally speaking, there are a number of survey methods that can be applied to broadly outline areas suitable for constructing shallow wells.
Most common are:

- study of geological maps
- study of aerial photographs
- study of topographical maps
- study of satellite images
- hydrogeological field surveys
- geophysical surveys

However, these survey methods do not tell us where exactly it is possible to construct shallow wells and neither do they tell us much about the quality of aquifers, yield of wells and ground water quality.
The only direct method applicable to select shallow well sites is by test drilling and test pumping.
In selecting the necessary equipment to carry out survey test drilling and test pumping, the following considerations have been taken into account:

- low cost
- durability of equipment
- reliability of results
- simple to operate
- easy to transport
- little maintenance
- to be manufactured locally

Hand operated equipment fulfils most of these criteria and should therefore be used, wherever this is possible.
Machine-drilling should be limited exclusively to those areas where hand-drilling equipment cannot penetrate into the water-bearing formations.
Test-pumping can under all circumstances be carried out with hand-operated equipment and the use of motor pumps should be avoided.

Apart from the test-drilling and test-pumping, which form the essential parts of a shallow well survey, there are a number of other activities that have to be carried out. A complete survey for shallow wells exists of the following parts:

- pre-selection of potential well sites
- test-drilling
- test-pumping
- water quality check
- recording of information
- recommendations for construction

B. WHY SURVEY

By experience it is known that in areas with a hydrogeology favourable for making shallow wells, one out of 2 or 3 test-drillings may be approved for well construction.

In areas with a hydrogeology less favourable for shallow wells, usually only one out of 10-15 test-drillings can be approved for well construction. This means that a shallow well construction programme without the support of a preceding survey will be disastrous since anly about 15% of the wells would probably be totally successful.

By carrying out test-drillings the hydrogeological environment of a well site is explored in a relatively cheap and fast way by people specialized in this type of survey and this enables us to choose optimal well locations regarding yield, water quality and distance to the consumers.

Summarizing, the main advantages of a properly carried out survey are:
- to guarantee the construction of successful shallow wells
- to select optimal wells regarding yield, water quality and location
- to save the high costs involved in construction of unsuccessful wells

In Morogoro Region the survey is aimed mainly at the finding of well sites which can be hand-drilled because hand-drilled wells are at least twice as cheap as hand-dug wells and because the construction time for hand-drilled wells is a few days against a construction time of a few weeks for hand-dug wells. since the criteria for approval of a hand-drilled well site are sharper than for approval of a hand-dug well site, the survey for drilled wells usually is more extensive. However, since the average costs for surveying a well site is only about 10% of its construction costs when it is hand-drilled and only 5% of its construction costs when it is hand-dug, it is clear that a more extensive survey, aimed at the selection of hand-drilled well sites, will more than pay itself.

C. THE SURVEY DEPARTMENT

Activities

Besides the selection of well sites, which is the primary task of the MWCP Survey Department, a number of other activities are undertaken by this department.

a. General planning of survey field activities.
b. Co-ordination of information on the MWCP to the villages.
c. Further development and improvement of survey methods and equipment.
d. Training of MWCP survey staff.
e. Training of survey teams from outside the MWCP.
f. Collection, elaboration and reporting of field data.
g. Special investigations.

Sub a

In planning the survey for shallow wells, the following factors should be considered:

- Priority villages and areas.
- The accessibility of villages during the different seasons.
- Seasonal ground water level fluctuations of shallow aquifers: In areas where the seasonal ground water level fluctuations are considerable (3-10 m), well siting should preferably be carried out during the last part of the dry season, when the ground water levels are low. This to avoid drying wells.
- Salinity of the shallow ground water: In those areas where the salinity of the shallow ground water tends to be high (Electrical Conductivity 1500-200 µS/cm), it is also safer to carry out well siting during the last part of the dry season because usually the salinity of the ground water will increase during the course of the dry season and thus the E.C. value might exceed the standard of 2000 µS/cm.

Sub b

An important task of the project is to inform the villages on the MWCP before the actual well siting is started. Because the surveyors usually are the first representatives of the MWCP who enter a village, it is part of their activities to take care of the information.

Sub c

The survey methods and equipment used within the MWCP have largely been developed during the Shinyanga Shallow Wells Project.
In Morogoro, the survey methods have been refined and the equipment has been adapted to the specific hydrogeological conditions of this region. Important recent improvements are the development of a new survey test pump and some new augers.

Sub d

Form IV leavers, or people with a similar level of education can be accepted to be trained for surveyor. The training is an "on the job" training and takes place exclusively in the field.
After about three months of training, a surveyor usually is ready to start working on his own, but it may take up to a year before a surveyor has obtained sufficient experience to be able to work successfully in areas less favourable for making shallow wells.
Therefore, regular training and checks on the surveyor's work by a hydrogeologist are necessary.

Sub e

The Survey Department has training facilitities for surveyors from outside the project also. These trainees are either sent by the Regional Water Engineers or they are working with various shallow wells projects in the country.
The training period is three months, two of which are spent in Morogoro Region and the last month in the region where the trainee is stationed. Thusfar surveyors have been trained from the Regional Water Engineer's offices in: Morogoro Region, Coastal Region, Dar es Salaam Rural, Dodoma Region, Iringa Region, Tanga Region (Tridep), Arusha Region (Ridep). Hydrogeologists from the Ridep in Mwanza Region and the Singida Ground water Project in Singida Region have been briefed also on the survey methods and use of survey equipment.

Sub f

Survey activities, progress, field data, planning and developments are being reported twice a year in MWCP progress reports.

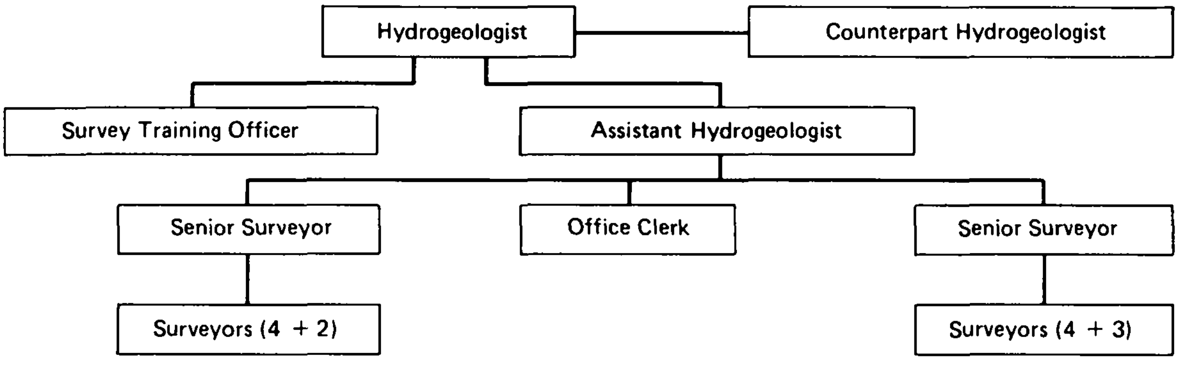
Sub g

Special investigations carried out by the Survey Department include:
- shallow well siting for missions, schools, hospitals, institutes, farms and small industries in Morogoro Region
- well siting for high yield shallow wells to be used as a water source for pumped water supply systems for villages, institutes and hospitals
- survey activities on behalf of other water supply projects in Morogoro Region e.g. the Morogoro Domestic Water Supply Plan, the Morogoro Gravity Plan, the Morogoro Piped Water Supplies Project
- geological investigations of dam sites and construction sites of water tanks

Personnel

To meet with the project's production goal of 250 well sites per year, at least six surveyors are needed with the MWCP's Survey Department. In addition to this, two more surveyors are needed for special assignments and training of surveyors from outside the Project.
Another five surveyors are currently being trained to start survey activities in the southern part of Morogoro Region (Kilombero and Ulanga Districts).

The present organization of the Survey Department is illustrated below:



Equipment

Up to now, in Morogoro Region, the well siting could be done exclusively with hand-operated equipment.
Two sets of hand-drilling equipment are used: a lightweight set which can be operated by one man, and a heavyweight set which is operated by four persons.
The average depth of the survey drillings in Morogoro Region is about 9 m, but regularly the drilling depth is between 10 and 16 m and sometimes even more.

A complete survey set, suitable for investigations down to 16 m, comprises the following items, inclusive of spares:

1. Hand-drilling equipment:
   a. lightweight set : 2 handles + 15 extension rods of 1 m eacht
      2 combination augers of 7 cm diameter
      2 combination augers of 10 cm diameter
      2 riverside augers of 7 cm diameter
      2 riverside augers of 10 cm diameter
      1 stone auger of 7 cm diameter
      1 stone auger of 10 cm diameter
      1 flight auger of 7 cm diameter
      1 spiral auger of 4 cm diameter
      1 stone catcher of 7 cm diameter
      1 stone catcher of 10 cm diameter
      1 bailer of 6.3 cm diameter

b. heavyweight set : 1 crosspiece with 4 handles
9 extension rods of 1 m each
2 riverside augers of 7 cm diameter
2 riverside augers of 10 cm diameter
1 combination auger of 7 cm diameter
1 combination auger of 10 cm diameter
1 stone auger of 7 cm diameter

(for investigations deeper than 10 m, a tripod, pully, cable, winch and more extension rods are needed)

c. casing set : 14 casing pipes of 9 cm diameter, length 1 m each
2 casing pipes of 9 cm diameter, length 1 m each, with slots
1 casing shoe
1 casing head
2 casing clamps
1 casing retriever

2. Pump test equipment : 1 pumphead
15 rising mains of 4 cm diameter, length 1 m each
1 footvalve
1 bucket

3. Survey instruments : 1 electrical conductivity meter
1 water level meter
1 compass
1 alarm clock
1 fluoride test kit

4. Survey forms : borehole description forms
village sketch forms
situation sketch forms

5. Tool box

Miscellaneous are: a trolley, wooden boxes for the survey equipment, camping equipment, stationery, boots, first aid box.

Apart from the bailer, the casing pipes, the electrical conductivity meter, compass and fluoride test kit, all other items listed above are either manufactured by the MWCP or available in Tanzania.

Repair of the survey equipment is done in the MWCP workshop.

<u>Transport and Communications</u>

Transport of the surveyors and their equipment to the village is done by Landrover.

In the village the surveyors transport their equipment on a small hand-trolley.
Landrovers are used also for field visits of the survey staff.

For communication purposes, two transceivers are being used in the field. A transceiver on the MWCP yard is on standby during office hours.

D. THE SELECTION OF WELL SITES

Preliminary Activities

On arrival in a village, the surveyor goes to the CCM office, where he introduces himself to the village secretary, the village chairman, the village manager and other officials. The documents he can use are a letter of introduction from the office of the RDD, and an identity card from the MWCP. After a brief explanation about the MWCP and the survey work in particular, the surveyor asks the village officials:
- to allocate him a camping place
- three labourers from the village (to be paid by the MWCP)
- to organize a meeting where the surveyor can inform the people of the village about shallow wells

During the meeting, the surveyor explains to the villagers the advantages of having shallow wells and how the survey and construction will be carried out with the cooperation of labourers from the village.
But what is more important, he explains how the wells should be used, how the well surroundings should be maintained and how the people can make use of the spill water to irrigate their shamba's.
A set of posters is used for illustrating the explanation, and posters are distributed to the CCM office, the school and dispensary (see Fourth Progress Report MWCP, middle page).

Planning of Well Sites

On the second day after his arrival in the village, the surveyor goes around the village with one of the officials who shows him where the people are living, where the villagers are fetching water and where they would possibly like to have shallow wells. He then draws a sketch of the village on which he makes a planning for the locations of the sites he wants to survey (annex I to this paper, planning of sites). Herewith the total number of people, as well as the lay-out of the village will be taken into consideration.
Usually the number of people to be supplied through one well will be between 250 and 400.

Selection of Well Sites and Test-Drilling Patterns under Different Hydrological Conditions

In planning the test drillings in a certain area, the surveyor will use the experience gained by him while working in areas with a similar hydrogeology; he will be advised also by the survey staff.
Typical hydrogeological environments in Morogoro Region are: river terraces, alluvial fans, alluvial plains, small valleys and pene-plains. The number of boreholes drilled on one site may vary from 2 till more than 50 but is at present 7 on an average in this Region.

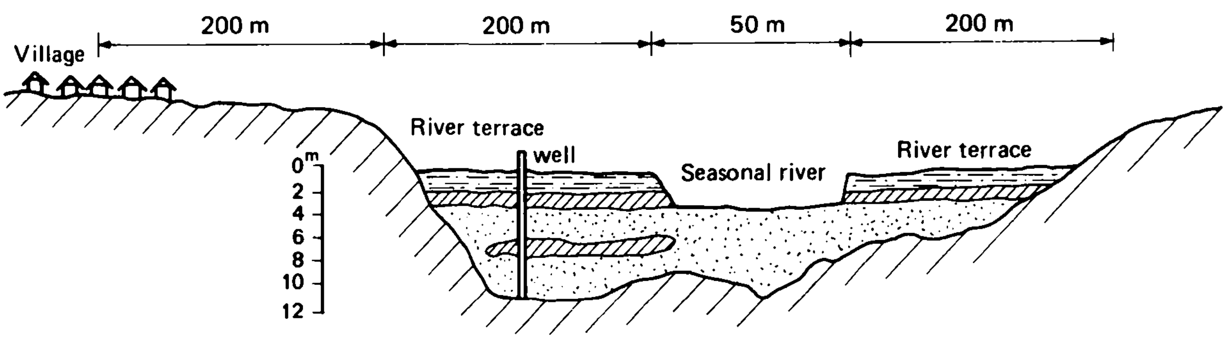
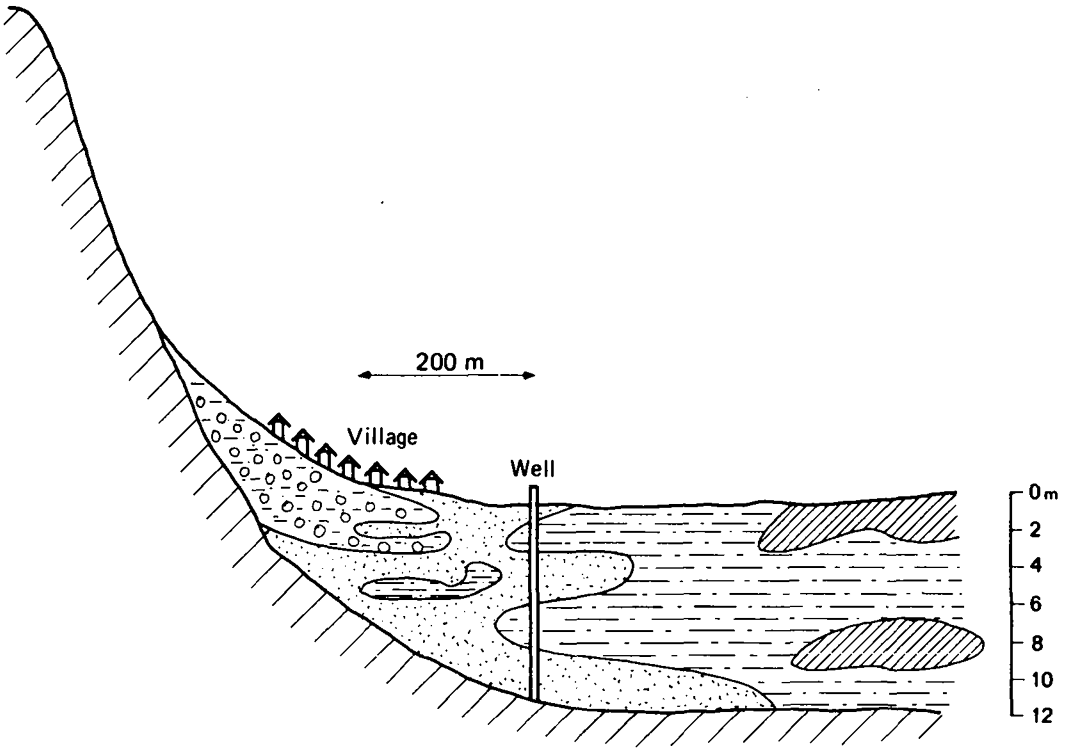


FIGURE 1. RIVER TERRACE

River terrace sites

Drill boreholes parallel to the valley, at distances of a least 10 m from the present riverbed and with relative distances of about 50 m (longitudinal profile). Where a promising aquifer is found in a borehole, a profile will be drilled perpendicular to the longitudinal profile.
The intention is:

- to try and find a well site with an underground connection with the present riverbed, but as far as possible from the river so that a good natural filtration of the water is guaranteed
- to try to locate the well site as close as possible to the village but as far as possible from the present river (flooding, erosion)



2. ALLUVIAL FAN

Alluvial fan sites

The best locations are usually not far from the mountains, where the coarsest and most permeable material has been deposited.
Drilling will be executed along profiles at right angles to the mountain range in order to find out where exactly the basement material changes into coarse grained alluvial fan deposits and where the coarse grained deposits pass into fine grained sediments.

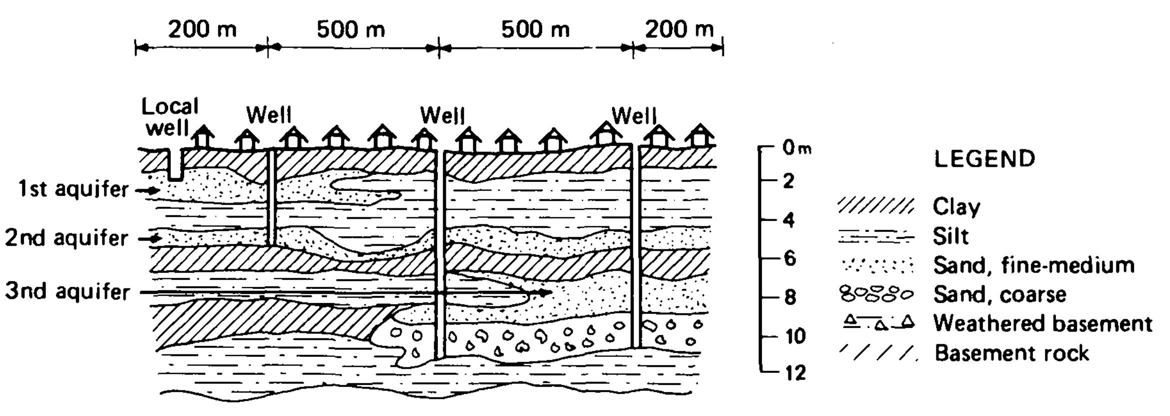


FIGURE 3. ALLUVIAL PLAIN

Alluvial plain sites

Because of the flatness of this type of area, most of the time it is not possible to predict from the surface where the best locations are for well sites. Therefore drilling will proceed along parallel profiles through the village at relative destances of 50 to 200 m. In this way a clear picture of the hydrogeology of the area is obtained and the best well site can be selected accordingly.

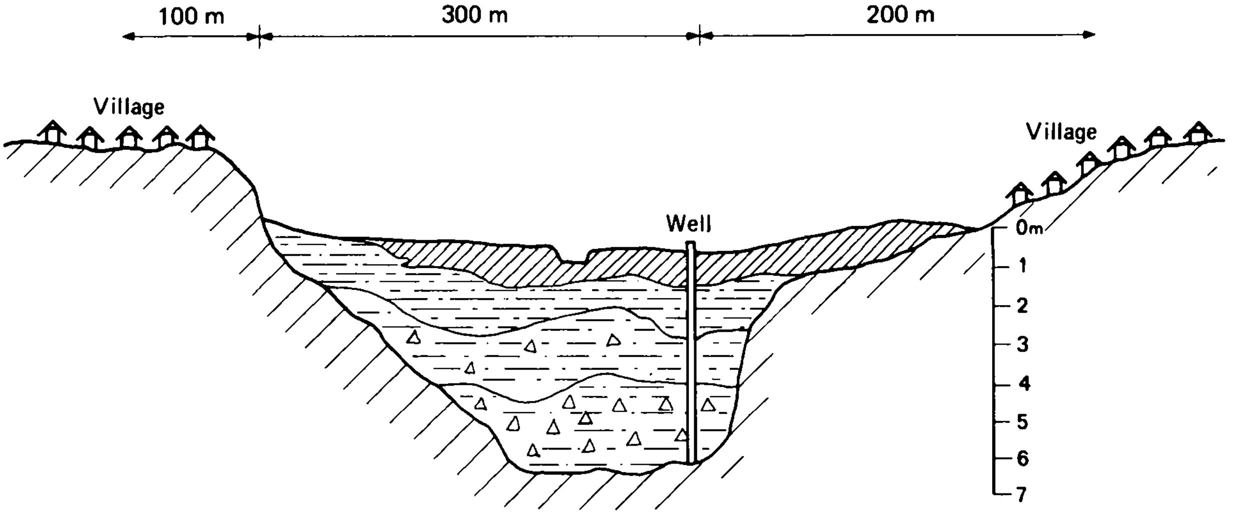


FIGURE 4. SMALL VALLEY

Small valley sites

Profiles will be drilled across the valley, more or less at right angles to the present riverbed.
Because of flooding of such areas it is utterly important to locate the well sites as far as possible from the present river course, on slightly elevated locations.

Peneplain sites

Such areas are usually underlain by basement, the upper part of which may be weathered, covered with a few metres of silty soil.
The best prospects for well sites are in depressions, small valleys and of course near pools and wet places.
A number of boreholes can be drilled along two profiles perpendicular to each other.

Test Drilling

Although essentially the drilling of survey holes with hand operated equipment is a simple technique, it requires a lot of skill and experience to operate the equipment with optimal results and minimal repairs.
By experience mainly, the surveyor has to learn which augers to use under which soil conditions and especially what are the limits beyond which he should not push his equipment in order to avoid breaking down of augers, extensions and casings.

The purpose of the various augers is as follows:

- Combination auger

  The body of this auger consists of two blades, the ends of which are forged into the auger's end.
  Upwards the blades diverse gradually up to the desired diameter. Depending on the width of the blades, the auger is suitable for clay, silt or sand.
  The blades of the combination auger have an average width so it can be used in many kinds of soil.

- Riverside auger

  The body of this auger is a tube with two blades welded at the bottom. The blades are spoon shaped so that the soil is steadily pushed into the tube.
  This auger is very suitable for use in hard, stiff soils, in sand and in soils mixed with gravel.

- Stone auger

  If the gravel content of the soil is so high that the riverside auger is not yielding adequate results, then sometimes the stone auger can be used to lift large stones that block the drilling operation.

- Flight auger

  This is a complete swivelled auger with a specially hardened bit, which makes the auger suitbable for penetrating cemented soils and weathered rock.

- Spiral auger

  This auger is made of a steel strip, forged into a spiral. With this auger, hard layers e.g. laterite and calcrete, can be broken loose and the material brought out with other auger types afterwards.

- Stone catcher

  This auger is made of a round iron bar, forged in the shape if a spring. It can be used to remove large stones from the borehole and also as a fishing tool for equipment, lost in the borehole.

- Bailer

  The bailer or pulse auger is a tube, fitted with a valve at the bottom. It is used inside the casing for penetrating water-saturated sand layers by moving it up and down.

In brief the drilling proceeds according to the following rules of thumb:

An area of about 2x2 m is cleared around the drilling site. Drilling is started then with the lightweight set using a Ø 10 cm combination or riverside auger.
In case a very hard and dry top soil is encountered, sometimes the upper 50 cm have to be broken up with a pick axe or hoe. If the soil is very hard to drill (e.g. stiff clays), first a pilot hole is drilled with the Ø 7 cm augers and afterwards the hole is reamed with the Ø 10 cm augers.

When the water table is passed and the hole starts caving in or in case very loose, dry material is encountered, a casing has to be placed.
The lowest two casings are slotted, the others are blind.
At the bottom of the string of casings is a casing shoe, the knife edge or toothed cutting end of which is slightly wider than the outer diameter of the casing.
During lifting, the drilling rod has to be disconnected in lengths of not more than 3 m, to prevent bending of the extensions.

If no progress is made anymore with the lightweight set, but continuation of the drilling with hand equipment is still thought possible, the heavyweight set has to come into action.

Drilling is stopped when:
- a waterbearing layer is encountered that has to be pump tested
- the hole is 16 m deep, and no aquifer is found or expected at greater depth
- coarse gravel, stones, very stiff clay of hard rock is encountered and further progress is impossible without damaging the equipment

The material from the borehole is laid out neatly in rows, each row representing a full meter of depth.

Immediately after finishing the drilling, a borehole description is made, using a form that was specially designed for this purpose (Annex II to this paper).

Test Pumping

If, in a survey drilling, a water-bearing layer with some prospects has been found (e.g. a confined aquifer of at least 1 m thickness or an unconfined aquifer of more than 2 m thickness), and the electrical conductivity of the ground water is below 2000 µS/cm, usually a pump test will be carried out in order to get some insight in the yield of the test borehole.

A simple, locally made, hand-operated pump is lowered into the borehole. The depth at which the pump is operated is adjustable by adding 1 m extensions to the rising main.

After the static water level has been recorded, the test can start.

Hand-pumping is continued for an hour, provided that the pumping level of the ground water does not descend below the pump intake, in which case the pump intake would have to be lowered by adding more extensions to the rising main. If this is not possible, the test will be stopped.
During the test, the yield, the water level and the electrical conductivity of the ground water are measured and recorded every ten minutes.
Immediately after the pumping is stopped, the recovery of the ground water level in the test hole is measured for a period of five minutes with intervals of one minute. A model pump test is shown as Annex II to this paper (backside of the borehole description form).

Experience has shown that the maximum possible yield of the hand pump used for survey pump tests is about 3000 litres per hour. Provided that enough effort is put into the operation of the pump, the yield of the pump test will depend mainly on the borehole and aquifer characteristics.
Experience again has taught us that a yield of more than 1000 litres per hour during the survey pump test, is sufficient for construction of a hand-drilled shallow well.
If the yield of the survey pump test is between 500 and 1000 litres per hour, the survey of the site will be continued in order to find a borehole with a yield of at least 1000 litres per hour. Should such a borehole not be found, then that one with the highest yield might be approved for construction of a hand-drilled or hand-dug well.
Pump test yields below 500 litres per hour are disapproved.

Water Quality Check

At the end of the pump test a water sample is taken and a simple check is carried out to test it for its suitability as drinking water. The water should neither smell nor taste salty, sour, soapy or bitter, so should in fact be almost tasteless.

Furthermore it should be clear and colourless after standing for a few minutes. The water must not contain any visible living organisms like worms nor the remnants of plants or other visible debris. The total dissolved solids content is checked by means of an electrical conductivity meter.

Chemical analysis of many ground water samples throughout Morogoro Region has shown that in this region toxic or health affecting chemical substances are not likely to occur in concentrations exceeding the Tanzanian Standards. Therefore the water quality check as described above is sufficiently safe to approve or disapprove the site during the survey stage.

The bacteriological quality of the ground water can easily be controlled by selecting aquifers and well locations which are not liable to contamination.

It need not be said that a well site can only definitely be approved, after a complete analysis of the ground water has proven its suitability for drinking water.

<u>Criteria for Approval or Disapproval of Well Sites</u>

It is up to the experienced surveyor to approve or disapprove a survey test well. The factors he has to consider are:

a. the yield of the pump test
b. the appearance, colour, odour, taste and E.C. of the ground water
c. the location of the test well
d. the hydrogeology of the site

Sub a

If the pump test yield was more than 1000 litres/hour, the well can be approved for construction as a hand-drilled well with a PVC tubing.

If the yield was between 500 and 1000 litres/hour, the survey will be continued on this site to try and find a well (usually in the same aquifer) which will yield more water. In case such a well cannot be found, then the test hole with the highest yield might be chosen for construction as a hand-drilled or a hand-dug well.
Often the hydrogeologist will be consulted on this decision.
Pump test yields below 500 litres per hour can be accepted neither for the construction of drilled nor for dug wells.

Sub b

If during the pump test the E.C. value of the ground water stays constant and below 2000 µS/cm, the well can be approved.

If, however, during the pump test the E.C. value increases considerably, but does not yet exceed 2000 µS/cm, this may be an indication that after some time of prolonged withdrawal, the water might become too salty. In such a case the survey will be continued to try to find a safer location.

When during the pump test the E.C. value of the ground water exceeds 2000 µS/cm, the well will be disapproved.

Sometimes it happens that the E.C. value of the water standing in the borehole, measured during drilling, exceeds 2000 µS/cm but that during the pump-test this value decreases considerably.
In such a case it is quite safe to approve the construction of a well. Salts sometimes tend to get concentrated in clays and when drilling through clays, the water in the borehole may get mineralised temporarily by these salts. When such a well is pumped, water will be drawn from the aquifer and the E.C. value will decrease rapidly until the value of the ground water from the pumped aquifer is reached.

Sub c

The location of the well site is very important and many factors have to be taken into consideration:

- The site has to be within walking distance (1 km) from that part of the village for which the well is meant.
  The location of the site has to be discussed with the people from the village because if alternative traditional water sources are within closer range from the village than the well site, the future well might not be used at all.
- The site location has to be accessible on foot throughout the year.
- The site location should not be subject to flooding during the rainy season.
- The location should be so that there is no danger of contamination or pollution of the ground water.
- The location should not be in a depression but preferably on a slope or elevation so that spill water from the future well, as well as rainwater will always drain away from the well.

Sub d

When surveying a site by means of test drillings, gradually insight is gained into the hydrogeological conditions of the site.
This knowledge has to be used to evaluate the extent of the aquifer and its recharge possibilities in order to assure a continuous water supply throughout the year.

In villages where local hand-dug holes are already existing, sometimes information on ground water level fluctuations from shallow aquifers can be obtained from the people of the village.

Final Activities

After the completion of the actual survey activities there are a number of matters that have to be arranged by the surveyor before leaving the village.

a. On all approved sites a concrete benchmark will be placed indicating the MWCP borehole number.
b. The surveyor has to show the approved sites to the officials of the village.
c. The surveyor has to explain the meaning of the benchmarks to the people so that they will not be removed. He also explains that it may take a few months before the actual construction of the wells will start.

Recording and Filing of Survey Data

In the field, the surveyor uses three types of forms:
a. the borehole description form
b. the village sketch
c. the situation sketch

If available 1:50,000 topographical map sheets are used also.

Sub a

On the borehole description (Annex II to this paper), the underlisted data can be recorded:
- the location of the borehole (village, ward, division, district, coordinates)
- lithological description of the borehole samples
- hydrogeological information, such as water content of the different layers, the static water level in the borehole, the depth(s) of the aquifer(s) encountered, the E.C. of the ground water in the different layers
- the pump test data
- recommendations for the construction (total well depth, depth of screen)
- the names of the labourers from the village who helped drilling the borehole

Sub b

The village sketch (Annex I to this paper, review of sites) is drawn by the surveyor after finishing his survey drilling in a village. This sketch, not necessary to scale, shows the lay-out of the complete village, sub-villages included, with all the important roads, buildings, rivers, existing water supply facilitites such as local wells and taps if present.

Sub c

The situation sketch (Annex III to this paper) shows the situation around one site. It shows amongst other things the lay-out of that part of the village, where the site is located.
Again the main buildings, houses, roads, tracks, rivers, vegetation as well as water sources are indicated.
The location of all boreholes will be plotted on this sketch and distances between the boreholes as well as between the boreholes and some fixed points on the sketch are to be measured and marked on the sketch. The situation sketch is supposed to be a blow-up of part of the village sketch and has to show enough details so that the locations of the boreholes are fixed without misunderstanding.

If available, the extent of the village as well as the locations of the approved and disapproved sites are marked by the surveyor on a 1:50,000 topographical map sheet.

One copy of all survey forms is sent to the Construction Department of the MWCP and one copy is sent to the project manager's office.
The original papers are filed in the office of the Survey Department.

Recommendations for Construction

The end products of the Survey Department are approved well wites, and all information on:

- the location of the well site
- the type of well
- its construction particulars
- problems to be expected during the construction drilling
- the accessibility by car of the well site during the different seasons

is handed over to the Construction Department.

This information comprises:

- benchmarks with borehole numbers, indicating the exact position of the approved well site in the field
- copies of the village sketch and the well site situation sketches.
- copies of the survey borehole description forms
  On this form, recommendations on the type of well, total well depth, depth of screen and if necessary slot size of the screen and grain size of the gravel pack are given.
- lithological profile of the approved survey boreholes
  From the borehole description a lithological profile is drawn in the survey office. This profile is used by the Construction Department in making their design of the well.

E. STATISTICAL SURVEY DATA

Production Rate of Approved Well Sites

Experience of two years of survey in Morogoro Region has learned us that on an average in one month a surveyor drills and tests a total depth of about 230 m of boreholes.
With an average depth of the survey drilling of 9 m, a surveyor thus drills about 25 survey holes in one month.

The table below, based on experience in Morogoro Region, shows how many approved sites per month can be found by a surveyor working in areas with different grades of difficulty in finding sites.

Classification of area with relation to the possibilitites of finding well sites	Average number of drillings required to find one approved well site	Number of approved well sites/month/ surveyor
Very good - good	2 - 3	8 - 12
Good - fair	4 - 8	3 - 6
Fair	10 - 15	1 - 3
Poor - very poor	50	less than 1

In the areas classified as poor - very poor, many survey drillings usually are not very deep because of the presence of hard basement rocks close to the surface. Therefore even if on an average more than 50 drillings are necessary to find one approved well site, a surveyor still may be able to find one site per month in such areas.

Between May 1978 and May 1980, a total number of 442 approved well sites have been found by the Survey Department. A breakdown of these sites per area is shown on the next page.

Area	Total number of approved sites	% of total approved sites	Average number of drillings required to find one approved site	Total number of drillings
Kilosa	113	30	2 - 3	333
Berega	104	25	7	728
Mvomero	50	11	6	300
Doma	41	9	10	410
Tundu	41	9	6	246
Ngerengere	37	8	15	555
Morogoro	27	6	6	162
Geiro	9	2	53	477
	442 sites			3211 drillings

Only six approved well sites will be constructed as a hand-dug wells; all other 436 approved sites could be approved for hand-drilled construction.

From these figures can be calculated that during the past two years the average number of survey drillings necessary to find one approved well site in Morogoro Region is 7. With an average drilling rate of 25 holes per month, one surveyor thus finds 3 to 4 approved sites per month or 42 per year.
Since the production goal of the MWCP is 250 wells per year, 6 surveyors are necessary to meet the project's production goal.

Summary of Geography and Hydrogeology of Well Sites in Morogoro Region

At present there are 360 villages in the northern part of the region (Morogoro and Kilosa districts) with a total rural population of 543,000. The rural population is highly concentrated in a few areas: the Uluguru and Ukaguru mountains and their adjoining piedmonts and foothills.

According to age and lithology, the rocks in the project area can be grouped into four major divisions:

- Pre-cambrian rocks — (gneiss, granulite, dolomite) Approximately 70% of the project area.
- Karroo rocks — (sandstone, siltstone, shale) Approximately 6% of the project area.
- Jurassic rocks — (sandstone, mudstone, limestone) Approximately 4% of the project area.
- Quaternary/Tertiary rocks — (clay, silt, sand, gravel) Approximately 20% of the project area.

The relation between the location of the villages and their geological surroundings is shown below:

Geographical location	Main geological formation	Approx. number of villages	No. of villages where shallow wells are possible	
			proven	estim.
Wami (rift) Valley	Quaternary/Tertiary sediments	55	75	85
Uluguru mountains	Pre-Cambrian granulite, gneiss	90	--	20
Ukaguru Mountains	Pre-Cambrian gneiss	100	24	50
Uluguru foothills, E and S	Pre-Cambrian gneiss, dolomite	50	12	38
Uluguru foothills, W and N	Pre-Cambrian gneiss	40	20	30
Ruhembe Valley	Quaternary sediments	9	7	9
		360	93	200

Although this summary indicates the general geological surroundings of the different geographical units of the project area, it is not representative for the hydrogeology of the well sites, surveyed up to now. Namely, the bulk of the well sites (about 90%) is in unconsolidated sediments of Quaternary/Tertiary age and the main types of aquifers are: river terraces, buried river channels, alluvial fan deposits, colluvium.
Ten percent of the well sites are found in weathered and decomposed basement rock, mainly gneiss.
Figures 1 to 4 show four hydrogeological environments, typical for Morogoro Region; the most ideal locations for shallow wells under these different circumstances are indicated also.

Drilling Depth, Aquifer Depth and Aquifer Quality

In Shinyanga Region, the average depth of survey drillings was about 5 m at the beginning of this project and about 6 - 7 m towards the end of the project. Deeper survey holes were drilled only occasionally and the deepest hole ever drilled with hand equipment was 15 m. With this knowledge, survey in Morogoro Region was started and during the first months of this project, the depth of the survey holes was also between 5 and 8 m with an average of 6 - 7 m.
Gradually, however, a new policy was developed.

It was decided that in areas where several aquifers are present at different depths, preferably not the upper aquifer but the second or even the third one was to be selected for exploitation.
The reasons for this are obvious:

- deeper aquifers usually are confined and ground water level fluctuations are relatively small compared to those in unconfined aquifers
- less danger of drying up of the aquifer
- less danger of contamination of the aquifer
- longer travel time of ground water, hence better natural purification

At present the average depth of the survey drillings is 9 m but this depth is not exactly representative for the survey in alluvial areas, because also many unsuccessful very shallow boreholes in basement areas are influencing this number. Actually in alluvial areas the present average depth is between 9 and 12 m and regularly deeper holes are drilled. The maximum depth drilled so far with the lightweight survey set is 25 m.

In plain areas, underlain by Quaternary/Tertiary sediments deposited in river valleys and alluvial fans, often several aquifers occur at different depths.
Sometimes they are interconnected but often they are separated from each other by clays and silts.
The depth of the uppermost aquifer may be between 1 and 4 m. If a second aquifer is present, it may be found between 4 and 10 m and deeper aquifers occur between 10 and 16 m on an average.

About 50 percent of the alluvial aquifers exist of fine-to coarse-grained, more or less clean sands. Thirty percent of the alluvial aquifers are silty or silty-clayey sands and 20 percent of the aquifers are sandy silts.

The aquifers in the weathered basement zone exist of inhomogeneous fine to coarse materials often with abundant mica.
Laterites or calcretes are seldom encoutered.

Water Quality

In general in Tanzania the shallow ground water is less mineralised than the deeper ground water.
This fact has also been proven in Morogoro Region.

Analysis of more than 200 water samples from different approved shallow well sites in Morogoro Region has learned us that toxic and health-affecting substances are not likely to occur in concentrations exceeding the Tanzanian Water Quality Standards. Sometimes the iron content of the shallow ground waters is found to exceed the tentative Tanzanian standard of 1 ppm; values between 1 and 8 ppm do occur.

Since, however, the presence of iron in water is only considered objectionable because it may impart a brownish colour to laundry and affect the taste of beverages, and its presence in excess of the standard does not effect the human health whatsoever, values up to 10 ppm could still be accepted, especially in these areas where attractive alternative sources are not available. It is advisable to consult the future consumers (the village people) on their opinion on the taste of the water in case the iron contents is high.

Prospects for Shallow Wells in Morogoro Region

Based on the experience gained so far during two years of survey in this region, it is tentatively estimated that in at least 200 from the total of 360 villages, sufficient shallow well sites can be found to meet the water demands of their population.

Since the villages where shallow wells are not thought possible are mainly located in the high mountain areas where the total population per village is below the average of 1500, it is estimated that in the northern part of Morogoro Region, at least 400,000 people, or almost 75% of the rural population, can be supplied with shallow wells.

On hydrogeological grounds, this percentage may even be somewhat higher (up to 80-85%) in the southern part of Morogoro Region.

ANNEX I

MOROGORO WELLS CONSTRUCTION PROJECT

Village Sketch - Survey Section

Date	
Surveyor	

Village :................................

Ward :................................

Division :................................

District :................................

Appr.number of people	nr.
Planning/Review of sites	nr.

Approved well sites:	Disapproved well sites: ....

North Arrow

Mark: subvillages, important buildings, main roads with destination, approved sites, disapproved sites.

For legend see situation sketch forms

MOROGORO WELLS CONSTRUCTION PROJECT

Borehole Description - Survey Section

Date	
Drill. Equip.	
Surveyor	

Village :................................

Ward :................................

Division :................................

District :................................

Co-ordinates:............. — ....

Borehole number	
Disapproved	Approved
Checked by	

Depth m-GL	Major Parts lithology	Major Parts gradation	Minor Parts lithology	Minor Parts gradation	Consis-tency	Colour	Wat.cont. dr	m	w	wt	EC µS/cm	Kind of auger	Profile m-GL
—													0
—													
—													2
—													
—													4
—													
—													
—													6
—													
—													8
—													
—													
—													10
—													
—													12

Profile scale (m-GL): 0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24

INDEX

Lithology		Gradation		Colour	
clay	= cl	fine	= fn	black	= blk
silt	= slt	medium	= me	brown	= br
sand	= sd	coarse	= cs	grey	= gy
gravel	= gr	**Consistency**		blue	= bl
stones	= st	soft	= sft	green	= ge
sandstone	= sd.st.	sticky	= stk	yellow	= ye
laterite	= lat	loose	= ls	white	= wh
calcrete	= cal	weathered	= wed	red	= red
mica	= mi	hard	= hd	orange	= og
basement	= bm				
very	= ve	**Kind of auger**		dark	= d-
much	= mu	clay	= cl	light	= l-
little	= li	riverside	= ri	mottled	= mot
layers	= lay	bailer	= ba		

▌ water bearing — ▼ water level — ground level = GL — liters/hour = l/h

Total drilling depth :................m-GL

Aquifer(s) depth(s) :...... — ....m-GL

:...... — ....m-GL

:...... — ....m-GL

Water level :................m-GL

Tested yield :................l/h

Max. drawdown :................m

EC at T_0 :................µS/cm

EC at T_{60} :................µS/cm

Screen depth :................m-GL

Pump intake depth :................m-GL

Transmissivity :................m^2/day

Remarks:

RECOMMENDATIONS FOR CONSTRUCTION

Total Well Depth :................m-GL

Depth(s) of Screen(s) :...... — ....m-GL

:...... — ....m-GL

Pump Test

Borehole number :................

Date :................

Water level :................m-GL

Screen depth :................m-GL

Pump intake depth :................m-GL

Content 1 bucket :................liter

Before starting the pump test, slowly pump 2-5 buckets to develop the borehole!

Time minutes	Number of buckets	Water level m-GL	EC µS/cm
T_0	X		
T_{10}			
T_{20}			
T_{30}			
T_{40}			
T_{50}			
T_{60}			
	+		

If pump test fails, give the reasons!

....

....

....

....

....

....

....

Yield = ... x .... liter (content of 1 bucket) = ...liter/hour

Number of buckets	T_{10}	T_{20}	T_{30}	T_{40}	T_{50}	T_{60}
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						

Recovery Test

Time minutes	Water level m-GL
T_{61}	
T_{62}	
T_{63}	
T_{64}	
T_{65}	

Names of daily paid labourers

1. ....

2. ....

MOROGORO WELLS CONSTRUCTION PROJECT

Situation Sketch - Survey Section

Date	
Surveyor	

Village :.................................

Ward :.................................

Division :.................................

District :.................................

Co-ordinate: :.............. ....

Site number(s)	
Number(s) of approved Borehole(s)	

North Arrow

Tarmac Road

Road

Track

Foot path

Railway

River

Dry River bed

Bridge/culvert

Telephone or Electricity line

House

CCM — CCM Office

School — School

H — Hotel

Disp. — Dispensary

Shop — Shop

Church

Mosque

BH1 — Survey Borehole, approved

BH2 — Survey Borehole. Disapproved

HH/DW — Handdug Hole/Drumwell

CW — Concrete lined shallow well

SW — Shallow well with Handpump

Grass

Shamba

Sisal

Bushes/Shrub

Tree (name)

Palm Tree

Area temporarily flooded

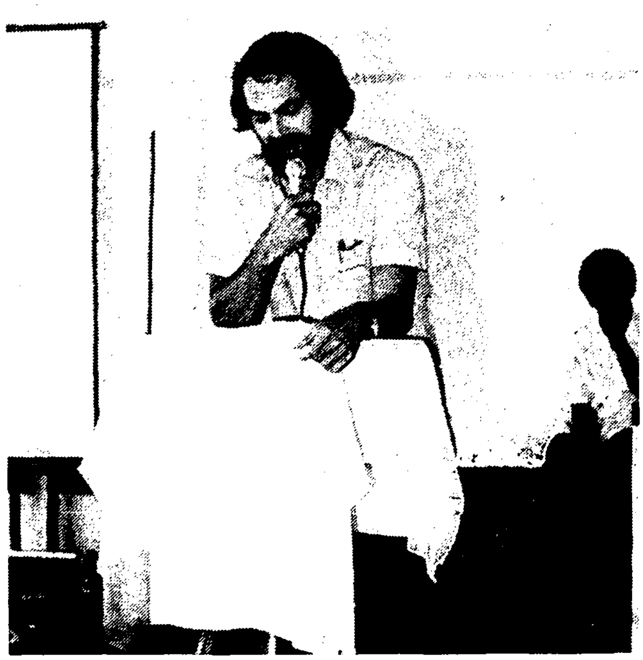
Steep Hill

Basement outcrop

270 m — Distance in meters

Data Existing Water Holes/Wells

Hole/Well	Depth	W.L.	E.C. µS/MC
1	........m	.......m	....
2	........m	.......m	....
3	........m	.......m	....
4	........m	.......m	....
5	........m	.......m	....
6	........m	.......m	....
7	........m	.......m	....



3.2.3. CONSTRUCTION OF HAND-DRILLED SHALLOW WELLS

Paper presented by R. Blankwaardt, Training Officer Construction MWCP

A. WHY HAND-DRILLED SHALLOW WELLS

The techniques for the construction of hand-drilled shallow wells as applied in the Morogoro Wells Construction Project (MWCP) have been adopted (with some minor alterations of equipment) from the Shinyanga Shallow Wells Project. There the construction of hand-dug wells with concrete rings was the normal practice.
However, in the search for cheaper and easier construction methods, equipment for hand-drilled wells was developed whereby the concrete rings were replaced by PVC screens and casings of much smaller diameter. This construction method was applied to those aquifers with a direct yield of more than 1000 liters per hour.
After some time it was found that approximately 50% of the wells that can be made in Shinyanga Region, could be made by the hand-drilled method. From January 1977 till the end of 1978 a number of 40-50 wells has been drilled by hand in the Shinyanga Region.

After these two years, when considerable experience had been obtained, the belance was made up. The advantages were all too obvious for all kinds of aspects: time, energy, materials, transport, money.
Figures 1 and 2 show the severe drawbacks of hand-dug wells with respect to time and money.

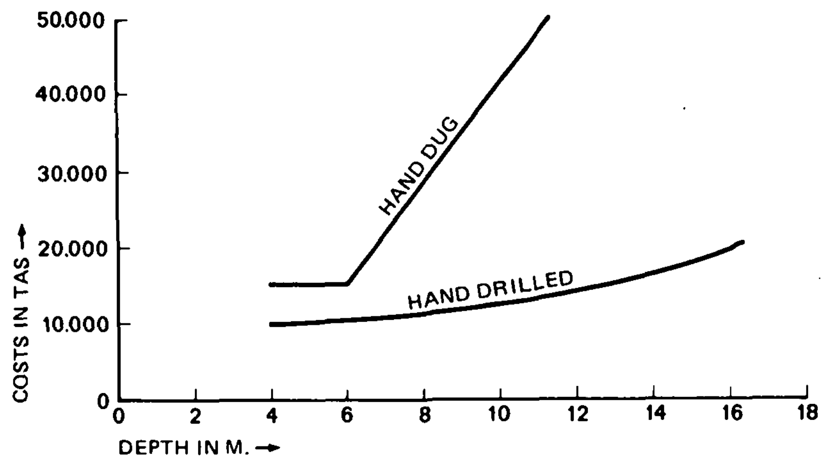
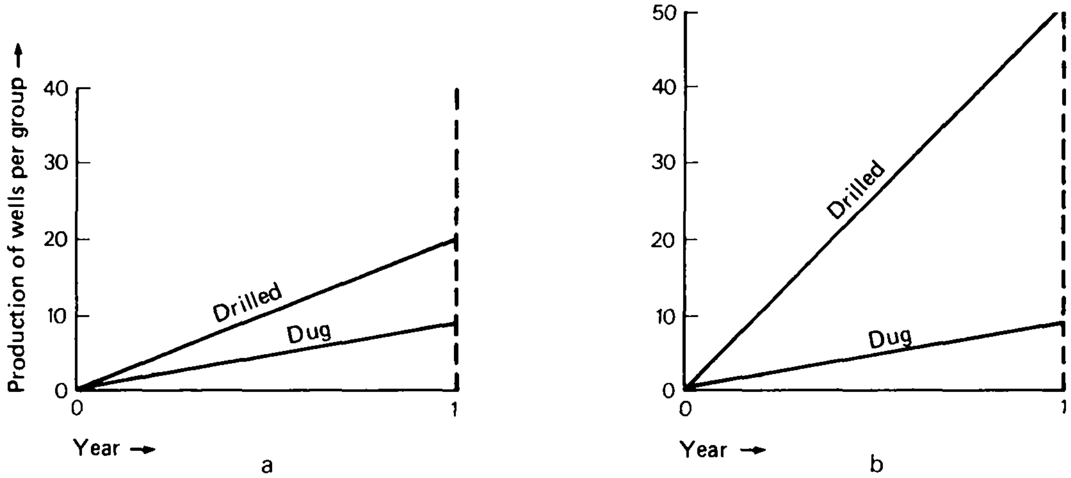


FIGURE 1 COST OF SHALLOW WELLS

Figure 1 shows a graph of costs versus depth for both hand-dug and hand-drilled wells.
At a depth of 6 to 7 meters there is a sharp increase in the price of hand-dug wells. This is caused by the fact that at that depth the normal suction pumps, which are used to keep the water out when digging, will not function anymore. Heavier plant e.g. expensive electric underwater pumps have to be used.
Besides that, the availability of cement for and the transport of the concrete rings is going to count in a heavier way. Also the difficulty of work is more than directly proportional to the depth of the well, thus sharply increasing the labour costs.
Summarizing, the costs of a hand-dug well are approximately T.Sh. 15,000/- as long as the well is not deeper than 6 to 7 meters.
On the other hand, the costs of a hand-drilled well (including overhead and survey costs) will vary from T.Sh. 9,000/- to 14,000/- as a maximum.

A second important aspect is the construction time. Experience has taught that the construction time for a dug well is 3 to 7 weeks (although it could easily be 3 months as well), whereas the average for a drilled well is 4 to 6 days, say one week (in Shinyanga and Morogoro Regions). This is of special importance for the 1991 target, as shown in Figure 2. It shows two graphs of production versus time. They are based on data for 8 meters deep wells, which is the average depth of the wells in Morogoro Region.



a : with the same budget as for dug wells
b : with unlimited budget

Based on 8 m. well: dug 6-7 weeks 25000/.
drilled 1 week 10000/.

FIGURE 2. PRODUCTION OF SHALLOW WELLS

The difference will be clear from Figure 2a where money has not been taken into consideration. One drilling crew can produce 50 hand-drilled wells versus only 8 hand-dug wells.

But even if the budget for digging and drilling would be the same, still the production of drilled wells would be 2.5 times as high as for hand-dug wells. See Figure 2b.

Besides these main advantages of drilled wells, there are the much less transport problems, construction difficulties, the easy repair of broken equipment, less need of cement and, last but not least, the much better working conditions.

It would not be fair, however, to state that everywhere in the country where shallow ground water is available, it would be possible to construct small diameter tube wells. We must take into account that there will remain poor aquifers which make it necessary to build storage capacity in the well.

So far in Morogoro, however, the survey results were such, that all the wells could be made by drilling.

B. SET-UP OF THE CONSTRUCTION DEPARTMENT

The Tasks of the Department

The main tasks of the Construction Department are:
1. Drilling and construction of wells with a target of 250 per year.
2. Administration of field data and supplies.
3. Training of personnel.
4. Innovation and testing of equipment and construction methods.

For the performance of these tasks the department has been organized according to the scheme in Figure 3.

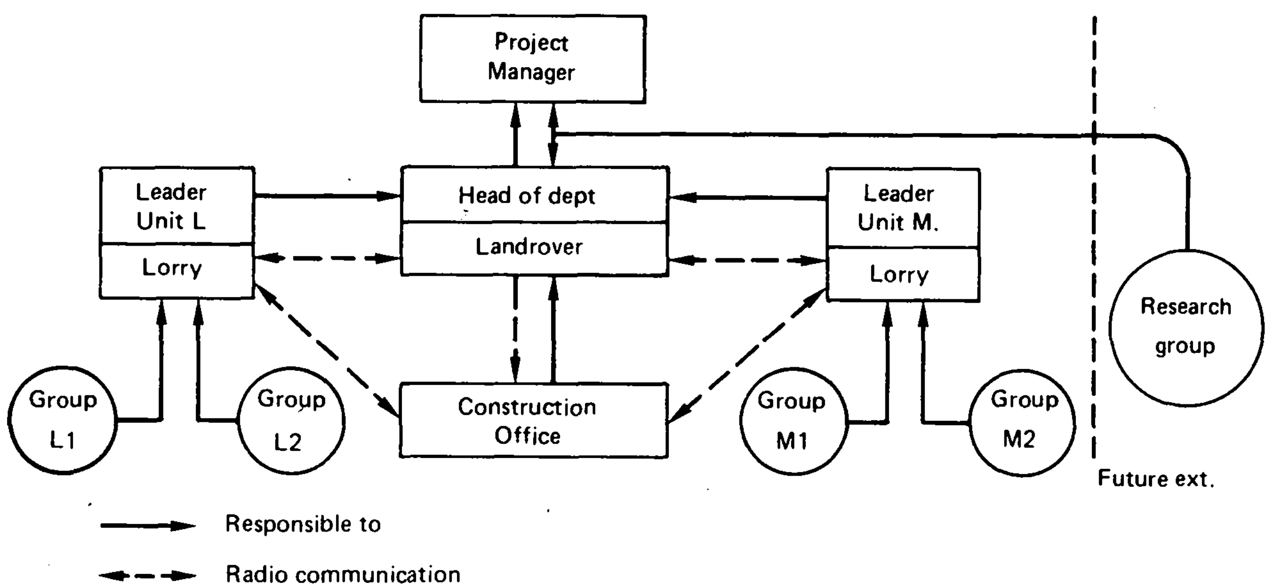


FIGURE 3. ORGANISATION OF CONSTRUCTION DEPARTMENTS

Both office and construction units are responsible to the head of department, who in his turn has to render account to the project manager.
Besides the above mentioned tasks, overall organization and quality control of products and production methods belong to the duties of the head of department.

Planning of the field activities is mainly dependent on progress of the surveying and on seasonal conditions. For the coordination of all these activities there are regular staff meetings and for discussion of planning and specific technical problems, a survey-construction meeting is held every two weeks.

Ad 1 - Construction of 250 wells per year

Four drilling groups (called L1, L2, M1, M2 in Figure 3) do the actual construction work in the villages. Last year their production was just a little below this target.
This number might be extended to five in the future.
Each group has a group leader and two socalled heavy hand drillers.
All are project employees.
Usually the group will recruit 4 to 5 casual labourers through the CCM office of the village they work in.

Every two groups form a unit which is supervised by a unit leader who is responsible for planning, organization and logistics of the unit (L and M).
That means:

- design of the wells
- transport and supplies
- contacts with authorities
- data collection in the field
- finances in the field

Each unit has a lorry with crane at its disposal although the crane is not an absolutely necessary item.

The unit will have its highest productivity if the two groups are working quite close to each other, thus reducing the transport.
Transport is also considerably diminished by radio communication between the units, the home office and the head of department.

Ad 2 - Administration of field data and supplies

The office personnel at the project yard in Morogoro is fulfilling a central role in the communications with and the supply of the units in the field and the administration of all incoming field data. They take care of all requests from the field for materials and repair of equipment.
They are the link between construction office on one side and stores and factory on the other side. The office keeps record of all essential data such as borehole descriptions, week reports, transport logbooks, well reports, maintenance forms, etc.

Ad 3 - Training of personnel

The project tries to achieve high quality standards for its products.
This has its repercussions on the recruitment and further education of personnel:

- Standard VII certificate is required for the drilling crews. Further skill is developed through on-the-job training and regular theory lessons.

- Group leaders should also have shown capacities for planning and organization, although in fact all group members should be able to replace him in case of illness or leave.
- Because of their heavy tasks, unit leaders must have either a certificate of the Water Resources Institute or Form IV with extended experience in the technical field.
- Office personnel should have Form IV certificate.

All workers in the project start off with a probation contract of 3 months. After that time - when the candidate proves to be good in his job and willing to learn - this will be changed into a definitive contract.
The project is trying to get official grades for well drillers recognized by the Ministry of Water, Energy and Minerals (Maji). This will probably be settled as soon as the Water Resources Institute has taken over the training for other Regions from the MWCP.

Ad 4 - Innovation of equipment

The task of the department is dealt with in Chapter F.

The Relation with Other Departments

The earlier mentioned production rate of 50 wells per year per group can be reached if and only if the project as a whole is well organized. As the Construction Department is the production unit of the project, it is also the most vulnerable part of the project.

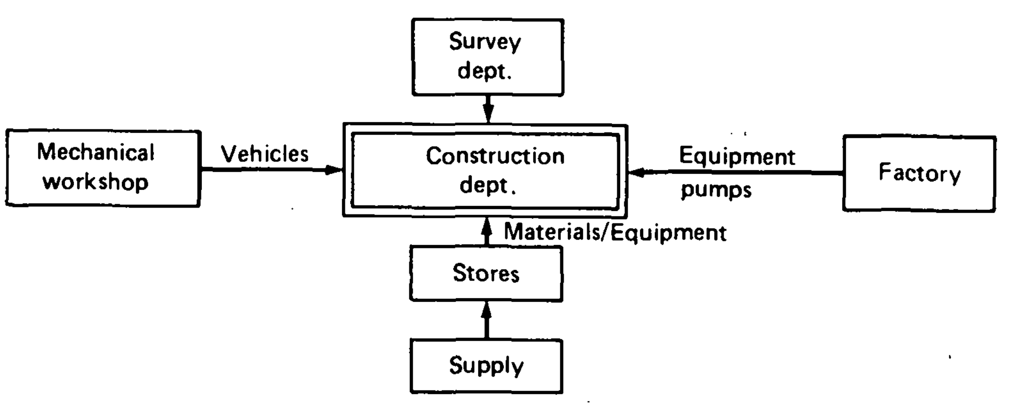


FIGURE 4. THE CONSTRUCTION DEPARTMENT WITHIN THE PROJECT

This becomes clear when we take a look at Figure 4. This shows the dependency of the Construction Department on other parts of the project.

For a good functioning of the department, it has to obtain data of approved sites from the Survey Department, building materials and drilling equipment from the stores, locally made and repaired equipment from the workshop and the transport facilities have to be arranged by the mechanical workshop.

If all these departments are not well tuned to each other, this will have immediate repercussions on the production of wells. This, however, is a matter of overall management and organization.

C. OUTLINE OF THE FIELDWORK

The work in the field does not only consist of the technical construction of shallow wells. The contacts with the village authorities are just as important.
Also there is related preparatory and finishing paper work in the office.

Before a group starts working in a particular village, design of the wells have to be made. From the Survey Department are obtained:
- a village lay out
- situation sketches of the approved sites
- vertical soil profile
- a soil description form with results from the survey pump test and recommendations for the screen depth and the total depth of the well

Based on these data the unit leader prepares the designs for the wells. The group leader receives the design and the survey borehole description so that he can compare this with his own finding. If he finds big differences he can ask advice from the surveyor concerned.

The first thing to do for the unit leader when a group starts in a new village is to pay a visit to the CCM representatives.
It is discussed what the group is going to do in the village and necessary things can be arranged by the CCM office, namely
- cooperation with villagers
- appointment of daily paid labourers
- education of future users of the wells
- a place to set up a tented camp
- a safe store for equipment and materials

After these talks with the CCM, all approved sites will be visited in order to make a planning for the work in the village.
Also inquiries will be made about locations where building materials such as gravel pack, sand and stones or gravel can be collected.

In the meantime the camp is set up and the drilling equipment is transported to the first site, where preparations for the construction can be made. The site has to be cleared to obtain good working space. The tripod is set up and the equipment is laid in order so that the actual drilling can start. A typical lay-out of the site is shown in Figure 5.

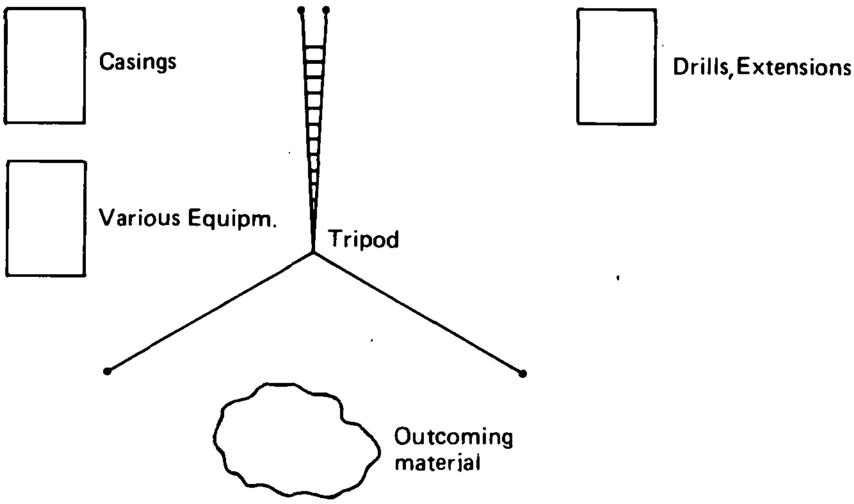


FIGURE 5. PLAN OF A CONSTRUCTION SITE

For a well of average depth the total construction will take 3 to 4 days, including drilling of the borehole, installation of PVC and gravel pack, pump test and building of the slab. After several days (when the slab has got its strength) the pump can be installed, which is a matter of an hour's work only.

Every opportunity to stimulate participation of the villagers should be taken. Some suggestions are:
- an opening ceremony of the well
- official appointment of pump attendants
- cleaning programs set up by the school
- health education in dispensaries

All these things fall in the category of the extension work. It cannot be stressed enough that this is one of the most important things for preventive maintenance of the wells.
A sociological study of the project by BRALUP will reveal whether the project is on the right way in this respect.

D. THE CONSTRUCTION OF A HAND DRILLED WELL

The Design

The most important part of the well is the intake for water from the aquifer. If this has not been constructed properly, the lifetime of the well will not be very long, no matter how good the pump may be.
Its location must therefore be chosen very carefully and the screen must be well embedded in the filter material. It should also be sealed off very well from possible upper aquifers, if there is danger of pollution. A typical design for a hand-drilled shallow well is given in Figure 6.

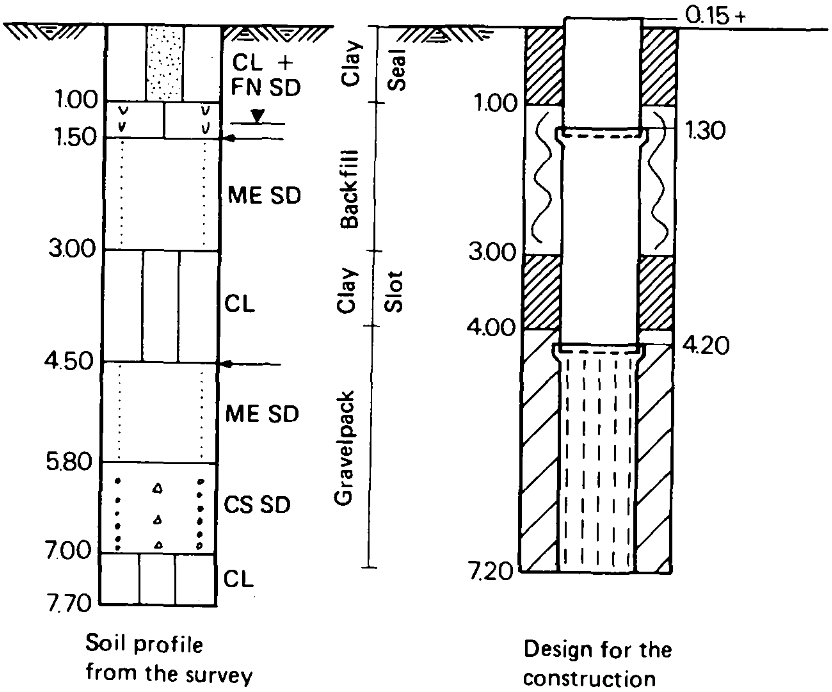


FIGURE 6. A TYPICAL DESIGN FOR A SHALLOW WELL

The hydrogeological conditions (alluvial deposits) are typical for the Morogoro Region.

In our concept of construction slotted PVC pipe is used as a screen, surrounded by a so-called gravel pack.
There should be a good tuning of the sizes of the slots, the gravel pack and the grains of the aquifer.
The criteria are the following:
- there should be enough slots to create low entrance velocitites
- the gravel pack should not clog the slots

- the gravel pack should act as a filter for the surrounding aquifer material
- the gravel pack should be coarse enough to let through the finest particles of the aquifer for good development

Combination of a slot size of 0.6-0.8 mm and a gravel pack sieved between the practical measurements of 1.2 mm (mosquito gauze) and 4.6 mm (coffee tray wire) seems to be a guarantee for a long life of the intake in almost any aquifer.

The diameter of the PVC pipes is determined by three factors:
1. the diameter of the borehole, which means the diameter of the drilling equipment
2. the thickness of the gravel pack should be sufficient
3. the maximum size of the cylinder to be installed

Recently a change has been made from PVC Ø 160 mm to PVC Ø 125 mm, after an adaption of the 3" cylinders, which saves a lot of money since the price is 2/3 of the old one.

The Construction

Figure 7 shows the flow chart of the complete construction procedure. On the right hand side is written the necessary equipment and on the left hand side the required materials for the several stages of construction.

The Drilling

Construction starts off with drilling a borehole of suitable diameter in the near vicinity of the survey borehole.
The drilling equipment is essentially the same as that for the survey. The only difference is that it is some sizes bigger and heavier. This equipment is hoisted and lowered by means of a pulley system hung from a tripod with winch and cable. All separate parts, however, have been designed in such a way that they can easily be handled by one or two men.

On top of the (extended) drill a cross piece with handle bars is mounted so that the drill can be turned into the soil by manpower. Usually 4 to 8 men are required to do the job, depending, of course, on the soil conditions.

The soil conditions also determine what type of drill has to be used. Four types of drill are available:
1. the auger bit + flight, mainly used for clayey and silty materials, possibly mixed with sand
2. the conical auger, used to penetrate and crush very hard and dry clay layers
3. the riverside bit for use in layers which contain a lot of gravel or stones

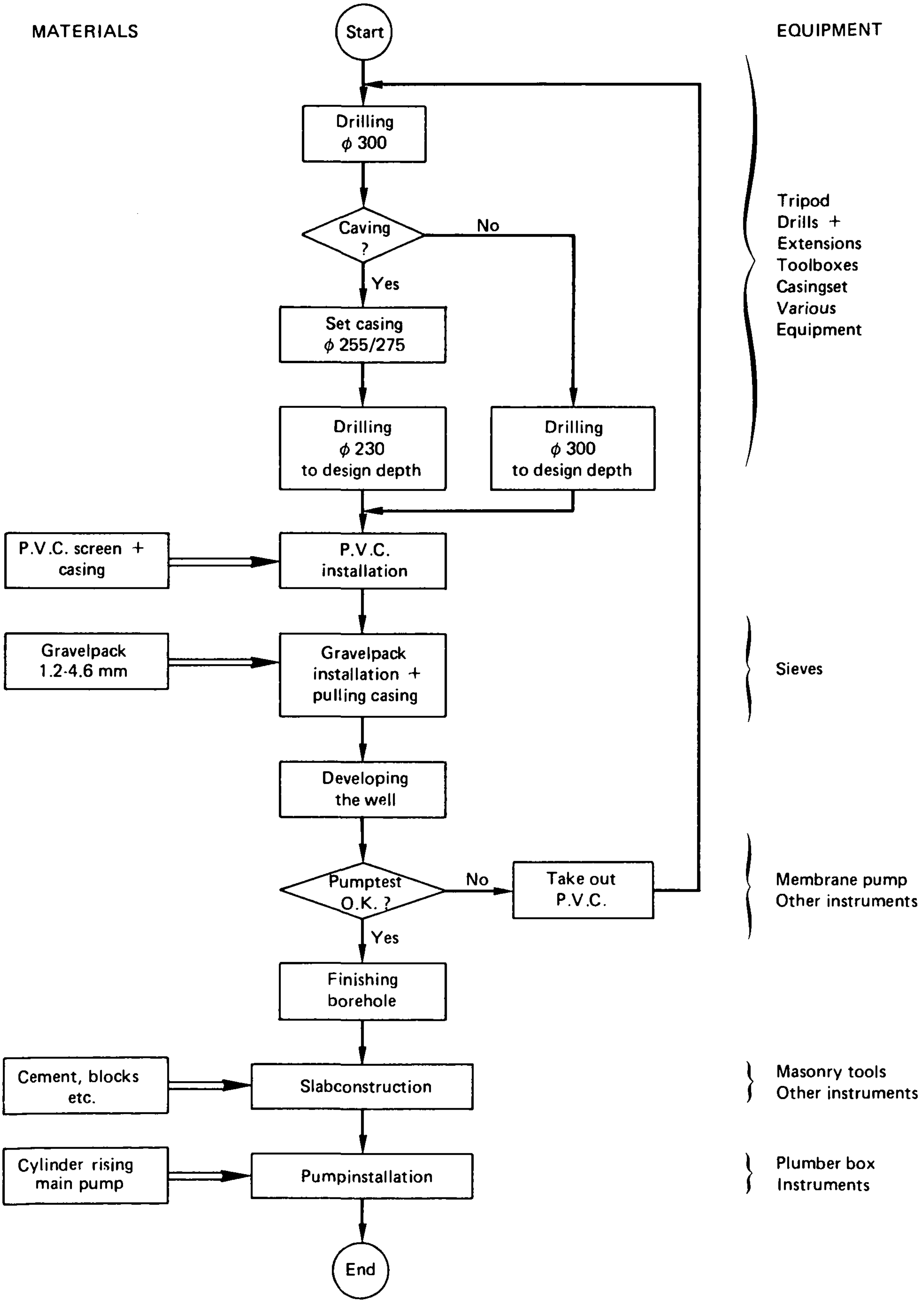


FIGURE 7. FLOWCHART OF CONSTRUCTION

These three types are available in two sizes. One of a diameter of 300 mm for drilling without casing. The casing has an outside diameter of 275 mm and the inside measures 250 mm. The second has a diameter of 230 mm and is used inside the casing, which is inserted when the borehole starts caving. This happens especially in sandy layers under the water table. In that case the 4th type is applied, which is actually not a drill, namely the bailer: a plain steel pipe with cutting shoe and bottom valve.

A big advantage of this "heavy hand drill" equipment is that most of it can be produced from materials readily available in Tanzania. (Some small exceptions are e.g. the cutting edges of the drills which have to be made from special steel.) This means that it can also easily be repaired by a good welder.

Installation of the Screen

When the design depth has been reached, the screen can be installed. Normally the whole assembly of PVC tube is placed in the borehole at once, sealed off at the bottom with a wooden plug. Screens and casings are available in standard lengths of 3 meters.

Then the gravel pack is poured into the borehole until the screen is fully covered. This is done in combination with the pulling out of the casing. It should be done extremely carefully, because a small mistake at this stage may spoil the whole performance of the well afterwards.

Development and Pump Test

Before the borehole is filled up to the top, first the aquifer is developed. The reason is that the soil of the aquifer, directly adjacent to the gravel pack, is always somehow affected during the drilling.
Sometimes a thin clay layer has been created on the inside of the borehole. This can be removed by intermittent pumping for which a high capacity membrane hand pump is used.
The only drawback of this pump is that it is a suction pump and therefore not suitable for water levels lower than 7-8 meters below ground level.

When the water has lost its initial brown colour (caused by fine soil particles) a pump test is done with the same pump for half an hour. If the yield of the well is sufficient (> 1000 l/hr) the borehole is finished by filling it up with a clay seal (if necessary) and backfill material.

If for some reason the yield is not sufficient, the well will have to be redrilled. The PVC is taken out and cleaned. So the only loss will be two or three days' work and some gravel pack.

Slab Construction

The making of the slab requires good masonry skills from the group members.
A solid circular slab is constructed around a pre-fabricated cover, on which the footplate of the pump will be fixed by means of cast-in anchor bolts. The circular shape is of course arbitrary. It might just be a square one as well.

The slab is provided with a spill water outlet and a ditch is dug towards a lower lying drainage area. The diameter of the slab is approximately 3 meters.

The use of cement is reduced by the use of big stones in between which a mortar is poured. Another advantage is that stones are more easily available than gravel, which is required to make "real" concrete.

Special attention must be given to the temporary coverage of the slab in order to prevent premature evaporation of the water that is necessary to build up the final strength of the construction.
The building time is approximately one day.

Pump Installation

When the mortar of the slab has obtained a good part of its strength (say after 2 or 3 days) the pump cylinder with rising main can be installed. This is a very simple procedure that takes only one hour.

The cylinders applied are of the type with foot valve and piston valve. They are available in sizes of 2" and 3" internal diameter. The cylinder is connected to the pump by means of a rising main of 1½" and pump rod of ½", the latter being attached to the piston in the cylinder and to the moving part of the pump. As the word says, the rising main is the conduct channel through which the water is pumped up.

The ground water level determines the size of the pump cylinder. This is due to the characteristics of the applied pump. It is a foot pump (called "kangaroo" pump for its jumping action) in which a pressed down spring is the constant driving force. That means that a small size cylinder has to be applied if the water level is low (say below 5-6 meters), otherwise the spring force will not be sifficient to bring the pump head back into position. The other way round, if a small cylinder is applied with a high water level, the force in the spring will make the pump head jump up too fast.

This problem can be avoided by using a hand pump, although such a pump shows other disadvantages. The kangaroo pump can be applied for water levels down to approximately 15 meters below ground level.

Investigations are carried out by the workshop to develop a hand pump which is near to "maintenance free".

Administration

During the construction of the well, the group leaders keep record of the following:

- soil description
- quantities of PVC and gravel pack
- pump test results
- quantities of cement, sand and stones for the slab construction
- final design of the well

Later on the data on the pump installation are added and everything is written on the so-called "well description form". This form is filed in the office.

Quantities of materials are transferred from this form to the "well report", on which the running costs for that particular well are calculated.
Further data concerning labour and transport costs are derived from the weekly report, composed by the unit leader.

Whenever a well needs maintenance, the one who has executed the repair will fill out a "maintenance form", from which the essential data are transferred to the reverse side of the well report.

All these specially designed forms have been added to this paper as Annexes 1 through 4.

Together with the survey forms these forms will be filed in the administration office.
This makes it possible that even after years everybody can have direct access to everything that is known about the wells.

E. EVALUATION OF CONSTRUCTION ACTIVITIES

Production of Wells in Morogoro Region

From the start of the project in December 1978, production of the wells has been realized by four groups of "heavy-hand-drillers" and very occasionally by a mobile drill rig "B80".

In the year 1979 216 wells have been completed, 4 of which were abandoned, almost reaching the target of 250 wells per year.
In 1980 up to the end of July, a total of 101 wells has been constructed.

This brings the total production to 313 wells. If we count that 250 people will use the water from one well, we can say that approximately 75,000 people in the villages have been supplied with clean drinking water within 400-500 meters from their homes.

A graph of production per month is shown in Figure 8. The minimum around April 1979 is due to heavy rainfall and bad accessibility of roads and sites.

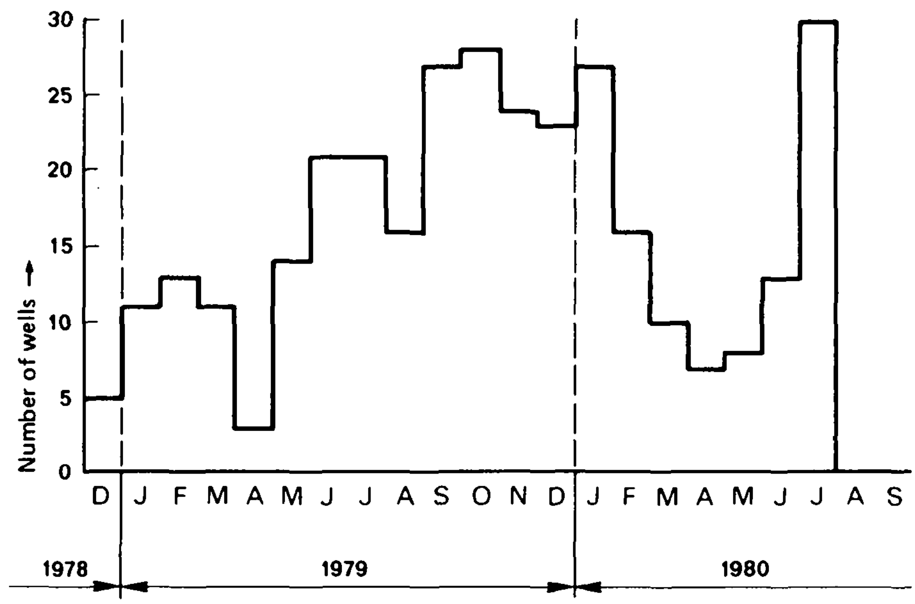


FIGURE 8. PRODUCTION OF WELLS IN MOROGORO REGION

The minimum around the months of April and May 1980 is not only due to rainfall, because there was not much rain this year. It was also due to some severe illnesses and organizational problems which have been solved by now. The months of January 1979 and 1980 compare badly, because of starting-up problems in the beginning of 1979.

Figure 9 shows the frequency distribution of the depth of the wells drilled in Morogoro. It is varying from 3.50 to 15 meters. Most of the wells, however, (approximately 65%) are in the range of 6 to 10 meters.
The average depth of drilling is 8.50 meters.

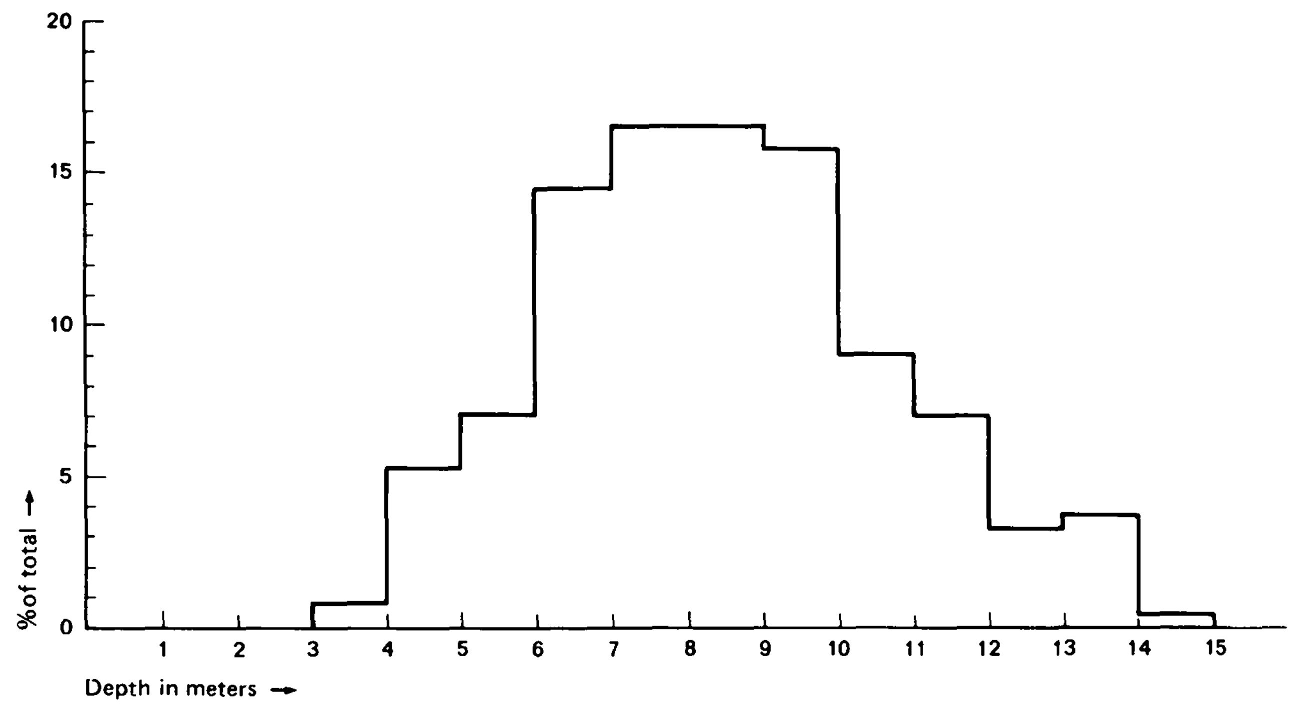


FIGURE 9. FREQUENCY OF WELL DEPTH

Performance of the Wells

In June 1980 an investigation was carried out into the performance of the first one hundred wells that have been constructed in Morogoro. All these wells are at least one year old.

As far as the construction was concerned, special attention was given to the intake, the slab construction, the cylinder and the pump. Some of the results of this survey are given below:

- Of all wells the intake was working satisfactorily (high enough yield and clear water), which means that the combination of 0.8 mm slots and 1-4 m gravelpack has been chosen well.
- Some of the slabs needed repair. It turned out that the central prefabricated concrete cover had subsided some extra centimeters. This is mainly due to bad compaction of the underlaying soil and can easily be improved by better instruction of the crews.
- All cylinders but 4, worked properly. These 4 showed leaking foot valves.

- Eighty of the wells were equipped with prototype kangaroo pumps and 25 of these needed immediate replacement because of broken springs. About one year ago, this pump has been improved to such an extent that no complaints have come so far and that a long lifetime may be expected.

It was very much encouraging to see that the general conditions and the state of the surroundings was much better in villages where some extension work had taken place.

Cost of the Wells

The total running costs of a well of average depth were calculated for the first year of construction to be approximately T.Sh. 11,000/-. These costs include:

- labour costs of Tanzanian staff
- running costs of transport
- materials (imported as well as locally purchased or manufactured)
- running costs of the well siting by the survey department

Omitted from these costs are the costs of expatriate staff and depreciation of equipment and vehicles.

The total costs can be roughly broken down as follows:

- labour costs	20%
- transport costs	15%
- materials (imported)	55%
- materials (local)	10%
total	100%

It will be clear from these figures that efforts to reduce the costs should in principle be directed towards reduction of the proportion of imported materials. Furthermore attention should be given to reduction of investment and depreciation costs of equipment and vehicles.

Performance of the Drilling Equipment

After working with the heavy hand-drill equipment for almost four years (including Shinyanga), the following conclusions can be made:

- the equipment works quite satisfactory as it penetrates any soil except hard laterites and basement
- operation of the heavy hand-drill is quite simple and does not require highly specialized personnel
- broken parts of equipment are easy to repair
- the costs of investment, maintenance and operation are relatively low, especially when compared to machine-driven drill rigs
- the maximum drilling depth is approximately 15 meters, mainly due to the high frictional forces between soil and steel casing

- transport of the equipment is sometimes troublesome with respect to its weight and the necessity to use a lorry

F. INNOVATION OF EQUIPMENT AND MATERIALS

The main reasons for a systematically set up innovation/research programme are:
- reduction of investment and running costs
- quality improvement of products
- creation of better working conditions
- increase of production

It is a task of the Construction Department that can only be fulfilled in close cooperation with other departments and with help from other sources, sometimes even far outside the project.

The most important thing is that all improvements are well tested in the field. This takes time which is sometimes frustrating for the inventors. However, new ideas may be fine, but if they are not thoroughly tested, they are just good for the dust-bin.

As this testing requires some special skills and as it can easily lead to overburdening of the production groups, a special research group will be established in the near future.

One of the experiments with a probably big impact is the development of a lighter hand-drill set with smaller diameter.
This set should be very easy to handle and transport, thus taking away the necessary use of a lorry and improving the working conditions. The investment costs will be much lower than those of the heavy hand-drill set.

A second subject is the development of a high quality, "maintenance free" hand pump, which can be manufactured in Tanzania. This would create the possibility to use one standard size cylinder and would cut the expenses on imported goods. The price of such a pump could easily be half the price of the kangaroo pump, not regarding the costs of maintenance.

The third activity is mainly aimed at import substitution. Some examples are:
- manufacturing of tripods in the project's factory instead of importing them from Holland
- try out of the slotting machine at BOKO in Dar es Salaam, so that PVC screens will not have to be imported
- try out to manufacture the brass parts of the cylinder valves by Arusha Metal Industries

Last but not least, there is the quality improvement of the construction procedures such as:

- a better slab construction, e.g. made of concrete, which will last longer
- construction of a washing basin at some distance from the well, thus reducing the danger of pollution
- improved extension work, although rather a social aspect still very much contributing to the lifetime of the well

The first mentioned topics - the light hand drill and the hand pump - may have a great impact, especially where delivery of equipment to other regions is concerned.

The outlooks are promising and results will be published as soon as the experiments have been rounded off with satisfactory field tests.

MOROGORO WELLS CONSTRUCTION PROJECT

Well number	

Well Description - Construction Section

Village :..................................

Ward :..................................

Division :..................................

District :..................................

Date start :............................

Date completion :............................

Operator :............................

Total Well Depth :...............m-cover level

Water Level :...............m-cover level

EC :...............µS/cm

1. Borehole description

Depth m-GL	Major Parts		Minor Parts		Consis-tency	Colour	Wat.cont.				Drill	
	lithology	gradation	lithology	gradation			dr	m	w	wb	diam. cm	type
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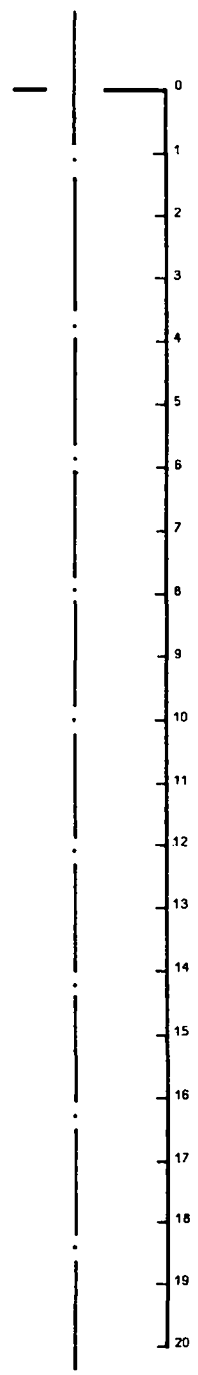
Lithology		Gradation		Colour			
clay	= cl	fine	= fn	black	= blk	dark	= d-
silt	= slt	medium	= me	brown	= br	light	= l-
sand	= sd	coarse	= cs	grey	= gy	mottled	= mot
gravel	= gr	**Consistency**		blue	= bl		
stones	= st	soft	= sft	green	= ge	very	= ve
sandstone	= sd.st.	sticky	= stk	yellow	= ye	much	= mu
laterite	= lat	loose	= ls	white	= wh	little	= li
calcrete	= cal	weathered	= wed	red	= red	layers	= lay
mica	= mi	hard	= hd	orange	= og		
basement	= bm					ground level	= GL

2. P.V.C. Installed

Diameter	......./.......mm
Slot size	...............mm
Screen	.... x 3.00 m + ...m
Casing	.... x 3.00 m + ...m
Sockets	....
Cover	....

3. Sketch P.V.C.



4. Gravelpack

Size	..... - .....mm
Karai	....
Depth	From .... to ....m-GL

5. Pumptest

time minutes	Water level m-GL	Drawdown m	Number of buckets
T_0		X	X
T_5			
T_{10}			
T_{15}			
T_{20}			
T_{25}			
T_{30}			

______ x

Content of 1 bucket in litres: ______ x

______ 2 x

Yield in L/hr: ______

6. Recovery test

Time minutes	Water level m-GL
T_{31}	
T_{32}	
T_{33}	
T_{34}	
T_{35}	

Type of pump: ....

If pump test fails, give the reasons:

....

....

6. Slab construction

Material	Unit	Number
Cement	bag	
Sand	box	
Stones	box	
Cement block	—	

7. Pump installation

Date	Pump type	Cylinder		Rising main								Socket
		Diam. mm	Type	4.00	3.50	3.00	2.50	2.00	1.50	1.00	0.75	

Pump attendants: ....

Construction Week Report **ANNEX II**

Week:............

Unit:............

Date	Well no.	Labour M.W.C.P.		Daily Paids		Car No	Km/ Mls	Km each day	Driver	Plant no.	Hrs	Work description
		GR.	GR.	GR.	GR.							

MOROGORO WELLS CONSTRUCTION PROJECT

ANNEX III

Well report - Construction Section

Well Number	

Village : ....

Ward : ....

Division : ....

District : ....

Date start : ....

Date completed : ....

Date Pump Installation : ....

Group + Operator : ....

Date											Qty	Unit Price	Total —
Labour Man days	M.W.C.P.												
	Local												+
											Total Labour	Tsh.	

Transport Kilometers	No.												
	No.												
	No.												+
											Total Transport	Tsh.	

Materials		Unit	Qty	Unit Price	Total
P.V.C mm ⌀	screen	m'			
	casing	m'			
	socket	EA			
Cover PVC/Wood		EA			
Gravel pack		Karai			+
			Total Borehole	Ths.	
Concrete cover		EA.			
Cement		EA			
Cement block		bag			
Stones		box			
Sand		box			+
			Total Slab	Tsh.	
Pump		EA			
Cyl. ...... mm		EA			
Rising Main		—	—	—	← Total Tsh. (Rising main + Pumprod)
Socket ⌀ 1½"		EA			
Grease		kg			
Oil		ltr.			+
			Total Pump Tshs	Tshs	+

Rising main + Pumprod			
Length	Qty	Unit Price	Total
6.00			
4.00			
3.50			
3.00			
2.50			
2.00			
1.50			
1.00			
0.75			+
	Total	Tsh.	

Total Materials Costs	Tshs	
Total Labour Costs	Tshs	
Total Transport Costs	Tshs	+
Subtotal	Tshs	
Overhead...........%	Tshs	+
Total Running Costs	Tshs	

Check of Well		Maintenance necessary ?		Maintenance of Well			
Date	By	No	Yes	Date	By	Form No.	Costs Tsh

3.2.4. SUPPLY

Paper presented by A. van der Wel, Supply Manager MWCP

A. INTRODUCTION

An introduction on the supply of shallow well materials should start, in our opinion, with the recall of a recommendation adopted at the Regional Water Engineers' conference held in Shinyanga, October 1977.

Rec. no. 4

"When a region will adopt a sizeable shallow well construction programme a need will immediately arise for a supply unit where all the necessary equipment and materials for shallow well construction can be bought, as one could not expect this equipment to be procured from different sources by each region on its own.
Standardization and ready stock is a requisite. This includes also the provision with spares for the maintenance of installed pumps.
The meeting recommended that, in the event that the Shinyanga Shallow Wells Project would move to Morogoro, inclusive the manufacture of equipment, Shinyanga should still function as a supply centre for West-Tanzania".

It is interesting to observe how, three years after these words have been written, the actual situation has developed. We therefore refer to the underlined parts of the above resolution.

"All the necessary equipment and materials"

Up till now deliveries from the Morogoro Wells Construction Project have been strictly limited to those items regarded "strictly shallow wells related", which is a considerably more narrow definition than the one adopted in Shinyanga.

"Standardization"

Although some basic principles for shallow well construction seem to be more widely accepted now, we are still far from any real standardization.

"Ready stock"

Up till recently within the Morogoro Wells Construction Project there has been kept a stock only to cover the "own" project requirements. Orders from other customers were processed on arrival, resulting in orders to the MWCP factory, viz. orders for purchase abroad. As a result a delivery time of at least three months had (and still has) to be taken into account.

"The supply centre for W-Tanzania"

Morogoro has gradually developed into a main supply centre for shallow well materials. Although Shinyanga has supplied and still supplies pumpheads of the Shinyanga model to other projects, the Shinyanga Shallow Wells Project itself so heavily depends on material support from the Morogoro Wells Construction project that one cannot speak of a fully operational second supply centre for W-Tanzania.
At the start of the Morogoro Wells Construction Project no stockpiling for deliveries to third parties was considered necessary/feasible for three basic reasons:

- the number of regions adhering to the training programme and, consequently, to be supplied with shallow well materials could not be predicted with sufficient exactness
- as most of the imported material was forwarded by air substantial stockpiling was not considered necessary, as air transport was expected to guarantee a reasonably prompt delivery after receipt of the order
- a too extensive stock was regarded dangerous in view of rapid product development, thus to avoid the risk of unacceptable obsolescence

Moreover it had been foreseen that the existing MWCP organization and staff could handle the supply to third parties as some "additional" activity.

These assumptions have been proven basically wrong, as a result of which the supply from the Morogoro Wells Construction Project presently is not functioning satisfactory:

- the volume of demand from other regions has exceeded expectations
- the original principle of importing by air freight no longer stands, the prohibitive price compelling us to import materials by ship wherever possible
- the existing MWCP organization and staff have been insufficiently able to cope with the double demand from their "own" as well as from other projects
- local manufacture at the MWCP sofar did not sufficiently develop into regular production

B. EXPERIENCE WITH LOCAL PRODUCTION AT MWCP

Part of the MWCP programme consists of local production of, in principle, all tools, equipment and materials needed for the execution of the project and for supply to third parties. Therefore a factory, or rather a general purpose metalworkshop, has been built and equipped at the MWCP yard at Morogoro. So far this local manufacture has not been fully realized because of:

a. Insufficient availability and/or poor quality of raw materials.
b. Difficulties in getting and retaining skilled workers. Consequently, continuous training of workers consumes much production time and effort. High salary demands resulting from the rapid industrialization of Morogoro and from the skill obtained, are insufficiently met by the government salaries paid in our project.
c. Frequent minor design changes as a result of experience gained.

A serious point of consideration should be our principle only to supply materials that are "strictly shallow well related". (N.B. For some closely related projects like the Shinyanga Shallow Wells Project this principle has not been maintained anyhow.)
Shallow well projects were originally supposed to obtain sufficient local materials on the Tanzanian market.
This applies for materials such as steel, pipes for the manufacture of rising mains, PVC, various tools and others. Considering the highly unsatisfactory local supply situation, plus the unlikeliness of a rapid improvement, we doubt if maintaining the above principle is in the interest of the development of shallow well construction in Tanzania.

To overcome some of our supply problems and to create a buffer against unexpected delays in the supply from abroad it has been decided to raise the present stock level.

Wherever possible supply from stock will take place. However, expecially in the near future, one should still count on a delivery time of at least three months.

C. FUTURE DEVELOPMENTS

Supply is not a purpose in inself but an instrument to reach certain goals. This simply means that before any decision on supply matters can be made more important policy matters should have been decided upon first. The supply decisions to be made greatly depend upon any such policy decision.
The number of variables in the process is such that some outline for discussion should be given in order to arrive at an orderly decision-making process.
Hereafter we have made an attempt to provide some outlines for the discussion. Wherever appropriate we did not hesitate to put forward our opinion for consideration by this meeting. This has been done rather to activate the discussion than hoping to arrive at our specific solution. By doing so we morely hope to arrive at some firm decision regarding the main topics.

1. Resolution adopted at the 1980 RWE conference in Tanga: "Wherever feasible rural water supply should be undertaken by means of shallow wells".

2. Decision on : Estimated no. of wells to reach the target. Estimated no. of wells per region indicating minima and maxima.

3. Decision on : Main construction principle:
   - hand-drilled
   - hand-dug
   - machine-drilled

4. Decision on : Basic design and standardization.
   Without a far reaching standardization any target for shallow well construction is unlikely to be met, in view of supply but especially in view of future maintenance needs.
   Full standardization should be reached in our opinion on:
   - pump cylinders, pistons and valves
   - rising main/pump rod combination
   - moving/wearing parts of pump heads

   We would prefer limiting the choice of pump heads to a maximum of two basic types:
   a. A simple vertical action pump like the present kangaroo pump for depths down to ± 10 meters. (Morogoro region: 75% of constructed wells.)

Advantage

- Sturdy sealed unit without removeable parts.
- Great ouput per stroke, enabling the attachment of cattle watering points and small-scale irrigation which in our opinion deserve more attention.
- Remains operational even in case of a partial breakdown.

Disadvantage

- Not easy to operate by small persons or children.
- Local production with some difficulties (needs more manufacturing skill, choice of material).

b. A simple all-steel lever pump for depths exceeding ± 10 meters.

Advantage

- Easy to operate.
- Lever construction enabling operation to greater depths with a limited choice of cylinder sizes. Consequently also to be used on existing boreholes down to ± 40 meters.
- Easier to manufacture locally, from material more likely to be locally available.
- Easy to maintain.

Disadvantage

- Completely out of order in case of essential breakdown (causing dangerous health situations by people reverting to "old" means of water supply).
- Has a lower output per stroke.
- Can be more easily damaged by outside influences.

5. Calculation of quantities. Indication of possible sources of material.

6. Decision on basic principles of supply.
   - Decentralization of supply per region/project will lead to a counterproductive splintering of efforts.
   - Any supply centre should be an independent unit, dealing with supply and production matters only and not being involved in actual shallow well construction.
   - Local production should be emphasized, not as a purpose in itself but rather to facilitate later maintenance and continuous availability of spare parts.
   - Local production of mass items, such as pump heads, should be given priority over specialized items, such as drilling material, of which only limited numbers are likely to be needed.

- Locally available materials are to be used wherever possible, but only if
  - . sufficient quality can be guaranteed
  - . continuous supply is likely
- In all supply decisions with regards to shallow wells quality considerations should always range before the price: the concept of shallow wells in terms of investment is so competitive as compared to other means of rural water supply that no minor savings may be allowed to frustrate the final result.

D. HOW TO IMPROVE THE PRESENT STATE OF SUPPLY FROM MWCP

1. <u>MWCP-internal</u>

- Supply to MWCP and to third parties should be more thoroughly separated in terms of organization as well as staff.
- The stock should be raised till a level enabling delivery of the majority of items from stock. Though this is presently being done, we feel that no optimal situation has as yet been reached.
- Regular customers should be provided with a list containing items available from MWCP, with a short description(sketch) of the item involved. A recent list of such items is attached to this paper.

2. <u>Steps to be taken by our customers</u>

- Try to give us some (non-committing!) indications of your purchase intentions.
- Order well in advance and count on a delivery time of at least three months.
- Order only those items explicitly stated on the supply list. If you do not possess such a list, ask for it first. Strictly adhere to the description given in the list and order only separate items, so not just "a survey set".
- Ensure that payment be made before collection of goods. As a matter of principle no deliveries will take place without prior payment.
- Be aware that the request to send a pro forma invoice is no firm order yet. Only after receipt of a cheque, LPO, or other explicit written order will we start processing the order. Consequently delivery time will start counting from that moment on.
- Spread your orders during the financial year. A pileup of orders made just before the end of the financial year causes congestion, confusion and delay.
- Never send any car for collection of goods without prior arrangement.

ANNEX I - ITEMS SOLD BY MOROGORO WELLS CONSTRUCTION PROJECT

List of survey equipment, light

Bailer DSL Ø 63 mm
Riverside auger DSL Ø 100 mm
Riverside auger DSL Ø 70 mm
Open clay auger DSL Ø 100 mm
Open clay auger DSL Ø 70 mm
Spiral auger DSL Ø 40 mm
Stone auger DSL Ø 70 mm
Extension rod with sleeve DSL Ø 19x1000 mm
Handle extension rod

List of survey equipment, heavy

Riverside auger DSH Ø 100 mm
Riverside auger DSH Ø 70 mm
Stone auger DSH Ø 70 mm
Extension rod square Ø 40x1000 mm
Extension rod Ø 30x1000 mm
Crosspiece
Crosspiece handle
Bolt M12x50 mm

Casing set survey

Casing plain Ø 90x1000 mm
Casing slotted Ø 90x1000 mm
Casing shoe Ø 90x100 mm
Casing head Ø 90x100 mm
Casing clamp Ø 90 mm
Casing retriever Ø 60 mm
Chain spanner 12"

Survey test pump set

Pump head Jolly Jumper
Rising main Ø 1½"x1000 mm
Foot valve Ø 1½"

Survey Instruments

Compass
Water level meter, 10 m
Electric conductivity meter
Fluoride test kit (optional)

Hand drilling equipment set HHD

Auger bit Ø 300x350 mm
Auger bit Ø 230x350 mm
Auger bit conical Ø 230x500 mm
Flight auger Ø 300x1000 mm
Flight auger Ø 230x1000 mm
Riverside auger Ø 300x1000 mm
Riverside auger Ø 230x1000 mm
Bailer Ø 180x1000 mm
Extension rod Ø 65x3000 mm
Extension rod Ø 65x2000 mm
Extension rod Ø 65x1500 mm
Extension rod Ø 65x1000 mm
Extension rod Ø 65x500 mm
Extension rod with disk Ø 65x1000 mm
Cross piece
Cross piece handle Ø 65x1250 mm
Extension catcher
Extension hanger
Bolt M16x80 mm + chain + R-spring
Auger cleaner

Casing set HHD

Casing slotted Ø 250"275x1250 mm
Casing plain Ø 250/275x1250 mm
Casing shoe Ø 250/275x200 mm
Casing hanger Ø 250/275x200 mm
Casing hanger bar Ø 34x800 mm
Set thread protectors Ø 250"275 mm
Casing clamp Ø 275 mm
Pipe for casing clamp Ø 50/38x3000 mm
Casing retriever Ø 220 mm

Tripod set

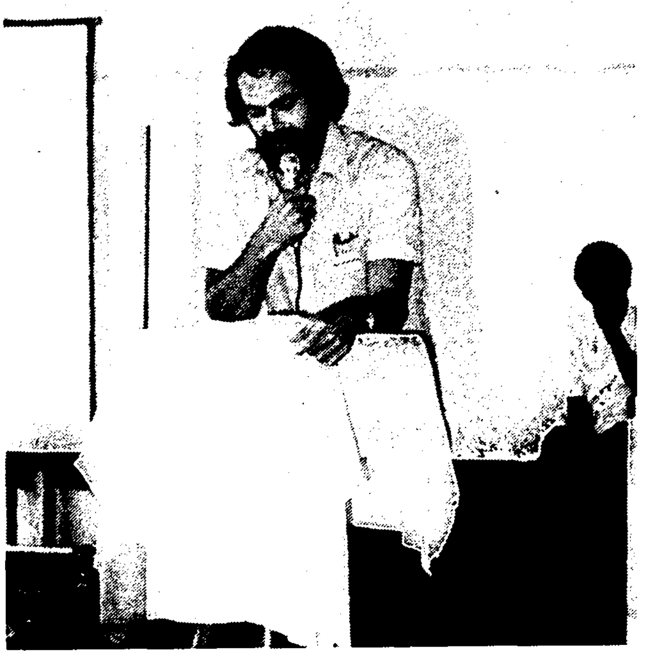
Tripod
Foot plate 300x300 mm
Foot plate 400x400 mm
Pulley, single with swivel eye, Ø 5"
Pulley, single with door and swivel hook, Ø 5"
Winch, two speed
Cable Ø 10x25 m
Thimble for cable Ø 10 mm
Cable clamp for cable Ø 10 mm

Dewatering pump set

Membrane pump
Handle membrane pump
Hose pipe Ø 2½"x20 m
Hose clamp Ø 70 mm

List of Well Construction Equipment

Plain pipe, PVC, Ø 100/110 mm, length 3 m
Plain pipe, PVC, Ø 117/125 mm, length 3 m
Screen, PVC, Ø 100/110 mm, length 3 m
Screen, PVC, Ø 117/125 mm, length 3 m
Plug for PVC screen Ø 100/110 mm
Plug for PVC screen Ø 117/125 mm
Kangaroo pump, complete with anchor bolts
Pump cylinder, complete Ø 3"
Bolt M16x25 mm
Nut M16
Lock washer M16
Pumprod hanger Ø 22x200 mm
Retriever for PVC pipe Ø 100/110 mm
Retriever for PVC pipe Ø 117/125 mm
Gravel pack sieve 1½ mm
Gravel pack sieve 5 mm
Spanner, combination 24 mm



3.2.5. TRAINING FOR SHALLOW WELLS

Paper presented by R. Blankwaardt, Training Officer Construction MWCP

A. INTRODUCTION

In the contract between the Governments of Tanzania and the Netherlands, it was embedded that the Morogoro Wells Construction Project, besides the construction of shallow wells at a rate of 250 wells per year, would:

- establish training facilities in Morogoro for teams from other regions
- offer these teams the possibility, upon completion of their training, of obtaining the necessary equipment for implementing a similar shallow wells programme in their regions
- provide a basis for the supply of tools, equipment and materials for use in other regions

Training of teams from other regions in shallow well survey/construction was considered to be very useful: it would enable the Regional Water Engineers to have their personnel trained in the hand-drilled wells construction system as applied in Morogoro, and with those people, to start a wells programme in their region.

It was clear that such a nation-wide training programme could only be set up after proper starting up of the first task of the project: regular production of shallow wells.

Furthermore many preparations had to be made:
- recruitment of traning staff for survey and construction
- preparation of syllabi for survey and construction
- arrangements with the Ministry, concerning
    - selection of regions to be trained
    - recognition of grades for shallow well technicians
    - funds for nights-out allowances, travel warrants, etc.
    - supply of camping equipment

That was the reason why the training of other regions started only in July 1979, the project itself having started in July 1978.

B. SET-UP OF THE TRAINING

Syllabi and Grades

A training syllabus has been attached to this paper as Annexes 1 and 2. It is divided in two parts:
a. hydrogeological surveying for shallow well sites
b. construction of shallow wells

The syllabus is based on the booklet Shallow Wells available at the MWCP.

Each part of the syllabus is broken down into subjects for Grade III and Grade II training, all topics being covered by the training programme in Morogoro.
This syllabus has been submitted to the Ministry for approval and subsequent recognition of the grades.

From the start of the training it was suggested that trainees, after a successful examination at the end of the training period, would be recommended to be upgraded tot Grade III level.
After an additional 6 months' practice in their respective regions and an examination thereafter, they could be promoted to Grade II level.
Discussions with the Ministry on this subject are continuing.

It was decided that the training would be aimed at hand-drilled wells. Construction of hand-dug wells was left out, as it was considered that
- in most regions experience in hand-dug wells does exist already

- drilled well sites can be found in sufficient quantity for starting up a programme in each region
- in large programs hand-dug wells should be avoided as much as possible due to high costs and cumbersome organization

Composition of the Training Groups

The original idea was that a training group should consist of one surveyor and two drillers. Furthermore it was thought that having small groups, more than one region at the time could be trained.

This concept did not work out very well.
First of all the attention of the limited training staff was split up too much. Secondly, and even more important, it became clear that if a region seriously wants to start up a shallow well programme, it has to send at least 2 surveyors, one unit leader and a construction team of 3 to 4 people.

- Two surveyors with Form IV certificate. It turned out that in other regions the survey of suitable sites can be quite difficult and therefore time consuming. Besides that, the survey can always go ahead of the construction without any restriction.
- One unit leader with Chuo Cha Maji certificate and preferably some working experience. He will be essentially responsible for the set-up of the whole shallow well programme and especially for the planning and organization of 1 or 2 construction groups.
- Three to four heavy-hand-drillers with Standard VII as a minimum. A group consisting of 4 people would be better, as such a group can always be split up later into 2 experienced construction teams.

The Training Programme

The duration of a training course is put at 3 months. There are two courses, one for hydrogeological well siting and one for well construction.

Both courses start off with an introduction at the MWCP yard in Morogoro, followed by 5 to 6 weeks on-the-job training, primarily aimed at the main subject. Then one week is spent at the yard for theory lessons, both for survey and construction.
After that, an exchange takes place for a period of two weeks. Surveyors get training in construction and vice versa. The aim is to make everybody familiar with the activities of the others and to get insight into the relations between the two subjects.
Then, during one month, the groups will make a complete performance on their own, closely supervised by the training staff.
Formerly, this part of the training took place in the Morogoro Region too, but this has been changed into performance in their own regions. The reasons for this change are the following:

- the groups will become a little bit more familiar with the hydrogeological conditions in their own region and with the specific problems they can expect later on

- the regional authorities (who will have to provide the funds!) will have an easy opportunity to visit the sites and to gain knowledge about this type of rural water supply

The training course in finished with a one week stay in Morogoro, where equipment is cleaned, papers and forms can be worked out and a final examination is given.

Recently a one month course for welders was introduced and approved by the Ministry. The aim of this course is to give a specialized training to professional welders, so that maintenance and repair of equipment can take place in the workshops at the regional Maji yards.

Organization

The Ministry acts as intermediary between the regions and the MWCP, in order to plan, coordinate and streamline the training programme, in consultation with the MWCP.
The MWCP has always strongly recommended to train teams for those regions which show real interest in the survey/construction methods for shallow wells and order equipment.
The reason is not that the MWCP wants to sell as much equipment as possible, but the training will have much more effect, if the people concerned can continue their work immediately after the training courses.

As the delivery time for equipment coincides with the duration of the course, it was always advised to the Region Water Engineers to order their equipment before the start of the training.

For the duration of the training the trainees are housed in tents either in the field or at the project yard in Morogoro.
Arrangements have been made with the Ministry that it supplies tents and camping equipment through the Regional Water Engineer's Office in Morogoro.

The Ministry also takes care of all salaries, nights-out allowances and travel warrants for the trainees. These funds are also supplied through the office of the Morogoro Regional Water Engineer.
The MWCP supplies all the necessary training equipment, varying from booklets to drilling equipment and transport.
The project also takes care of the transport to and from the regions for the last part of the training course.

C. TRAINING OF SURVEYORS

The training of surveyors in siting suitable locations for shallow wells is mainly an on-the job programme. During the field work period the trainees work together with surveyors from the project.

They are frequently attended by the training staff, who assist the trainees with the practical execution of the job and discuss and explain the theoretical matters at the site.

First the surveyors are made familiar with the actual execution of the hand-drilling. Then the elaboration of the drillings and the interpretation of the obtained data is taught. At last the most crucial part of the survey is elaborated upon, i.e. how to locate the most promising areas around a village and how to carry out the investigations.

This tripartition, however, is not strict. Already in the beginning attention is paid to subjects which will be taught and discussed more profoundly later on, during the theoretical part.

The course at the office sets in good order all the information which has already been discussed in the field, and in this way provides the surveyor with the required background information.

Although the training course in mainly based on the Shallow Wells booklet, especially for the theoretical parts additional short notes and exercises have been written.

During two weeks the surveyors are trained in constructing a well and installing the pump, thereby obtaining a better understanding of the demands that are made upon the execution of the survey, by the well constructing units.

After that, the surveyors will have to show off their knowledge in their own region. Also the organization and planning of survey and all administrative matters will be discussed during that time. A final examination is given in Morogoro.

D. TRAINING IN SHALLOW WELL CONSTRUCTION

Just like the surveying training course, the programme for training shallow well construction is mainly an on-the-job programme.

During the first 5 to 6 weeks of fieldwork the whole drilling group (including the unit leader) works under the supervision of an experienced group leader of the MWCP. Here the group is taught the use of equipment and tools and the proper well construction procedures. The group works on approved well sites in the execution programme of the project.

The aspirant unit leader is taught the administration, the supplies and the transportation for the team. Gradually he is made familiar with the planning and organization for the construction. Training staff assists the group and all relevant subjects are discussed at the site.

In the same week as the surveyors, the construction team gets theory lessons in Morogoro and obtains the necessary background information. Lessons are regularly alternated with exercises.

In the two weeks' exchange they are made familiar with the well siting, so that it will be clear in which way the survey data of approved sites are obtained.
During the training month in the region, the team will work independently under leadership of the unit leader. In this period all other aspects of well construction, such as the contacts with the village authorities will be brought up.

Also for the construction the course is rounded off with an examination. The training course covers all subjects of the Grade III and Grade II syllabi.

E. TRAINING COURSE FOR WELDERS

The duration of this course is one month and it takes place in the workshop of the Morogoro Wells Construction Project. Welders attending this course are expected to have a Grade II certificate (welder/fitter) and to have ample workshop experience.

The course comprises on-the-job training:
- maintenance and repair of drilling equipment both for survey and construction
- overhaul and repair of installed equipment such as pumps and cylinders
- manufacturing of rising main and pump rod
- manufacturing of moulds

Besides these subjects, the trainees are made familiar with the functioning of different types of pumps (kangaroo pump, hand pump, membrane pump).

Experienced workshop staff supervises the programme.

So far, welders from Tanga, Iringa, Dodoma and Arusha Regions have successfully finished the course.

F. FOLLOW-UP IN THE REGIONS

From the start of the training programme for survey and construction in August 1979, employees from 7 regional Maji offices have attended the course in Morogoro, up to the date of today.

Training for the Morogoro Region - as close to the project as possible - was executed as a pilot project. Then, toward the end of the year, a combined training of the Coast, Dar es Salaam Rural and Tanga Regions was carried out.

For these regions one surveyor and two drillers were trained. Later on Tanga Region sent one more employee for the survey course, in order to start up a crash programme in the Korogwe District (cholera outbreak).

From that time on (January 1980) no more combined training groups were accepted and furthermore part of the course was transferred to the respective regions.

Whitin this new concept teams from Dodoma, Iringa and Arusha have been trained, the latter just having finished the final examinations and ready to start a programme in the region.

So far, firm orders for equipment have been received from 4 regions, whereas teams from 7 regions attended the training. Therefore trainees from 3 regions have no equipment to work with.
Whatever the reason for not ordering equipment may be, it is quite sure that the knowledge gained from the training will depreciate very rapidly, if no proper follow up of the activities in the regions takes place.
This is a waste of money, time and energy, both for the Ministry, the Regional Water Engineer's Office and the MWCP.

Furthermore, it would be very much advisable that trained persons with a central role in future shallow well programmes, such as surveyors and unit leaders, will have a fixed base in the regions for at least a couple of years.

G. FUTURE OF THE TRAINING

Since the annual conference of Regional Water Engineers in Tanga, where it was decided that "shallow well technology should be used whenever possible and feasible", the Water Resources Institute in Dar es Salaam has shown great interest to take over the training for shallow well surveying and construction.

From the month of May on, several meetings were held between the Institute and the MWCP on the feasibility of official establishment of the training course at the Institute and on how such a transfer might be organized.

Agreement was reached upon the following subjects:
- the first course under full auspieces of the Institute, starting in November this year, will be a pilot project and will be more or less a copy of the Morogoro courses
- this first course will be looked after by the training officers of the MWCP
- teaching activities will be taken over gradually by instructors of the Institute, who will be trained as well during this course
- the course will be held in Dar es Salaam/Ubungo with field training in Coast Region

- all training materials for the first course will be supplied by the MWCP
- a textbook (manual) on survey and construction for shallow wells will be written by the MWCP staff

Furthermore the Water Resources Institute is planning to include shallow well technology in its 3-year curriculum, for which the MWCP training officers have promised to give lectures.

These developments are very much cheered by the Morogoro project for the following reasons:

- At present the course is given in Morogoro by expatriate staff. Taking over by a Tanzanian Institute is one of the aims of development aid.
- The Water Resources Institute has been set up specifically to train people contracted by Maji. A shallow wells course will fit in the objectives of the Institute.
- A training course conducted by the Institute will get the official recognition which has been looked for so long.

ANNEX I - SYLLABUS FOR WATER TECHNICIAN (SHALLOW WELL SURVEYING), GRADES II AND III

Water Technician Grade III (Shallow Well Surveying)

Introduction into organization of shallow well project.
Introduction into methodology of shallow well siting.
Introduction into hydrogeology.
Knowledge of hand-drilling materials.
Use of the equipment under different hydrogeological circumstances.
Simple check of well yield under survey conditions.
Taking soil samples.
Maintenance of tools and small equipment, on-site.
Drawing situation sketches of the surveyed areas.

Water Technician Grade II (Shallow Well Surveying)

Organization of well siting, at Grade II level.
Construction of shallow wells, hand-drilled type.
Description of borehole samples.
Interpretation of drilling results.
Choosing a well site.
Determination of the best way to execute a well siting programme under different hydrogeological circumstances.
Indication of well sites on maps 1:50,000.
Drawing borehole profiles.
Drawing geohydrological cross-sections.
Administration of records.
Understanding of (hydro)geological concepts and processes, necessary to execute a good survey programme (Grade II level), including:

- types of rock
- weathering, transportation and sedimentation of materials
- hydrological cycle
- aquifers, aquitards and aquicludes
- ground water movement
- flow pattern and water level around and in a well
- properties and design of a good well
- chemical and bacteriological water quality and it hazards
- porosity and permeability

ANNEX II - SYLLABUS FOR WATER TECHNICIAN (SHALLOW WELL CONSTRUCTION) GRADES II AND III

Water Technician, Grade III (Shallow Well Construction)

Introduction into organization of shallow well project.
Introduction into methodology of shallow well construction.
Introduction into equipment for hand-drilling.
Construction of hand-drilled wells, Grade III level.
Construction methods for shallow to medium depth wells.
Handling of heavy hand drilling (HHD) equipment.
Application of drilling bits, bailers and casings.
Cleaning and storage of HHD equipment.
Taking soil samples.
Preparation of gravel pack materials.
Installation of well screen and gravel pack.
Testing of well yield.
Construction and installation of well cover and slab.
Installation of manually operated pumps.
Maintenance of wells and pumps, Grade III level.
Maintenance of tools and small equipment, on-site.

Water Technician Grade II (Shallow Well Construction)

Organization of shallow well project at Grade II level.
Elementary knowledge of hydrogeology for well siting.
Introduction into hydrogeological survey methods for shallow well siting.
Design of shallow wells.
Construction of hand-drilled wells, Grade II level.
Selection of drilling material in relation to soil type.
Description of soil samples.
Construction of wells in loose soils.
Supervising hand-drilling, at Grade II level.
Developing a well.
Calculation of well yield.
Maintenance of tools and small equipment, on-site.
Water quality.
Field stores administration.
Preparation of weekly reports at Grade II level.
Supply of equipment and materials.
Simple cost calculation.

ANNEX I - SYLLABUS FOR WATER TECHNICIAN (SHALLOW WELL SURVEYING), GRADES II AND III

Water Technician Grade III (Shallow Well Surveying)

Introduction into organization of shallow well project.
Introduction into methodology of shallow well siting.
Introduction into hydrogeology.
Knowledge of hand-drilling materials.
Use of the equipment under different hydrogeological circumstances.
Simple check of well yield under survey conditions.
Taking soil samples.
Maintenance of tools and small equipment, on-site.
Drawing situation sketches of the surveyed areas.

Water Technician Grade II (Shallow Well Surveying)

Organization of well siting, at Grade II level.
Construction of shallow wells, hand-drilled type.
Description of borehole samples.
Interpretation of drilling results.
Choosing a well site.
Determination of the best way to execute a well siting programme under different hydrogeological circumstances.
Indication of well sites on maps 1:50,000.
Drawing borehole profiles.
Drawing geohydrological cross-sections.
Administration of records.
Understanding of (hydro)geological concepts and processes, necessary to execute a good survey programme (Grade II level), including:

- types of rock
- weathering, transportation and sedimentation of materials
- hydrological cycle
- aquifers, aquitards and aquicludes
- ground water movement
- flow pattern and water level around and in a well
- properties and design of a good well
- chemical and bacteriological water quality and it hazards
- porosity and permeability

ANNEX II - SYLLABUS FOR WATER TECHNICIAN (SHALLOW WELL CONSTRUCTION) GRADES II AND III

Water Technician, Grade III (Shallow Well Construction)

Introduction into organization of shallow well project.
Introduction into methodology of shallow well construction.
Introduction into equipment for hand-drilling.
Construction of hand-drilled wells, Grade III level.
Construction methods for shallow to medium depth wells.
Handling of heavy hand drilling (HHD) equipment.
Application of drilling bits, bailers and casings.
Cleaning and storage of HHD equipment.
Taking soil samples.
Preparation of gravel pack materials.
Installation of well screen and gravel pack.
Testing of well yield.
Construction and installation of well cover and slab.
Installation of manually operated pumps.
Maintenance of wells and pumps, Grade III level.
Maintenance of tools and small equipment, on-site.

Water Technician Grade II (Shallow Well Construction)

Organization of shallow well project at Grade II level.
Elementary knowledge of hydrogeology for well siting.
Introduction into hydrogeological survey methods for shallow well siting.
Design of shallow wells.
Construction of hand-drilled wells, Grade II level.
Selection of drilling material in relation to soil type.
Description of soil samples.
Construction of wells in loose soils.
Supervising hand-drilling, at Grade II level.
Developing a well.
Calculation of well yield.
Maintenance of tools and small equipment, on-site.
Water quality.
Field stores administration.
Preparation of weekly reports at Grade II level.
Supply of equipment and materials.
Simple cost calculation.

Iron and manganese sometimes do occur in concentrations above those allowed for in the Tanzanian water quality standards. Apart from giving a peculiar taste to the water and possible staining of laundry no real harm can be attributed to either iron or manganese, so in case no alternative water sources were available, the villagers were consulted first, to see whether they would accept water with higher iron or manganese concentrations.
In order to limit possible contamination of the well water from outside, the project had reverted to tapping not the upper but the second ground water layer.

Mr. van de Laak once more stressed the importance of maintenance of wells and pumps. In this he saw the main advantage of shallow wells over piped and especially pumped supplies in that the village itself can maintain shallow wells and hand pumps, but no motor pumps. He stressed the need for repeated information to and education of the villagers with regard to maintenance of shallow wells and hand pumps.

The chairman, Mr. Bushaijabwe, after thanking all contributors, explained that when the Government of Tanzania conceived the idea of a national water master plan, the idea was, and still is, to investigate the water resources in the country, and therefore any regional water supply project should be preceded by a water master plan.
The chairman also expressed his gratitude to the Water Resources Institute for having agreed to incorporate the training in shallow well survey and construction - up to now part of MWCP - in their programme.
He also pointed out that when cost estimates are being prepared for the provision of water to the people the water supply to livestock should be included.

When asked for comments by the chairman, Mr. Schonborg stressed the point that master planning is a continuing process, and that the master plans are supposed to provide data, required for the continuing and dynamic process of water management. Thus the need for water master plans would remain, be it that the set-up of the water master plans themselves might well be different in the future.

3.3. RURAL WATER SUPPLY CONSTRUCTION PROJECT IN MTWARA AND LINDI REGIONS

Paper presented by Matti Rantala, Project Manager Finnwater Consulting Engineers

A. INTRODUCTION

Based on the agreement on technical cooperation between the Government of Tanzania and the Government of Finland the Mtwara-Lindi Water Resources Inventory and Development Plan was made during the years 1974-76. The report on this work "Mtwara-Lindi Water Master Plan" (Finnwater, March 1977) includes among other things a phased rural water supply development plan for Mtwara and Lindi regions. The systems have been designed to meet the estimated water demand in 1995 and the implementation period covers the years 1976-91.

Based on this plan the government of Finland agreed, in response to a request from the Government of Tanzania, to establish a Rural Water Supply Construction Project in Mtwara and Lindi Regions. The contribution from Finland for the first phase of the project from January 1978 to March 1980 amounted to 14,631,000 FIM corresponding to about 30,500,000 TAS.

The Government of Tanzania has agreed to bear the cost of the local component, i.e. mainly local salaries, totalling 3,400,000 TAS.

B. TERMS OF REFERENCE

The first phase of the implementation project included:
- complementary geophysical and hydrogeological investigations for locating the most favourable well sites
- engineering design of wells and water supply systems
- implementation of the construction work, including acquisition of materials and supervision
- carrying out deep borehole well drilling
- implementation of the training programme

The total amount of work to be done within the projects includes:
a. the construction of approximately 550 shallow wells with hand pumps
b. construction of 11 piped water supply systems, with a design population of about 130,000 people
c. the implementation of a training programme

C. COSTS

Contributions from Finland and Tanzania for the project totalled about 33.9 million TAS.

During the project period about 12.0 million TAS were spent on the shallow well programme and the remainder of 21.9 million TAS on water supply systems.

The costs include all the expenses of the project, purchase of vehicles, equipment and construction material. Running costs of the project are also included i.e. fuel, spare parts, costs of expatriate and local personnel, travelling etc.

Five hundred and fifty six shallow wells were constructed, thus the cost per well was approximately 22,000 TAS, about 75.- TAS per person (approximately one well per 300 people).

Piped water supply systems were constructed to supply a total of 130,000 people at a total cost of 21.9 million TAS. Distribution networks had already been constructed in Kitangari and Nachingwea. The work undertaken by Finnwater was, therefore, restricted to supplying a source of water and pumping stations. These systems supply water to 70,000 people, the cost being 2.2 million TAS. The balance i.e. 19.7 million TAS was spent on the remaining water supply systems for 60,000 people - a per capita cost of about 330.- TAS.

D. SHALLOW WELL PROGRAMME

General

The shallow well programme covers the construction of 550 wells equipped with hand pumps. According to design standards one well to be constructed per 200 people, these wells are due to serve 110,000 people. In reality, at present, a greater number of people are fetching water from shallow wells, because in most cases one shallow well per 250-350 people has been constructed. In those villages where a piped water supply system already exists or where one will be constructed in the near future, one well per 400-800 people has been or will be constructed. The purpose being to provide an alternative safe water supply if the piped system is out of order.
Generally the wells have been constructed as near to the village as possible. In some villages the wells have been constructed further than one kilometer from a village to secure a perennial supply of water. In such cases some seasonal wells have been constructed nearer to the village because these wells can usually provide the villagers with safe water for 6-10 months of the year; otherwise they would use polluted water from traditional sources during the rainy season instead of collecting water from the well.

Shallow well production

During the project period a total of 597 shallow wells were constructed, 41 of these have been unsuccessful for various reasons and they are no longer in use. The net production has thus been 556 wells.

Concrete ring wells (RW), machine auger wells (MW) and hand auger wells (HW) have been constructed.
The types and numbers of wells by Districts are listed below:

District	Number of wells				
	RW	MW	HW	Total	Abandoned
Mtwara	109	16	5	130	14
Kewala	-	5	6	11	7
Masasi	191	4	-	195	14
Lindi	76	14	15	105	6
Kilwa	73	6	4	83	-
Liwale	16	5	-	21	-
Nachingwea	11	-	-	11	-
Total	476	50	30	556	41

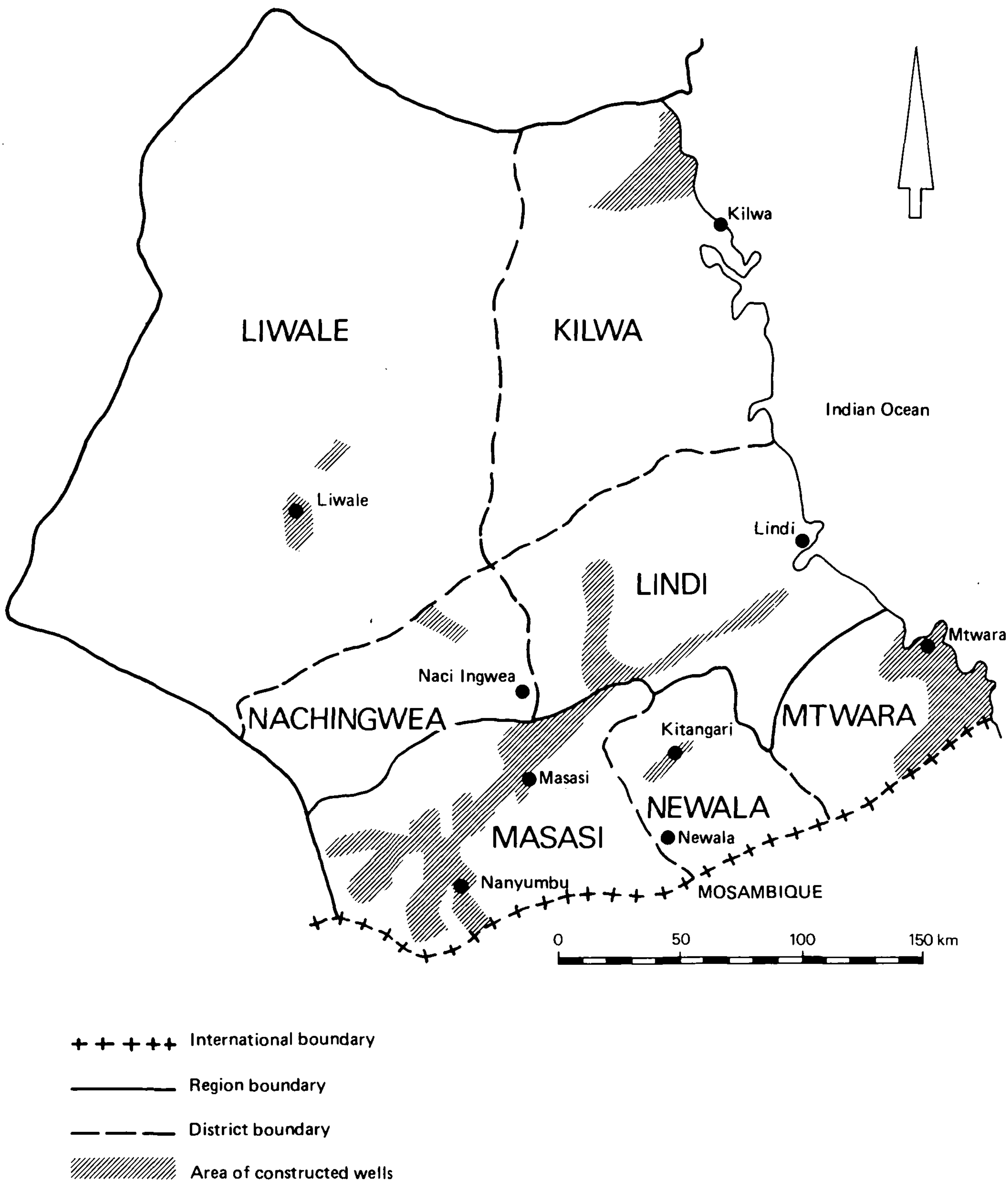


FIGURE 1. AREAS WHERE SHALLOW WELLS HAVE BEEN CONSTRUCTED

At the end of the project period about 90 wells were without pumps due to a shortage of pumps. A new delivery of pumps is expected at the beginning of June, 1980.

The areas where wells have been constructed are shown in figure 1.

A diagram illustrating the production of shallow wells is presented in figure 2.

Concrete ring wells

Most concrete ring wells have been dug by two hydraulic tractor excavators, which are able to dig to a depth of approximately 5 m. When deeper wells are needed the work has been continued by hand-digging. About 20 wells have been dug solely by hand. The wells have been lined with 1 m internal diameter and 0.5 m high concrete rings reinforced with two round iron bars. For the deepening of wells, concrete rings of 0.8 m internal diameter are used. They can be installed telescopically inside the normal rings and the digging can be continued inside these rings down to the required depth. The structure of a normal ring well is shown in figure 3.

During the project about 5,000 well rings were manufactured. To minimize transportation costs the manufacture has taken place at five different sites: Mtwara, Nanganga, Masasi, Lindi and Tingi. Stone material for concrete has been supplied from the Finnwater quarry in Nanganga and from some local suppliers.

The normal procedure in ring well construction is as follows: Firstly a tractor excavator arrives at a possible well area selected in advance and starts digging in the most suitable place. The site has in some cases been preinvestigated by a machine auger rig or by a light hand auger survey set. The digging of a test pit down to the required depth takes from 15 min. to 2 hours depending on the soil conditions. After digging the test pit is pumped dry by a diesel driven membrane pump. If the yield is high enough and the quality of water suitable, a ring well is constructed in the pit, alternatively the excavator backfills the pit by using its front loader. The test pit is dug large enough for the rings and the filter gravel. The rings are installed and backfilling done partly manually and partly by using the front loader of the excavator. The hand pump is installed by a separate group. The concrete slab around the well is made some weeks later, when the settlement of soil is almost complete.

Machine auger wells

The project has in use a tractor installed machine auger rig. The rig has been used mainly for shallow well siting, but also for shallow borehole well production.

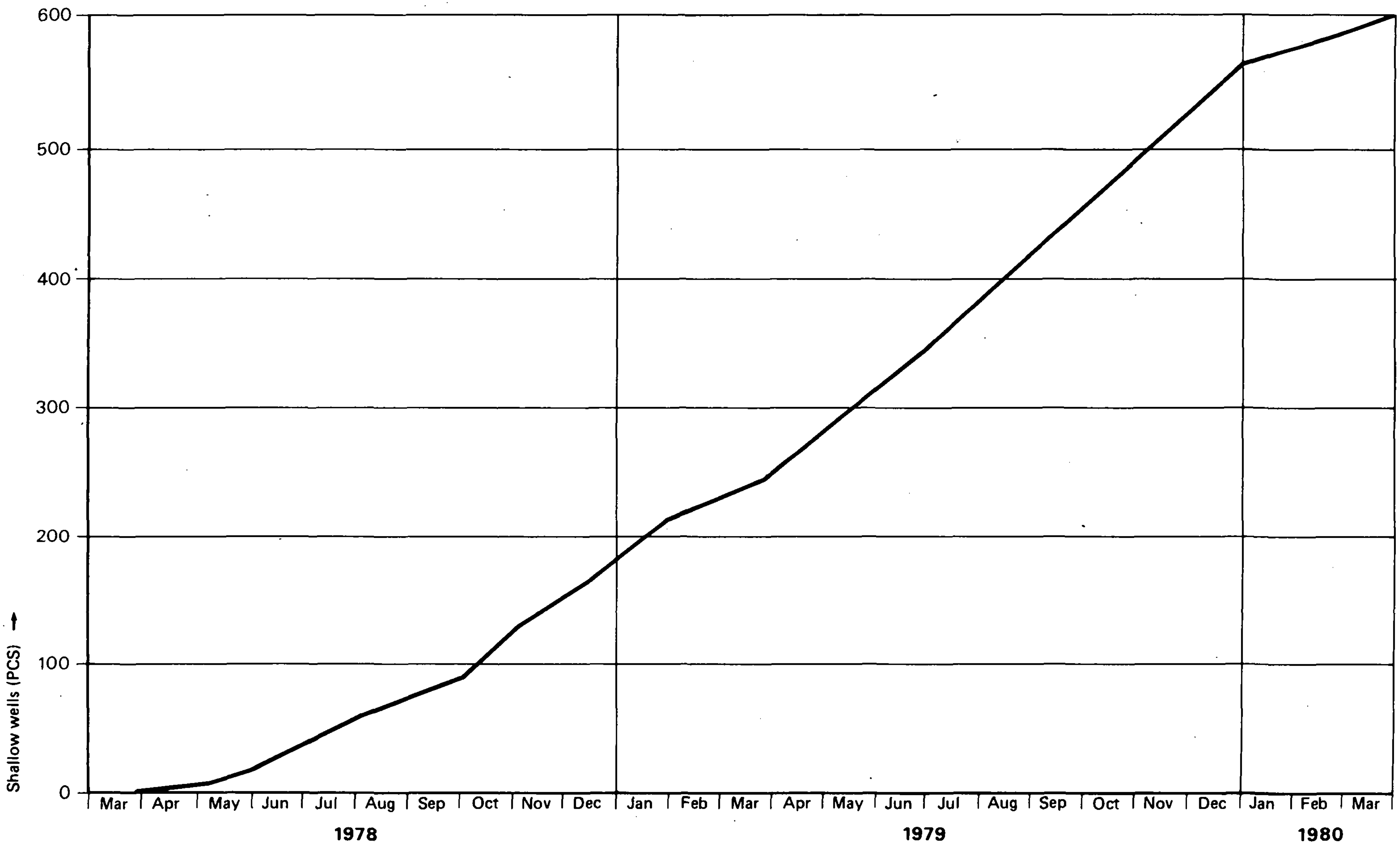


FIGURE 2. PRODUCTION OF SHALLOW WELLS

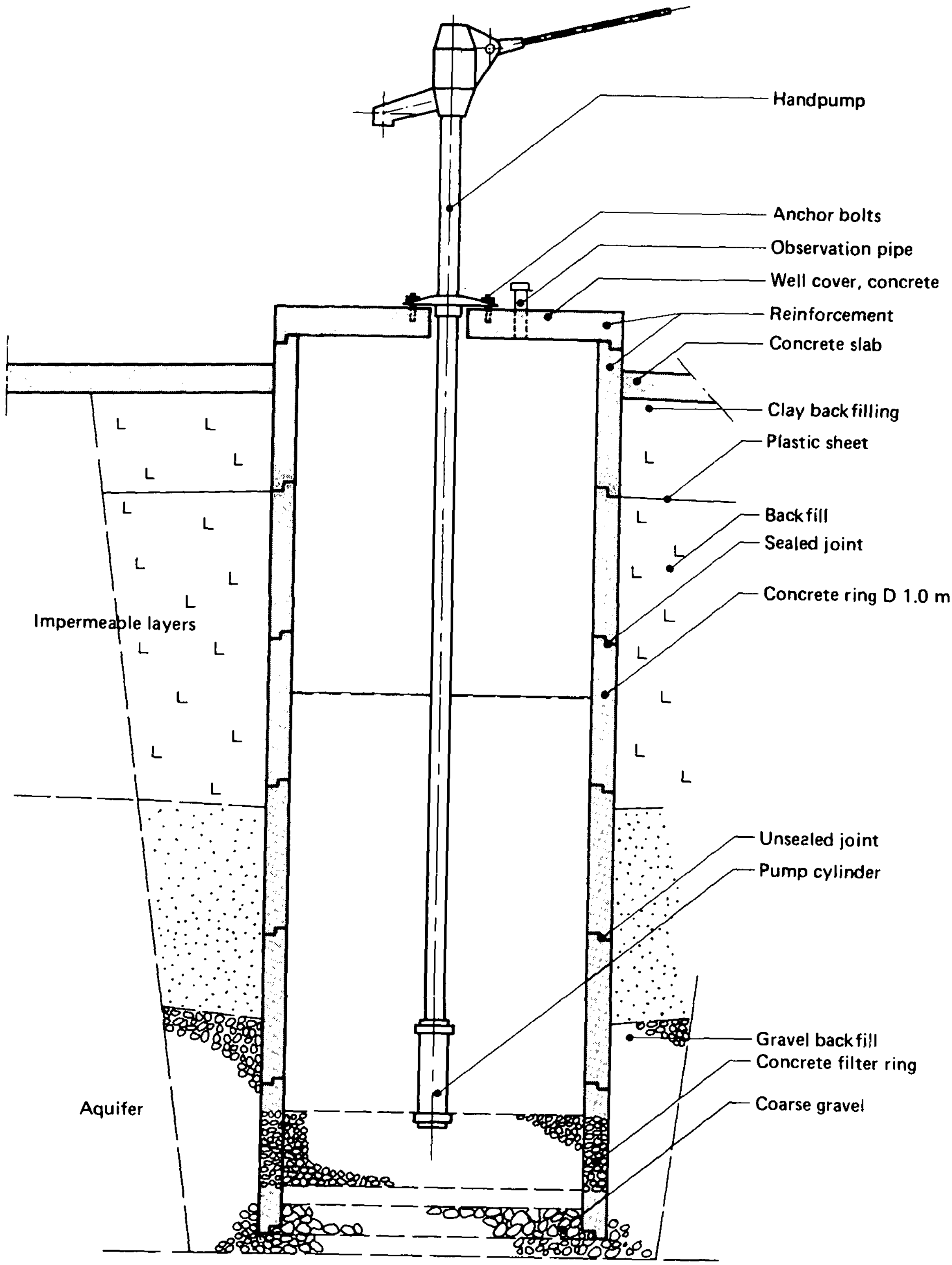


FIGURE 3. SHALLOW RINGWELL

Especially for investigation purposes the rig has been very effective, due to its high drilling speed and good penetration capacity.

Machine auger boreholes have been constructed where the soil conditions are favourable for the natural development of the well, i.e. when course gravel and sand layers saturated with water are available. The structure of a machine auger well is shown in figure 4. Steel casings and stainless steel screens are welded together and flushed down the hole with compressed air and water. The bottom of the well casing is then sealed with concrete. Finally the well is developed by flushing with compressed air. The method is cheap and quick in favorable conditions. Because an artificial filter cannot be used this method is not suitable for silt and fine sand formations. In the early stages of the project about 20 machine auger wells were constructed in Mtwara and Newala by using sawn slotted screens. Due to the large slot openings (1.8 mm) the main part of these wells were yielding too much sand and therefore they are no longer in use. After the stainless steel well screen arrived more than 80% of the constructed machine auger wells have been successful.

Hand auger wells

Two hand auger sets suitable for shallow borehole drilling were supplied to the project in May 1979. The drilling method is the same as has been used elsewhere e.g. by the Dutch in Shinyanga and Morogoro.

Well siting has been done either by a machine auger drilling rig or by a light hand survey set.

Drilling takes place inside a 250 mm steel casing. PVC well pipes and screens, which vary from 100 to 150 mm in diameter, are installed inside the casings. After pouring filter gravel the outer steel casing is removed and the well is completed.
Hand auger wells have been constructed mainly in areas where machine auger wells are not possible due to silt and sand formations being to fine, and also in areas where the ground water table is too deep for ring wells. The structure of a normal hand auger well is shown in figure 5.

Hand pumps and well maintenance

Hand pump types

During the project period three different types of hand pumps have been used. In 1978 four Kangaroo pumps failed after a period of between two weeks and two months following installation. When the pumps were lifted the PVC-cylinders were also in poor condition.

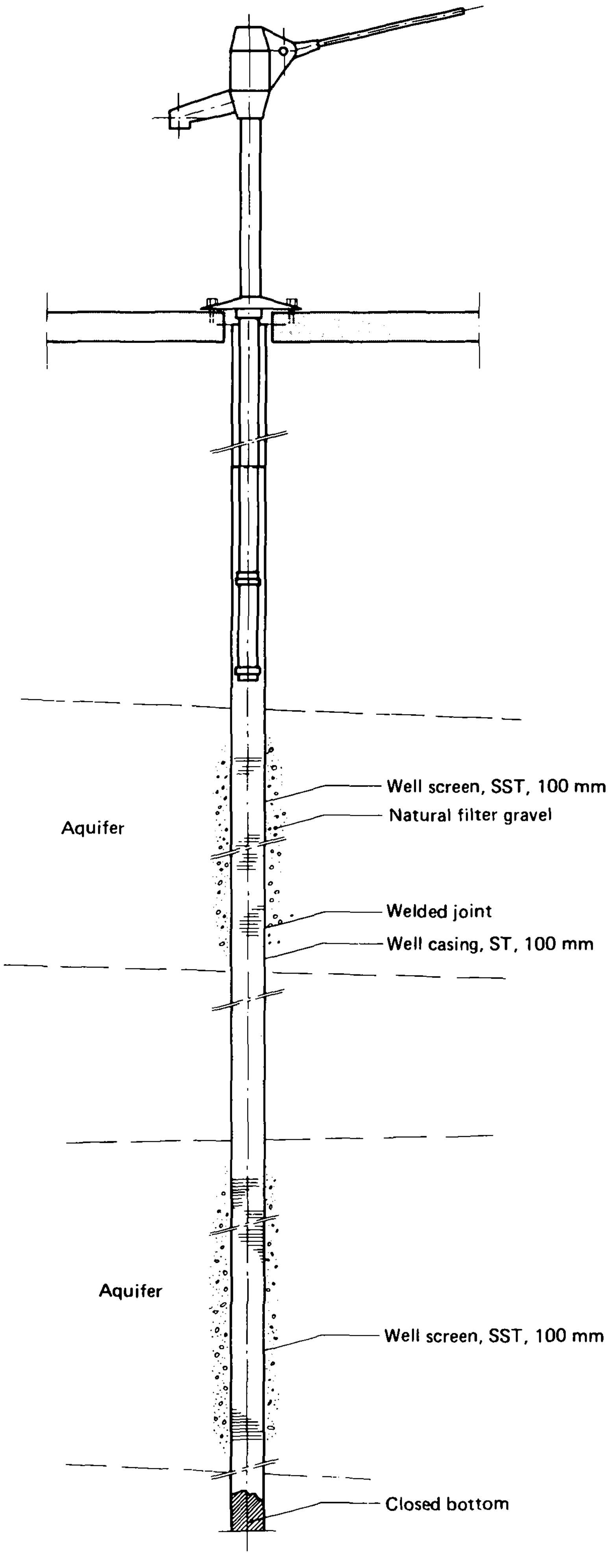


FIGURE 4. MACHINE AUGER WELL

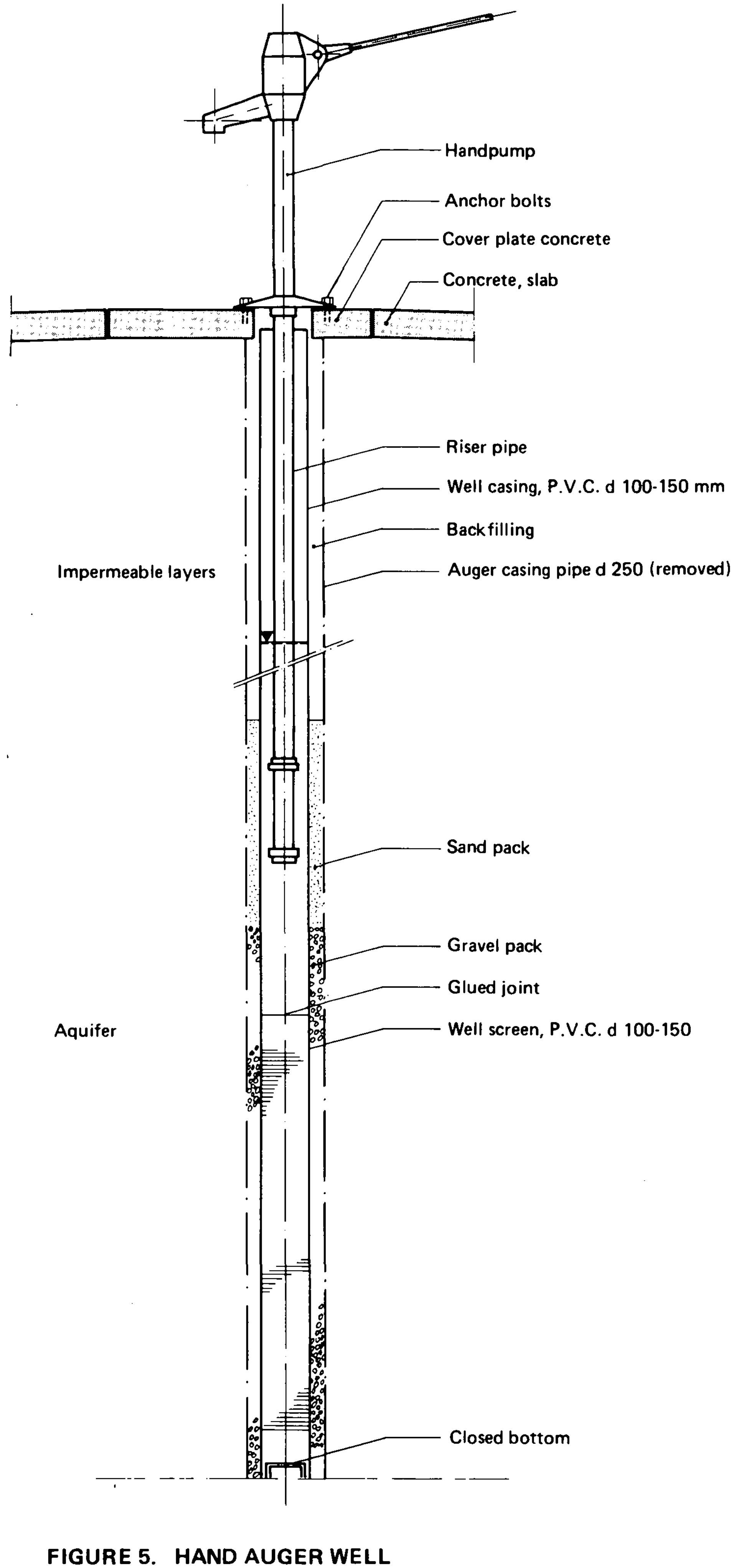


FIGURE 5. HAND AUGER WELL

About half of the fourty Shinyanga pumps have been installed, the rest are being used for spare parts. About fifteen of these pumps are still in use and are working satisfactorily. The original PVC-cylinders have been replaced by NIRA or Dempster pump cylinders. The main disadvantages with the Shinyanga pump are that it is heavy and a disproportionate amount of time and work is needed during the installation stage and in subsequent maintenance.

Five hundred Finnish-made NIRA hand pumps have been supplied and nearly all installed during the project. The NIRA pump developed specially for this project has been designed according to the following principles:

- all parts, subjected to continuous mechanical wearing are made of the best possible materials such as bronze, stainless steel, teflon, brass etc.
- the pump has been designed to withstand vandalism
- the assembling and disassembling of any length of pump can be done with a pipe vice and a pipe wrench
- a 3-4 man pipe installation group using a pick-up Landrover is able to transport and install several pumps per day
- the pump has been made as simple as possible so that it can be manufactured in developing countries

According to the experience gained during two years the assembling and installation time of a NIRA pump is about 20% of that of a Shinyanga pump. The pump is also reliable and needs very little maintenance if the water level in the well is not deeper than 10 m. Structure of NIRA-hand pump is presented in figure 6.

The maintenance of wells

The maintenance of shallow wells is done by well attendants and by a mobile maintenance group. Two attendants have been or will be trained to maintain shallow wells in each village where such wells have been constructed.

The duties of well attendants are:

- to grease the pump twice a month, to check the general condition of the pump and to make such repairs as can be undertaken without spare parts
- to take care of the draining and tidiness of the area surrounding the well
- to inform the District Water Engineer's Office of any defects appearing in the structure of the well and pump

Generally, the repair and maintenance work has been the responsibility of a mobile four men maintenance group, using a pick-up Landrover. The duties of the mobile maintenance group are:

- to repair broken pumps and well structures
- to clean and disinfect the wells, when needed

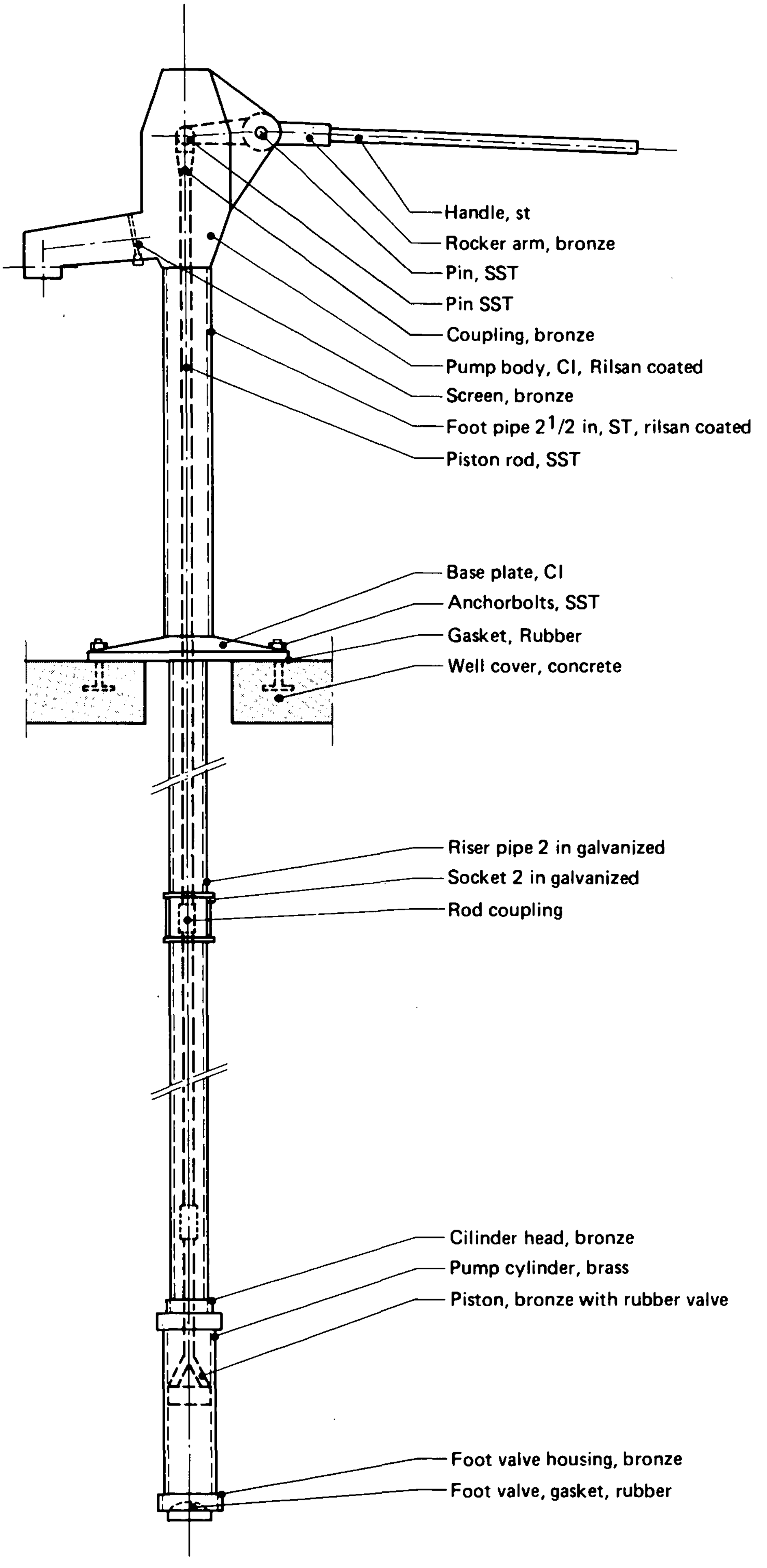


FIGURE 6. NIRA HAND PUMP

- to inform the well attendants and villagers how to take care of the well
- to report on the condition of the wells by using a special card reserved for each well
- to collect water samples for the water laboratory, when so asked

At present there is only one group taking care of the maintenance of the shallow wells in use. Every well is visited on average three times a year. With this degree of maintenance about 90% of the hand pumps are always in working condition. This has been considered to suffice since the aim is to construct at least two wells for every village. The number of mobile maintenance groups will be increased in the future according to demand.

E. WATER WORKS PROGRAMME

General

The water works programme comprised the construction of eleven piped water supply systems designed to supply a population of about 130,000 people. Some small modifications to the original project programme were made during the project period. One water supply project was replaced by shallow wells and two projects were omitted from the construction programme.
Nevertheless the total population now served by water supply projects exceeds the original target by about 10,000 as a result of changes in population following the planning phase.

Works completed and materials used during Phase 1 are as follows:
- 10 deep production borehole wells
- 7 shallow production borehole wells
- 3 shallow ring wells
- 10 borehole pumping units
- 6 other pumping stations
- 4 concrete water tanks (160-230 m^3)
- 17 elevated steel water tanks (10-100 m^3)
- 7,500 m steel water pipeline (90-200 mm)
- 62,000 m PVC-pipeline (63-225 mm)
- 12,000 m PE-pipeline (40-63 mm)
- 148 public water taps

The above quantities, whilst differing from those specified in the terms of reference, are equivalent. Most machinery and construction materials including eg. pipes, fittings, pumps, reinforcement bars and steel water tanks have been imported by Finnwater from overseas. The most important construction materials supplied locally have been timber, cement and stone material for concrete.
Most workers have been employed from the villages.

Foremen, plumbers, masons, carpenters, mechanics and other skilled labour were permanently employed by the project and were moved from site to site during the project. Such tasks as bush clearing, trench digging and back-filling for the pipelines were carried out under self-help contracts with the villages. The contract price, about 1 TAS/meter, was paid in a lump sum to the village, once the whole job was completed. Self-help projects utilized only one foreman to supervise the work, with a plumber and 3-5 workers to install the pipes.

F. TRAINING

General

The purpose of the training programme is to make Mtwara and Lindi Regions as self reliant as possible in respect of continuous implementations, operation and maintenance of water supply systems. The training activities have continued throughout the whole project period, consisting of training courses and on-the-job training.

Training of shallow well attendants

For each village where shallow wells have been completed, two shallow well attendants have been or will be trained. Candidates for training as attendants have been selected by the village chairman. Candidates have normally been working temporarily with well construction groups participating in well construction.

A one or two days training course was arranged when shallow wells in five to twenty villages in one area were completed.

Up to the end of 1979 nine shallow well attendant courses had been arranged and 152 attendants trained. These attendants are taking care of about 325 wells.

Follow-up work and supervision of shallow well attendants has been carried out by a mobile maintenance group, which regularly visits the village.

Training of water works attendants

One to four water works attendants have been trained for each completed water supply system.

Candidates for attendants must have first participated in the construction work and become familiar with the water works system.

An individual course has been conducted for each water supply system and has consisted mainly of on-the-job training in the project workshop in Mtwara, and in the pumping station under the supervision of the project personnel.

Training has continued beyond the initial course with a follow-up period, when a pumping station has been visited, with occurs on a regular basis. Detailed running and maintenance instructions are given and the supply of spare parts is arranged.

Training of foremen

About twenty foremen working on the project have participated in a training programme, which will be of three years duration. Each year has been divided into a period of about 8 months on-the-job training and a period of about 3 months course training.
During on-the-job training the trainees are working as foremen in the project and becoming familiar with practical work and skills. During the period of course training the trainees are provided with the necessary theoretical knowledge.

The training programme for foremen was started in 1978 as on-the-job training. The first course training was conducted from 29th January to 27th April, 1979 and the second from 11th February to 15th May 1980.

Each course training period is devided into different sections. The general course is common for all trainees. This provides a general idea of the whole water technical sector.
Special courses are different for each group. The aim of these courses is to give more detailed information about the actual area where the trainee will be working. The training groups are as follows:

a. civil engineering group
b. shallow well group
c. mechanical group
d. hydrogeological group

Training of skilled working groups

During the project period on-the-job training of separate working groups has been conducted. For the investigation, construction and maintenance of water supply systems this skilled labour is needed. Up to March 1980 the following working groups were trained:

- 1 shallow well machine auger group
- 2 shallow well hand auger groups
- 2 shallow well excavator groups
- 3 shallow well investigation and well deepening groups
- 1 hand pump installation group
- 1 shallow well concrete slab making group
- 2 shallow well maintenance groups
- 2 water works machine installation and maintenance groups
- 1 elevated steel water tank installation group
- 2 concrete water tank and house construction groups
- 2 pipeline installation groups
- 1 mobile machine maintenance group
- 1 resistivity sounding group

- 1 seismic sounding group
- 2 vehicle maintenance groups
- 1 well ring and concrete block manufacturing group
- 2 steel construction groups
- 1 well disinfection and water laboratory group

Practical training

The project has provided an opportunity for programmed field work for students from the Water Resources Institute. Five students from the Water Resources Institute visited the project from 1-11-1978 to 22-12-1978 and six students from 13-8-1979 to 29-11-1979 for field training.

G. PHASE II 1980-1982

Phase II of the Rural Water Supply Construction project in Mtwara and Lindi Regions will be implemented during 1980-82. The project is financed together by British Government, Finnish Government, Tanzanian Government and UNICEF.

The financial contribution of UNICEF will cover the supply of materials for the distribution network of Kitangari Valley (Makondeko) project. This project will supply water for about 100 villages, design population being 210,000.

British Government will finance the main part of other materials and equipment needed in the project. Tanzanian Government will pay the local costs, which mainly consist of local salaries. Finnish Government will finance the running costs of the project including consultant staff, transportation and other services, borehole drilling, as well as some materials and equipment.

The total costs of phase II will be approx. 90 million TAS and water will be supplied for about 500,000 people.

DISCUSSION OF PAPER PRESENTED BY MR. RANTALA

Upon a remark by Mr. Rugeiyamu that it was reported that breakage of parts of the rocker arm of the Nira pump had occurred in the past, Mr. Rantala answered that to his knowledge no such thing had happened, but that problems with the stainless steel shaft of the handle's bearing had been solved. Moreover, the pump design had been adapted several times and a completely new design was about to be tested at the end of the year.

On questions by Mr. Radhakrishnan, Mr. Rantala answered that between 50 and 70 wells are seasonal, thus not giving water at the end of the dry season. According to reports from the maintenance groups about 10 percent of the pumps is not working, as an average. In Kilwa District almost all pumps had been installed just before the rainy season made the area inaccessible for the maintenance groups, as a result of which the percentage of inoperative pumps might be higher there. In the meantime the road was open again so that maintenance in Kilwa District had been resumed.

Mr. van Lissa asked how many holes were dug for each successful shallow well. Mr. Rantala answered that in Masasi area some 50 to 10 holes were required for each succesful well; in other areas the possibilities were better: two holes for each succesful well. In Mtwara Region half of the population is living on the Makonde plateau, where no shallow wells are possible; of the remaining population about half can be supplied through shallow wells. In Lindi Region about half the total rural population can be supplied through shallow wells.
In principle the Tanzanian water quality standards are followed. According to master plan experience the only problems are with salinity, so that each shallow well group is equipped with a conductivity meter. In certain areas a higher conductivity is accepted, up to 3500 microsiemens/cm.

The chairman pointed out that the present temporary Tanzanian water quality standards accept a rather low standard, just in order not to have to abandon a considerable number of boreholes on chloride content or conductivity alone. At the moment Maji and the Ministry of Health are reviewing the temporary standards.

On questions by the chairman about the shallow wells in Nachingwea District being constructed more or less along the river, Mr. Rantala answered that in that district salinity is a big problem and that the number of wells is thus fairly limited: 11 wells only. The water quality of the shallow aquifer is better than that of the deeper aquifers, however. In practice the shallow wells have to be constructed rather close to the rivers, and even though it is tried to make the shallow wells not too close to the rivers, in some cases the distance is no more than 5-10 m. Even then the shallow well water, though possibly originating from the same river, has a much better quality than the river water proper.

3.4. SHALLOW WELLS IN SHINYANGA REGION

Paper presented by Y.N. Kashoro, Project Manager Shinyanga Shallow Wells Project

A. INTRODUCTION

The Shinyanga Region is one of the twenty Regions in Tanzania, situated in the north-west, south of Lake Victoria. It has an area of about 50,000 km^2 divided up in four Districts and one Sub-District namely Shinyanga, Maswa, Bariadi, Kahama and Meatu Sub-District. It has a population of 1,325,000 people, settled in 684 villages.

The region has a semi-arid tropical climate, with an average rainfall of 700-1000 mm yearly. Rains mostly start in mid-October and end in early May. Elevation in the region varies between 1500 meters above mean sea level in Bariadi District and 1100 meters above mean sea level in some parts of Kahama District; the major part of the region has an undulating landscape. The temperature is fairly constant through the region with high values ranging from 28°C in March to June and 32°C in October, while the minimum daily temperature varies from 15°C in June - July to 19°C in the last three months of the year.

B. SHINYANGA SHALLOW WELLS PROJECT

The Shinyanga Shallow Wells Project started in October, 1974 as follow up of implementation recommendations by the Shinyanga Water Master Plan Survey which was carried out in 1973. In the survey report it was recommended that 2000 shallow wells be constructed in Shinyanga Region as a quick and cheap method of serving most of the population in the region. This was followed by a bilateral agreement between the United Republic of Tanzania and the Kingdom of the Netherlands, whereby it was agreed to set up a construction unit to construct 700 shallow wells and in the course of construction to train Tanzanians who will man the project; this task was accomplished in June, 1978 and the project was handed over to Tanzanians.

To date there are around one thousand shallow wells serving over two hundred ninety thousand people as follows:

District	Wells	Villages	Population Served
Shinyanga	365	115	109,500
Maswa/Meatu	262	80	78,600
Bariadi	222	52	66,600
Kahama	145	50	43,800

C. SELECTION OF WELL SITES

Requests and applications for wells construction come from the villages to districts and finally to the region; at the district level the applications are compiled in an order of priority, the most needy villages first, then these lists of villages are sent to the Regional Development Committee and a copy to the Regional Water Engineer. The Regional Development Committee decides which district or part of the region should be started first, bearing in mind that concentration in one particular area could be cheaper and faster in construction.

Having known the villages and their priorities the Hydrogeologist studies the areal photos and maps and all data available to see the possible seepage areas - river beds - old river beds, possible valleys, vegetation etc. This is followed by a visit to the village. In the village he contacts the Village Chairman, and others whom he asks questions related to water as to where they are fetching their water during the dry season, he sees where are some wet places likely to hold ground water, vegetation such as sugar canes and bananas are signs of ground water presence, a number of places are visited in the village and a reconnaisance survey is made, looking for suitable sites for making shallow wells bearing in mind accessibility, possibility, soil condition and types of soil, their hardness, the distance from the village to the well and population of the village.

By doing so, studying general geology of the area, recharge areas, possibility of shallow aquifers, rainfall and evaporation also governs the selection of a good well site and the survey plan is made.

D. SURVEYING OF WELL SITES

After a thorough investigation most potential sites are marked and a survey is carried out to prove the presence of water, its quality and quantity, in the ground. Methods used in surveys are hand-drilling and in hard material a mechanical drill is applied. Hand-drilling could easily go down to 10 meters in sands, loam and other loose materials, while the mechanical drill is capable of penetrating hard weathered and cemented materials and normally drilling goes on until the water table is reached. However, if during drilling some soil tends to cave in or collapse, a casing is applied, on reaching the aquifer the thickness of the aquifer is measured and a pump test is carried out to determine the yield of the well and a water sample is taken for analysis to determine its quality.
In Shinyanga Region high fluoride and salts contents are the main hazards to the potability of ground water, especially in East and Central Shinyanga District and Maswa; these factors influence the health of consumers; however, bacteriological and organic pollution are taken care of during the selection of sites and do not cause problems; once they are known, they could be eliminated.

E. WELLS CONSTRUCTION

In Shinyanga there are three methods applied in constructing wells, these are:
1. hand-dug wells
2. hand-drilled wells
3. mechanical drilled or dug wells

1. Hand-dug wells

These are constructed by using the traditional method of digging a hole with a hoe or pick axes; in hard layers a hole is dug virtually plumb to the required depth depending of course on how deep the aquifer is, after this it is lined with concrete rings and covered on top with a concrete cover. Hand-dug wells become very expensive if the depth goes more than 10 meters deep. This is mainly due to dewatering pumps and of course lifting of soils from well, which is time consuming and sometimes too laborious due to hard layers. One well sinker with four self-help labourers can dig 2 wells of 7 meters deep.

2. Hand-drilled wells

These are drilled by using a 25 cm auger and a couple of self-help labourers, who turn around the auger, and by so doing drill a hole to the required depth.

The hole is lined with slotted 15 cm PVC casing and gravel packing is applied outside the pipe. This method is very cheap and quick but only applies in sand and soft materials where it is not difficult to penetrate with such auger. One foreman and eight self help labourers can drill 2 wells a week.

3. Mechanical drill

Where the aquifer is deeper and the material is harder so that it cannot be penetrated by hand drills, a percussion rig is applied. Drilling is carried out like in a normal borehole drilling; the hole is cased with slotted 15 cm PVC pipe with gravel filter packed outside; this method with some modification to the machine could be quicker and very cheap in constructing shallow wells; one foreman, four rig crews and three labourers make one well a week.

F. THE SHINYANGA PUMP

The Shinyanga pump which is an improvement of the UNICEF and Uganda pump consists of four main parts:
- pump stand
- wooden upright and handle
- rising main and pump rod
- pump cylinder and piston

After taking the necessary measurements, according to the depth of the well, the pump in installed, rising main and pump rods are cut, threaded, and screwed together with the pump cylinder. The pump is then lowered in the well, then on the pump stand the wooden uprights and handle are bolted together.

With the exception of cylinder and piston the rest of the pump is fabricated in the Shinyanga workshop. The workshop has a capacity of manufacturing thirty five (35) pumps a month. Since June, 1978 about two hundred (200) have been sold to other regions in Tanzania as follows:

Pumps sold to other Regions

1.	Regional Water Engineer, Mtwara	40
2.	Regional Water Engineer, Singida	35
3.	Regional Water Engineer, Kagera	10
4.	Regional Water Engineer, Mwanza	16
5.	District Water Engineer, Urambo	17
6.	Regional Water Engineer, Tabora	45
7.	Mission - Karitao	1
8.	Ridep, Mwanza	35
9.	Lions Club, Shinyanga	1
	Total	200

G. MAINTENANCE OF SHINYANGA SHALLOW WELLS

When construction is completed the well is handed over to the Village Chairman together with a handing-over certificate. Two people are selected and given on-the-spot training on how they should look after their well - things like tightening of nuts, cleaning of surrounding, greasing, oiling. Names and numbers of pump parts are shown to the would-be attendants and one repair request form is handed to them, that in case of break down this form should be filled and sent to the District Maintenance Officer (DMO) who is housed in the office of the District Water Engineer (DWE). The District Maintenance Officer on receipt of such request takes the necessary actions. Most of the villages are now understanding this system and the problem is that sometimes due to lack of transport and an increased number of breakdowns, the District Maintenance Officer cannot cope with all the requests which are coming. We are thinking of employing a Maintenance Officer at Divisional level as the amount of well repair increases. Apart from this regular inspections are carried out to wells to see their condition and general cleanness. Also checks are carried out on water level, pollution, and chemical fluctuations; see Table I and II.
In Shinyanga, unless there is some installation fault, a Shinyanga pump normally takes about two years without repair; women and children are the most frequent users who look well after their pump. They know that a breakdown would mean walking a long distance to unclean water, so nobody plays with or takes anything from the pump.

Table I - Wells Inspection Report from June, 1979 to May, 1980

District	Wells	Inspected	Repairs	Low Recharge Wells	Dry Wells Nov.'79	Wells Polluted/ Disinfected
Shinyanga	365	400	120	80	15	30
Bariadi	212	300	50	10	3	4
Maswa	152	200	30	5	10	7
Meatu	110	95	20	3	5	5
Kahama	145	310	46	6	3	24
Totals	994	1,305	266	104	36	70

Table II - Chemical Fluctuations in wells

District	Well No.	February 1979	October 1979
Shinyanga			
Bugogo	64/4-20	6.9 ppm Fluoride	8.2 ppm
Nkolondoto	65/1-35	4.9 ppm "	6.8 ppm
Mwamaza	64/2-34	6.0 ppm "	7.7 ppm
Ibadakuli	64/2-148	5.8 ppm "	6.2 ppm
Ngokolo	64/2-149	5.5 ppm "	6.8 ppm
Maswa			
Malampaka	49/1-39	5 ppm	6.4 ppm
Gula	49/4-43	1500 EC	1700 EC
Muhida	49/1-2	1500 EC	1900 EC
Meatu			
Paji	66/2-37	1700 EC	2100 EC
Paji	66/2-40	1750 EC	1890 EC
Mwanjoro	66/2-60	1800 EC	1980 EC
Mwanyagula	66/2-27	1770 EC	2100 EC

ANNEX I - VILLAGE REQUEST FORM

JAMHURI YA MUUNGANO WA TANZANIA

KWA: Fundi wa Visima Vidogo Vidogo,

k.k. Mhandisi wa Maji,
Wilaya ....
....

TAARIFA YA KUHITAJI MSAADA KWA MAREKEBISHO

Kuhusu kichwa cha barua hapo juutunakuarifu kwamba tunahitaji msaada kwa marekebisho ya kisima kijijini kwetu.
Jina la Kijiji ....
Jina la Mwangalizi ....
Namba ya Kisima ....
Kisima kimeharibika vipuli Na. ....
....
Maelozo zaidi: ....
....
....

DISCUSSION OF PAPER PRESENTED BY MR. KASHORO

Mr. Collin asked for the nature of pollution encountered in Shinyanga Region, the criteria applied and methods used in testing the water quality. Mr. Kashoro explained that samples are taken from suspected wells and the number of E-coli measured. Furthermore there is a laboratory at the RWE's yard in Shinyanga. Wells that prove to be contaminated are chlorinated for one night each.

To questions of Mr. Blankwaardt regarding:
a. production rate today of hand-dug and hand-drilled wells
b. how many villages are constructing their own wells, and
c. whether Maji is providing the materials and tools to the villagers

Mr. Kashoro replied that:
a. 120 wells per year can be constructed if all material is available
b. so far 3 wells have been constructed in Bariadi by villagers, and 6 in Kahama
c. Maji has not yet provided any materials or equipment to the villagers

Unlike Mr. Rantala, Mr. Kashoro had not encountered any problems with the Shinyanga pump, some of which are in operation for already 3 years.

When asked so by Mr. Helland-Hasen, Mr. Kashoro mentioned investment costs of T.Shs. 20,000/- to 22,000/- per well.

Mr. Swere requested Mr. Kashoro to give a fair judgement about the 3 pumps, i.e. the Kangaroo pump, the Finnish hand pump and the Shinyanga pump, which Mr. Kashoro would rather leave to the donors to decide.
Mr. Msimbira emphasized again the danger of pollution and diseases carried by water as shallow wells are constructed near villages and settlements.
In November 1980 the UN assembly is going to launch the International Drinking Water and Sanitation Decade and if by 1991 a reasonable level of development has to be reached there should not be talk of reducing but of increasing the investment, according to Mr. Msimbira. To questions of the chairman pertaining to the difference in for instance the financial organization of Shinyanga and Morogoro, Mr. Kashoro replied that if all materials are available running a shallow wells programme is no problem. At first Shinyanga was a foreign aid project and still money and equipment is being supplied by the Government of the Netherlands. Mr. Kashoro is also of the opinion that to reach the target 60,000 wells use has to be made of machines, but in that way no knowledge is transferred to the villagers. The target can be reached if the villagers make the wells themselves, but there is no money available to supply the material.

3.5. MAJI SHALLOW WELL PROGRAMME MWANZA

Paper presented by J. Ringelberg, Project Manager

A. INTRODUCTION

In the Mwanza Region 30% of a total population of roughly 1.4 million people are supplied with water within 400 meter from their homes. Leaving one million still without a clean and safe source of drinking water.

Summary of activities

In the Mwanza Region the Maji organisation under the Regional Water Engineer tries to solve the water problem of the people and to implement the political target of the government by working through three main sections:

a. Survey and Construction of new pipe supply systems.
b. Operating and maintenance of existing systems.
c. Construction of new shallow wells and rehabilitation of existing boreholes.

Situation

Choosing a solution for the ever urging water problem in Mwanza we have to take into account the climatological situation, the hydrogeological situation and the geographical location of this Region. We are convinced, regarding the long dry season period, the difficult hydrogeological situation of the far inland villages and the long supply lines from the administrative centers as Dodoma and Dar es Salaam, that the best alternative will be to develop a strong shallow and medium deep well production unit besides the existing pipe supply units.

Financing

The World Bank was willing to grant a loan to the Government of Tanzania for the Ridep Mwanza with an amount of 15 million shillings to be spent on the Maji component over five years. This money should be spent on shallow wells and rehabilitation of existing boreholes only. A village contribution of 25% of the costs should be paid for buying and installing the pump. A pilot production scheme of fifty introductory wells to be installed in fifty villages has been approved (these introductory wells are free of charge).

B. PAST PERFORMANCES

Studies

The tri-Region Water master plan study by Broconsult prepared a draft with a solution for the water supply problem in the Mwanza, Mara and West Lake Regions.

Implementation

Implementation of above studies faces financial limitations, for the plan consumes 250 million shillings in the first six years only, based on an estimated cost per capita of 80/- only.

Planning and programme preparation

As above mentioned funds are not available and doubtly will ever be available, the Regional Development Director and the Regional Water Engineer strongly pushed for World Bank assistance by joint financial cooperation in construction of shallow and medium deep wells in the rural areas.
For this reason, Maji Mwanza was able to start a shallow well construction section with a present output of six new wells a month and an estimated production over the financial year 1980/81 of 150 wells.

C. POSSIBILITIES FOR RURAL AREAS

Time schedule

In the World Bank appraisal Report No. 1867a TA the mentioned target for Mwanza was 540 wells over five years.

New technologies

This target can be implemented much faster due to the new adapted technologies developed by the Shinyanga and Morogoro Wells Project by drilling wells instead of digging. For Mwanza this means that roughly 162,000 people (12% of the population) can be supplied in three years, instead of five. However, in order to implement a schedule as mentioned above the organization still has to be improved.

D. IMPLEMENTATION OF THE PROGRAMME

Start

With the help of the Shinyanga and Morogoro Well Construction Projects the Mwanza programme was rapidly staffed and equipped and is still increasing its production capacity.

Facilities

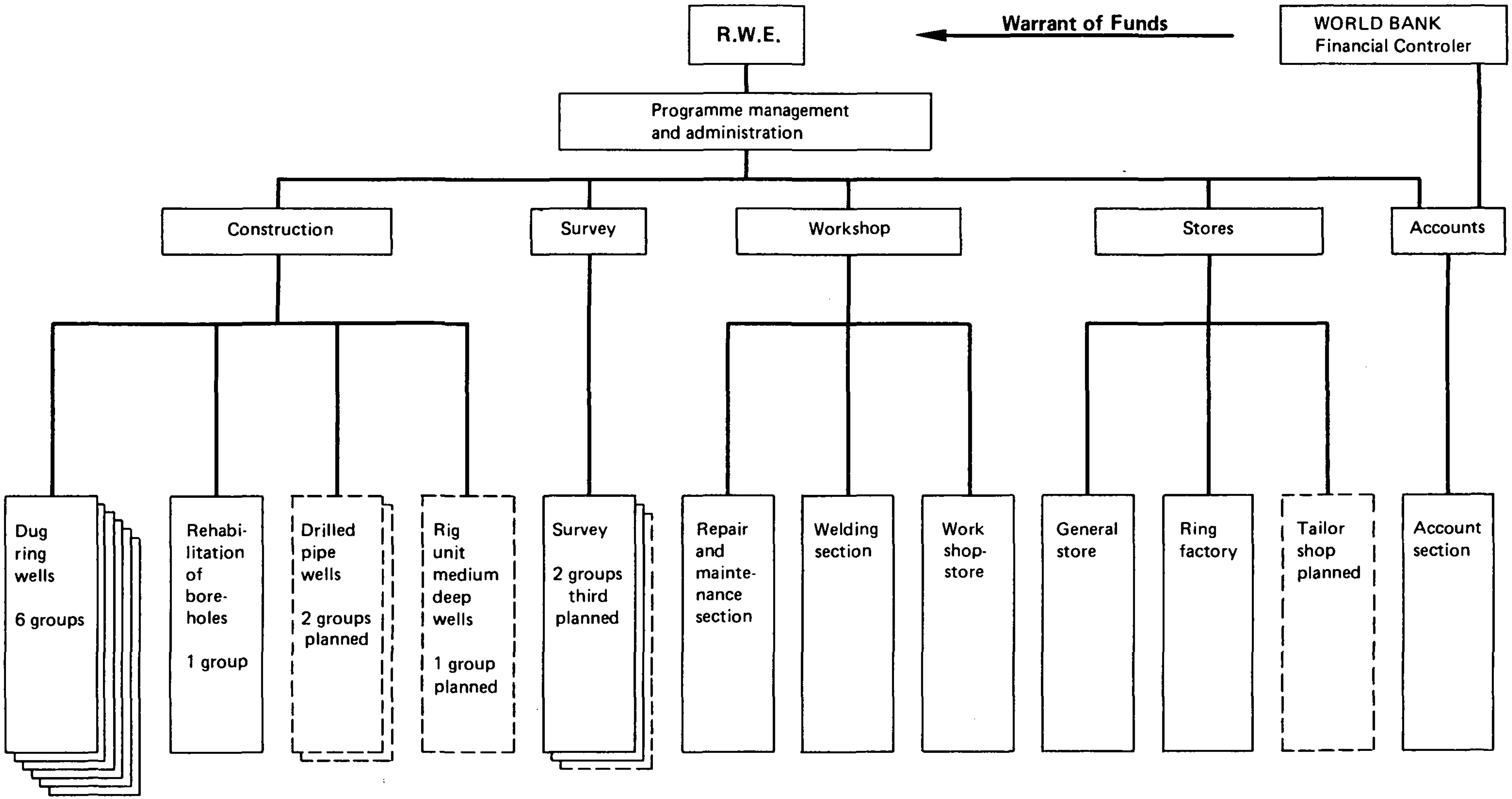
The programme is using its own store. Workshop and office are still under construction. For the time being the Shallow Well unit uses the facilities in the existing Maji compund in Mwanza-town.

Transport

The project vehicle park exists of
3 Toyota pick-ups
1 Landrover short chassis
3 Isuzu trucks long wheel base
2 Isuzu truck tipper

Survey and well siting

The survey section is working under a hydrogeologist, equipped with a Landrover short chassis. The two survey teams are each equipped with a Toyota pick-up and hand-drill survey sets. One team is working in Magu and Kwimba districts surveying for mainly ringwells in weathered granite aquifers.
The second team is surveying in Sengerema and Geita districts for mainly (drilled) pipe wells. The equipment used are hand-drills bought in Morogoro.



R.W.E.
Warrant of Funds
WORLD BANK
Financial Controler
Programme management and administration
Construction
Survey
Workshop
Stores
Accounts
Dug ring wells
6 groups
Rehabi-litation of bore-holes
1 group
Drilled pipe wells
2 groups planned
Rig unit medium deep wells
1 group planned
Survey
2 groups third planned
Repair and mainte-nance section
Welding section
Work shop-store
General store
Ring factory
Tailor shop planned
Account section

A mechanical survey drill has been ordered to extend the survey possibilities for later planned machine-drilled medium deep wells in the Magu, Kwimba and Misungwi Districts. No geo-electrical survey is used.

Construction

The well construction section is divided into two units to which two other units will be added.

a. Ringwell construction unit.
   Existing of six digging groups and two lorries making wells up to eight and nine metres deep in weathered granite aquifers.
b. A pump installation and borehole rehabilitation unit existing of one group only, which is installing all the pumps and also rehabilitating old boreholes by making pump tests, constructing slabs and installing hand pumps on top of it.
c. In September 1980 we will start our pipe well construction unit which the heavy-hand-drill. Staff, drills and casings are already there and siting is in progress.
   Estimated output: three wells a month depending on whether we will start with a second team or not.
d. In the financial year 81/82 we hope to start a unit for medium deep wells from 10 to 25 meter deep. However, first we want to have more approved sites before we decide to buy equipment for this type of construction methods.
e. Production target 1980/81.

	72	Ring wells
	50	Borehole rehabilitation wells
	30	Pipe wells
Total	152	Wells

Workshop

The workshop is able to cope with all the present maintenance and repair jobs. The present situation in the Maji facilities is not satisfactory and an own workshop for the Shallow Well unit is urgently needed.

Stores

The store section has its own building ready and is shifting from the Maji compound to the Nyakato site.

Administration, staffing and supplies

These parts are mentioned together because these are the limitations of the programme blocking fast progress.

a. Staffing and administration

The programme is lacking an accountant, an assistant hydrogeologist and a stores officer. At present the jobs are done by the existing staff which has a workload far exceeding the normal standards. Due to this, the administration of the programme often sinks below acceptable levels and delay is unavoidable.

b. Supplies

Due to the geographical location and other circumstances spare parts, construction materials etc. are very difficult to obtain. The poor cement supply has already seriously delayed the construction of the workshop and office facilities.
To improve this unacceptable situation we have three ways in mind:

1. We ask Prime Minister's Office to increase the assistance to the Ridep Procurement Officer in Dar es Salaam. Especially staffing, for Mr. Moore is procuring materials and equipment for five Regions and has even to type his own letters.
2. We will try to obtain cement also through the normal Maji channels.
3. If cement supply does not improve we ultimately want to go for transport contractors to obtain it right from the factory.

ANNEX I - RESULTS OF SURVEY SECTION PER 1-8-1980

District	Number of surveyed sites	Number of approved sites	Constructed	In stock
Magu	59	39	11	28
Kwimba	60	38	7	31
Misungwi	11	7	2	5
Mwanza	--	--	--	--
Sengerema	--	--	--	--
Geita	10	8	--	8
Ukerewe	--	--	--	--
Total Mwanza Region	140	92	20	72

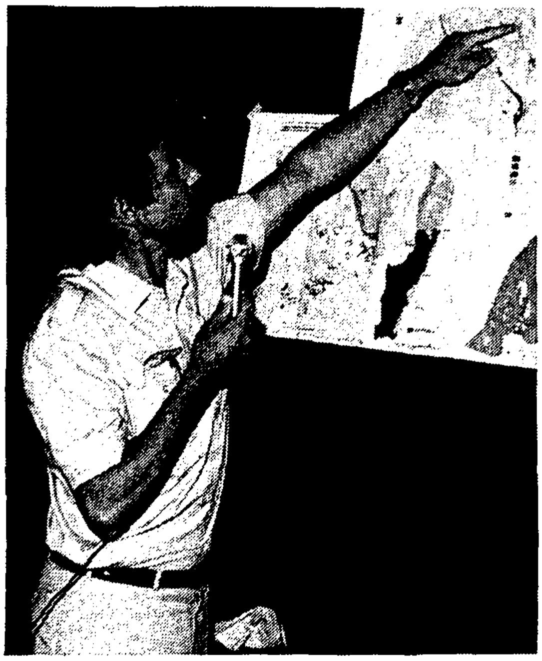
ANNEX II - LIST OF FINISHED WELLS

Month	District	Village	Well No.
February	Magu	Ilendeja	34/1 - 5
March	Magu	Matela	34/ - 3
	Magu	Nyashigwe	34/1 -10
	Magu	Nyamatembe	23/3 -12
April	Magu	Shigala	23/3 -14
	Magu	Malangale	23/4 - 1
	Magu	Gininiga	23/4 -10
May	Magu	Busega	23/3 - 8
	Magu	Mwanangi	23/3 - 1
	Magu	Bubinza	34/3 - 2
June	Kwimba	Nyamikoma	34/3 - 1
	Misungwi	Koromije	34/3 -18
	Misungwi	Ibongoya	34/3 -16
	Magu	Bubinza	34/2 - 2
July	Kwimba	Sumaha	34/4 -11
	Kwimba	Isagala	34/4 -19
	Kwimba	Mwamajira	34/4 -31
	Kwimba	Ngundya	34/4 - 8
	Kwimba	Bujingwa	34/4 - 1
	Kwimba	Kishili	34/4 -27

DISCUSSION OF PAPER PRESENTED BY MR. RINGELBERG

Referring to a statement about government bureaucracy Mr. Rugeiyamu asked about the other problems encountered.
Mr. Ringelberg replied that the World Bank had given a loan for Ridep-Mwanza to the Government of Tanzania. The money thus has to come from Treasury first, and just like all other Maji sections the shallow well unit has to buy from a warrent of funds. Only afterwards the money is refunded by the World Bank.
On a project employing some 150 people, including 138 casual labourers, various posts remain vacant: accountant, stores officer and assistant hydrogeologist.

On a question by Mr. Mtonga about the cost of a well, Mr. Ringelberg aswered that for each well a cost calculation form is filled in. At this moment average construction costs per well amount to T.Shs. 24,000/-, including survey costs of approx. T.Shs. 1950/- per well. The hand-drilled wells are expected to be approx. 25 percent cheaper: T.Shs. 18,000/- per well. The required contribution of the village for each completed well (after the introduction period) is T.Shs. 6,000/-.



3.6. SHALLOW WELLS IN TANGA REGION

Paper presented by Dr. Hartmut Floegel, Hydrogeologist RWD - TIRDEP

A. ABSTRACT

The physical and hydrogeological setting over most of the Tanga Region is such that shallow wells equipped with manual pumps are the cheapest and/or only way of ground water extraction for drinking water supply. A small well construction unit has been formed within the Regional Water Dept. in 1979. The techniques developed by the Shinyanga Shallow Wells Project and the subsequent Morogoro Wells Construction Project are applied in the Region. The Shallow Well Programme is backed up by TIRDEP.
The total available funds are minimal at present and need to be increased as some 700,000 people are still without safe and adequate water supply. Frequent cholera outbreaks demonstrate this situation drastically.

B. GENERAL SETTING

This chapter gives some general information on the topographical conditions, the water occurrence and the water use in the Tanga Region. Most of it is an extract from the "Tanga Water Master Plan" (1).

Geomorphology

The Region covers some 27,000 km² and features the following zones:
- The coastal zone of 20-50 km width has an elavation of about 100 m a.s.l. and is made up of sediments of Karroo to Quaternary age. The plain is limited in the west by a more or less pronounced escarpment, which is the border between the coastal sedimentary succession and the inland metamorphic rocks of the Usagaran System.
- The mountains of the East and West Usambaras rise quickly from 500 m to more than 2,000 m a.s.l.
- The interior dissected highlands gently rise to over 1,000 m a.s.l. west of Handeni. Further west, inselbergs attain elevations of almost 1,800 m a.s.l.
- The Umba Plain with an elevation of 500 m a.s.l. lays to the north east of the Usambara Mountains and is less dissected than the highlands. Hills and mountains rising above the plain have the shape of elongated chains.

(1) Tanga Water Master Plan. Vol. III: Ground water Resources; AHT - TIRDEP, MAJI, 1976.

- Of the two broad tectonic valleys, one runs along the southwestern border of the Usambaras and the other one separates the western from the eastern part.

Ground water occurrence

No aquifers of great extent are present. Locally, small aquifers are found along the coast. In the interior, ground water can accumulate only where weathered zones are present on top of the crystalline basement or where a secondary porosity exists due to faults and fractures.
The gross water balance for the Tanga Region is given below:

	$10^6 m^3/Y$	%
Preciputation	24,955	100
Run-off	2,072	8.3
Baseflow	460	1.8
Ground water	1,237	5.0
Consumptive Use	21,186	84.9

Ground water prospects of the area vary widely and have been classified as follows:
- Good in the tectonic valleys.
- Medium to good along the coast. However, the danger of sea water intrusion is high.

- Low to medium in the Umba Plain and the dissected highlands, where the salinity varies strongly.
- Low in the western coastal plain due to the high salinity hazard of the Lower Karroo beds in the north and the generally high salinity within the Jurassic marls in the south.
- None in the mountain areas and in other areas of basement outcrop.

Ground water recharge occurs mainly in the thin weathered zone of topographical depressions, where the stored water eventually is consumed by the vegetation. Therefore, emphasis should be given to shallow wells to recover this water before it is lost. Also in areas where the salinity increases with depth, like along the coast where a thin fresh water layer floats on top of salt water, shallow wells are the only solution to exploit ground water of acceptable quality.

Population and water supply

Based on the 1978 census, the total population of the Tanga Region is 1,050,000.
365,000 or 35% of the inhabitants are supplied with piped water, most of which is surface water from rivers or reservoirs. Additionally, 120,000 people in western Tanga Region will receive piped water from the Pangani river as soon as the Handeni Trunk Main is completed.

With respect to town and village population, the water supply (WS) distribution is as follows:

	TOWNS		VILLAGES	
District	with WS	without WS	with WS	without WS
Tanga	1	-	11	7
Pangani	1	-	19	4
Muheza	1	-	38	125
Korogwe	1	-	15	100
Handeni	1	-	32	40
Lushoto	1	-	31	98
Total	6	-	146	374

C. DUG WELL HISTORY UNTIL 1979

The oldest wells still in use have been constructed by the Arabs in coastal settlements. The wells are rock lined and/or cut into the coral limestone. Water still is lifted by rope and bucket. Their depth ranges from 3 to 5 m.

During British rule many wells were constructed, mainly using concrete rings with a diameter of 0.9 tot 1.2 m.
Most of the wells had been equipped with hand pumps and they had been closed with concrete covers including a metal or wooden manhole lid. Today, the pumps are either missing or remnants are left only. The manhole lids or the whole covers are removed and water is lifted again by rope and bucket. Many of the concrete rings are dislodged due to caving and some wells are in a state of collapse.

Since independence, large and small diameter concrete ring wells were built by MAJI for village water supplies. They usually have concrete covers and are equipped with 2" to 3" centrifugal pumps.

One well was found near Msente in the Handeni District, which was constructed and equipped with a Shinyanga pump in 1969 with the aid of UNESCO. Since 1977 the pump is broken and more or less beyond repair.

Apart from the above mentioned, more sophisticated wells, hundreds of wells without covers were built by the villagers. Most of them are unlined shallow pits, some of them are reinforced by timber or uncut rocks. Many of these wells dry up during the non-rainy season.

The physical and biological water properties are unsatisfactory in all wells which are open and where water is abstracted by rope and bucket. Furthermore, the immediate vicinity of the wells usually is such that polluted water percolates down back into the well. As a result, cholera outbreaks are quite frequent in the Region. Therefore, improvement and rehabilitation of dug wells was proposed by the Tanga Water Master Plan in 1976.
Unfortunately, neither funds nor personnel were made available for implementation of this proposal until 1980.

D. PRESENT SET-UP OF THE SHALLOW WELL PROGRAMME

The 1979/80 Programme

A Shallow Well Programme first was introduced by the Regional Water Department for the 1979/80 financial year. The programme consisted of the construction of 10 wells equipped with manual pumps at 10 different villages along the coast. Construction equipment was limited to some shovels and pickaxes and an old mould for 0.38 m high concrete rings of 1.5 m diameter. Mr. Challange was put in charge of the activities. Other staff assigned included three concrete ring well sinkers and three new assistants, which were trained from October to December 1979 at the Morogoro Wells Construction Project, as surveyor, driller and pumpfitter respectively. The total funds allocated were T.Shs. 32,000/- from Regional funds and T.Shs. 110,000/- from the SIMAVI, a village development organisation, which is financed by the Institute of Child Health at the University of London.

The writer only arrived in February 1980, for a first two month assignment to start-up and manage a shallow well construction unit. The assignment is within the framework of the project "Strengthening of the Output Capacity of the Regional Water Department", which started in July 1979 and is one of the many TIRDEP Projects. The present total input for the Shallow Well Programme amounts to T.Shs. 290,000/-.

TIRDEP itself, a technical assistance project, is the first and largest RIDEP Programme of Tanzania and was initiated in 1972. It is mainly financed by the West German Government; upto 1981 the sum of T.Shs. 307 million has been allocated. The various projects are implemented through regional functional offices.

Well construction fell far short of the programme. Only three wells could be completed. They are located at Migombani, Kirare and Mahandakini. The total costs were T.Shs. 103,000/- or T.Shs. 34,000/- per well. The main reasons for this slow progress and the high costs were:

- lack of experience
- transport problems
- lack of survey and construction equipment

In February/March 1980, orders went out from the TIRDEP Project to the Morogoro Wells Construction Project for two light and one heavy duty survey set, a tripod and a handrill set. In April one light survey set and a tripod were received, the other items are still outstanding. Items like moulds for concrete rings, sieves, tools, etc., were ordered and/or purchased locally.

Well survey started on March 13th with help of a Morogoro surveyor, who identified four well sites until April, 9th. Work continued by own staff on May, 22nd. A second surveyor started training at Morogoro on May 15th and a mechanic got a one month training in well maintenance at the same place.

The 1980/81 Programme

For the 1980/81 financial year, a programme was prepared by the writer in April to survey and construct 38 wells and to rehabilitate 9 wells.

Unfortunately, the current budget for the Regional Water Department was cut drastically and the available funds for the Shallow Well Programme are as follows at the moment:

A.	Regular Regional Fund	T.Shs.	125,000/-
B.	SIMAVI	"	85,000/-
C.	Tanga Lions Club	"	18,400/-
		T.Shs.	228,400/-

A. is forseen for six wells in some of the cholera stricken villages in Korogwe District
B. for four wells in Muheza District and
C. for the rehabilitation of two wells in Kwale

However, a proposal has been put forward to use these funds for labour and transport costs only and to purchase the necessary construction material for 36 wells through the ongoing TIRDEP Project.
In the meanwhile, survey work is continuing and first orders for construction material have been placed.
Furthermore, two trucks have been ordered, but delivery will not be before early 1981.

DISCUSSION OF PAPER PRESENTED BY MR. FLOEGEL

Mr. Mutaboyerwa recalled that the Mwanza/Ridep programme had problems with supply and staffing and problems of a financial nature, and wondered whether the Tanga/Ridep project was facing similar problems.
Mr. Floegel admitted that this was the case: no accountant, lack of transport facilities and difficulties with stores.

As in Tanga and some other areas possiblities for shallow wells are limited, the chairman inquired after any experience with alternative water supply methods, say storage of rainwater. Both Mr. Grace and Mr. Pattegar could give some examples of storage of rainwater, in the Caribbean and Ghana, respectively, whereas Mr. Grace added that in Iringa two schemes for tapping springs are being investigated.

3.7. THE TANZANIA/AUSTRALIA WATER DEVELOPMENT PROJECT SINGIDA REGION

Paper presented by D. Collin, Hydrogeologist, Ground water Project Singida

A. INTRODUCTION

During ministerial level discussions in Canberra in July 1974 agreement was reached to set up a ground water development project in the Singida Region of Tanzania. The resulting Memorandum of Understanding stressed the project's bilateral nature whereby Tanzania provides labour, mid level staff, premises, fuel and some drilling supplies and Australia provides two drilling rigs, support vehicles and expert staff. Drilling commenced in June 1975 and by the end of 1976 some 43 boreholes totaling 2594 m had been drilled. Of these 62% were regarded as successful and were approved for the fitting of pumps.

To assist Maji in bringing these holes into production Australia later agreed to supply diesel pumps and windmills as well as an expert in the installation of these units.

Makers of the pumps and engines also sent experts for training local staff in the correct operation and maintenance of their products. Up to now 24 windmills have been erected and 14 diesel pumps installed. Our experience in Singida suggests that windmills are able to meet water requirements for the human and animal population of the villages for the 8 dry months of the year and that the diesel pump is only needed for the remaining four months. Each windmill and diesel unit is connected to one steel or concrete tank and this is connected to about 4 standpipes. No reticulation system is provided so we have a fairly compact system making maintenance much easier.

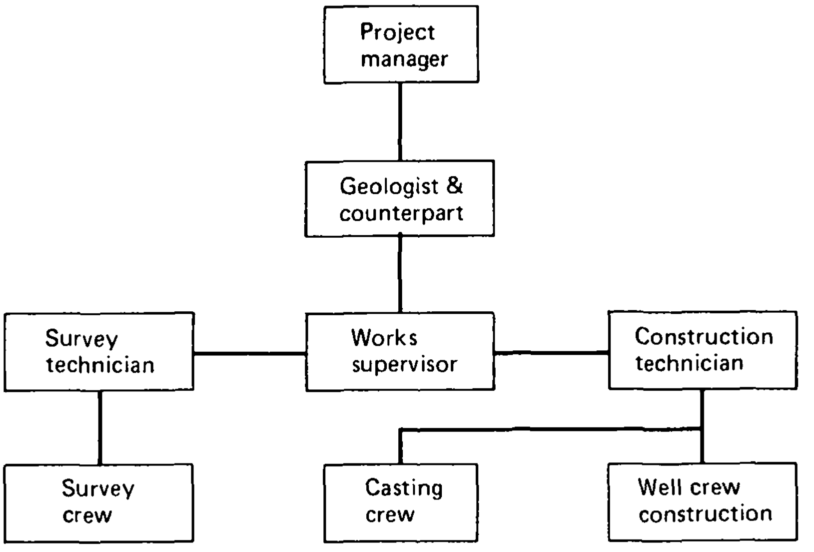
As the Project was receiving favourable comment from its Tanzanian and Australian sponsors it was decided to make a survey of the Region's water supplies, as a basis for future development. Inspection of the main sources of supply in 307 gazetted villages was made during a 20 week survey late in 1977 and the main findings were:

1. Surface sources such as springs, dams, swamps, and flowing rivers provide the main source of water for 14% of villages surveyed.
2. Boreholes supply 23% of the villages but an examination of the performance of equipped boreholes shows that at any one time only 1/3 of these are in operation due to problems with fuel supply, spare parts and maintenance.
3. The remaining 63% of villages obtain their water from shallow wells located on the edge of Mbugas or in river alluvium. Only 7% of villages had lined wells and in most cases the original pump was broken or missing.

Once the overwhelming importance of shallow ground water resources was appreciated it was decided to start a shallow well programme for Singida along the lines developed by the Dutch Team in Shinyanga. This has been visited by our Project coordinator, Manager and Geologist in 1977 and we were very impressed with what we saw in the field and in the base workshop.

B. THE ORGANIZATION OF THE SHALLOW WELLS PROJECT

To make the best use of common services such as workshop, housing and laboratory it was decided that the shallow well project would form part of the overall water development project for the Region. The geologist from the 1977 survey was appointed to take charge of the programme in January 1979 and shortly after another expatriate was appointed to establish the concrete casting yard and to take charge of field operations. Two water technicians were provided by Maji to control the survey party and construction teams. The management pattern is as shown below.



As mentioned above the shallow wells project fits in the overall water development project which has the following components:

1. A large workshop where vehicles, drilling rigs, pumps and engines are maintained. Two Australians are employed here with one having responsibility for training mechanics and welders.
2. A laboratory for testing water samples prior to developing boreholes or shallow wells. This laboratory is equipped for basic chemical and bacteriological testing and is operated by a technician trained at Maji Ubungo.
3. A borehole drilling and equipping section. Drilling staff consists of a supervisor and two drillers - all Tanzanian - whilst the pump and windmill section is controlled by an Australian works supervisor.
4. The last section of our project is involved with the Water Master Plan for Singida and Manyoni Townships and it is expected that the two geologists will spend a considerable effort on this work in the next few months.

All of these components share transport, storekeeping, accounting and managerial facilities and although competition, for transport especially, does sometimes arise, the various sections work together fairly successfully.

C. THE SURVEY SECTION

Due to the present shortage of tents for the use of the survey party our activities have been concentrated in Singida District. However, within this area the villages to receive attention are nominated by the Regional Water Engineer in consultation with his colleagues in the Regional Planning section.

Once a village has been chosen for shallow wells it is visited by the geologists to make a preliminary selection of survey sites. Village committees are asked to take part in this selection as they can often recommend suitable sites or advise where old wells, capable of rehabilitation, can be found.

The survey crew, consisting of a technician and three labourers, then puts down hand auger holes and performs a 1 hour pump test if water is found. All soil material and water data is logged and completed forms are returned to the office for assistance with well design. Water samples are taken to the laboratory for assessment of fluoride content and total dissolved solids. At present one survey team is in operation but his will shortly be split to provide the nucleus for two teams. The survey team is self-contained for transport but we have not yet made any wheel barrows to enable the team to move locally without the use of a Landrover. Production is usually about 2 holes and tests per day, to a maximum of 10 m.

D. CONSTRUCTION OF WELLS

Based on experience in Shinyanga and Morogoro we have developed facilities for making ring wells and tube wells. So far we have made 32 ring wells and seven tube wells but we hope to greatly increase the proportion of tube wells.

Lining rings, both solid and permeable types and their variants, are made in the casting yeard using moulds purchased from National Engineering in Dar es Salaam. Digging and placing of rings on site follows conventional methods. Our main problem here is that our soil profiles are often very sandy and where there is adequate water we have a flowing sand situation. Dewatering outside the rings does help, but in these cases it is generally desireable to make a tube well where the steel casing automatically seals off this sand.

Tube wells appear to be successful in the Region but so far we have been held back by lack of 150 mm diam. plain and slotted rigid PVC casing. This material is made by Tegry Plastics in Dar Es Salaam but distortion of the walls of the casing make it impossible to cut threads for joining the sections. Further development work using thinner walled material and belled ends is called for and it appears that Maji's Boko workshop could well undertake to obtain and prepare this material.

Due to the high cost of imported hand-drilling equipment our tube wells have been constructed using an Edeco diamond drill rig. This is trailer mounted and diesel operated and is far from ideal for our purposes. We are hoping to exchange this in the near future for an auger type machine mounted on its own four-wheel-drive truck. So far I have been unable to convince our project management that hand-drilling appears to be entirely suitable for use in Singida Region.

Pump fitting is undertaken by a separate team and so far we have used only the Shinyanga type pump. We are very impressed with the latest Kangaroo type pump and we hope that one of the outcomes of this conference will be to set up a procurement system whereby all Regions will be able to draw from the output of the Morogoro factory.

E. MATERIALS AND SUPPLIES

Like many other projects it is in this area that we are having our main problems. Our supplies are drawn partly from Maji and partly from Australia. In the latter case we have adverse conditions such as distance and cost. Sea freighted materials have to be transhipped at Singapore since there is now no direct service from Australian ports to Dar es Salaam. Deliveries of heavy and bulky components such as tube well linings are now taking up to 6 months. Items sent by air freight have to be transhipped at Amsterdam or Frankfurt which again increases cost and delay. Ordering of supplies is also difficult as letters to Australia from Singida take about 3 weeks. The telephone service is also not the best but we are hoping for significant improvements next year when the micro wave link to Dodoma is complete.

On the local supply scene out major problems are with supplies of cement, fuel and pumps. Cement supplies are drawn through Maji plus whatever we can obtain by local purchase from the RTC's annual allocation of less than 1,000 tonnes. In this case we have to transport the cement from Wazo Hill to Singida and this has caused excessive wear and tear on our trucks. Railing of supplies to Manyoni is possible but delivery takes about 10 weeks from ordering and advance payment.

Although we prefer Kangaroo pumps so far we have drawn our supplies of hand pumps from the Shinyanga factory through Maji's normal ordering system. This has been fairly satisfactory but there have been periods of several weeks when no pumps were available in the Region. Advice that 30 are now available for collection in Shinyanga was received last week and we hope that this will form the basis of a permanent stock of pumps available for fitting as soon as a well is completed.
Shortages of petrol and diesel fuel are also a source of worry. Government stores normally supply our fuel through Maji but due to the fact that we and the Regional Water Engineer's vehicles are one of the Region's main consumers we have recently been asked to arrange our own supplies from Moshi. At present we have two written-off Isuzu ten tonners and we hope to make up one serviceable vehicle as a tanker. As we are due for delivery of 4 ten tonne Isuzu trucks, fitted with cranes for shallow well work, it is essential that adequate fuel be made available. Our storage capacity is 18,000 l of diesel and 9,000 l for petrol but so far the tanks have never been full. However, a typical borehole made by Schramm rigs takes about 2,500 l of diesel, so this capacity is not excessive.

F. OPERATION AND MAINTENANCE

In the event of pump breakdown we rely on the person nominated by the village water committees to report to the chairman, who contacts us regarding the need for repair. We are intending to upgrade the district workshops to undertake the repair of diesel engines and pumps and it should be a fairly simple exercise to add on a hand pump repair unit to that workshop.

For the windmills and diesel units, where there are paid operators we do make maintenance visits at monthly intervals but so far have not found this necessary for hand pumps.

G. CONCLUSION

To wind up this summary of our experience I would like to say that I am personally convinced that shallow wells provide the only possibility of meeting our national target regarding village water supplies. From experience gained during the last five years I believe that for townships, and institutions such as hospitals and prisons, there is still a need for boreholes and either diesel or windmill pumps. However, for the majority of remote villages properly constructed shallow wells provide the optimum solution to the water supply problem. The outstanding merits of shallow wells are seen as:

1. Speed and ease of construction. Construction methods are available using hand labour only, thus avoiding the use of drilling rigs and their problem of operation, maintenance and fuel supply. Deep bores require powered pumps with further problems of maintenance and fuel supply.
2. Exploitation of a supply of clean, accessible water which would otherwise be wasted. Risk of contamination is greatly reduced and many sources combine a filtering and storage capacity at no cost.
3. We have adequate knowledge of construction methods and suitable hardware is available. Without belabouring the appropriate technology aspect any observer can see that shallow wells and hand pumps are right for villages as their construction and operation is understood by village people and they deliver the right amount at the right place at the right price.

Let us hope that this conference will assist in reducing the remaining problems of organization and supply so that many more village people will quickly receive the benefits which shallow wells can offer.

DISCUSSION OF PAPER PRESENTED BY MR. COLLIN

Mr. Lehd requested some additional information on the use of windmills in Australia, upon which Mr. Collin replied that experience with windmills in Australia covers a period of 40 to 50 years. Their most important application is in remote areas that are devoted to the raising of cattle and sheep. Especially in the artesian basin in north-east Australia windmills are very much used. Particularly the above-ground part of the windmill can operate economically and automatically for long periods of the year, with maintenance for instance at 3-monthly intervals. The windmills switch themselves on when the storage tanks are half full, and off when they are completely full. Windmills are robust, reliable and economical, thus very well applicable to Tanzania.

On a question by Mr. van der Wel why the project uses Shinyanga pumps of T.Shs. 4,500/- each, in stead of Kangaroo pumps (T.Shs. 2,000/- each) Mr. Collin answered that this was purely because of transport problems. Kangaroo pumps will be used in the near future.

Mr. van Krimpen asked for information about the price of windmills. Mr. Collins answered that prices vary with the size of the fan and the height of the tower. A small windmill, with 10 feet fan diameter and 30 feet high tower costs T.Shs. 23,500/-, to which about 15 percent has to be added for transport. This price includes rising main, pump rod, air chamber, check valves and associated fittings.
A windmill with 17 feet fan diameter on a 40 feet high tower, would cost T.Shs. 59,000/-. In both cases the cost of the borehole, estimated at T.Shs. 80,000/- should be added.
In Australia so-called squatters' tanks are used: prefabricated galvanized iron tanks that are fairly low, with a large cross sectional area. A 5000 gallon tank would cost some T.Shs. 10,000/-. In Singida ferrocement tanks of 22,500 l capacity are used. These tanks, with a total weight of about 7 tons, are transported to the site on a trailer. No detailed cost figures are available yet, but according to Australian practice the cost should be about 300 Australian dollars, or approx. T.Shs. 3,000/-.

On a question by Mr. van Lissa, Mr. Collin replied that during the 4 windless months diesel pumps are used. Because windmill pumps are of the reciprocating type, whereas the diesel-driven pumps are rotary pumps, two boreholes are required at each site.

On questions by the chairman, Mr. Collin answered that 63 percent of the villages in Singida Region draw water from shallow aquifers, indicating that at least in those villages shallow wells would be possible. This was confirmed by Mr. Mellya.

Mr. Pattegar inquired whether the Arusha windmill had been tried out. Mr. Collin answered that this was not the case and that, seen the very long experience with windmills in Australia, it was decided to bring in windmills of a proven design.

3.8. WATER QUALITY CONTROL BY ZONAL WATER LABORATORIES

Paper presented by Veli Aalto, Water Chemist, MAJI, Ubungo

A. INTRODUCTION

For several years efforts to supply rural areas with water have been concentrated on providing water for the people with the main emphasis on quantity and less on quality. But there is a strong relationship between water quality and health; more than 19,000 Tanzanians every year die from faecal-oral diseases. Maji, being the Government's instrument responsible for the supply of water to the people has to make sure that the water it supplies is safe for drinking purposes. To secure the quality or product we must be able do determine it.

The set-up of Maji water quality laboratories is inadequate already for the present situation, not to speak of the future, when tens of thousands of new water sources and schemes will be in operation. The central laboratory, the Soil and Water Laboratory in Ubungo is reasonably well supplied with equipment to do complete physical, chemical and bacteriological analysis, but its capacity is only about 2000 samples per year. The regional water laboratories in Mtwara, Mwanza and Shinyanga are inadequate concerning staffing, instrumentation and mobility. They are not capable to serve those regions properly. These laboratories are just the remains of the respective water master plans.

In May 1977 SIDA together with Maji prepared the terms of reference for a Tanzanian Rural Water Quality Programme. Brokonsult AB was awarded the contract. The final report was submitted in 1979. Maji has studied the report and has accepted its findings and recommendations and is now in the process of implementation.

B. THE FINDINGS OF THE REPORT

Physical and chemical water quality, although not always according to WHO standards, is quite often acceptable. In some areas there are several problems with excessive fluoride or dissolved salts contents. Quite often iron and manganese are found in excessive concentrations, especially in ground waters.

Bacteriologically the waters are mostly unacceptable. Bacteriological contamination often exceeds even the international standards for swimming water. Especially almost all surface waters are badly contaminated.

Many water schemes are out of operation or they are operating poorly because of bad design, faulty construction or inadequate maintenance. The water quality surveillance system is inadequate to control the situation. It is quite too small.

The reason for this situation is the lack of money, manpower and central control of water quality and technology.

C. THE SUGGESTIONS OF THE REPORT

1. The consultant suggested certain revisions on existing water laws and water quality standards. Maji is working on these problems.

2. On water treatment the consultant's opinion was, that treatment being usually too expensive and difficult to build, operate and maintain in the rural areas, the main emphasis should be put on the water sources, intake designs and source protection. Treatment for rural supplies should be nil or very simple, like extended storage and in extreme cases chlorination. Shallow wells and boreholes with hand-operated pumps should be preferred to diesel pumps and piped supply. In piped systems gravity lines are the preferred possibility.

   This conference is one proof that our Ministry has taken a positive attitude concerning these recommendations. Treatment with extended storage is not yet realised because this method has not been studied yet in Tanzania.

3. The report also calls for the immediate function of an independant body to be charged with water quality surveillance within the frame work of Maji. The consultant proposes the formation of a Water Hygiene Division with the following sections:
   - planning and reporting
   - central Water Quality Laboratory at Ubungo
   - administration/accounts
   - special programmes such as Public Education, Regulations and legislation

   The sections of the proposed Division will have the following functions:

   (i) Plans and Reports Section

   - to plan the functions of the Division
   - handle the reports from the Water Hygiene Centres
   - secretariat of the National Water Hygiene Committee
   - maintain records of the Water Quality Emergency Fund

   (ii) Administration and Accounts Section

   - will handle all administrative matters of the Division
   - will also handle the accounts of Ubungo Water Quality Laboratory and Division as a whole

- it will cooperate with the accounts sections of the RWE in handling the accounts of the Zonal Water Hygiene Centres
- it will procure and store equipment, chemicals and materials needed by the Ubungo Water Quality Lab as well as Zonal Water Centres

(iii) Programmes Section

- will prepare reports and recommendations on treatment methods, based upon the technical literature etc.
- will prepare recommendations on source protection and scheme design
- will prepare regular revision estimates of treatment costs
- will review and advice the Director of the Division in legislation and regulations relevant to water quality problems
- will prepare seminars with RWE's and RHO in the water quality programme implementation
- will prepare materials for the public education campaigns

(iv) Water Quality Laboratory Ubungo Section

- this will serve as Maji central water quality laboratory
- it will provide technical supervision to the Zonal Water Hygiene Centres
- it will analyse those analyses which cannot be done at the Zonal Water Hygiene Centres
- it will conduct research on water quality aspects
- participate in training of laboratory technicians and treatment plant operators
- it will also serve as a Zonal Water Hygiene Centre for Coast and Dar es Salaam Regions

The programme will initially consist of:
- the construction of 5 Zonal Water Hygiene Centres at Mtwara, Mwanza, Shinyanga, Mbeya and Moshi
- training of water hygiene engineers or chemists to man the centres and run the laboratories
- purchase of six mobile laboratory units (Landrovers with bacteriological field kits) for Mtwara, Mwanza, Shinyanga, Mbeya, Moshi and DSM. The number of mobile units will increase as the programme expands to cover the whole country effectively.

The duties of the Zonal Water Hygiene Centres are the following:

- They shall monitor the drinking water quality in one to three regions. Special weight is put on the bacteriological quality and on-the-spot examination of the schemes.
- They shall report their findings to the Water Hygiene Division, to the RWE and to the Regional Water Hygiene Committee.
- They shall recommend necessary action for upgrading of polluted schemes and follow up the results of their recommendations.
- They are under the Central Water Laboratory, Ubungo

D. ACTION BY MAJI

Organization changes are difficult and somewhat sensitive so that we cannot wait for big news very soon. The practical question of Zonal Water Hygiene Centres is progressing in Maji. The laboratory technician training has been going on over three years and the first batch of twelve graduated last May. The water hygiene engineer/chemist staff will not be available soon. Actually in this case we must very heavily rely on the help of the donors. Most of these persons must get their B.Sc. training abroad, because the University of Dar es Salaam does not have the necessary capacity. Also concerning the initial staffing (water hygiene engineers/chemists), laboratory equipment and mobile laboratory units we will be very much depending on the prospective donors.

At the moment Maji is approaching possible donor organizations in order to establish a certain amount of zonal water laboratories. The donors are asked to supply the necessary laboratory equipment for basic physical, chemical and bacteriological examination, a mobile unit and an expatriate water hygiene engineer/chemist. The material cost depends on circumstances but is about T.Shs. 250,000/- for one laboratory. This will not yet include the necessary buildings, the university education of Tanzanian counterparts and the running costs of the laboratories.

Now you will ask why Maji is building this organization beginning from the bottom. The answer is that we must. The task of the water quality surveillance at the moment is too big for our present laboratory set-up and while the number of organized schemes is all the time increasing our situation is getting more and more critical. Something must be done soon and that something is the network of zonal water laboratories. Without proper control of water quality the situation will get completely out of our hands and its repair will be much more expensive and difficult later than what it is now.

DISCUSSION OF PAPER PRESENTED BY MR. AALTO

Mr. Grace stated that under the circumstances, regrettably, treatment of rural water supplies is out of the question, if only for financial reasons. He recommended to inform the villagers that the water supplied has the best quality that is attainable under the circumstances, but not necessarily meeting the standards, so that it might be better to boil the water before consumption.
Mr. Aalto replied that under the circumstances it is not possible to provide water according to WHO standards. The bacteriological standards could not be met in practice either, but must be considered good standards for the future. He recommended a policy whereby repeatedly the worst sources are somewhat upgraded, so that after some 20-30 years all would have been improved up to internationally accepted standards.
He regarded boiling all water before consumption impractical, fearing that no trees would be left in Tanzania if this would be carried out. He mentioned that the fluoride problem is being studied and that, rather than allowing fluoride contents of over 8 mg/l to be accepted, the upper limit of 8 mg/l is expected to be lowered.

The chairman stressed the importance of extensive campaigns to educate the villagers regarding rural water supply in general, and the need to boil water from suspected sources in particular.
Mr. Lucas suggested that the shortage of trained water hygiene engineers and chemists might be remedied in the same way in which the shortage of hydrologists was overcome, some 6-7 years ago, viz. by having special courses at the University of Dar es Salaam.

3.9. TRAINING BY THE WATER RESOURCES INSTITUTE

Short paper presented by Mr. M. Kivugo, Principal, Water Resources Institute

In 1971, when it was decided to start the massive programme of providing water to all Tanzanians, immediately the problem was realized that the bulk of the required manpower would be the middle level technicians. Thus the Water Resources Institute was founded, which has the following functions:

1. To conduct training programmes leading to the diploma in water resources engineering, with emphasis on hydrology, hydrogeology and water supply. In this 3-year programme recently a course on water quality was started, with an intake of 15 students each year. The first batch of them graduated in May, this year.
2. To arrange and provide for opportunities for ministerial in-service as well as up-grading training. This is where the shallow well programme comes in. If we adopt any kind of appropriate technology it is our responsibility as a ministerial body to do the training.
3. The Institute will act as a ministerial examination body for the course conducted in the Regions. Every RWE is supposed to train the personnel he needs. In May/June the Institute conducts examinations for the various courses given in the Regions. This is necessary to ensure uniformity in training and equal opportunities for all regarding up-grading and scheme of service.
4. To provide facilities for seminars, congresses, etc. on matters related to water.
5. To provide, when and where necessary, consultancy services to the different technical departments of the Ministry and other interested national institutions.

When we were in Tanga and resolved that in order to reach the target of providing water to every household within easy reach by 1991 the shallow wells technology should be adopted, wherever feasible and acceptable, I felt that the Institute will have the duty to train these people. When I was approached by the Morogoro Wells Construction Project, I automatically felt that, should we adopt the shallow wells technology, whatever training is going on in Shinyanga, Morogoro and Mtwara, should be part and parcel of the regional training programme, because the personnel will have their future to think about and a kind of recognition here is necessary.

I should like point out that the shallow well technology is already partly incorporated in the training courses of the WRI.
The way I should like to incorporate this as a particular training is not different from the way we are conducting other short courses, as in draughtmanship, survey, etc. Suggested is a course of 3 months, followed by practical training in the home Regions of the surveyors and well sinkers. After some time they will come back to the Institute for a continued assessment of their performance.
They can then be examined at the Institute and be given some kind of diploma or grade.

DISCUSSION OF PAPER PRESENTED BY MR. KIVUGO

Upon a remark of Mr. Rugeiyamu that 3 months is a short period for training, Mr. Kivugo answered that the Institute has not yet started the training. It is intended that the first batch of trainees will exactly follow the MWCP training programme, together with instructors from the WRI. The facilities of the MWCP will be used. The WRI will study the technologies used by the various shallow well projects, as well as all possibilities for well construction, pumps, etc., so that trainees will be familiar with the various methods and types of equipment.

Mr. Kashoro recommended a 6 months' training programme for people who in their own Region would have to set up a shallow wells organization and who could train their own people as well.

3.10. A NOTE ON SHALLOW WELLS TECHNOLOGY IN TANZANIA

Paper prepared by D.S. Bushaijabwe, Deputy Principal Secretary, and Mr. P.M. Rugeiyamu, Senior Executive Engineer, Ministry of Water, Energy and Minerals

This short note seeks to look back on the development of the shallow wells technology in Tanzania, to highlight some of the shortcomings on the present shallow wells arrangements together with their solutions and to look into the future on how best to attain and spread the optimally improved technology throughout the country with as little dependence on foreign assistance as possible. Within this scope a lot of questions and answers could be stimulated during this seminar and hereby help in closing nearer to the objective we have assembled here for. Jointly find ways and means for decision makers to popularise this technology with a view to accelerate the rate of providing water to our people.

Since times immemorial our ancestors were collecting water from various water sources such as perennial rivers, lakes, ponds, dug wells etc. The dug wells as they are very well known by most of us were made manually in very soft formations like the sandy river beds. Sometimes crude tools were used to make wells in open plains -"mbugas" - where it was thought the phreatic surface was not very deep. In some cases where the water table was as deep as 8-10 metres the people could still skillfully dig the water holes so as to be able to get out the water for themselves and their animals. Such carefully dug wells have been found in different places in Tanzania e.g. in Misenyi in Kagera Region, Nachingwea plainlets in Lindi Region, Kitwai plains in Tanga Region etc.

The question, however, that has remained persistent with those concerned with the provision of water to people has been on how to improve the dug wells so as to obtain good water qualitatively and quantitatively, ensure safety of the wells and above all make it fairly easy to abstract the water from the wells.

During the colonial times some progress was made towards this end. Some tools for augering were designed and lining of the wells was advanced so as to improve the stability of the wells and the potability of the abstracted water. Some types of hand pumps were also introduced such as the Uganda hand pump, UNICEF hand pump, MAJI hand pumps etc. These developments improved the then existing situation to some extent; there was therefore no need to continue refining the dug wells.

After independence the water development authorities further continued to improve the dug wells so that they could be used as intakes for pumped rural water supply schemes. Shallow well construction teams were established in some of the Regions. Two well sizes were chosen for uniformity purposes - one with 8 ft. diameter and another with 4 ft. diameter. Moulds with the above mentioned sizes were sent to the Regional Water Engineers offices.

With the intention of stepping up an accelerated well construction programme particularly in the wake of the Shinyanga Water Master Plan recommendation, the Government accepted the implementation of the Shinyanga Region Shallow Well programme. This programme brought more improvements on the shallow well technology. For the first time filter medium was introduced in the construction of the shallow wells. Better perforated concrete rings for well lining were made use of besides other modifications. The Shinyanga pump was developed as an improved version of the MAJI/UNICEF hand pump. More research and determined efforts resulted into the Kangaroo pump which has obvious advantages over the Shinyanga pump although it incorporates several imported parts like the spring and foot valve.

The Morogoro Shallow Well Programme followed the Shinyanga one. The two programmes have a lot of similarities in technology because the expertise is rendered by the same firm. Tube shallow wells have been introduced. These have advantages over the ring shallow wells. They are cheaper to construct and can be done much faster. However, they have a definite disadvantage of having a considerably less holding capacity than the ring wells.

Following the Shinyanga Shallow Well programme experience the Lindi/Mtwara Shallow Well programme was launched. In this programme the wells remained lined with concrete rings while the hand pumps used were directly imported from Europe. These pumps are reputed to be very durable although the connecting brass piece between the handle and the pump head has exhibited easy fatigue failure.

Looking back at all these developments and other too recent to be mentioned one is tempted to ask as to whether or not we have attained the optimum efficiency in developing the shallow wells. Is there room for further improvements? Can the shallow wells we are constructing now help us achieve the 1991 objective; the objective being the provision of potable water within easy reach (400 m) to all Tanzanians? Given the present day, possibly the immediate future Tanzania, are the shallow wells being constructed and their auxiliary structures sufficiently safeguarded against pollution? Are shallow wells going to be an acceptable alternative to other systems of water supplies for developed villages? Do current shallow well programmes prevent villagers from resorting to their traditional sources? Is it possible that shallow wells may be inherently expensive? These questions and a host of others are to be answered with the realisation that we are a poor country.

In implementing the present shallow well programmes some of our presuppositions are that the consumers will collect water from the shallow well and take it home; and therefore no washing will be done at the well site. On the contrary this is not so, leading to the contamination of the wells. In some of the shallow wells excess water that splashes off from the pumped water oozes back into the well while some of it dirties the well site.

Hence extra drainage arrangements to counteract the two offensive problems are essential. But then these arrangements will cost more money but are virtually essential.

As already pointed out conditions do exist that favour shallow wells to be used as water intakes for pumped water supplies. It is our considered opinion that wherever possible shallow wells should be constructed in such a manner that those wells can be used as intakes for pumped water supplies in future when funds do allow. For as we develop villagers will build modern houses which will require water- borne facilities and therefore tap water.

Tanzania has been quite lucky in getting technical assistance from Holland and Finland so as to advance this shallow well technology. Indeed we pay great tribute to the Governments and people of those countries for their participation and assistance in this regard. However, during this conference one might be interested to know what the other Regions are doing in this regard or intending to do in the near future in advancing the shallow well technology. During the Tabora Regional Water Engineers Conference 1978 it was agreed that in as far as possible the RWE's should use at least 10% of their annual development budget on shallow wells. In Tanga recently again we realised the need of stepping up the shallow wells production in the Regions. However, what is quite clear is that so far most of the Regions don't have sufficient skilled manpower and equipment to meet that challenge. This leads to the obvious conclusion that we have to step up our training programme so as to be able to get sufficient trained teams in the Regions. Also the necessary required equipment has to be made available so as to step up the shallow well production in the Regions. We hope that the donors will realise how immense the job ahead of us is, and instead of engaging only contractors for this exercise also if financial and other logistical support is made available to the RWE's then we can be able to forge ahead at a considerable pace aimed at attaining the objective.

DISCUSSION OF PAPER PRESENTED BY MR. RUGEIYAMU

Mr. Msimbira stressed the advantage of ring wells over tube wells: if anything would go wrong with the pump on a tube well, the villagers would be deprived of water as long as the pump would be out of order, whereas a ring well with a manhole would still enable a bucket to be used for fetching water.

3.11. GEOTECHNICAL APPROACH TO SHALLOW WELLS CONSTRUCTION

Paper by R.O. Lucas, Senior Materials Testing Engineering, Maji Ubungo and S.N. Lupimo, Assistant Executive Engineer, Maji Ubungo

A. INTRODUCTION

Shallow wells are not new to Tanzania. They have been in existence for several centuries now. However, the development of the shallow well has been slow, both qualitatively and quantitatively. Even in recent times, since the beginning of the 20th century after the introduction of planned water supplies, shallow wells remained among the least developed technologies.

A break-through for the shallow well technology came as late as 1974 when on the recommendation of the Shinyanga Regional Water Master Plan report, the Shinyanga Shallow Wells Project was initiated. About 750 shallow wells were constructed in this project, the success of which is underlined by the follow-up of similar projects in other regions. These include the Mtwara/Lindi regions where about 550 shallow wells were constructed. Others are the Morogoro Wells Construction Projects (RIDEP), in Tanga, Mwanza and Arusha regions.

In keeping with the rapidly growing role of the shallow wells in the water development programme in Tanzania the Ministry of Water, Energy and Minerals, in its annual conference held in Dodoma in 1977 resolved as follows:
"................... that shallow wells be constructed wherever possible and that 25% of the Rural Water Supply Development Budget be set aside for their construction".

In the 1980 annual conference the Ministry committed itself further on the role of the shallow wells. It was then resolved as follows:
"................... that an appropriate technological mix emphasising on the shallow wells technology as a least cost alternative be worked out and used as a means of realizing the objectives of the programme where possible. Further, the Ministry should institute a machinery for the shallow wells projects".

The rural water development implementation target is to provide clean potable water to within 400 m distance of all residential locations by 1991.

It has been established that shallow wells are more economical and simpler to handle than most other technologies, and that they cost about one-tenth of the alternative options. Construction of shallow wells requires a minimum of skill and almost no mechanized equipment. Further, manually operated pumps are generally sufficient for their exploitation.

Thus shallow wells have a substantial contributary role in meeting the already set target in view of the limited available national resources.

B. GEOTECHNICAL APPROACH

If shallow wells construction is undertaken as a national project, as it seems likely, tens of thousands of shallow wells will be constructed. In order that the project may contribute usefully towards the attainment of the 1991 target the wells should be constructed to ensure useful time. Since many shallow wells will be about 10 years old by 1991 a lifetime of at least 15 years should be aimed at. Experience with shallow wells in Tanzania so far has shown that maintenance of hand pumps is a major problem. Considerable effort is already directed towards the solution of this problem. The next logical problem will be the lifetime of the wells themselves. Three main factors influence the lifetime of a shallow well: the drying up of aquifers, the lowering of the ground water table and the clogging of filter materials. To minimize on these problems it is imperative that a geotechnical approach to shallow wells construction is adopted. This has to be so since about 75% of Tanzanian villages will be having shallow wells as their sole water source in the near future. Otherwise the whole shallow well project may be bogged down with unuseful wells.
Geotechnical approach calls for due attention to well siting, design, construction, maintenance, monitoring and feed back.

Reconnaissance survey

Since the shallow wells construction is going to be undertaken as a project it has to be executed systematically. Thus the starting point is a proper reconnaissance survey of the project area. This survey will seek to locate and map out prospective areas for shallow wells construction.
The maps will then facilitate speedy implementation. Mapping could be accomplished by a detailed study of relief and geology maps aided by both ground and airborne field trips. The first guidelines come from the pattern of the topographical features, vegetation cover, location of alluvial plains, laterite formations and weathered rock.

Topographical features

Relief is a major determining factor and in most cases it can be relied upon for reconnaissance purposes. In general the high lands are less likely to be successful shallow well areas than the low lands.

Vegetation

The use of vegetation is rather limited. It is mostly applicable in the semi-arid areas and along water bearing geological faults.

In general the geobotanical studies involve the observations of the characteristic differences - the plant cover in relation to the geological features and hydrological conditions of an area.

The phreatophyte plants are particularly known for their dependence on ground water. If their roots are not in contact with ground water, they perish. Thus plant associations in which phreatophytes are a dominant species serve as direct water indicators.

Alluvial plains and terraces

The alluval plains and terraces are another source of ground water. They are normally found in depressions and valleys. Usually the wider the alluvial plains the larger the aquifers and the better the ground water conditions.

Well siting

Villages located within the potential shallow well areas on the reconnaissance map will be singled out for shallow wells construction. A detailed investigation will then follow to locate the positions or sites of wells. The final well sites depend on the distance from the villages and availability of adequate ground water. Well siting is facilitated by exploratory borehole drilling and judgement of the experienced surveyor. Use of geophysical instruments will be preferred if available.

The exploratory drilling may be done by hand or powered augers. During the drilling operation an accurate soil logging of the subsurface formation is done to facilitate the exact location of the water bearing layers. When water is struck in a substantial aquifer a pump test is carried out to determine its yield. Depending on the yield the survey team will either recommend or not recommend a shallow well construction at the site.

Design

In order that a shallow well should have the longest life time possible it has to be designed properly taking into account the properties of the aquifers. These would include aquifer depths, types, yields and means of water extraction.

a. Depth of aquifers

Correct depths of aquifers have to be determined to facilitate the accurate positioning of concrete filter rings or slotted casings.

b. Type of aquifers

An aquifer or water bearing stratum could be a sand or gravel of fine, medium or coarse gradation.

When water flows from the aquifer into the well it exerts a seepage force on the water bearing material and drags the loose material along with it. To prevent the aquifer material from entering the well appropriate concrete filter rings or slotted casings packed with graded sand/gravel material on the outside are provided. For this configuration to be effective it is imperative that it fulfills the filter condition to the water bearing stratum material. If this condition is not met the finer materials from the aquifer will clog the filter and drastically reduce the useful lifetime of the well.

c. Yield of aquifers

When an aquifer is located its yield should be determined by a pump test. The amount of the yield will help to decide whether to have a tube well, ring well or simply abandon the site. Tube wells are suitable for high yields and ring wells are more appropriate for low yield aquifers.

d. Means of water extraction

To draw the water from the well it is common practice to use a hand pump. Diesel or power driven pumps are used for piped water supplies. In remote country villages a bucket and rope may be used before a pump is available.

e. The external features of the well

These will depend upon the position of the well and the means of drawing water. If a hand pump is used the well should be covered to leave only a small opening for the installation of the pump. If the rope and bucket is used then there should be a movable cover or an opening big enough to allow the bucket through. An appropriate drainage should be provided around the well to avoid the development of unhealthy muddy conditions.

Shallow well construction

Technologically there are three approaches to the actual shallow well construction namely by hand digging, hand auger drilling and machine operated auger drilling.

Hand digging is applicable to ring wells and is done with hoes, pick axes, buckets and spades. The villagers are capable of constructing their own shallow wells this way on self-help basis.
When digging or drilling through unstable materials which cave in, it is necessary to use concrete rings or casings. Also when digging through an aquifer for a ring well, it is normal to keep the water level manageably low by pumping. If a pump is not available, the well may be deepened in stages. Thus the well is dug by hand in water as far as possible.

During the dry season when the water level drops the well is then deepened further to increase the water depth. For the completed wells all aquifers must be provided with either concrete filter rings or slotted casings as the case may be, and packed with graded sand/gravel materials.

Well monitoring and feed-back

For the success of the shallow well project it is of utmost importance that only impending shortcomings of the wells are detected at an early stage. To do this an early warning system in the form of a well monitoring team is essential. The main task of the team will be to monitor the performance of the wells and report back its findings. Among the important data to be collected will be the change in ground water level and yield. Based on the team's findings it will then be possible to decide whether a particular well needs further deepening, filter cleaning, a supplementary well, or abandonment.

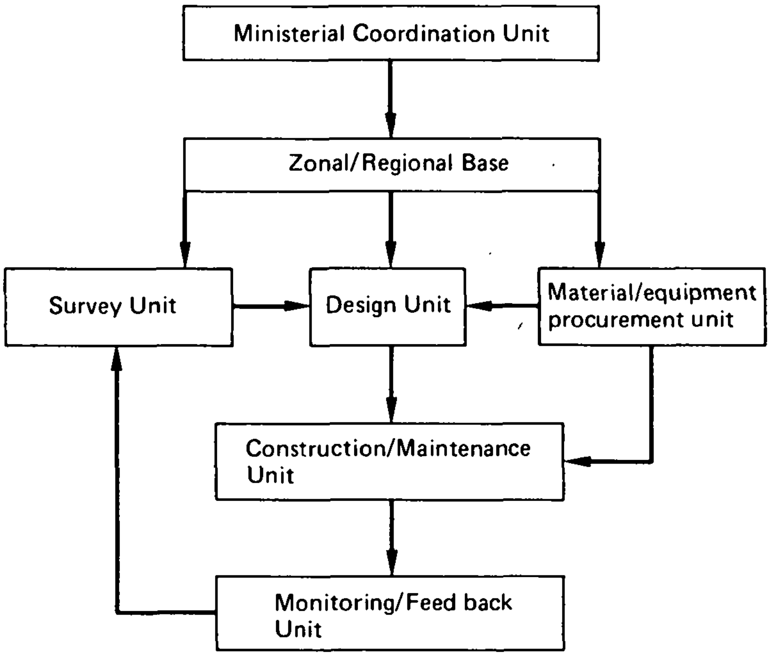
C. IMPLEMENTATION FRONT

The shallow well project as envisaged in the Ministerial annual conference held in Tanga in 1980 is an enormous task. There are about 8,000 villages in Tanzania. About 75% of these can be supplied with water by shallow wells, i.e. 6,000 villages. Assuming that each village will have about 2,500 inhabitants by 1991, then, at an average of 250 people per well, a total of 10 wells will be needed in each village. This makes it 60,000 wells for the whole country. Thus each of the 20 regions of the mainland Tanzania will need a total of 3,000 wells.
To meet the target wells have to be constructed at the rate of 300 per year per region for the next 10 years, that is up to 1991.

To date the implementation of the rural water supply programme declared in 1971 is running at only 40% achievement. Evidently, given this record it is unlikely that the 1991 target will be met. If the construction of shallow wells is to contribute as much as it is expected there will be a need for increasing the number of parties engaged in the well projects. Thus the implementation front should be widened to include villagers, regional water engineers as well as more donor supported contractors.

All parties will then operate under the ministerial guidance, coordination and supervision.

Below is a suggested functional organization flow chart:



References

1. 6th WEDC Conference: March 1980: Water and waste Engineering in Africa.
2. Maji Review publications: Volumes 1, 2, 3, 4 & 5.
3. Summary Report on the Annual Conference for Regional Water Engineers and Ministerial Officials held in Tanga, from 6/5/1980 to 9/5/1980.
4. Summary of the meeting of Regional Water Engineers, Regional Geology and Mines Officers, with Officials of the Ministry of Water, Energy and Minerals held in Dodoma from 13/4/77 to 16/4/77.
5. Shinyanga Regional Water Master Plan Report.
6. Mtwara/Lindi Regional Water Master Plan Report.

DISCUSSION OF PAPER PRESENTED BY MR. LUCAS

Mainly due to the fact that the available time had been consumed, no questions were put forward.

The chairman expressed his gratitude to all speakers for presenting their papers on the various aspects of shallow well technology, i.e. survey, construction, maintenance and training, which contribution will be of great value when the resolutions have to be prepared.
The participants were requested to formulate ideas about a design for a pump to be manufactured in Tanzania and about an operation and maintenance organization. Also the village participation should be incorporated in the resolutions, which will also be discussed in the donor meeting.

4. CLOSURE OF THE CONFERENCE BY MR. D.S. BUSHAIJABWE, DEPUTY PRINCIPAL SECRETARY, MINISTRY OF WATER, ENERGY AND MINERALS

Ladies and Gentlemen,

It is my pleasure to have the opportunity to say a word or two at the end of this conference on shallow well technology. As you might have learned during the course of this seminar, the Ministry has been appreciating and still does appreciate, the efforts, the genuine contribution by the various friendly countries coming to the help of Tanzanians in developing their resources, the water resources inclusive. As you know, development is a gigantic exercise which calls for the cooperation of all people in a given country. We in Tanzania are lucky that we have some genuinely friendly countries which make efforts to help us develop ourselves, for, as Mwalimu says, the task of developing ourselves lies with us. This task does definitely lie on the heads of Tanzanians, but there is always the need for assistance from those who are genuinely ready to help us develop ourselves and we, in Tanzania, are 100 percent happy to accept such genuine assistance.

Ladies and gentlemen, when my Principal Secretary, Mr. Mwapachu, was opening this conference he did point out that any technology that will help us provide water to all Tanzanians by 1991 (1991 being the year, designated by the Party, that all Tanzanians should have water) and that can possibly be formulated for us, or that we ourselves can possibly formulate, will be very much appreciated in as far as it can help us attain that Party's objective.

We do recognize that the shallow well technology is one of the least-cost technologies that can help us fulfill the Party's directive, and hence the need for us all who have been participating in this conference, to pull up our socks and make sure that this technology is not only popularized, but is spread throughout our country wherever such technology can be applied.

I was not present when Mr. Rugeiyamu was giving his paper, but I know this technology has been in existence ever since mankind set foot on this earth. Be that as it may, the indication here is that we have to develop this technology to the utmost level, so that it can possibly benefit our own people.

Mr. Bonnier wrote over there that the costs involved in providing water to our people by 1991 are 12.5 million shillings per region per year. This is a very big sum of money by Tanzanian standards. Unless and until we exhort the villagers to fully participate in the efforts brought about by the Government in the field of water supply, I am afraid that we cannot reach the goal we're after.

As I said, the genuine assistance from the friendly countries is very much welcome in this field, but I want to repeat here once again, that the task of developing this country definitely lies not only on the educated brains on the few privileged people of this country, but on the total masses of this country.

Ladies and gentlemen, having said that, I should like now to say that in the Ministry we are faced with various big duties beside water development. We have duties pertaining to energy development, to mineral development, and the present indications do show that if we put in efforts we can possibly develop not only our water resources but also our mineral and energy resources. Hence the call by us in Tanzania that again genuine assistance is called for from friendly countries. We believe that this genuine assistance, once given to us, we shall be able to use, not only for the development of ourselves, but even for the development of those who have given that assistance. For I believe assistance in one way or another is a two-way traffic. One might help you today because he is in the capacity to help you, but you might help him tomorrow, not necessarily in the same way he has helped you, but in a different manner which may even be more beneficial to him than what he had thought.

Ladies and gentlemen, I am not going to while away your time anymore, but allow me to say that we pay great tribute to the Netherlands and to the Nordic countries for having been able to convene this conference here in Morogoro Region, where expert exchange of opinion has been floored, for the benefit of not only we who have been in this conference, but for all those in Tanzania who share the need for water supply through this least-cost solution, the shallow well technology. I am not going to forget to thank the Morogoro Wells Construction Project for the efforts they have taken to cooperate with the organizers, with the secretariat, with

other bodies that have been involved in the preparation and the final successful staging of this conference. I must give them all the Ministry's appreciation and tribute for this wonderful work they have done.
I want also to thank the management of the Mikumi Wildlife Lodge for having agreed to allow us to meet in their beautiful hotel. Let me say that they have been patient enough for any inconvenience that we might have caused to them.

There are also other people to be thanked. These are the people of other countries, who have not participated either physically or financially in the staging of this conference, but they have been with us at least in thought. All these do deserve the Ministry's gratitude and I believe they also deserve your own gratitude.

Having said that, ladies and gentlemen, I cannot stop until I have thanked particularly Mr. Schonborg, Mr. Msuya, Mr. Lucas, Mr. Balaile and indeed all other members of the secretariat for the wonderful work they have done in order to make our deliberations come to this particular stage. I have definitely to say "thank you" to you all.

One of the resolutions, ladies and gentlemen, has been that we should be having some coordination meetings. It is unfortunate that we are making this resolution only now. This resolution should have been made years back, because it is through mutual cooperation, through mutual understanding, that we can possibly move forward in whatever our endeavours are.

Ladies and gentlemen, I think I have wasted too much of your time already, but allow me once again, and this is on behalf of my Principal Secretary, Mr. Mwapachu, to say "thank you very much and bon voyage".

APPENDIX 1 - LIST OF PARTICIPANTS (in alphabetical order)

Mr. V.S. Aalto	Chemist, Maji
Mr. W. Balaile	Ag. Director, Project Preparation Maji
Mr. B.K.C. Bali	Economist, Mipango
Mr. Ivan Blakely	UNICEF
Mr. R. Blankwaardt	Training Officer (Construction), MWCP
Mr. C.J. Bonnier	Project Director - MWCP
Mr. D.S. Bushaijabwe	Deputy Principal Secretary, Maji (chairman)
Mr. D.M. Chalange	Shallow Well Proj. Tanga
Mr. M. Chingu	Eng. Tanga
Mr. Z.K.M. Choholo	RWE Morogoro
Mr. D. Collin	Hydrogeologist, Ground Water Proj. Singida
Mr. Ede	Reg. Manager CCKK
Miss. E. Edman	Prog. Officer - Sida
Mr. J. Effraimson	Superv. Eng. Finnwater
Dr. H. Floegel	Shallow Well Proj. Tanga
Mr. H.G.A. van de Graaf	Regional Planning Advisor, Morogoro
Mrs. M.J.H. van de Graaf	Secretary, MWCP
Mr. D.P. Grace	Reg. Manager CCKK
Mr. S.G. Hasanali	RWE Arusha
Mr. E. Hellan-Hasen	Proj. Manager - Norconsult
Mr. A.J.A.J.M.G. Hennekens	Third Secretary Netherlands Embassy
Dr. J.D. Heijnen	National Shallow Wells Programme
Mr. Joyakarani	Eng. Morogoro
Mr. Kapyela	RWE Ruvuma

Mr. Y.A. Kashoro	Project Manager Shinyanga Shallow Wells Proj.
Mr. A.K. Kigingi	Eng. Morogoro
Mr. J. Kinyunyu	Mwanza
Mr. V.T. Kiossev	Principal Design Eng. Maji
Mr. J.B. Kitambi	RPO DSM
Mr. M. Kivugo	Principal, Water Resources Institute
Mr. M. van Krimpen	Hydrologist, Ridep-Mwanza Shallow Wells Project
Mr. F.J.H. van de Laak	Proj. Manager - MWCP
Mr. N. Lauritsen	Danida Steering Unit
Mr. H. Lehd	Proj. Manager - CCKK
Mr. R. van Lissa	Geohydrologist, MWCP
Mr. S. Loof	Reg. Tech. Advisor - Sida
Mr. R.O. Lucas	Sen. Met. Testing Eng. Maji
Mr. A.E. Lyamuya	RWE Kilimanjaro
Mr. J.S. Makundi	Eng. Ground Water Proj. Singida
Prof. A.C. Mascarinhas	Director, Bralup - University of DSM
Mr. J.M. Mbirigenda	RWE DSM
Mr. R. Mehta	JLO/UNDP - PMO
Mr. T.P. Mellya	RWE Singida
Mr. T.E. Mfala	Eng. Iringa
Mr. S.G. Mkuchu	Eng. Morogoro
Mr. O.T. Mloka	Eng. Morogoro
Mr. N. Msimbira	Ass. Chief Eng. (Construction) Maji
Mr. S.H. Msoffe	Eng. Mara
Mr. M. Msuya	Hydrologist Maji
Mr. S.M. Mtimavalye	Eng. Dodoma
Mr. R. Mtonga	Eng. Dodoma
Mr. R.M. Muhabuki	Hydrologist - Lindi
Mr. J.A. Mukumwa	RWE - Mtwara
Mr. W.M. Munuo	Eng. Rukwa
Mr. A.J. Mutaboyerwa	Planning Officer, PMO
Mr. B. Mwapachu	Principal Secretary, Maji
Mr. A. Mzee	Ass. Chief Eng. (Maintenance) Maji
Mr. M.O. Ngalisoni	RWE Mbeya
Mr. N. Nkoma	Director, Construction & Maint. (Maji)
Mr. J.S. Nyalaja	Eng. Mara
Mr. B.G. Pattegar	Unesco
Mr. C. Radhakrishnan	RWE - Lindi
Mr. M. Rantala	Proj. Manager, Finnwater - Mtwara
Mr. C.W. Rasmussen	Manager, CCKK
Mr. J. Ringelberg	Project Manager, Ridep - Mwanza Shallow Wells Proj.
Mr. P.M. Rugeiyamu	Sen. Ex. Eng. Maji
Mr. D. Rutashobya	Hydrologist - Maji
Mr. S.J. Rwakatare	Eng. Kagera
Mr. C.K. Rwakiromba	Eng. CCKK Mbeya
Mr. C.I. Rwechungura	RPO Tanga
Mr. K. Samset	Jr. Prog. Off. JLO

Mr. B. Sandberg	Eng. WRI - Maji
Mr. R. Schonborg	Coordinator, WMPCU
Mr. B. Sedin	Proj. Manager - Sida
Mr. A.A. Senguo	RWE Tabora
Mr. H. Sorensen	Danida Steering Unit
Mr. E. Ström	Geotech. Eng. - Norconsult AS
Mr. R. Swere	Director Manpower Dev. Maji
Mr. P.O. Thomas	Financial Controller, Ridep Mwanza
Mr. R. Trietsch	Project Manager, National Shallow Wells Programme
Mrs. L. Trigg	Secretary, Australian High Commission
Mr. A.L. Vakolavene	RWE Coast

APPENDIX 2 - MOROGORO CONFERENCE ON WELLS, MIKUMI WILDLIFE LODGE
18-8-1980 - 21-8-1980

CONFERENCE PROGRAMME

DATE	HOUR	ITEM	ACTIVITY	BY
18-8-'80	15.00	1.01	Arrival and registration of participants	All
	20.30	1.02	Welcome dinner	All
		1.03	Opening speech	P.S.
19-8-'80	08.00	2.01	Morogoro Wells Construction Project	
			Introduction	Bonnier
			Organization	v.d. Laak
			Survey of well sites	van Lissa
			Construction	Blankwaardt
			Materials and supplies	v.d. Wel
			Operation and maintenance	v.d. Laak
			Training	Blankwaardt
	13.30	2.02	Lunch	
	15.00	2.03	Experience from other shallow well projects	Papers delivered by representatives from each project
			Mtwara/Lindi	
			Shinyanga Shallow Wells Project	
			Shinyanga/Mwanza RIDEP	
			Tanga	
			Arusha	
			Singida	
	20.00	2.04	Dinner	
	22.00	2.05	Shallow wells in a national perspective	Bonnier
		2.06	Discussion	All
20-8-'80	08.30	3.01	Briefing	Bonnier
	09.00	3.02	Field trip	MCWP-staff
			Start of construction	
			Survey of well sites	
		3.03	Tour of MWCP compound and workshops	MCWP-staff

DATE	HOUR	ITEM	ACTIVITY	BY
		3.04	Lunch at MWCP canteen	
		3.05	End of construction Pump installation	MWCP-staff
	20.00	3.06	Dinner	
21-8-'80	08.30	4.01	Can shallow wells help us reach the 1991-target? Discussion on how best to coordinate efforts and resources with respect to: - funds - organization - manpower - procurement - technical criteria - equipment and materials Coffee break and lunch fitted in	Chairman: P.S.
		4.02	Summary and resolutions	P.S.
	16.00	4.03	End	P.S.
26-8-'80	10.00		Donor meeting Details to be becided during conference	Decision-making bodies: Maji HQ, Donors Embassies

APPENDIX 3 - DRAFT PROPOSALS FOR RESOLUTIONS

In order to have an organized manner of reaching firm and relevant resolutions, the following process was proposed by the conferende secretary and accepted by the conference:

1. The conference is divided into nine groups, each of which consisting of participants from all categories represented.

2. The groups are to prepare a minimum of three draft proposals for resolutions within the frames of the conference through group discussions lasting two-three hours.

At the end of the group discussion session, a total of 48 draft proposals were presented to the secretariat.

A. TARGETS

- Shallow wells should be used whenever possible, but it should be kept in mind that shallow wells are not the only or final solution for water supply.

- Shallow wells in those locations where it is feasible and economical compared to other methods.

- It is recognized that there is a conflict between qualitative and quantitative goals. Full participation by the people can probably only be at the expense of the number of wells sunk. Yet a great involvement of the Party, the people themselves (including women) and education is essential for a permanent success.

- Shallow wells should not be the only solution for reaching the 1991 target of supplying water to every Tanzanian. It should supplement piped water supply as cases like hospitals, schools etc. cannot depend on shallow wells. Areas should be chosen for construction of shallow wells for temporary rural domestic supplies, i.e. where there is no other cheap alternative supply shallow wells shall be undertaken.

- Recognizing the desirability of village self-help, we resolve that all efforts should be made to ensure village participation and transfer of technology to villagers for the construction, operation and maintenance of shallow wells, with the full technical and material support of the ministry to the level and in each area required by individual villages.

- The conference noted with appreciation the assistance received by the Government from various donor agencies in the effort to undertake shallow well programmes throughout the country and further resolved to request them to continue to support the proposed National Programmes.

- Wherever feasible, shallow wells should be applied in all regions before other forms of rural water supply will be considered.

- The 1991 target set by the Government and the Party must still be the firm guideline for any decision concerning planning and implementation of water supply projects in Tanzania. In order to reach this target maximum investment cost may not exceed available funds, and the choice of technology must be made accordingly.

- Based on Government standards and criteria, shallow wells should be recognized as a main solution along with other methods of supply in water supply planning.

- To attain the target of 1991 to supply water to every rural household, the shallow well technology will play the major part.

- Having noted with concern that not all regions in Tanzanian which could benefit from shallow wells technology have as yet benefited from this technology, we resolve that the Tanzanian Government should endeavour to promote this form of development where feasible, as in the other regions.

- The conference realizes that the implementation of the shallow wells program with a view to meeting the party's 1991 target is an enormous one, and that it cannot be left to only one implementation institution. The conference therefore resolves that all the able institutions be allowed to implement the programme under the guidance of a ministerial national coordinating unit. The implementors would include the villagers, the RWE's and the donor agencies.

B. ORGANIZATION

- An autonomous national institution should be set up and funded by donor countries. This institution should arrange procurement and distribution of materials to all regions undertaking construction. Regional shallow well construction units should be under the RWE set up. Where necessary, expatriates should be provided by donor countries.

- The coordination of the shallow well programme should be under a coordinating unit directly under the ministry. The main function of this unit should be to carry out a national shallow well programme, including standardization of technology, supply and transport of materials, training, etc etc.

- Shallow well programme shall be under RWE organization.

- Shallow well projects should be established in each region as soon as possible. These projects should initially be under the responsibility of donors.

After the target is reached, and no later than 1991, the responsibility should rest fully with an appropriate Tanzanian authority.

- In keeping with resolution three above, we resolve that donors be assured that funds will continue to benefit that region or regions with which the donor has a special relationship.

- An independent evaluation unit should be formed for evaluation of project process and implementation either at the end of short projects or reasonably spaced for larger projects.

1. All efforts should be directed towards implementation of the best solution in terms of cost and social standard. Such solution could be shallow wells.

2. As soon as possible the Government should take steps to create a body which should:
   a. standardize equipment and materials for shallow wells
   b. test systems, materials and equipment
   c. provide for manufacturing/procurement and distribution of all materials and equipment
   d. supervise and coordinate the shallow wells programmes

- Shallow well projects should be established in all regions in the country where this is possible.

- As for shallow wells the RWE organization if strengthened and given logistic and material support can take up a shallow well prgramme.

- Noting that shallow well technology offers a low cost alternative, high self-help component and manageable technology at village level and observing that the (construction of) shallow well implementation has so far been based on capital intensive methods the conference resolves that shallow well construction as one of the technologies in the development of water resources be given a priority by instituting a national programme based on labour intensive methods and full participation of the beneficiaries.
  To facilitate the implementation of the above resolution the conference recommends to the Government to adopt the following mode of operations of the programme.

  a. To institute a policy whereby village governments shall be deemed necessary (wherever possible) to own progressively adequate number of shallow wells and be fully responsible for their development and maintenance regardless of the existence of other resources within the village.

  b. The organization of the programme should be based on the following division of responsibilities.

1. Village government

Ownership, clearing, hand digging or drilling, lining, maintenance and protections.

2. RWE/RDD

Mobilisation, implementation, planning and coordination and finding village contractors.

3. RWE/RDD

Survey and siting of well locations, supervision of construction work, installation of hand pumps, maintenance inspection and assistance, quality control/training.

4. National Shallow Wells Development Centre

Production, procurement and distribution of materials, tools, transport and equipment upto the village.
- Programme monitoring and evaluation.
- Coordination with donors, PMO, MAJI, and other institutions
- Administration of the programme funds.
  Maji Headquarters: Policy, financial assistance.
  Overall control and administration of the programme.

C. STANDARDIZATION

- As far as possible standard equipment, fittings and materials should be used and should be tried to be manifactured in Tanzania.

- Considering the need for uniformity in the use of hand pumps in the shallow well programme and the fact the the Shinyanga pump has been in use for the longest period and in the largest number and has been found satisfactory, the conference recommends the adoption of this pump on a uniform basis, subject to such progressive improvements as may be needed and found possible.

- The design of shallow wells should be done according to the norms of the ministry, which will be modified periodically depending on the experience as reported by a monitoring unit, which should be set up shortly.

- We resolve that donors, while continuing to support individual regions, agree to accept the principle of standardization.

- Hand pumping units should be standardized.

- Maji should evaluate existing experience with various equipment and decide on standardized types and feasable production in Tanzania.

- In order to coordinate efforts to standardize pumps and construction equipment a technical coordination committee should be set up consisting of representatives of the ministry and of on-going shallow wells programmes, in order to arrive at a standardization and interchangeability of basic parts. This of course taking into account the ineviable variation of systems according to different prevailing conditions. First task of this committee should be the drafting of a time schedule for basic standardization. As a matter of principle all new shallow wells projects should meet with this committee to discuss the basic technical principles of their project, and, wherever possible, to adhere to the standards set by the committee.

- To promote standardization and procurement efficiency necessary for a smooth running and coordinated national shallow wells programme, we resolve that an independent and self-administering national body be established, having responsibility for procurement, fabrication and supply of all equipment required for construction and maintenance of shallow wells.

- There is a need for standardization of materials and equipment. The actual work shall be left to technical committees.

- After studying the various hand pumps and their application, availability and easy to manufacture, the meeting resolves that Shinyanga hand pump should be used throughout the country.
  In fact more that 7 regions are now using this pump: Mwanza, Musoma, Shinyanga, Singida, Kagera, Kigoma, Mtwara. However improvements and modification should continue. Kangaroo pumps are not made in Tanzania. Springs have to be imported. Grown-ups to operate is.

D. COORDINATION

- Water development in Tanzania has failed at fundamental points. One apparent reason being the lack of donor coordination leading not only to waste of money, but also to the creation of confusion and uncertainty on the part of the recipient, Tanzania:
  "Donors should therefore immediately establish an appropriate coordinating Committee with the necessary authority to-on behalf of the donor countries and agencies-cooperate with appropriate Tanzanian Authorities in questions concerning
  . standardization of materials, tools and equipment
  . choice of technology
  . supplies and procurement
  . water development strategies"

- It is high time that the donors, Maji and PMO coordinate and cooperate and Maji/PMO should be the coordinating body.

- A coordination body where Maji, PMO and Donors are represented should meet on a regular basis to advice on the implementation of the shallow well projects. Firm guidelines should be prepared by this body on
  - standardization of systems, material and equipment
  - supply systems

- The Government should spell out a clear policy on cooperation and coordination between different donors and donor projects.

- Each water supply project should from the start be integrated with the RWE organization.

- There is a big need for cooperation and coordination between the donors themselves and between the Government and the donors.

- Maji should coordinate the shallow well activities in all regions in order to have an optimum shallow well technology.

- A national institution should be responsible for coordination between donor countries by arranging regular meetings with the donor countries. The Water Master Planning Coordination Unit which is monitoring all water business should coordinate with the institution and the donors on behalf of Maji.

- The coordination will happen by Maji through WMPCU.

E. FABRICATION, SUPPLY

- It should be an obligation of the Government to establish the following:
  1. pump factory in Tanzania: capacity realisticly planned for the coming years
  2. concrete factory for production of concrete slabs, concrete casing, etc.
  3. plastic casing ought to be solved by negotiation with plastic factories

- It is desirable to establish a factory which makes as many components of the shallow wells as possible.

- The Dutch team in Morogoro should be given all assistance and cooperation from Maji, various donors and Regional Authorities in training, advising and supply of equipment for shallow wells throughout the regions in the high achievements and set-backs experienced also in other projects.

F. MAINTENANCE

- As the maintenance question is crucial to the success of any shallow wells programme, the matter of ownership of the well, which is 100% linked to the maintenance responsibility, should be urgently settled. In our opinion the ownership, and consequently the maintenance responsibility, should be at village level.

- (Ownership and maintenance)
  The ultimate goal is that the villagers own and maintain their water schemes.

- The donors should provide money for training and maintenance for particular projects for a minimum of 5 years. In some cases equivalent number of counterparts should be trained during the execution of the projects.

APPENDIX 4 - SELECTED DRAFT PROPOSALS FOR RESOLUTIONS

General

The secretary proposed the following process for arriving at a reasonable number of selected draft proposals to be discussed and passed by the conference.

1. All relevant draft proposals will form the basis for selecting a limited number to be discussed for passing.

2. The selected draft proposals will be entered, and the conference invited to pass those selected proposals.

3. All draft proposals will appear in the final report.

4. Anybody who feels that major issues or topics are deleted, is free to submit a written draft proposal to be considered by the conference at the end of the session.

The process was agreed upon by the conference.

Analysis of draft proposals

1. The basis for the conference is the Tanga resolution. Proposals concerning the degree of application of shallow wells, or the usefulness of this technology at all, are not being considered relevant, this being clearly read in that particular resolution.

2. Very few of the proposals meet the basic requirement with respect to formulation, and most are more or less statements without the necessary preambles. It has therefore been the task of the secretariat to compose or rearrange the material gathered in order to arrive at complete draft proposals for further consideration.

3. All proposals are documented, arranged in groups, and are therefore available for reference out of their original order or context. Discussion group identification is eliminated.

4. Guidelines for selection of proposals are found in the covering letter of the invitation to the conference, and in the conference programme:
   - firm resolutions with respect to future application of shallow well technology
   - how best to coordinate efforts and resources with respect to funds, organization, manpower, procurement, technical criteria, equipment and materials

It has also been kept in mind that the resolutions will be put to immediate use in the donor meeting following the conference.

5. Five out of 48 proposals are rejected as non-relevant in this context.

6. It has been a governing principle that one good resolution is better than 10 bad ones, and it is the firm belief that the lower the number, the greater the impact. All accepted proposals are, however, regarded as being valuable input in future shallow well implementation, and in recognition thereof, the documented proposals will appear in the report of the conference.

Grouping of proposals

The following grouping has been made, and the distribution of proposals are recorded, this being considered an indication of importance put on the groups:

TARGETS	12 proposals
ORGANIZATION	10 proposals
STANDARDIZATION	10 proposals
COORDINATION	9 proposals
MAINTENANCE	3 proposals
FABRICATION/SUPPLY	3 proposals
Rejected	5 proposals

Selected draft proposals

1. Recognizing the desireability of village self-help, we resolve that all efforts should be made to ensure village participation and transfer of technology to the villagers for the construction, operation and maintenance of shallow wells, with the full technical and material support of the ministry to that level and in each area required by individual villages.

2. The conference has with appreciation noted the assistance received by the Government from various donor agencies in the effort to undertake shallow well programmes throughout the country, and further resolved that these agencies are requested to continue to support the proposed national programmes.

3. Having noted with concern that not all regions in Tanzania which could benefit from shallow wells technology, as yet have done so, we resolve that the Government should endeavour to promote this technology where feasible also in those remaining regions.

4. Water development in Tanzania has failed on fundamental points for various reasons. One likely reason is the lack of donor coordination, and another the lack of cooperation between the donors operating in the water development field and the Government of Tanzania.
   We therefore resolve that
   a. the donors and the Tanzanian Government are urged to establish a pattern of regular meetings for mutual consultation and coordination of water development strategies, and
   b. the donors are urged to establish a coordination committee that is given the necessary authority to cooperate with Tanzanian Authorities in matters related to
      - the standardization of materials, tools and equipment
      - the standardization of technology, and
      - supplies

5. Recognizing the ultimate goal that the villagers own and maintain their water supply system, it is felt that the constraints present enforce the application of methods, materials and equipment that have minimal maintenance requirements and that, for that reason alone, may have to be imported.
   Only after an efficient maintenance organization, based on self-reliance of the villages, will have been established, the emphasis could be shifted to local production, even if this would increase maintenance requirements.

6. Noting that shallow well technology offers a low-cost alternative, a high self-help component and a manageable technology at village level, and furthermore observing that the construction of shallow well implementation has so far partly been based on capital intensive methods, the conference resolves that shallow well construction as part of the water development in Tanzania is given priority by instituting a national programme based on labour intensive methods and full participation of the beneficiaries. The national programme should include the establishment of shallow well projects in each and every region.

7. To facilitate the development of the national programme of shallow wells in all regions the conference resolves that the Government adopts the following mode of operation of the programme:

   a. Ownership

      To institute a policy whereby the village governments shall be deemed to own progressively an adequate number of shallow wells, and be fully responsible for their development, regardless of the existence of other resources in the village.

b. Responsibilities

The organization of the programme should be based on the following distribution of

VILLAGE GOVERNMENT	-	Ownership, clearing, hand digging or drilling, lining, maintenance and protection.
RWE/RDD	-	Mobilization, implementation, planning and coordination and finding village contractors.
RWE/RDD	-	Survey and siting of well locations, supervision of construction work, installation of hand pumps, maintenance inspection and assistance, quality control/training.
NATIONAL SHALLOW WELL DEVELOPMENT CENTRE	-	Production, procurement and distribution of materials, tools, equipment to the village. Coordination with donors, PMO, Maji and other institutions.
MAJI HEADQUARTERS	-	Administration of programme funds. Overall control and administration of programmes.

APPENDIX 5 - SHALLOW WELL QUESTIONNAIRE

The conference gave an outstanding opportunity for transfer of knowledge and exchange of opinion between personnel engaged in shallow well technology. One mode of communicating personal opinion is the inquiry, and a questionnaire was prepared for the benefit of all present as well as for decision makers for later use.

The questionnaire is included unabbreviated:

QUESTIONNAIRE

Please tick (V) the answer that in your opinion is right, and that could also be realized within a reasonably short time.

1. Who should be responsible for village water supply

0	village	0	health
0	district	0	PMO
0	region	0	CCM
0	Maji	0	other (please specify)

2. Who pays/should pay for the construction of a shallow well

0	villagers	0	health
0	district	0	PMO
0	region	0	donors
0	Maji	0	other (please specify)

3. Who should survey for shallow well sites

0	DWE	0	Maji Dodoma
0	RWE	0	donor project
0	contractor	0	other (please specify)

4. Who will construct the shallow well

0	villagers	0	RWE
0	district	0	Maji
0	contractor	0	donor project
0	other (please specify)		

5. Who is the owner of a shallow well

0	the "people" (who?)	0	the RDD
0	the village manager	0	the donor
0	the katibu	0	nobody
0	the DWE	0	other (please specify)
0	the RWE		

6. Who should, and can, maintain the shallow well

0	villagers	0	RHO
0	DWE	0	contractor
0	DHO	0	donor project
0	RWE	0	other (please specify)

7. Who coordinates standardization of methods, materials and equipment
   0 Maji (which body?)
   0 Technical Coordination Committee (Maji + donors)
   0 other (please specify)

8. Who should supply the typical shallow well equipment, materials, tools
   0 Morogoro Wells Construction Project
   0 Maji (Wazo Hill)
   0 other national supply body
   0 other (please specify)

RESULTS OF INQUIRY

Note: not all questions have been answered on every form, whereas often multiple answers have been given. The total number of questions answered is, therefore, not constant throughout the questionnaire.

Question 1 WHO SHOULD BE RENSPONSIBLE FOR VILLAGE WATER SUPPLY? (61 answers)

Answers:	a.	village	30	village 28 village + district 2
	b.	region	16	region 13 region, applying for donor project 2 region; a national body to be formed by the Technical Coordination Committee (Maji + donors) should allocate funds to the Region 1
	c.	district	10	
	d.	no answer given	5	

Question 2 WHO SHOULD PAY FOR THE CONSTRUCTION OF A SHALLOW WELL (99 answers)

Answers:	a.	donors	24	
	b.	villagers	23	villagers 16 villagers with assistance from district 1 villagers + district 50/50 (possibly on loan basis) + donors for pilot projects 1 villagers + donors 4 villagers together with PMO and donors 1
	c.	Maji	19	
	d.	region	17	

e. district 9
f. PMO 4
g. Health 0
h. no answer 3

Question 3 WHO SHOULD SURVEY FOR SHALLOW WELL SITES? (89 answers)

Answers:

a. RWE 35
   - RWE 32
   - RWE + Maji Dodoma 1
   - RWE with assistance from Maji Dodoma and donor project 1
   - RWE and donor project that constructs shallow wells 1

b. DWE 23
c. donor project 19
d. contractor 5
e. Maji Dodoma 2
f. parastatal organization specifically aimed at shallow wells 1
g. national body to be formed by Technical Coordination Committee 1
h. no answer 3

Question 4 WHO WILL CONSTRUCT THE SHALLOW WELL? (101 answers)

Answers:

a. villagers 23
   - villagers 18
   - villagers, with assistance from district/RWE 5

b. donor project 21
   - donor project 18
   - donor project + contractor 1
   - donor project + RWE 1
   - donor project since nobody else seems to be able or interested to 1

c. RWE 18
   - RWE 17
   - RWE + donor project 1

d. contractor 13
   - contractor 12
   - contractor + donor 1

e. district 11
f. Maji 10
g. national body to be formed by Technical Coordination Committee 1
h. no answer 4

Question 5 WHO IS THE OWNER OF A SHALLOW WELL? (75 answers)

Answers:

a. village 59
   - "people" 16
   - "people" (ujamaa) 1

			village(rs) 18 village council 1 village government 7 village manager 11 all people who use the well 2 villagers contributing to installation costs 1 katibu 2
b.	DWE	4	
c.	RWE	3	
d.	RDD	3	
e.	nobody	1	
f.	CCM	1	
g.	donor	0	
h.	no answer	4	

Question 6 WHO SHOULD, AND CAN, MAINTAIN THE SHALLOW WELL? (93 answers)

Answers:

a.	villagers	45	villagers 38 village government with district assistance 1 village, with rural medical aid (this is their official task) 1 pump attendants paid by the village 4 village with help of RWE 1
b.	DWE	24	
c.	RWE	13	
d.	contractor	4	
e.	donor project	4	donor project 3 donor project, as long as they use pumps and other equipment on trial 1
f.	DHO	0	
g.	RHO	0	
h.	no answer	3	

Question 7 WHO COORDINATES STANDARDIZATION OF METHODS, MATERIALS AND EQUIPMENT? (68 answers)

Answers:

a.	Technical Coordination Committee (Maji + donors)	46	
b.	Maji	18	Maji 5 Maji, design section 5 Maji, construction section 5 Standardization unit Maji, with engineering department with Govt. 1 Maji WMPCU 2

	c. no answer	4	
Question 8	WHO SHOULD SUPPLY THE TYPICAL SHALLOW WELL EQUIPMENT, MATERIALS, TOOLS? (90 answers)		
Answers:	a. Morogoro Wells Construction Project	32	MWCP 25 MWCP, but should be manufactured in Tanzania 1 MWCP for duration of project 3 MWCP + other national supply body 1 MWCP + donors 1 MWCP initially, Wazo Hill as soon as possible, possibly SIDO 1
	b. Maji Wazo Hill	19	
	c. other national supply body	15	other nat. supply body 12 any body or organization that is competent and has the capacity etc. 1 when the best ones are found and the "body" is able to supply something 1 Several distribution centres. Why should every problem be tackled on a national basis? 1
	d. ongoing other projects	7	ongoing projects 1 Finnwater project 2 donor projects 2 donor projects together, with Maji 2
	e. Maji construction division 2		
	f. Any organization agreed upon by the Technical Coordination Committee (maji + donors) 3		
	g. various	6	Mag'ula Industrial Complex 1 SIDO 3 RWE 1 Finnish Government 1
	h. no answers	4	

APPENDIX 6 - PAPERS ON SHALLOW WELLS, NOT PRESENTED AT THE CONFERENCE

Two papers on the possibilities of shallow wells in Tanzania, though not presented at the Morogoro Conference on Wells of 18-21 August 1980, are considered of sufficient importance to be included in these proceedings.

The first "Appropriate Technology in Harnessing Ground water in Developing Countries", was prepared by Prof. B.G. Deshpande, Department of Geology, University of Dar es Salaan, in March 1980. Unfortunately he was not able to attend the conference, nor did his paper reach the conference in time for distribution and discussion.

The second "The well, our best rural water source" was prepared by Mr. A.T. Doel, Department of Civil Engineering, University of Dar es Salaam, for publication in the Daily News and/or Kiswahili papers.

APPROPRIATE TECHNOLOGY IN HARNESSING GROUND WATER IN DEVELOPING COUNTRIES

A. (ABSTRACT)

In an aid programme often the context and requirements of the recipient country are not fully understood or sometimes ignored. The aid programmes are often governed not by considerations of demand but those of supply in as much as the donors offer such technological aid as is available with them or has proved appropriate in their own context. To illustrate such a misapplication of technology let us look at the controversial issue wether traditional dug wells should be replaced by tube wells as a source of water in rural areas.

Most developed countries are located in temperate regions whereas the developing countries are located in tropical regions. Not unexpectedly then technologies of exploration of water sources are different in different regions. Besides, such technologies have developed in keeping with other technological progress. When an underdeveloped country needs help, a developed country offers its own kind of technology.

Once sub-surface water is discovered there are mainly two ways of bringing it to the surface- a tube well and a traditional dug well or a combination. A tube well is drilled by an elaborate sophisticated mechanical device and completed with blind pipes, strainers, gravel packing according to the geological conditions. If it is successful, which is quite often a debatable point, a pump is fitted to lift the water with the help of diesel or electricity. The exploration, initial outlay in drilling machines, pipes, strainers, pumps and energy resources are heavy and paid in foreign currency. The cost of one tubewell of about 300 feet depth is about $ 20,000 and if the well is successful additional cost of pump and energy. The risk of pumps getting out of order in remote rural areas is indeed great.

The other method of obtaining ground water is a dug well which is initially a pit in the ground, usually 10 to 12 feet in diameter and reaching below the depth of the lowest water table, which is usually shallow but may be as much as 40 to 50 feet below the surface. If there is adequate water, for small requirements of a village or an agricultural field, it is lined with brickwork or masonry. A simple device for lifting water like a rope and a pulley over which water is drawn by a bucket is adequate. If necessary and convenient a small pump may also be used. The total cost would be about $ 4,000. A dug well requires no sophisticated equipment. There is no expenditure in foreign currency and almost no chances of failure if sufficient care is taken from the beginning. Tube wells are dependant on qualified personnel, economic and technological resources and should be thought of only when a country has achieved overall growth to off-set commitment of foreign exchange and technological back-up in maintaining a tube well and the pump in continuous working order.

For self reliance, economy, local employment, continued and assured service, minimal dependence on outside help and minimal disruption of traditional ways of life, dug wells are admirably suited to young developing countries. In many developing countries of the world dug wells are the only source of water for rural domestic and agricultural use.

B. (FULL TEXT)

Recently I had an opportunity to speak on the subject of appropriate technology before a small but interested audience at a Canadian University. Although my lecture was specifically about ground water the issue of aid to developing countries naturally came up during the question session. One rather astute student from an African country put his finger on what appears to me to be the core of the problem of technological aid programmes. He said bravely, barely able to disguise his strong feelings, "Don't you think that there is no such thing as foreign aid, only foreign trade?"

While the problem of technological aid has much to do with economic considerations, it is necessary to realise first of all that in developed western countries these considerations have for long time been controlled by the trends of technological development. It is even more important to realise that western technology is by no means the only technology and that is may not even be the most appropriate kind of technology for developing non-western countries.

It is hardly unreasonable to suggest that in an aid programme the context and requirements of the recipient country should be given priority over all other considerations. To do so, one would have to keep in mind the socio-economic history as well as future plans of the recipient. Foreign aid programmes are, on the contrary, often governed not by considerations of demand but by those of supply.

Developed donor countries rarely ask aid agencies to tackle a problem afresh. They merely offer such technological and other aid as is available with them and has proved appropriate in their own context.
Not surprisingly then, recipient countries are frequently supplied with aid that is beyond their means, that increases dependence on outside help, and that ignores perfectly satisfactory social conditions that are a product of a long tradition. An aid programme, in this way, not only discrupts social life in recipient countries but actually creates new economic and technological problems. By way of illustration of this kind of mis-application of aid, let us look at the controversial issue of whether traditional dug wells or other sources of water should be replaced by tube wells in developing countries in aid programmes.

To begin with, every one knows that water is among our most valuable natural resources. However, about 98 per cent of natural water on earth is confined to the seas and is useless for drinking or irrigation. On land, the chief sources of usable water are rain and snow. Much rain and melted snow water flows in the form of streams and rivers, pours into the seas and is thus no longer available for the use of man. Yet some of this water also accumulates in natural or man made lakes and reservoirs. While this water, where available, can be used, much of it either evaporates or is absorbed by vegetation. Only a very small proportion of rain or thawed water percolates underground to form "ground water". If we wish to utilise it, however, ground water still amounts to a considerable supply for man's needs.

Like various forms of surface water, ground water also seeks to attain a stable level by moving towards lower levels of ground except where it is trapped by more or less non-porous rock. Even this trapped ground water is lost gradually by slow percolation to the lower levels finally emerging into lakes or rivers or as springs. However, ground water is replenished every year by seasonal rain and snow. It should be obvious, therefore, that if man did not utilise this source of water, he would have only himself to blame.

But where does the supply of ground water become crucial? As it happens, most developed countries are located in temperate regions, whereas the less developed countries are located in tropical regions. Not unexpectedly, then, technologies of exploitation of natural water sources are different in different regions. Besides, such technologies have developed in keeping with other technological progress. When an underdeveloped country needs help with its water resources, a developed country offers its own kind of technology. Unfortunately, for a variety of reasons, such help fails to produce the results expected of it. The input by developed countries - including know-how, materials and personnel - seldom produces returns commensurate with the economic and social costs incurred by recipient countries.

More often than not, developed countries make acceptance of their kind of technology and materials a necessary condition of the offer of aid.

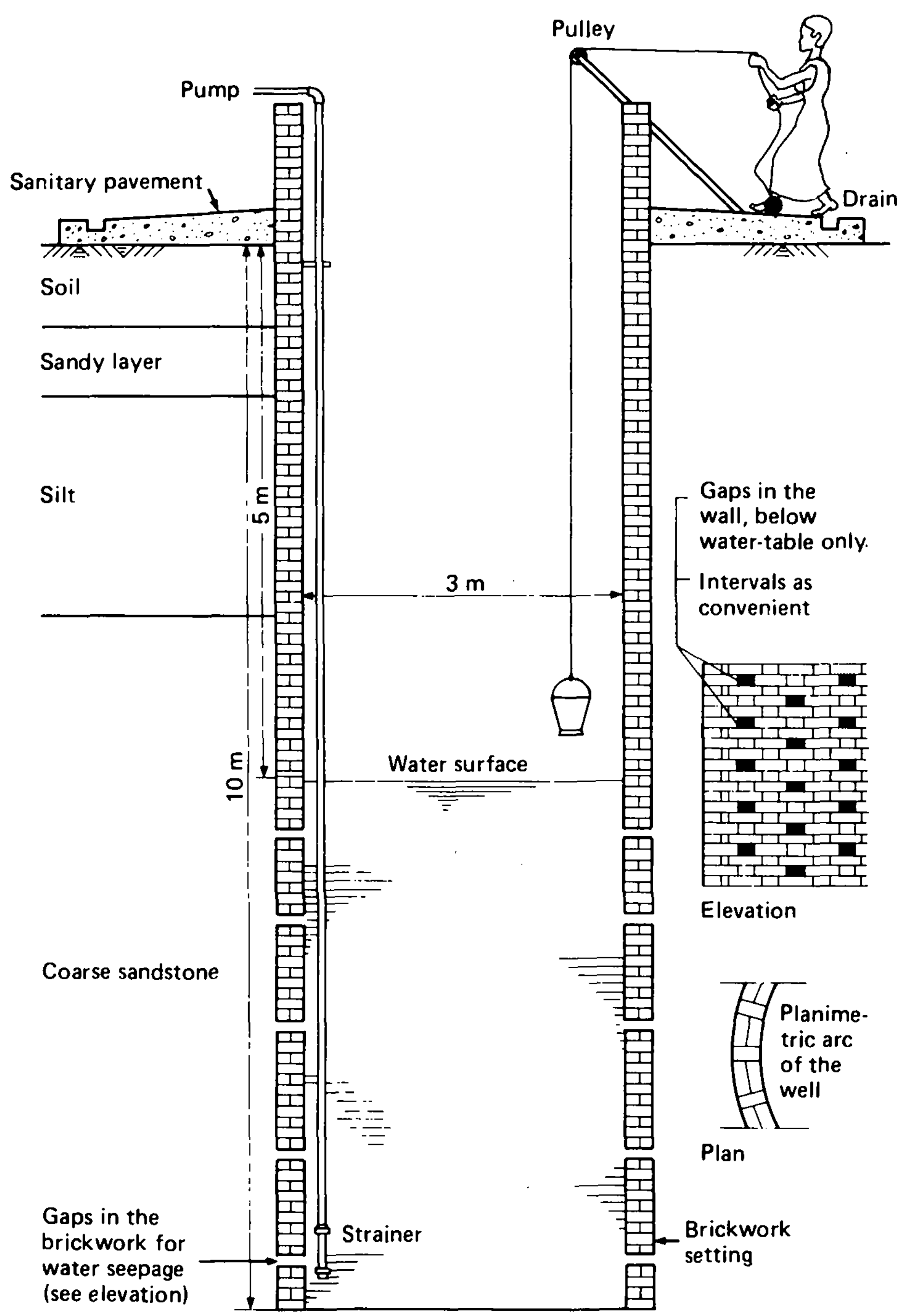


FIG. 1 IDEALISED SECTION OF A SHALLOW DUG WELL

Since there is no satisfactory system for auditing or computing benefits yielded by such aid, many anomalies in aid programmes go unnoticed. There is little doubt, however, that in many developing countries aid programmes fail to achieve their declared and ostensible objectives. This paper is an attempt to identify these anomalies and partly to offer suggestions towards resolving them, particularly in remote rural areas of developing countries.

In some ways the technology necessary for tube wells is complex. Basically, the drilling of a tube well is preceded by a search for ground water by means of the science of hydrogeology including geophysics. Locating ground water and assessing its depth and quantity is the business of hydrogeology. Its techniques help to dermine where ground water is, whether it is stagnant or mobile and whether its nature, quantity and schedule of replenishment are suitable for exploitation.

Once sub-surface water is discovered, we have to bring it to the surface. There are mainly two means by which this may be done: the modern tube well (bore-well) and the traditional dug well. A tube well is drilled with a drilling machine. There are various types of drilling machines, but the general principle common to them is to bore a hole in the ground by a rotary or a percussion process, secure it by introducing a pipe into it, and where necessary a strainer, and then use a suitable pump to lift the water. The diameter of tube wells varies between four inches and some 24 inches according to rock conditions and requirement for water. Tube wells for domestic, industrial or agricultural use are generally of eight to 10 inches in diameter. In depth they vary between a few feet to some 500 feet and more.

After the bore-hole is ready a blind pipe, or where necessary a screen, is introduced all down its length. If some portion of the hole is made of soft rock a protective casing is used to avoid caving in of the sides. Once drilling and casing is over, a pump to lift water is installed. It may be powered by oil or electricity.
Certainly such a complex unit requires constant maintenance and continual repair and replacement of parts (see fig. 2). Even if ground water is met at shallower depth a pump assembly is indispensable.

The other means of obtaining ground water is a dug well which is simple in design and easy and inexpensive in construction. A dug well is made by digging a vertical pit usually of about 10 to 12 feet in diameter and reaching below the lower level of ground water. Experienced village work men can dig to a depth of 50 to 60 feet and sometimes, even deeper, but the normal depth of a dug well is about 30 to 40 feet. Digging is usually continued below the shallowest level so as to tap the permanent water table.

If the pit is in soft and unconsolidated rock it is lined with rubble, masonry or brickwork. This construction is pointed to avoid contamination from surface water.

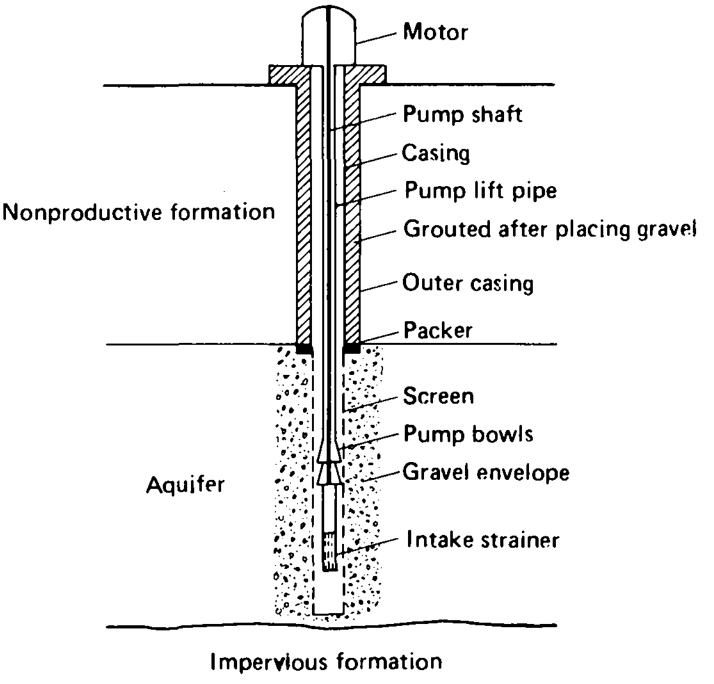


FIG. 2 GRAVEL-PACKED BORE WELL WITH PUMP

Below the shallowest level, that is winter water table, the pointing is partial or gaps are left in the work so that ground water may have free access to the well. In addition, the well is provided with a plinth of about three feet above ground, and this is extended by a sanitary pavement surrounding the well stretching about five to 10 feet from the plinth, to further eliminate percolation of wastes and contaminated water into the well. As the ground water passes through the aquifer or a porous rock medium good quality of water is expected. Apart from getting filtered through the porous rock it undergoes chemical processes like base exchange which purify the water.

The simplest means of lifting water from a dug well is some arrangement of a rope and a pulley over which water is drawn by buckets. In some places equally simple devices have been traditionally used, pulled by oxen or other draught animals. A dug well is thus versatile and admits of a number of adjustments according to the means and needs of a community. For an idealised diagram of a dug well see figure 1.

In some countries "shallow wells" are also built out of reinforced concrete rings. However, as these wells have to be narrow, about three feet in diameter, only one man can work in them at a time, thus their digging time is increased. Besides, the lowest rings, which are perforated or made porous to admit incoming ground water, soon get choked with sand, silt, clay or chemical deposits. As they cannot be dug or are not dug as deep as ordinary dug wells their supply of water is often restricted. Thus they have many disadvantages compared to traditional dug wells.

Since the relative advantages of dug wells and disadvantages of tube wells are usually glossed over by aid planners - whether they do so to boost their own trade and whether they are aware of the many complications arising from their promotion of tube wells does not here matter - it is necessary to tabulate the facts of the matter. But before doing so, we may take account of a standing objection against dug wells: that they are insanitary and unhygienic! It has already been stated that in their construction much care can be taken to avoid pollution and contamination. Further care can be taken by means of training given to users of such wells in basic sanitation and hygiene. Such training has been found to be within the reach of even the most uneducated villagers. Simple chemical purification of well water also helps. This can be demonstrated and looked after by health visitors in rural areas. The problem is no longer as serious as it once used to be. In any case, such an objection coming from western countries which have for decades continued to contaminate arable land with chemicals and lakes and streams with serious pollutants, and are at present fumbling with nuclear waste, is somewhat frivolous.

The relative cost structure of dug wells and tube wells in an average developing country, in US dollars is as follows:

Dug Wells		Tube wells	
Diameter 10 to 12 feet		Diameter 6 to 8 inches	
Depth 30 to 40 feet		Depth 300 feet	
Exploration cost	$ 500	Exploration cost	$ 1,000
Cost of digging	$ 1,500	Cost of drilling	$ 10,000
Masonry etc.	$ 1,200	Casing etc.	$ 5,000
Plinth etc.	$ 600	Pump and installation	$ 5,000
Lifting devices	$ 100	Developing and pump testing	$ 2,500
		Pump house	$ 1,000
	$ 3,900		$ 24,500
(Say US $ 4,000)		(Say US $ 25,000)	

These costs may vary from place to place, but the relative difference between the cost of dug wells and that of tube wells remains the same. In short a dug well costs a fraction of the cost of a tube well.

Since the tube wells involve greater depths of drilling, exploration for them necessitates application of hydrogeological methods including geophysical methods, that are time consuming, expensive and require considerable skill and equipment. The initial outlay of drilling a tube well (excluding pump and accessories which become relevant after the success of the well is established) is therefore very high, in the neighbourhood of US $ 20,000, most of which has to be paid in foreign currency. Electricity is expensive, and not always easy to come by; and fuel oil is becoming daily more difficult to obtain and more expensive than before, and once again involves payment in foreign currency. If the water supply is marginal, a dug well is still convenient but a tube well becomes uneconomical. And as these wells are usually located in villages, where skilled maintenance workers and spare parts are not readily (if at all) available, tube wells often lapse into permanent disue. If spare parts are made available often they too have to be bought from the donor country, involving more dependancy and foreign exchange. A dug well, in contrast, requires less sophisticated equipment for exploration. And yet the success ratio of dug wells is about 70 to 80 percent while that of tube wells is often as low as 30 percent.

Once again, to tabulate the essential points of comparison between tube-wells and dug wells, here is a summary:

Dug Wells	Tube wells
1. Exploration more assured	1. Exploration less assured
2. Capital investment little or nothing	2. Capital investment thousands of dollars
3. Maintenance cost little or none	3. Maintenance costs high. Disorders may mean closure

	Dug Wells		Tube wells
4.	Pump not essential, fuel costs avoidable	4.	Pump indispensable. Fuel cost unavoidable
5.	Construction about 15 days	5.	Construction time often as much as two months with risk of stuck-up and abandonment
6.	Yields variable but usually sufficient for small communities	6.	Not economic under a minimum quantity per hour or per day
7.	Recharge by rain almost immediate	7.	Recharge delayed according to depth and rock composition
8.	Shallow water ubiquitous	8.	Deep water sources comparatively rare
9.	Applicability universal	9.	Applicability restricted to proven areas
10.	Success ratio about 80 per cent	10.	Success ratio 30 to 40 per cent in virgin areas, more in established areas
11.	Contamination avoidable	11.	Contamination no real risk
12.	In case of failure only excavation cost is lost (goes towards local employment)	12.	In case of failure almost all operational cost is lost (significant and in foreign exchange)
13.	Human or animal power suffucient for normal lifting of water	13.	External energy source (diesel or electricity) essential
14.	Self reliance and local involvement high	14.	Self reliance nil. Increases dependence on donors
15.	Desirable in early stages of development	15.	Desirable when industrialisation and economy independent

It should be clear from all this that in the early stages of growth and development of a country dug wells are a better alternative to tube-wells. Tube wells are dependent on personnel, economic and technological resources, and should be thought of only when a country has achieved enough overall growth to offset such costs as an aid programme for them imposes. Open dug wells have long been hubs of rural social activity. Their numerous other advantages make it necessary to look upon tube-wells as exotic and unnecessary luxuries. For self reliance, economy, local employment, continued and assured service and minimal dependence on outside help, as well as minimal disruption of traditional ways of life, dug wells are admirably suited. Such time, money and efforts and donor countries generously wish to make available to developing countries can be deployed for far more essential and realistic programmes than those for tube wells.

THE WELL: OUR BEST RURAL WATER SOURCE

From a long way back in history wells have been treasured sources of water for mankind and his animals. References to wells are found in proverbs and ancient writings often with the one who had it built commemorated in the well's name. Not only that literature often mentions the quality of well water; its purity or its pollution. Within living memory very many rural communities in the industrial countries used wells for domestic supplies and the hand pumps can still be seen in position, though now disused. Let us take a look at the use of wells and peoples' attitudes to them in Tanzania today, for wells are common in most Districts, but the popularity for them has dropped until recently.

ATTITUDES

First, attitudes: Many people are vague about the processes of water supply and are impressed by pumps, pump houses, pipes, valves and tanks, but do not realise that none of these make water. Such installations can only move water that is already provided. Nowadays factories can produce many things, even, it appears, milk without cows, but no machinery can produce water in large quantities, and no scheme can supply water without a source.

WELLS NEED AQUIFERS

To understand wells and their benefits it is necessary to understand something about the water in the ground. Under our feet is the familiar soil in which grass, plants and trees grow. This soil may be termed the Root Zone and for most places, though not all, any water which collects in holes dug in this soil will be dirty and unsafe for drinking. But if deeper holes are dug and the water from the ground surface and root zone are kept out, clean water may be found.

This clean water may be found immediately under the root zone or it may be necessary to dig through some dry material to find water below it. Generally well diggers are looking for water that will enter the well at depths of 3 to 10 metres.

The ground in which this water is found is called the aquifer, which means: water carrier. Frequently the aquifer is a thickness of sand or it may be sandstone or cracked rock. It may be less than half a metre thick, or it may be many metres thick. In areas it may lie under the whole village and the surrounding land or it may be like an underground river winding left then right so that one successful well might enter it, but another well, not far away, misses it and is dry.

Whatever type of sand or rock and whatever its depth or extent the aquifer is most important to well water supplies, for the aquifer is the water gatherer and store, the water purifying works and the water distribution system.

The four tasks of the aquifer, gathering, storing, purifying and distribution, each of these needs looking at for a fuller understanding of the usefulness of shallow aquifers and wells.

GATHERING

The aquifer gathers water by rain water entering the soil i.e. by infiltration of rain water. It should be well known to everyone in Tanzania that rain infiltrates best through land clothed with grass, trees, bushes and close growing crops.
Having entered the soil some of the water is stored in the aquifers and slowly released to rivers, springs and wells, keeping them supplied during all or part of the dry season. Absence of plants reduces the ability of water to enter the soil. The heavier the rain and the steeper the land slopes the more important this fact is; without good plant cover heavy rain on sloping ground can cause erosion with floods on the land below and then so little water enters the ground on the hills that rivers, springs and wells dry up early in the dry season.

STORING

The same type of aquifer that gathers rain water from the land can also store water and for the same reason: aquifer materials are like sponges and have voids, i.e. gaps within them that act either as "passages" to the flow of water or as "rooms" for the storage of water. Of course these "passages" and "rooms" are very small, but the large size of many aquifers means that a very large volume of water may be stored. A bucket full of dry clean sand (not earth) can receive quite a lot of water, then if there is a hole in the bottom of the bucket some of that water will come out. This is some indication of the way an aquifer acts as a water store holding the water in its voids and releasing it slowly at a low point.

FILTERING

Almost all of the large man-made water filters in the world work by passing the water through a layer of sand that is between half a metre and one metre thick. Then it flows out clear and wholesome. The passage of water through an aquifer is in most cases a far greater distance of sand or similar pourous material. Thus in most cases the water flowing into a well has been filtered and is clean and wholesome and is often just as good as the best man-made filter water.
The reason why so many wells do not give water to this high standard is usually that unprotected or poorly maintained wells allow the good water from the aquifer to mix with polluted water from other sources. This is the difference between protected and unprotected wells, which will be discussed later.

DISTRIBUTION

Since water can flow in the aquifer, well supplies can be taken at a number of places. The volume available will depend on the level of water in the aquifer and the depth of the wells.

The rate of flow will also depend on the permeability of the aquifer; coarse sand, for example, has a large permeability, that is, water will flow quickly through it. A fine sand will allow a slower flow, and if, say, silt is also present, then the flow will be slower still. Where the permeability of the aquifer is great, a large population may be supplied from a central well, or even the water may be drawn out by a diesel-driven pump and distributed by pipeline, but where the permeability of the aquifer is low it is sometimes only possible to extract the water by a number of low-yield wells scattered throughout the aquifer. To attempt to pump the same total volume from a single source will lead to failure of the pump for the following reason. A diesel-driven pump set in a well in an aquifer of low permeability may pump at a greater rate than the well can supply. This results in damage to the pump and, if continued, in failure. The same will happen to a replacement pump unless it is smaller than the first.

Although the pump attendant should have a means of measuring the level of water in the well and should stop the pump when the level is dangerously low, the basic fault is not with the attendant, or the pump manufacturer. Such wells should not be used as diesel-pumped sources. But apart from this reason, since one of the objects of water supply is to get the water close to the people, we can say that if it is possible to take year-round supplies at places convenient to the consumers, and if this can be done without diesel pumps and pipelines by using shallow wells, then the shallow well solution is the right one.

SOME DISADVANTAGES OF PUMPED AND PIPED SCHEMES

Assuming we have a pumped and piped scheme with an adequate source, other problems that might occur are:

(i) leakage and wastage of water from the pipelines, at the tank and taps, can rob some people of their water supply and also cause pools to breed mosquitoes

(ii) equipment, spares and fuel require foreign exchange

(iii) the further the village is from district HQ, the more difficult communication and transport become for every item of maintenance and for repair of both pumps and pipelines

(iv) sooner or later an assistant pump attendant is required to take over when the first pumper is on leave, sick etc.

(v) another long-term planning consideration is the aim of many villages to own and operate their own transport for both village and nation. The same resources are being competed for by both transport and pumped and piped schemes, namely: people with some training in engine and machine maintenance, and foreign exchange for both initial equipment and operation including fuel.

DISADVANTAGE OF PROTECTED SHALLOW WELLS

(i) for some aquifers and in some hilly areas the wells may be positioned further away from the people than a tap would be, requiring a longer walk to the water

(ii) instead of turning on a tap it is necessary to pump the handle

(iii) where a village only has one well, breakdown of the pump suddenly cuts off the supply

ADVANTAGES OF PROTECTED SHALLOW WELLS

(i) shallow well schemes are quicker to install

(ii) independence from diesel fuel deliveries

(iii) most maintenance can be done by villagers

(iv) spares for repairs are cheap enough for villagers to keep them

(v) no need to support a pump attendant and his assistant

(vi) savings in first costs: a diesel-pumped scheme with pipelines rarely costs less than Shs. 400/- per head while protected wells are about Shs. 200/- to Shs. 20/- per person

(vii) savings in fuel costs

(viii) good quality water

(ix) if several wells are made in a village, the breakdown of a pump does not cut off the supply as the other wells will still give water. Time is gained to facilitate the repair.

THE ESSENTIALS OF A PROTECTED SHALLOW WELL

The principle of a protected well is to gather water from the aquifer only and to exclude any pollution. The well may be wide enough to be dug by hand or a narrow well drilled from the surface, but the principle is the same. At the aquifer it must be possible for water to enter without the sand collapsing into the well. This is usually achieved by using porous concrete rings or porous brickwork in dug wells and by using slotted pipe, called a "screen" in drilled wells. Elsewhere in the well non-porous materials are used, especially near the surface where polluted ground water might enter. For the same reason the ground surface should slope away from the well so that no puddles form to find a passage down the outside of the well to the porous section. The top of the well must be closed to prevent the traditional method of drawing water with ropes and buckets since these have stood on the ground and carry dirt into the well. Also when a well has an open top irresponsible people can throw rubbish into the well and animals can fall in. Since the top of a protected well is closed the water can only be drawn out with a pump, usually a hand-operated pump. Pit latrines must not be sited too close to the wells.

THE FUTURE

Recently shallow protected wells have been built in large number in Shinyanga, Mtwara, Lindi and Morogoro Regions. Other Regions and Districts are invited to send teams of people to Morogoro to be trained as well crews.
Trained well crews need survey drilling equipment which can be bought from the Morogoro centre. Using this equipment the best site for a village well may be found and advance knowledge of the type of soil to be dug obtained. Depending on the type of soil the well is in, the well diggers use hand-drilling equipment, screen and pipe or hand-digging equipment and concrete rings of various designs. All of these items are obtainable in Tanzania and so are the hand pumps which are fitted to the completed wells.

Well crews need time to learn their skills and they need the complete equipment and some form of transport to keep them supplied with materials in the field. The time, cost and organization to achieve this should not be underestimated, but as has been shown above the results are the cheapest village water supplies and at National, Regional, District and village level protected shallow wells are the self-reliance answer.