Report No. 3350.01

OVERSEAS DEVELOPMENT ADMINISTRATION

Project No. R3957

EVALUATION OF SWS FILTRATION SYSTEM

January 1986

London School of Hygiene
and Tropical Medicine
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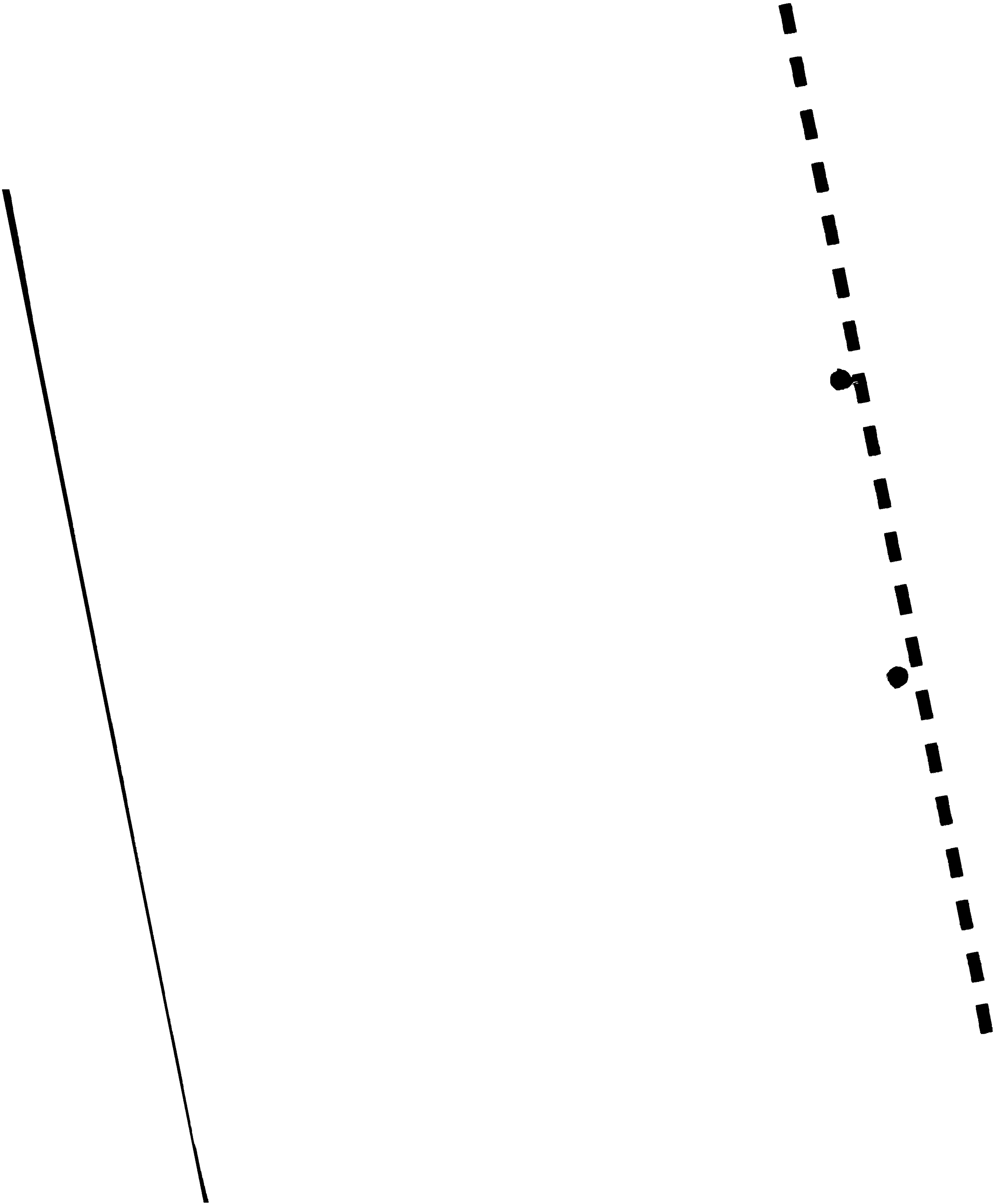

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SUMMARY

This report covers a six month research programme funded by the Overseas Development Administration (Project R3957) under the direction of its Engineering Division, to evaluate the SWS filtration system. The programme has been undertaken by Gifford and Partners in association with the London School of Hygiene and Tropical Medicine. Two full-time investigators spent nearly three months visiting and monitoring SWS installations sites in Zaire, Uganda, Sudan and Nigeria, and this was followed by evaluation studies, the compilation of results and report writing in Britain.

The low-cost filtration equipment is supplied by SWS Filtration Limited of Northumberland. The original SWS system which was developed in 1976-77 from a successful sea-water intake system consisted of the use of a box buried in the sandy bed of a river and a pump for extracting water from the box, using river bed material in and around the box as a filter medium. In 1980 an alternative system was developed with the introduction of a small stainless steel screen (known as a mini filter) which could be buried in river bed material without the box, or which could be buried in a box filled with granular material, placed in a river or stream and not buried below its bed.

A total of 38 SWS installations were visited and tested in Zaire, Sudan and Nigeria, and some abandoned sites were examined in Uganda. Most of the installations in Zaire were mini filters in spring protection works, where it was not possible to compare the quality of water before and after passing through the system. In Sudan the installations were all mini filters in containers placed in irrigation channels, and extensive tests were carried out on water before and after filtration. In Nigeria half the installations seen were of the original type with boxes buried in river beds. At the time of the visit, which was during the rains, most of these installations were not in use and only two were monitored. The other installations monitored in Nigeria were jetted tube wells using stainless steel well screens.

The investigations found that many installations had breakdowns from time to time and others had been abandoned (as in Uganda) because of hand pump failures. The pumps usually failed through over use or rough handling, causing excessive wear and breakage, and in the absence of readily available spare parts and repair facilities, users were very ready to condemn the equipment. The new 'Rower' pump now being supplied by SWS Filtration Ltd has a much better performance record than the earlier Lee Howl and Patay pumps.

Wherever it was possible to measure biological pollution before and after filtration, it was found that filtration reduced pollution, although the reductions were generally not significant in relation to health protection. This was particularly evident with the mini filtration systems in Sudan, largely due to the lack of an adequate filter medium. Performance in this respect was better with the original SWS system in Nigeria.

Data have been collected for the capital and installation costs of the various types of SWS equipment investigated. Reduced to costs per capita of people served, the SWS installations, with hand pumps, cost between £1.08 and £2.68 per capita. By comparison the per capita cost for a small slow sand filter in Sudan is £6.48.

The only equipment available at a cost comparable with the SWS products is a recently-developed packaged filtration system produced by Ideas Development Limited, of Worcester, England. Performance details of this equipment have not been seen.

Apart from this, and with chlorination ruled out on the grounds of cost and the supply of chemicals, feasible alternatives for reaching water in river bed aquifers are: hand dug wells, light mechanical boring systems, and the slow sand filter. Many existing slow sand filters in Sudan are out of order or not working properly, despite their very much greater capital cost.

The report concludes that:

(1) There are fundamental design defects in the SWS mini filter installations as used in Sudan which render the systems unreliable for the provision of potable water.

(2) Where the original SWS river bed system, in the "village" or "camp" unit is properly installed and used, it can reduce the pollution of raw river water, but its microbiological performance is poor in relation to international guide-lines.

(3) In its simplicity, portability to locations without vehicle access, ease of installation without skilled manpower or mechanical equipment, simple operation and maintenance and low cost, the SWS river bed system has many advantages over possible alternatives.

(4) For a great many communities whose only source of water is highly polluted, the insistence on water which is bacteriologically acceptable is hypothetical, and some improvement may often be better than no improvement.

As the SWS river bed system has been tested by scientific bodies in the UK and has been in use in the field for several years, some limited further research is recommended in the hydraulic design features of the system with a view to establishing improved criteria for installation and operation.

This report is divided into three parts. Part I includes the background to the study, a description of the SWS system and details of the investigations. Part II covers the field operations and Part III describes the performance of the SWS systems examined, the cost implications of the installations and the results of the evaluation. Appendices A to I include all the field data collected and other relevant material.

ACKNOWLEDGEMENTS

The participants of this investigation acknowledge their thanks to all those who assisted with this project, mentioning in particular:

Zaire: Dr K M Lusi, Medical Officer in Charge, Nyankunde, Haut Zaire, for full co-operation and support.

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Mr M J Hurst, Ministry of Agriculture, Fisheries and Food and Dr D Caddy, Anglian Water Authority for permission to reproduce the results of their work on SWS filter units.

PART I

1. BACKGROUND

1.1 Needs and Problems

According to UN statistics, 70% of the world's rural population or about 1,800 million people were without safe drinking water supplies in 1980[1]. The target for the Water and Sanitation Decade (1981-1990) is to provide safe water supplies for 85% of this rural population by the end of the decade. Allowing for population growth this means bringing basic services to some 1,400 million people. With limited financial resources available, it is clear that investment costs must be kept to an absolute minimum if there is to be significant progress towards achieving the decade's target.

Wherever possible groundwater is being developed for drinking water supplies because it is less likely to be polluted than surface water. But groundwater is not universally available or accessible, and even where it can be exploited, it has to be pumped and this is costly. Where groundwater is not feasible, surface water is then the only possible source, as it is for many millions of people who are now using polluted surface water supplies. These people generally belong to low income communities, mostly in rural situations without access to electric power or other energy sources. Treatment systems which depend on power are therefore not practical and the development of simple, low-cost treatment technology is of paramount importance.

1.2 Available Options for Rural Water Supply Treatment

There are various methods of rendering water potable which can be applied in the individual household or institution. Water can be boiled, filtered, or chemically disinfected; but although all these methods can be efficacious, few rural households in developing countries have the resources to use them, even were the consumers to be convinced that treatment would have a significant effect on their health.

To boil water, for instance, needs energy in forms such as firewood (at least 0.2 kg for each litre of water), or dung or straw, which are often even scarcer than water itself. Besides, disease is rarely exclusively waterborne in such households, where poor hygiene leads to frequent transmission of diarrhoeas and other infections by non-waterborne routes; domestic water treatment will therefore not normally produce a sufficient improvement in people's health for its benefits to be apparent to them and so justify the continued investment of care and resources which it requires. If their water is to be made potable, therefore, treatment must normally be effected at the level of the community as a whole, at the source.

Problems of cost, operation, and distribution of chlorine rule out the use of chemical disinfectants in almost all cases, leaving some form of filtration as the only feasible option. Slow sand filters have some application here, but the high turbidity of most surface waters in the tropics causes the filters to clog in a matter of days or even hours, so that they need to be cleaned with a frequency which is not usually practicable. While considerable research is under way to develop simple methods of pre-treatment to remove enough suspended solids to prepare the water for slow sand filtration, it has not yet led to a technology proven to work successfully in the field.

2. THE SWS SYSTEM

2.1 History

In 1976 a British company, SWS Limited of Skegness, Lincolnshire, engaged in the design, supply and installation of sand filter systems for marine and fresh water aquaculture and other purposes, introduced a simple filtration unit for use in streams or rivers with sandy beds, claimed to be suitable for water supplies in developing countries. The unit was described in a paper by Mr G S Cansdale, then Technical Consultant to the company, which was delivered at a conference at the University of Technology, Loughborough, the same year. The company is now trading as SWS Filtration Limited at Hartburn, Morpeth, Northumberland NE61 4JB.

The unit consisted essentially of an inverted open box, filled with and buried in river bed granular material, from which water was extracted by pumping from a chamber in the box, thus using the river bed material as the filter medium. The system, because of its simplicity and cheapness, aroused interest in many quarters.

The unit was tested for 10 months (1976-77) at a site on the River Ivel at Tempsford in Bedfordshire, jointly by Mr M J Hurst, microbiologist, Agriculture Development Advisory Service (ADAS) of the UK Ministry of Agriculture, Fisheries and Food, and by Dr D Caddy, Anglian Water Authority. Chemical and microbiological analyses of water samples before and after filtration were undertaken. A copy of the report[2] on these tests is given in Appendix I.

In 1977 this system was examined by the ITDG Water Panel and a statement[3] from the Chairman of the Panel included the following comments:

> "The ITDG Water Panel has considered whether it should endorse the manufacturer's claims of the effectiveness of the unit for use as the sole treatment for potable water

> supplies in developing countries. It was noted that the unit has only been used for demonstration purposes in developing countries but there was no reason to doubt its ability to remove suspended solids provided the sand was correctly graded.
>
> The Water Panel considered that claims for the efficacy in removal of micro-organic pollution should be viewed with scepticism until reports of tests being carried out in Essex are received. In particular removal of bacteria would depend on the development and retention of a schmutzdecke; with transient tropical stream flow successive erosion and deposition of bed material might so hinder maturing of the schmutzdecke that the unit could never be relied on to provide potable water without further treatment."

During 1977 and 1978 laboratory tests on this equipment were carried out at the Department of Microbiology, University of Surrey. This work was supervised by Dr B J Lloyd, Lecturer in Microbiology, and in a document[4] prepared by him and submitted to the Intermediate Technology Development Group Water Panel early in 1979, recommending a programme of site evaluation of the installations, he wrote:

> "These tests .... have demonstrated that the units develop a biological filter which produces physically clean water of improved bacteriological quality and with efficiencies approaching that of slow sand filters. However, the Water Panel has been reluctant to recommend them for treating drinking water because up to now detailed bacteriological data from units operating under realistic conditions in the tropics has been lacking. Nevertheless it was felt that such an inexpensive and simple device may be of great potential benefit in a world in which two-thirds of the human population, some 80% in rural areas, has no access to safe supplies of water. The SWS units must be installed and developed correctly, but then

> require minimal maintenance. Units are operational in Kenya, Tanzania and Malawi, but there are no sanitary data by which their performance may be fairly judged. The Water Panel agreed unanimously that additional funding should be sought in order to make a detailed investigation to establish whether the existing units in the tropics are consistently producing water of a quality approaching that of WHO drinking water standards with respect to bacterial and suspended solids content."

This proposal for the evaluation of existing units in the tropics was not, unfortunately, taken up by the Water Panel at that time. Meanwhile, and during the following four years, these SWS units were gaining popularity and were being supplied to a number of communities and organisations in developing countries, with funding from Rotary Clubs all over Britain. By the end of 1983 some £50,000 had been raised through the Rotary organisations and over 200 units had been despatched to 15 countries in Africa, 4 in South America and 1 in Asia. In addition to funding from Rotary Club sources, other organisations are now paying for the supply of these units.

In 1980 an SWS unit was tested for six weeks at West Mill Trout Farm, Ware, Hertfordshire, by Mr M J Hurst, ADAS, who reported that E.Coli type contamination had been reduced significantly although not altogether. This report[5] is also given in Appendix I.

2.2 Description of the Equipment

The original equipment, developed in 1976/77 and supplied until about 1980, is illustrated in Fig 2.1. It consisted of an inverted box made of GRP (glass reinforced plastic), 600mm x 300mm x 300mm deep, with a slotted septum buried in granular material below the bed of a river and beneath at least 300mm depth of water.

Various types of hand pump have been supplied, the most common being diaphragm pumps manufactured by Patay Limited of Iver (UK). This unit was known as the "village" unit. A pack, as funded by Rotary, consisted of the box, a Patay DD 120 pump, digging tool, suction hose, hose clips, base plate and mounting bolts.

In 1980 the design was modified by reducing the plan dimensions of the box to 300mm x 300mm and using a lighter model of Patay pump (DD70). This was the "camp" unit. By the end of 1980 another version, known as the "mini" unit was developed. The main component of this consisted of a stainless steel cylindrical screen 60mm dia x 80mm long connected by a 25mm dia plastic suction pipe to a hand pump. The screen could either be buried in existing river bed material, or in a container filled with bed material. This is illustrated in Fig 2.2. An alternative plastic screen is currently under development.

In 1981 a filter mat material was incorporated in the design for the mini-filter in a container filled with granular material. This is shown in Fig 2(c). Other arrangements of the mini-filter are illustrated in Fig 2.3.

In 1983, after a number of reports on the unsatisfactory performance of the Patay DD70 pump, the company developed a Bangladesh-type "Rower" pump, which is now supplied as standard equipment.

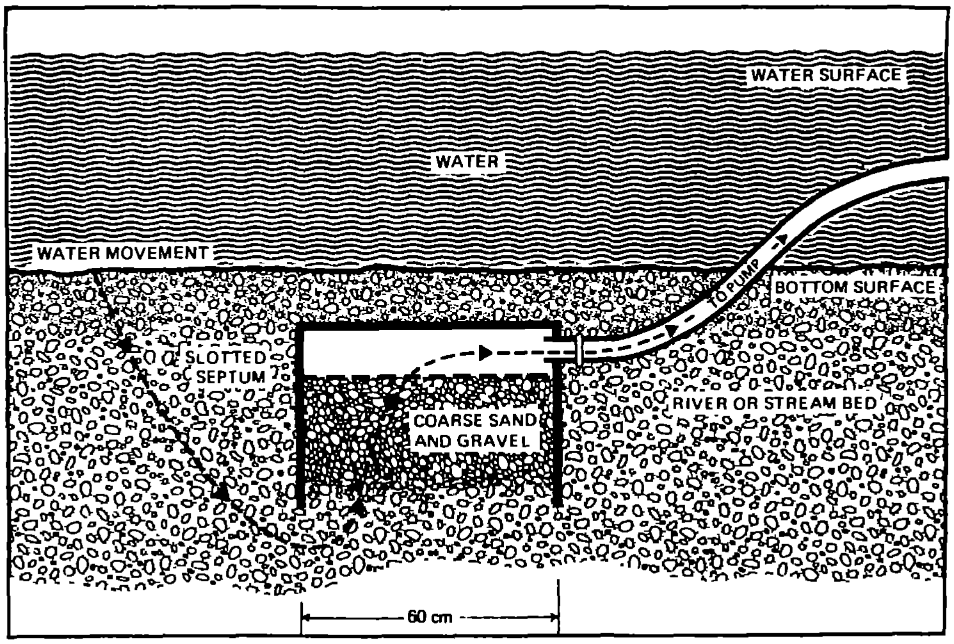
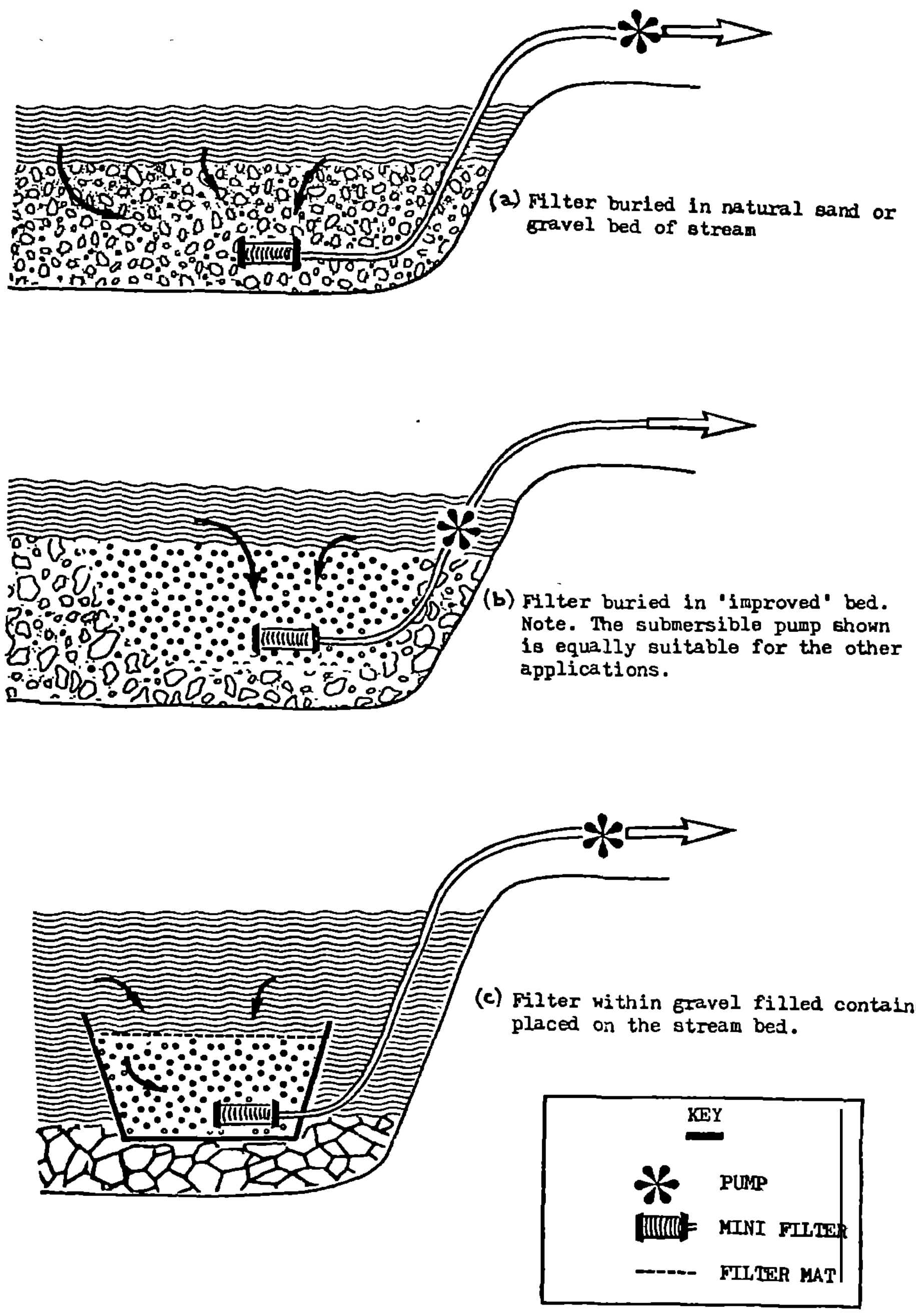


Figure 2.1 - Original SWS Filter Unit.

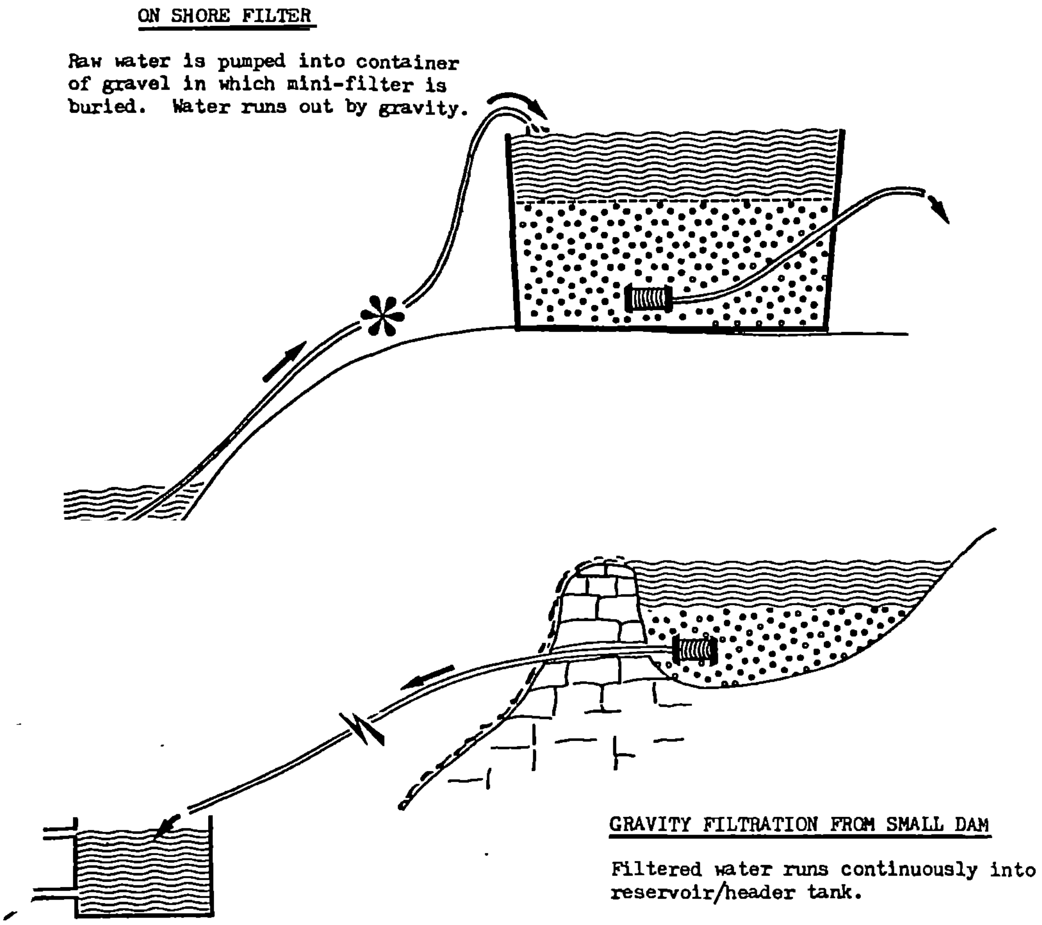


(a) Filter buried in natural sand or gravel bed of stream

(b) Filter buried in 'improved' bed. Note. The submersible pump shown is equally suitable for the other applications.

(c) Filter within gravel filled container placed on the stream bed.

Figure 2.2 - Some typical Mini-Filter installations.



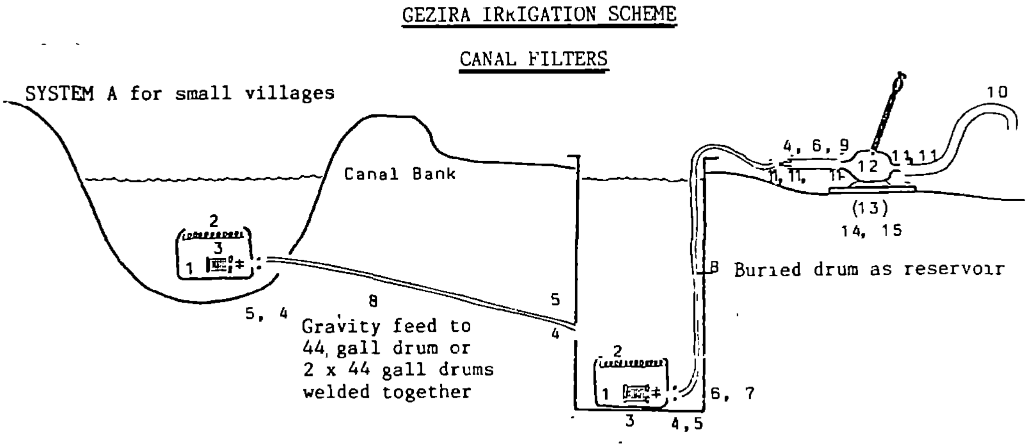
ON SHORE FILTER

Raw water is pumped into container of gravel in which mini-filter is buried. Water runs out by gravity.

GRAVITY FILTRATION FROM SMALL DAM

Filtered water runs continuously into reservoir/header tank.

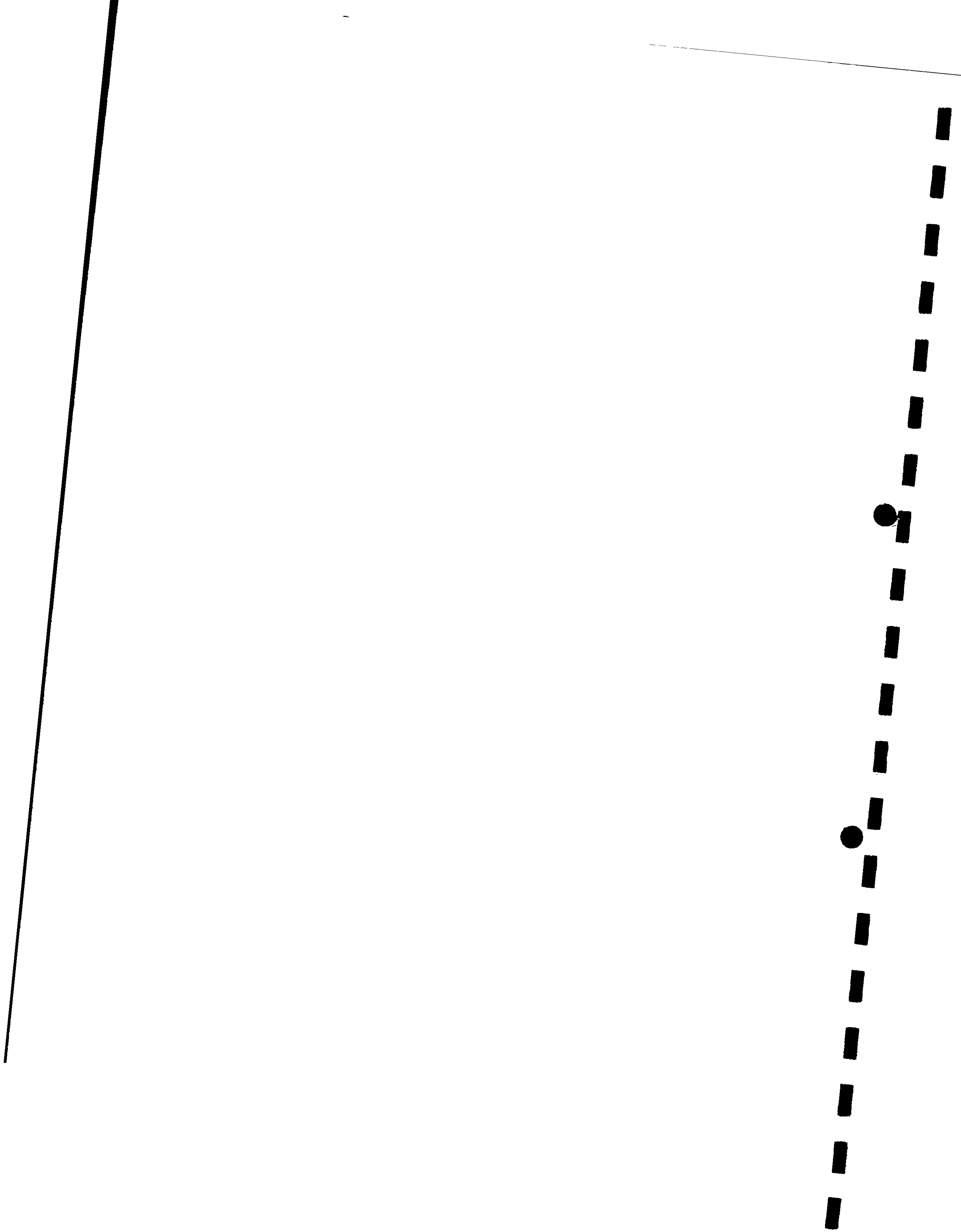
Figure 2.3 - Alternative Mini-Filter arrangements.

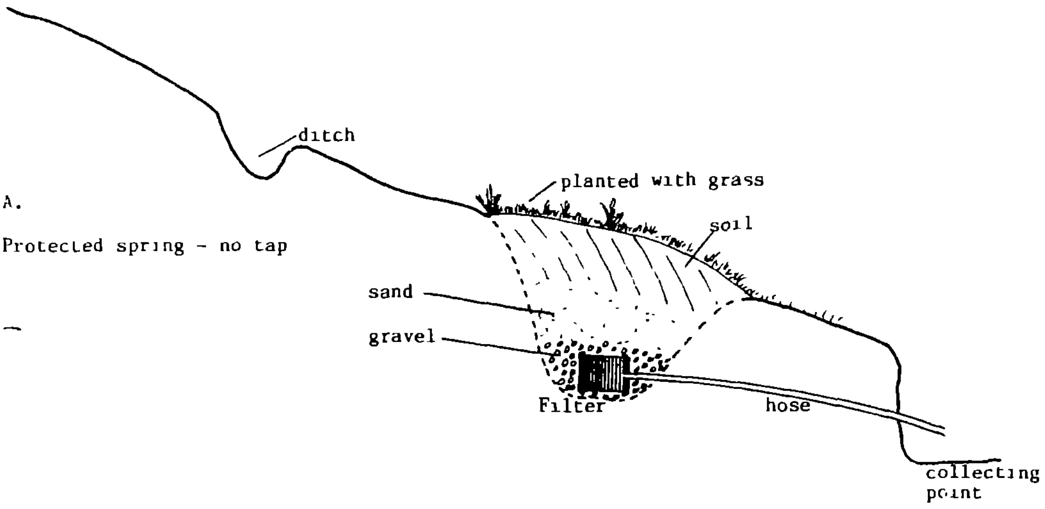


GEZIRA IRRIGATION SCHEME

CANAL FILTERS

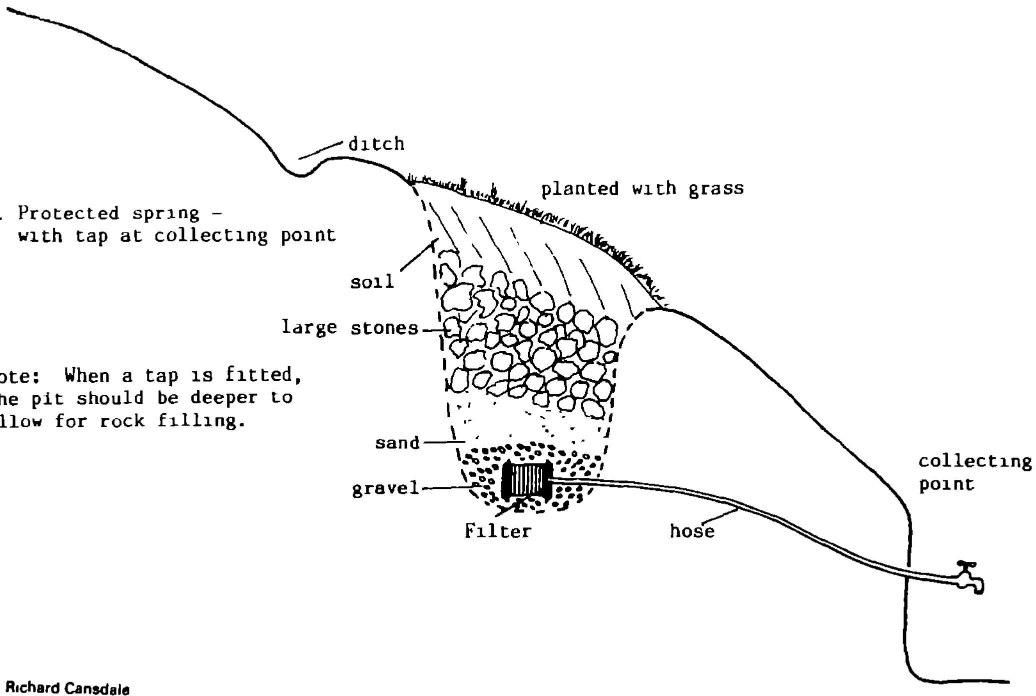
Figure 2.4 - Two containerised units in series.





A.

Protected spring - no tap



B. Protected spring -
with tap at collecting point

Note: When a tap is fitted,
the pit should be deeper to
allow for rock filling.

Mr Richard Cansdale
S W S Filtration Ltd
The Baker's Chest
Hartburn
Morpeth, Northumberland
Tel Hartburn (067 072) 214

Figure 2.5 - Spring protection designs.

2.3 Types of Installation

The SWS equipment has been used in Africa in the following four different types of installation.

(a) Spring Protection

There are various ways in which natural springs can be improved and protected. Where the spring is of the seepage type, emerging through soft ground, protection usually involves excavating into the soft material to locate the eye of the spring, laying an open ended or perforated pipe to collect the spring water and backfilling with granular material. In Eastern Zaire an SWS screen is used as the collector, as shown in Fig 2.5.

(b) Mini Container Unit

This has been described in 2.2 above and is illustrated in Fig 2(c). This system was introduced into the Blue Nile Health Project trials in the Gezira District of Sudan.

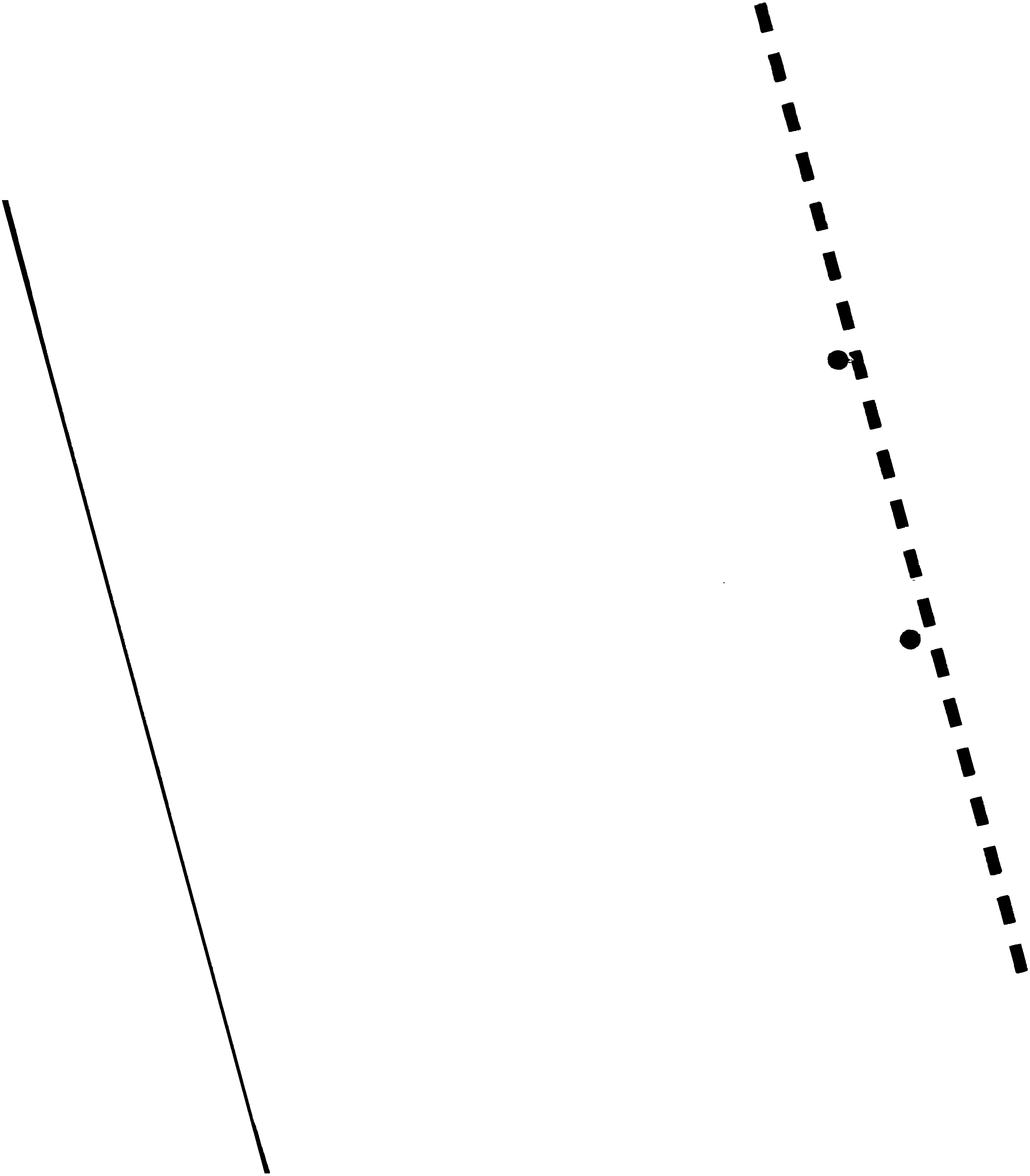
An improved version of this arrangement was developed using two mini-containers and this is illustrated in Fig. 2.4. Here water from the unit in the canal is led by gravity into a buried drum as a reservoir at the bottom of which is placed the second unit. The water supply is then drawn by pump from the second unit.

(c) River Bed System

This is the original system as described in Section 2.2 above. It has come to be known as the sub sand-river-bed system.

(d) Jetted Well

This type of system is used where shallow groundwater is found in sand. An SWS screen and pipe are lowered into the sand by a jetting process and water is subsequently extracted by pumping.



2.4 Procedure for Supply

SWS Ltd fulfills three roles in (1) supplying the equipment, (2) applying the funds collected by Rotary Clubs and other organisations in UK to provide the equipment to recipient groups and communities in developing countries, and (3) exporting the equipment to the recipients.

Most of the equipment is supplied through the Rotary International Village Water Supply Scheme, which was started in 1977. Rotary Clubs raise the money necessary to send out packs, while SWS identify locations suitable for the supply of these units. Checking may take several months as SWS try to ensure that the need is genuine, sites are suitable and the system will be properly used. A prerequisite is usually that there should be a responsible field worker on site at the receiving end. When a Rotary Club indicates that it would like to support a project, agreement is reached on the funds to be raised for a suitable, identified recipient site. The name of a field worker at this site is given to the Club in UK, and at the same time contact is made wherever possible with the nearest Club in the developing country, asking for help with customs clearance and local transport. When everything has been checked and agreed the packs are then despatched to their destination. The equipment is usually sent by air and the funds raised by Rotary Clubs in the UK cover landed costs at the nearest international airport to the site. After that the local organisation takes over.

2.5 Feedback on Performance

Reports from sites overseas where units have been installed have mostly been favourable, as the following extracts will indicate.

From Mr J A Peace, Rotary Club, Zaria, Nigeria, 29.3.82: "I am pleased to inform you that we have successfully installed the first unit. It has been in operation for two weeks, and the villagers are very pleased and proud of their new acquisition. The water from the unit is completely clear."

From an article by Mr Derek Joy, Principal of a Christian training college near Jos, Nigeria, Waterlines, Vol I, No 4, April 1983, describing the installation of SWS units in the water bearing beds of dry rivers by students from the college working with villagers: "A project such as this has a double purpose: the first, the provision of clean water, is obvious. Clear water is available even in the dry season and there may be no water visible in the river at all. The second benefit, often overlooked, is not to the villagers at all, but to the students and staff who bring the pump to the village and install it. To them, the facts are already known, but service is infectious: others are inspired and want to serve too."

From Mr Tim Rous, a water engineer attached to the Anglican Church in Eastern Zaire, 29.9.83 : "There are now approximately 15 water sources protected in and around Boga, some using just a filter and pipe where there is sufficient gravity feed, and others, often situated by the side of a stream, using a pump. Earlier in the year there was quite a severe drought, but although many streams dried up, it was encouraging to see that the water sources protected continued to provide a steady supply of clean water. The local people are delighted with the clean water supplies and recognise the benefit and the importance of clean water for health."

Reports have not always been favourable. Dr F G O Omaswa, Medical Superintendent, Ngora Hospital, Uganda, writing on 6.5.85 about five filter units which had been installed in Ngora District quoted from a report by the Field Worker who supervised the installations as follows: "All the SWS filter units broke down within a month. The quality of the water filtered in any case had not improved at all."

From this sort of feedback it is clear that there has never been precise monitoring of the performance of these installations, and references to "clean water" give no indication of the reduction of bacteriological pollution. In the report from Uganda, quoted above, it appears that in fact it was the pumps which broke down mechanically, and not the filters which have no mechanical components.

2.6 Reference Publications

The SWS filtration units have been referred to in a number of widely read publications on rural water supplies in developing countries. They are described as sources of filtered water in the London School of Hygiene and Tropical Medicine Bulletin No. 10 "Small Water Supplies"[6] and in a recent manual published by the Institution of Water Engineers and Scientists on "Water Supply and Sanitation in Developing Countries"[7]. The units have also been the subject of several articles in the Intermediate Technology Development Group journal "Waterlines"[8].

3. THE INVESTIGATION

3.1 Objectives

The objectives of this evaluation project were to study the use and performance of SWS filtration units which have been installed in Zaire, Uganda, Sudan and Nigeria; to collect and analyse water samples for bacteriological quality before and after filtration; to collect statistical data on the communities using these systems, and to assess the effectiveness of the SWS systems in relation to their capital cost, ease of installation, use and methods of operation and any observable health benefits. On instructions from ODA two prototype water quality testing kits were purchased from the University of Surrey and were field tested. A report on these kits is given in Appendix G.

3.2 Participants

The project was under the direction of the Engineering Division of the Overseas Development Administration and was carried out by Gifford and Partners, Consulting Engineers, Southampton, in association with the London School of Hygiene and Tropical Medicine. The ODA Engineering Adviser responsible for the project was Mr J M Bulman and the Administrative Supervisor, Miss M T Rosario.

Full time staff on the project were Mr E Buhl-Nielsen, Water Engineer, Gifford and Partners, and Mr N P Cox, Bacteriologist, London School of Hygiene and Tropical Medicine (LSHTM). The project leader and part time water engineering consultant was Mr P H Stern of Gifford and Partners, in conjunction with Dr A M Cairncross, tropical health consultant, of the London School of Hygiene and Tropical Medicine.

3.3 Project Arrangements

The original request for this project was submitted to ODA on 1 March 1984. The project was approved in principle in a letter from ODA dated 26 June 1984, with implementation delayed until after 1 April 1985. After some modifications and amendments a formal application for a grant for the project was submitted on 8 October 1984 and ODA approval was received in a letter dated 27 November 1984. The ODA document formally commissioning the Consultants was issued on 7 March 1985, the project duration being six months from 1 April to 30 September 1985. Field work was planned to cover three months and to include visits to installations in Eastern Zaire, Ngora District of Uganda and the Blue Nile Province of Sudan.

Despite several attempts at the end of 1984 and early in 1985 to obtain up to date information about the situation of installations in Uganda, very little information had been obtained by the time the project commenced. It was therefore proposed, early in April, that as there might be little to investigate in Uganda, the visit to Uganda be shortened and Northern Nigeria be included in the countries to be visited. This was agreed by ODA.

The Water Engineer and Bacteriologist left the UK on 8 May to undertake field work in Zaire, Uganda and Sudan which was completed on 5 July. Owing to the late decision to include Nigeria in the itinerary, there had not been time for the field team to obtain visas to enter Nigeria before they left UK on 8 May. Attempts were made, unsuccessfully, to obtain these visas first in Nairobi and then in Khartoum. On 5 July therefore the field workers had to return to UK to obtain their Nigerian visas in London. A second trip was then made to carry out the field work in Nigeria between 17 July and 7 August 1985.

PART II

4. FIELD OPERATION

4.1 Programme and Organisation

The programme in the field began on 8 May 1985. Nairobi was used as a base for operations in Zaire, Uganda and Sudan. Equipment not directly in use in each country was stored in Nairobi. Communications with Head Office, travel arrangements and preliminary report writing were done with the help of the offices of an associated firm in Nairobi. Advance arrangements for transport and accommodation enabled the maximum utilisation of the available time for field work in the countries of interest. Fourteen days of field work were completed in Zaire at two main locations. Field work in Uganda was curtailed because of the lack of working sites and amounted to only three days. Twelve days of field work were completed in Sudan after delays due to the Ramadan holiday.

The second field trip took the team to Nigeria, where they undertook a total of fifteen days of field work in the Plateau and Kano States, and returned to the UK on 8 August 1985. Appendix A contains a detailed itinerary of the field operation.

4.2 Procedure

The data collection consisted of recording the physical details, maintenance and performance history of the individual installations. In addition, specific tests were performed to assess the water quality.

The physical, maintenance and performance details were taken for reference purposes and to note any particular details that could affect or be responsible for the usefulness, acceptability, cost and success of individual installations. The data were recorded on proforma sheets which are reproduced in Appendices B, C, and D. Discussions were also held with local medical authorities to determine the health impact of the systems.

All water samples were collected using a sterile water sample cup. Raw water taken from channels, rivers and streams was collected by attaching a sampling wire to the cup. Filtered water was collected in a similkar manner after initially flushing the water through the system for either 15 seconds (when the system was in use at the time of sampling) or 60 seconds (when the system had been idle at the time of sampling).

The water quality tests were performed at each site using the Surrey University water test kit (see Section 3.1). The tests consisted of an examination of the physical parameters including colour, odour, temperature, pH, conductivity and turbidity, and a bacteriological examination using the membrane filtration technique to detect faecal coliforms. The water sample was filtered through a membrane which was then incubated with a selective media, membrane lauryl sulphate broth. Incubation was for 14 hours at 44°C (to conserve incubator battery life). Characteristic colonies were then counted. A detailed description of this procedure is given in HMSO Report 71, paragraph 7.8.

Tests on turbidity were conducted because of its influence on public acceptance of the water and its relevance to filtration performance. Tests on the other physical parameters were taken to detect any extreme range of values which might influence people's acceptance and also because of any influence they could have on later confirmatory bacteriological tests. The field bacteriological tests were made to measure the performance of the filters in the removal of faecal contamination and in order to determine the degree to which they satisfied accepted drinking water standards.

4.3 Constraints and Limitations

Each country was visited for a period of between two and three weeks of which at least ten days or more were spent in the field except for Uganda where no sites were operational.

Important data such as the maintenance and performance history, demographic details and in particular the health impact of the installations were sometimes difficult and even impossible to obtain. The bacteriological tests that were performed were limited in number by the capacity of the incubator used. The turbidity meter used could not measure values less than 5 Jackson Turbidity Units.

5. ZAIRE

5.1 Programme

The field operation in Zaire was based at two locations, one centring on the small town of Nyankunde and the other at Boga in the region Haut Zaire, Sub Region Ituri (see Fig 5.1). Several sites were also visited en route between the two centres of population. Mr Tim Rous, the engineer responsible for the installations, accompanied the field team on the site visits. Although the conditions of the roads resulted in considerable time being spent travelling, the exclusive use of one of the Boga Mission Landrovers enabled an ambitious programme of work to be achieved.

Useful discussions on the SWS system and its impact were held with Tim Rous and Dr K M Lusi, Medecin Chef du Zone (Medical Officer in Charge of the Zone) responsible for a large public health programme. Full co-operation and much invaluable help was also given by the hospital and mission staff at Nyankunde and Boga.

5.2 Sites

The terrain in this region of Zaire is mountainous with a sharp escarpment falling to Lake Mobutu on the East side and steep slopes down to the West. This ridge which runs approximately North-South incorporates the Ruwenzori Mountain range and provides a continental divide between the Eastern watershed leading to the Nile and Mediterranean and the Western watershed leading to the River Zaire and the Atlantic Ocean. The country is green, and abundant rainfall in the rainy season provides many hillside and valley springs. During the dry season many of these dry up, often causing acute local water shortages. Access and communications to the sites was very difficult and required a four wheel drive vehicle. It was certainly felt by those locally involved that transport difficulties hindered the development of water supplies and efforts were being made to improve this aspect of infrastructure.

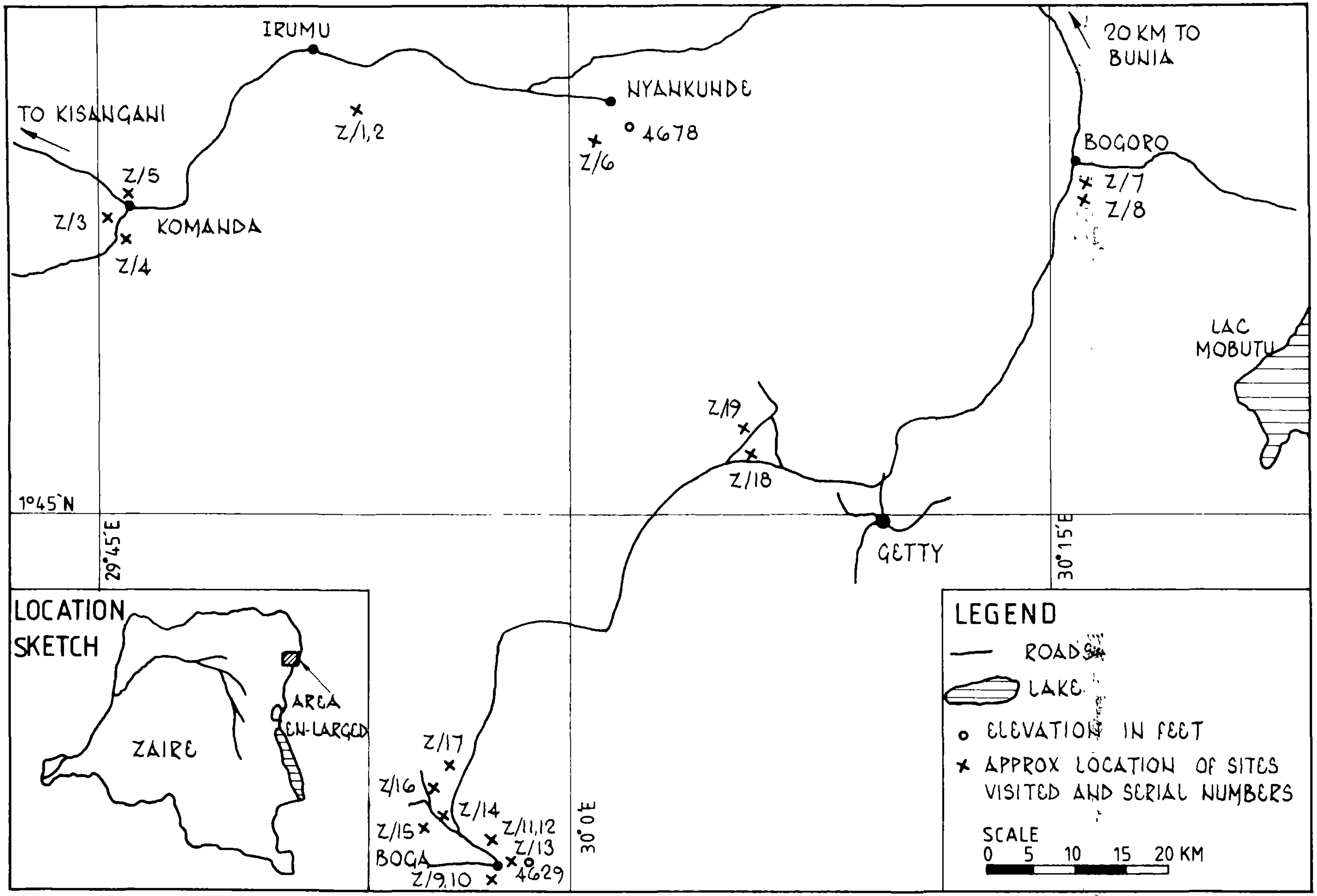


Fig. 5.1 SITE LOCATION MAP - ZAIRE

The sites visited in Zaire fell into two categories: (a) gravity fed installations using hillside springs and (b) valley bottom installations using spring or stream water. Except in one case where an SWS village unit was in operation, the installations utilised SWS mini filters as described in Section 2.3(a). Some traditionally protected spring sources were also examined for comparative purposes.

The great majority of people were subsistence farmers although at some sites the users were predominantly teachers or hospital workers. The number of people served per installation varied between 20 and 500.

5.3 Fieldwork

The duration of the fieldwork was approximately two weeks as can be seen in detail in the itinerary Appendix A. The physical data were recorded and the various tests (as described under Section 4.2) were carried out at 16 SWS sites, and at three typical traditionally protected springs. Details of these sites are summarised in Table 5.1. In addition to this, staff at Nyankunde Hospital and Engineer Tim Rous were taught the techniques involved in bacteriological water testing and the necessary underlying theory, enabling them to make full use of the equipment. Lectures and demonstrations were given, on request, to the students of Nyankunde Hospital and these were well received.

Table 5.1 - Filter Sites Investigated in Zaire

Ref No	Location/Site Name	Type of Installation
Z/1	Ndoya	SWS protected spring - valley bottom
Z/2	Matete	" "
Z/3	Komanda 1	" hillside
Z/4	Buliki	Traditionally protected spring -hillside
Z/5	Komanda 2	" "
Z/6	Mdododo	SWS protected spring - hillside
Z/7	Bogoro	Traditionally protected spring -hillside
Z/7	Berunga	SWS protected spring - hillside
Z/9	Boga Mission	" - valley bottom
Z/10	Rakaikara	" - hillside
Z/11	Chororo	" - valley bottom
Z/12	Karbarole	" - hillside
Z/13	Kahwa	" - valley bottom
Z/14	Kabaganzi 1	" - hillside
Z/15	Candip	" - hillside
Z/16	Kabaganzi 2	" - hillside
Z/17	Mutega	" - valley bottom
Z/18	Kabalu	" - hillside
Z/19	Chekele	" - hillside

6. UGANDA

6.1 Programme

The field operation in Uganda took place in Kumi country and centred around Ngora Town. The programme was curtailed because of the lack of working systems and only three days were spent in the field.

Extensive co-operation and help was given by the staff of the Water Development Department at Entebbe who made available an engineer, Mr Moses Guava, a Landrover and driver for the visit to Ngora. The staff of Ngora hospital gave valuable assistance with living accommodation and with locating the installations giving details of their history.

6.2 The Sites and Field Work

The terrain itself is flat with large outcrops of granite. Extensive areas are under swamp and the region is relatively well provided with surface water although many villagers have to walk great distances in the dry season when nearby sources dry up. The location of the sites visited are shown in Fig. 6.1.

Since all the previously installed sets were inoperational and had been abandoned at the time of the visit, investigations were limited to visiting the sites and also examining a few traditionally used sources. Bacteriological and other water tests were carried out at these sites at the request of those locally involved with water supplies. Useful discussions were held with some of the people responsible for the installation and maintenance of the SWS systems. Contact was made with people who intend to install SWS equipment at Tororo, near the Kenya border on the road between Jinja and Mbale, and information on their particular problems and concerns was obtained.

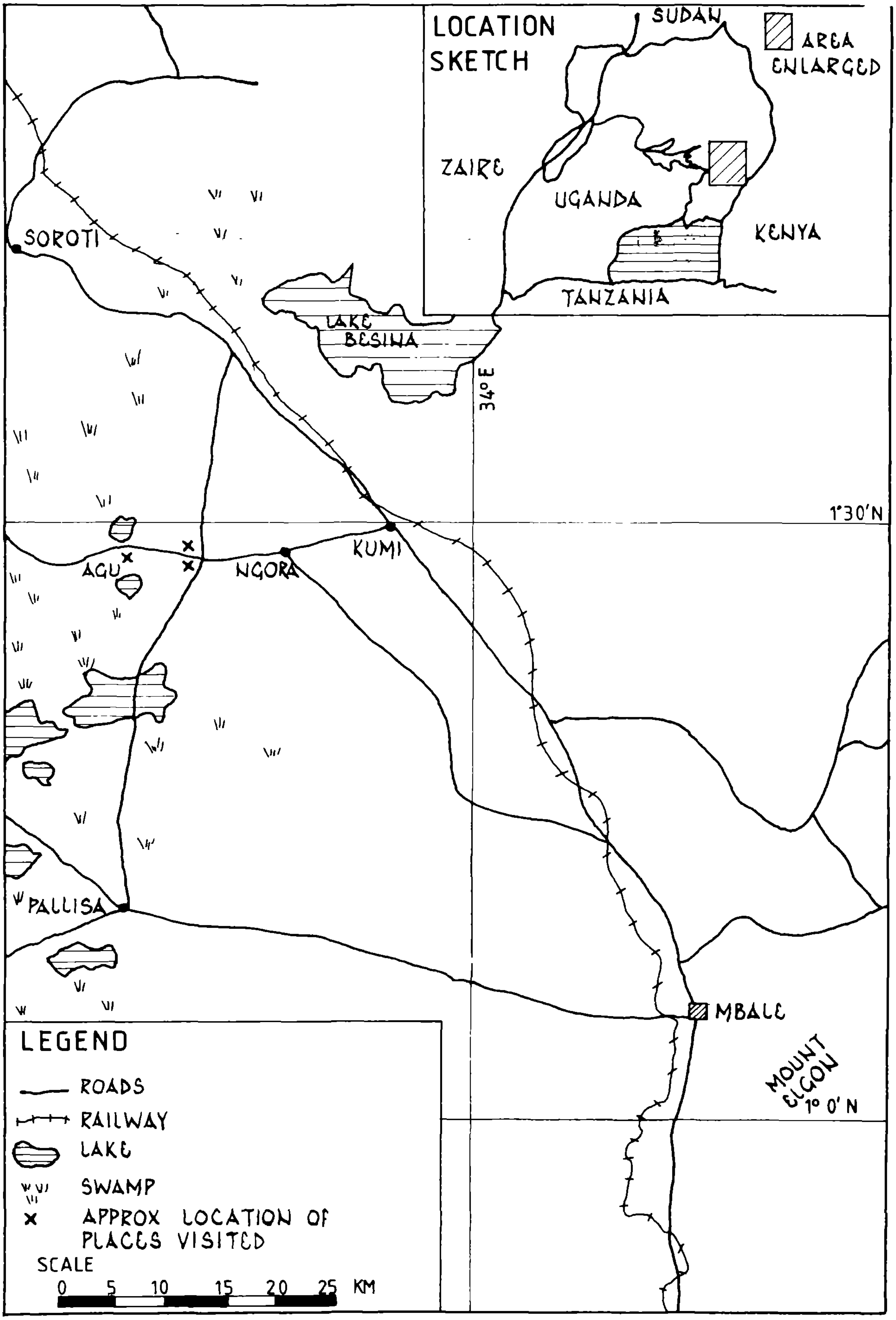


Fig. 6·1 SITE LOCATION MAP - UGANDA

7. SUDAN

7.1 Programme

The field programme in Sudan was carried out in the Gezira area, Central Region. The main part of the work was done in a small area near Abu Usher, known as the "Blue Nile Health Project Study Zone" (BNHP); other sites were also visited to the North of this zone (see location map, Fig. 7.1).

Blue Nile Health Project Engineers, Mr Sadiq Abdel Basit, and Mr Denver Brown, and Public Health Inspector, Mr Gimeel, accompanied the team on the first few visits in the area, were helpful in assisting with supplies and arrangements for the bacteriological testing and in the recording of the previous history of the sites. Very interesting discussions on the SWS systems, their history of use and impact on the project were held with the engineers mentioned above and other senior staff at the Blue Nile Health Project, Dr Omar Tameim, Dr Haridi, Unit Directors, and Mr Waziri, Public Health Superintendent, Dr Alan Fenwick, parasitologist, and others.

Full co-operation and assistance was given by the Blue Nile Health Project in providing accommodation and transport. The British Embassy, Khartoum, gave valuable help with fuel for transport and general support. The efficient transport and accommodation arrangements made for the field team and the relative ease of access and communications enabled very intensive investigations to be undertaken.

7.2 The Sites

The sites in Sudan were situated in the irrigated area known as the Gezira, between the two Niles and South of Khartoum. The terrain is flat and regular and dominated by the rich brown cotton soil. The climate is arid with very little vegetation other than irrigated crops.

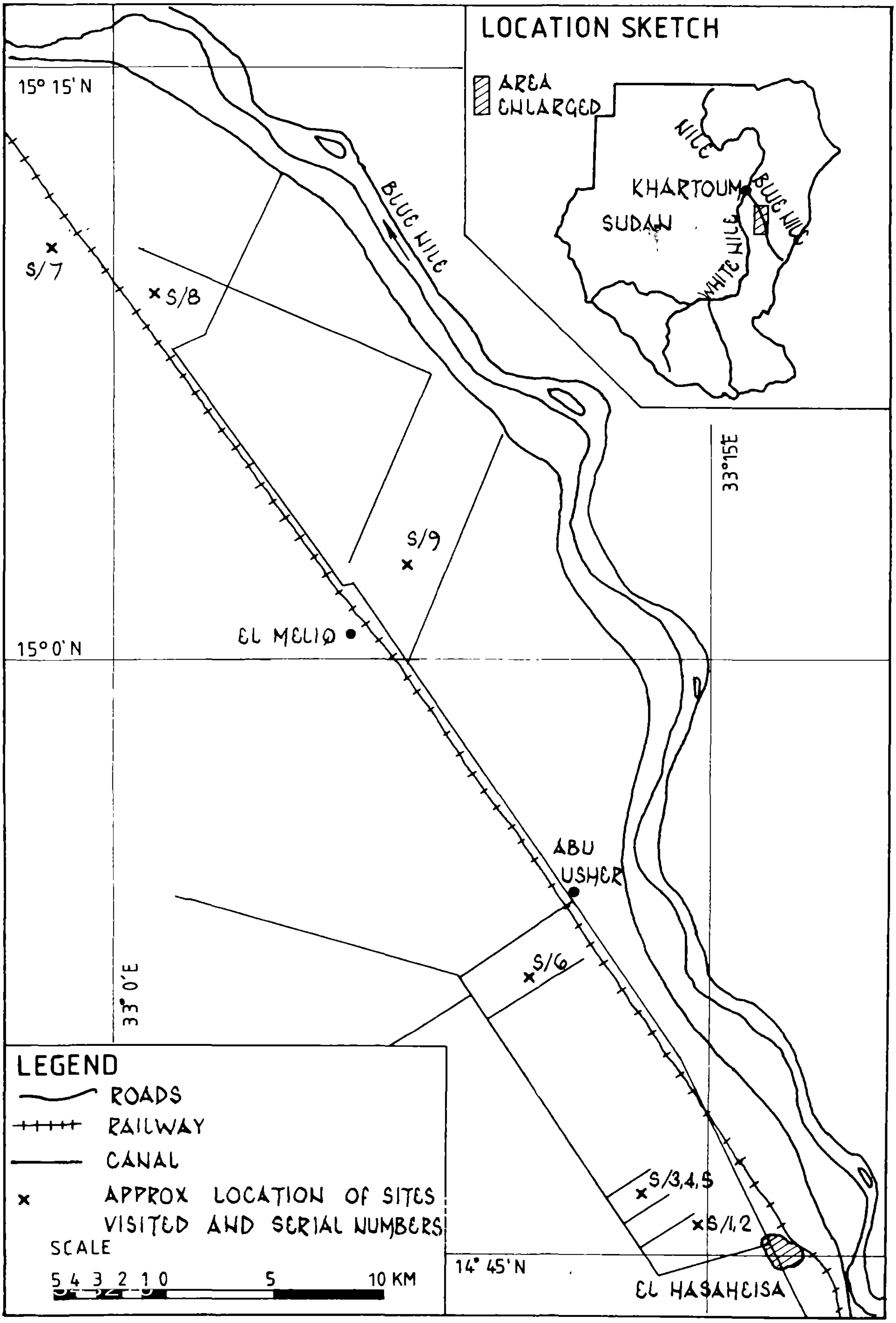


Fig. 7·1 SITE LOCATION MAP - SUDAN

The SWS installations which were the mini containerised type described in Section 2.3(b), were placed in either (a) field ditches known locally as abu ishreens, or (b) minor canals. They serve the needs of unregistered and therefore not officially recognised villages. The inhabitants of these villages are agricultural workers who have migrated from elsewhere to live and work on the irrigation scheme. The size of the villages served varied between 50 and 500 people and in general no other water supply is available to them except raw canal or ditch water.

The silt content and quality of the raw water varies tremendously over the year. The field team's visit coincided with the oncoming rainy season and the units were thus examined under the most arduous and silt laden conditions.

Access and communications are reasonably good except temporarily during rainy periods when the area becomes virtually impassable.

7.3 Field Work

Field work in Sudan was carried out for 11 days and the close proximity of six of the sites within the BNHP zone enabled very intensive tests (as described under Section 4.2) to be carried out at these locations. Three sites first visited on 22.6.85 had been in operation for three weeks since being last maintained. After the tests and examinations had been completed these installations were overhauled. The maintenance procedures were thus viewed and subsequent tests enabled the performance of the system to be examined on a daily basis as the filter mats became increasinly silt laden. Three sites north of the BNHP zone were also visited. A list of sites investigated is given in Table 7.1.

Table 7.1 - Filter Sites Investigated in Sudan

Ref No	Location/Site Name	Type of Installation
S/1	Shagra 1	SWS mini containerised unit - double filtration
S/2	Shagra 2	SWS mini containerised unit - double filtration
S/3	Jubara 1	SWS mini containerised unit
S/4	Jubara 2	"
S/5	Jubara 3	"
S/6	Tama	"
S/7	Wadelamin	"
S/8	Ashara Nafi	"
S/9	Warali	"

The two locally accepted alternatives to the SWS system; boreholes and slow sand filtration were also investigated and provided useful data for comparison. The public health inspector, Mr Gimeel, was taught the techniques involved in bacterological water testing enabling him to make full use of the equipment.

8. NIGERIA

8.1 Programme

The field work in Nigeria was carried out in Plateau and Kano States. In Plateau State the sites were visited with Mr Derek Joy who was responsible for their installation. Difficulty of access to the sites during the wet season hindered attempts to investigate more installations. In Kano State where the installations were under the auspices of the Kano State agricultural and river development authority, KNARDA, three main areas were visited centred around Rano, Birnin, Kudu and Hadegia. Mr Peter Aagard, Project Manager, assisted in arranging the visit.

Full co-operation and assistance was given by Mr Derek Joy and staff of Jarawan Kogi School in Plateau State and Mr Aagard and the staff at the various zonal headquarters of the KNARDA project in Kano State.

8.2 The Sites

The terrain in Plateau State is mountainous with large and picturesque granite outcrops. The climate is mild and rainfall relatively abundant.

The terrain in Kano State is much flatter and traversed with slower moving rivers than Plateau State. The climate is more arid although vegetation cover is still quite heavy.

The sites visited were of two types. Those located in Plateau State were of the original sub sand river bed extraction type and those in Kano State were a jetted tubewell system which had been developed by SWS. Both types are described in Section 2.3(c) and (d). In Plateau State the sites are predominantly situated in a mountainous terrain and installed in sandy river beds, some of which carried quite fast flowing streams. Fig 8.1 shows the approximate locations of sites visited. Accurate maps were not available.

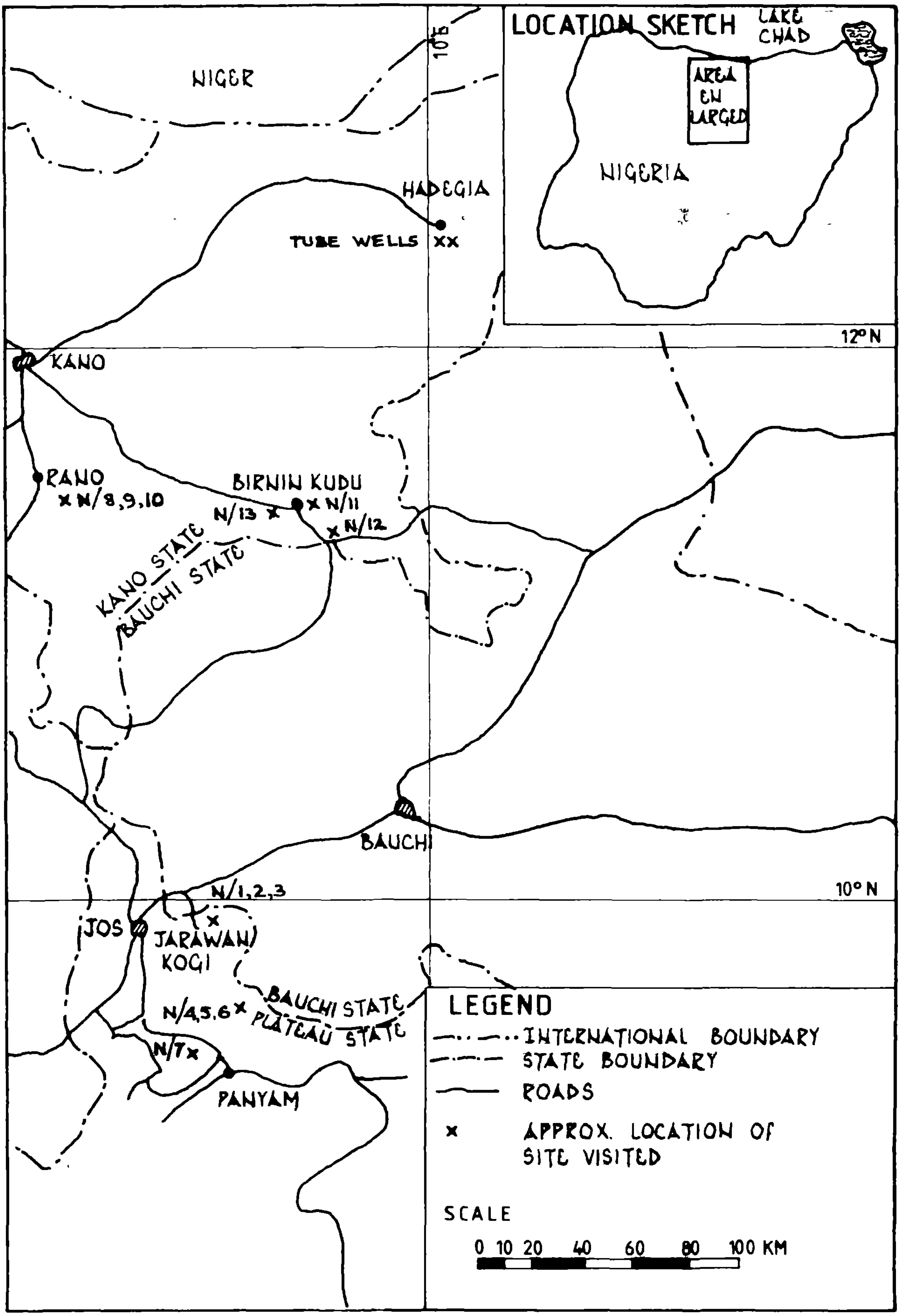


Fig. 8·1 SITE LOCATION MAP - NIGERIA

8.3 Fieldwork

Fieldwork in Nigeria was carried out for a period of three weeks of which two were spent in Plateau State and one in Kano State. The data recorded and tests carried out were as described in Section 4.2.

One unit in Plateau State was installed during the visit and the installation procedures and development of the system were thus viewed, providing valuable insights into the practicality of the methods. Repeat tests were very difficult to obtain because of the transport difficulties and most sites were only visited once.

In Kano State the SWS-developed washbore system served as a very useful and direct comparison to the buried village type unit as their usage in sub sand river bed extraction is very similar. Some tubewells were also examined as a more conventional solution to water supply in the region. The distances between the sites meant that only one visit was made to each site.

The functions of jetted wells or washbores and the buried village or camp units are identical. Where the sand is deep (in excess of 2m), the jetted wells have the advantage of a greater capacity for water extraction, but they normally require equipment in the form of mechanical pumps for the jetting and development process. The bacteriological performance of the jetted wells examined in Nigeria was good (Appendix D, N/8 to 12).

PART III

9. PERFORMANCE - PHYSICAL

This chapter describes the team's observations of the physical performance of the installations examined. In a number of cases, systems had been installed in ways which did not comply with the supplier's specifications. Poor performance and failure were attributable both to incorrect installation and use of the equipment and to problems arising from operation and maintenance. Guide-line specifications for SWS Spring protection, SWS Mini-Filter Containerised Systems and Sub Sand River Bed units are given in Appendix F.

9.1 SWS Spring Protection: Zaire

(a) Installation

A total of 16 sites of this type were examined in Zaire. The arrangement is described in Section 2.3(a) and in Appendix F.

The most common departures from the specifications were (a) the absence of a 200-300mm layer of sand, and (b) the absence of cut off trenches to reduce surface infiltration. Suitable coarse sand was often unavailable in the vicinity of the sites. Fine sand was found and tried but resulted in clogging of the system beyond repair. Backwashing and the development of the fine sand layer was attempted but without success. Fine sand entered the handpumps supplied and caused damage; the Patay pump's valves were prone to being held open with sand grains and the cylinder of the Rower pump was scoured by sand trapped between it and the piston. Small petrol pumps were considered by the engineer involved unsuitable for this type of self-help development.

The digging of cut off trenches was made the responsibility of the users, but was only occasionally carried out. This is very effective in reducing the surface infiltration on steep sided spring locations but less so on flatter slopes or in valley bottoms. The cut off trench and many other practical details are common to both SWS protected springs and other traditional systems. All are prone to the same difficulties and limitations.

(b) Operation

Of the 16 SWS sites visited nine were gravity fed and the others used hand pumps. The gravity systems require no manual operation, except the use of a tap where the storage of water is necessary. The flow rate and the potential number of users depend on the characteristics of the spring itself. The turbidity of the water was usually well within acceptable standards, as might be expected of spring sources. Test results have shown very little difference in the quality of water between SWS and traditional spring protection systems. The main advantage of the SWS system is the reduction of clogging problems.

(c) Maintenance

The SWS gravity systems are virtually maintenance free and in this regard are superior to traditionally protected springs which seemed to be more prone to blockage. The materials, filter screen, PVC pipe and connections proved very durable although not indestructible, e.g. galvanised iron piping was broken, probably by children playing on it.

If a cheaper screen, such as is being currently developed by SWS Ltd, were used, the system would be more cost effective. A screen that could be manufactured in developing countries would also be an important advantage.

9.2 SWS Containerised Mini Filters: Sudan

(a) Installation

This system and its common variations is described and illustrated in Section 2.3. In total 9 units of this type were visited in Sudan (site numbers S/1-S/9) and several abandoned sites were seen in Uganda.

The main features of the specifications that were not complied with were (a) the provision of suitable sand in the filter boxes, and (b) the arrangement of the filter mats.

Suitable sand was said to be extremely difficult to obtain in this region of Sudan and in view of this, sifted road gravel was used instead. The gravel, however, is coarse and cannot take the place of sand. Indeed, it has been said by one of those involved in the initial installation of the systems, that the gravel served primarily as ballast to keep the buoyant plastic container down and not as a filter medium.

As specified, one of the three layers of filter mat should be placed within the filter medium, just above the filter screen. This was not done in any of the units examined. Furthermore, the two layers of filter mat at the top of the container, should be in contact with the upper surface of the filter medium. This also was not done.

The difficulty of complying with the specification for the sand medium is a feature of the system that detracts from its purpose as a simple and cheap method of water treatment. To be properly effective, suitable sand would have to be found, imposing local costs and complications that have proved to be beyond the capacity of those involved in the installations.

It should also be noted that the SWS Ltd practice of sending out trial units for development by those locally involved has led to many non standard installations being used and a great deal of experimentation and understandable confusion over specifications. It is also true, however, that this has led to several very notable improvements in Sudan such as the provision of a clamp to prevent bypassing of the filter cloth and sturdy pump stands.

Within the limitations and constraints of the conditions in Sudan it would be fair to say that rigid compliance with the specifications is very difficult and compromises have resulted. These compromises have been implicitly accepted by SWS Ltd, as a report[9] written in February 1984, following a visit to Sudan shows. It was also recognised by SWS Ltd and others that a more professional engineering approach was required. Under the ODA technical co-operation programme this has now been arranged with the engineering unit of the Blue Nile Health Project.

Another considerable difficulty facing the SWS installations in Sudan is the position of the villages that they are designed to serve. Many of these villages are quite remote from the nearest permanent sources of water, usually minor canals. Most of the units have been installed in field water courses known locally as Abu Ishrins which, because they are part of the irrigation supply system, are supplied with water intermittently and in rotation. Normally the head gate or outlet pipe of a water course used for domestic supply is opened until the water course is full, and is then closed until the water course is almost empty and needs refilling. This results in a very unreliable water supply. Any water supply system utilising such a source of water would be subject to these severe limitations and a large storage capacity would be needed in times of intermittent supply.

These periods of inoperation have probably been a partial cause of the neglect of the systems. There is some evidence to show that units installed in minor canals, e.g. Wad el Amin, serial number S/7, have been more successful than those installed in field ditches, (serial numbers S/8 and S/9), where the units were completely abandoned.

Modifications incorporating double filtration, and the use of reservoirs are described in Section 2.3. Units serial numbers S/1, S/2 utilised double filtration with a cement lined reservoir which, when visited, was having a wooden cover fitted to it. Before this, the filtered water in the reservoir was open to wind blown contamination.

(b) Operation

The operating conditions for the filter units in Sudan vary throughout the year. The field team's visit coincided with the annual Blue Nile flood and consequently the irrigation water was extremely silty. The installations were thus examined under the most arduous conditions.

With the very high flow rates per unit area of filter medium associated with the SWS filter system large quantities of silt could be expected to be trapped by the filter cloth and this was indeed the case. However, the filters appeared to continue functioning over the ten days they were monitored, although there was an increasing strain on the pump. Since the units are operated by hand pumping operation is amenable to all people, children and adults.

(c) Maintenance

Experience in Sudan has shown that satisfactory maintenance requires a team specially trained for the purpose. Photo No 2 shows maintenance taking place. After the first day of monitoring tests had been completed all the units, S/1-S/6 in the BNHP Study Zone underwent maintenance. The following points were noted during this process.

maintenance undertaken since installation at six units in the Study Zone. Maintenance involves a considerable amount of senior staff time and the use and support of a vehicle. As breakdowns are not reported, frequent monitoring visits are required in addition to maintenance visits. It was felt by those involved that this level of maintenance could neither be sustained nor justified for units supplying such small numbers and depending heavily on imported materials.

The durability of the systems is poor. Some six units have broken down in Uganda. At two sites in Sudan S/8 and S/9, multiple units were found to be derelict. Although the complete breakdown of units is often associated with pump failures and this is discussed in Section 9.4, there are also serious problems with the durability of the other parts of the equipment. There are numerous abandoned filtration units lying in maintenance centres at two locations in Sudan. The stainless steel screen itself is virtually indestructible and the plastic container box is only known to have split once or twice. The hoses, however, are continuously subject to splitting and breakage and the important clamping device for the filter cloth frequently gives rise to problems because of rust and because of the weakness of the plastic rims of the container. The filter cloth itself, whether because of the action of the sun, the water, silt and algae growth or just because of rough handling, needed replacement in five of the six units that underwent maintenance. Under silty conditions the cloth is subject to a great deal of strain as it heaves in and out with the action of the pump and it becomes very thin.

Table 9.1 Maintenance undertaken at Six SWS Installations in Sudan, December 1984 to June 1985

(as recorded by the BNHP engineering unit Staff)

Name	Serial No	Dates	Maintenance Description	
			Filter Unit	Pump
Shagra	S/1	12/84	New unit installed 2 changes of filter mat, hoses repaired.	Original Rower Pump 1 change of pump washer. 1 change of Rower pump because of rim wear (old model).
		6/85	1 change of filter	
	S/2	12/84	New unit installed. 1 filter box broken and replaced.	New Patay pump installed. 4 Patay DD120 pumps changed.
		6/85	1 change of filter mat.	
Jubara	S/3	12/84	New unit installed. 2 changes of filter mat.	New Patay pump. Diaphragm changed, handle replaced.
		6/85	Hose repaired.	
	S/4	12/84	New unit installed. 2 changes of filter mat.	New Patay pump. Change of pump.
		6/85	Hose repaired.	Diaphragm change.
	S/5	12/84	New unit installed. 2 changes of filter mat.	New Rower pump.
		6/85		
Tama	S/6	12/84	New unit installed. 1 change of filter cloth. 2 repairs to hose.	New pump installed. 1 change of diaphragm.

Note: Maintenance usually involved the change i.e. replacement of the filter mat. Sometimes just the top layer was changed with the other two still being strong enough to be washed and used again.

The earlier oil barrel reservoirs used in the double filtration systems have been superseded by cement lined tanks because of corrosion of the metal.

(d) Filtration performance

The rate of filtration using the Patay DD120 pump can be 10 gal/min on an area of 1.5ft^2, equivalent to 19m^3/m^2/hr, which is nearly 100 times the normal rate for slow sand filtration of 0.2m^3/m^2/hr. As the rate of filtration depends on the capacity of the pump and the vigour of its operator, lower rates can be applied but these are not the practice as observed. The filter medium is a 3mm gravel less than 300mm in depth, compared with 1m depth of 0.15 to 0.35mm sand in normal sand filters.

Some observers have made superficial comparisons between the polluted ditches and the filtered water, leading to statements such as: "..... the canal water was grossly polluted ... by the time the water has passed from a filter in the canal to the reservoir and then been pumped out through a second filter in the reservoir its appearance was dramatically improved."[9] This is a common and understandable comment. However, the comparison is not valid because the canal water seen against silty banks is not being viewed under the same conditions as the filtered water held up to the light in a glass; both the depth and degree of luminosity are very different. When samples from the canal and the filtered water are both compared in sample bottles, observers find it impossible to tell the difference. The turbidity measurements (see Appendix E, S/1 - S/6) show that very little or no reduction in turbidity takes place. There have been some suggestions that this is due to the colour of the canal water which cannot be removed even by conventional methods such as slow sand filtration. However, the team's results (Appendix E, S/7) find that the turbidity was reduced by a slow sand filter to <5 JTU.

A curious result of the investigation was that no reduction in turbidity or indeed in bacteria levels took place during the ten day testing period after maintenance. At Jubara settlement, for example, three units were installed. Serial No S/5 was coupled to the less popular Rower pump and sited further from the village than S/3 and S/4 which were coupled to Patay pumps.

Within a day of maintenance having been carried out S/3 and S/4 were covered with a dark sediment whereas S/5 was still relatively clean (having been less used). When the pump was operated on the more heavily used units the filter cloth was seen to heave in and out with the pump action and the deposited sediment lift off its surface. This form of sediment bypass may explain why the filters did not become clogged sooner and also why the filter performance in terms of turbidity and bacteria removal did not improve as might be expected with increasing usage.

9.3 SWS Sub Sand River Bed Units: Zaire and Nigeria

This system is described and illustrated in Section 2.3. A total of 7 sites were visited, No Z/17 in Zaire and Nos. N/1 to N/4, N/6 and N/7 in Nigeria. The unit in Zaire was incorporated in a spring protection and not in a river bed.

(a) Installation

The systems of this type generally complied with specifications very well. Installation is easy but needs strict supervision to ensure that the unit is put deep enough into the sand bed. This cannot be done during periods of heavy river flow and the drier periods of the year are reserved for this activity.

The main feature that gives rise to difficulties is the development of the in situ filter medium, i.e. the river bed itself. The petrol engine pumps that had been supplied in

Nigeria were out of use. At one site where a unit was installed during the field team's visit the development of the filter was attempted with a DD120 hand pump. After a short time the handle snapped and the development and use of the unit had to be delayed until the handle could be replaced.

(b) Operation

The operation of the units themselves presented no difficulties other than those commonly experienced with hand pumps. During the dry season when the river water may fall below the bed surface the units will continue to function provided they are buried deep enough. This is of great practical advantage and the units were reported to be heavily used during this period. During the wet season when alternative nearer sources of water are available, the units are not used so much and are often removed. This had been done at Site No. N/2 as a precaution against theft which is prevalent. Sites N/1 and N/3 were incomplete because the filter boxes, pumps or both had been stolen. This demonstrates the vulnerability of portable systems to theft.

(c) Maintenance

The maintenance required (other than for the pumps) is confined to tightening hose connections and repairing split or damaged hoses. The durability of the filter boxes themselves is very high.

(d) Performance

Provided the equipment is installed correctly, its filtering performance depends on the quality of the natural river bed material as a filter medium. The site visits were, unfortunately, made during the wet season, when many units had been removed from river beds and only two sites had units in place which could be monitored. Site N/6 was a fast flowing stream with a heavy silt load. After pumping for 20 minutes turbidity was reduced from 1,000 to 500 JTU, but the outflow was still quite muddy and included fine silt and grit.

At site N/4 a unit was being installed at the time of the visit. Before development of the filter could be completed to bring the outflow turbidity down to the same level as the river water (which was very low at 10 JTU) the pump handle broke.

9.4 Jetted Well Screens: Nigeria

This system is described in Section 2.3. A total of 6 sites were visited, all in Nigeria.

(a) Installation

These installations were undertaken as part of the Kano State Agricultural and Rural Development Authority's programme. The jetted tube wells, known locally as washbores, were introduced by Richard Cansdale of SWS Ltd in 1982. A large number of these washbores have been installed, and they are used both for irrigation with small petrol engine pumps and for drinking water with hand pumps.

The systems were sited adjacent to sand bed rivers, where deep sandy aquifers could be found. The method of sinking the well screen enabled good penetration.

At one site a system was installed in a village more than 100m away from a river. The clay overburden was penetrated and the sand layer with its hydraulic connection to the river was thereby tapped. The depth of sand and the direct use of a well screen enabled easy and effective development of the natural aquifer and filter medium.

The specifications for installation have been rigidly adhered to and the resources and skilled manpower of this large project have been used to ensure success.

(b) Operation, Maintenance and Durability

The systems were operated by local farmers and villagers. This only required the operation of a pump. Maintenance was carried out by the project's central maintenance team. The maintenance problems stemmed either from pump malfunction or clogged screens. The washbores which were sited adjacent to large rivers were capped when not in use to prevent infiltration of muddy flood waters and debris. These caps were occasionally left off and the system thus blocked up.

The equipment is simple and very durable. Other than occasional accidental damage, breakages are uncommon. Theft, of components other than pumping equipment, is unknown and virtually impossible.

(c) Performance

The performance of the systems was excellent. At an extremely high discharge of 600 l/min water was delivered which was clear (turbidity < 5 turbidity units) and comparatively free of bacteriological pollution (See chapter 10). The water was filtered during its passage through several metres of sand.

9.5 Pumps

Three types of hand pumps have been supplied by SWS Ltd over the years for use with this filtration systems.

These are:

The Lee Howl semi rotary pump
The Patay lightweight alloy, double diaphragm pump
The SWS Rower pump

The Lee Howl pump (which is no longer supplied) has been generally recognised by all those involved as unsuitable for community rural water supplies as it is primarily a pump for

individual household use. This pump was a significant contributory factor to the failure of units in Uganda, and setbacks in the earlier Sudan programme. It is reported as having a very short lifetime and this was borne out by the observations of the field team. A list of pump defects, recorded in a paper by Elias[10] is given in Table 9.2.

The Patay pump has been supplied in two models, the DD70 and the DD120. These pumps have the advantage of a widespread acceptance by users. However, field experience has shown that these pumps too are unsuitable except for very small communities or individual households. A short extract from a recent SWS Ltd report on the programme in Sudan concludes:

> "In view of the findings, it will be suggested that the double diaphragm pumps are restricted to the very small camps with only a handful of houses ...."

The major problems associated with the Patay pumps are:

Snapping of the handle

Excessive pivot and handle socket wear

High discharge capacity (especially the large DD120 model) which is not matched to appropriate filtration rates.

A list of pump defects recorded by Elias10 is given in Table 9.3. Some of these are illustrated in Photos No. 8.

Although, as has already been stated, the failure of SWS installations, has often been caused primarily by pump failure, it must be emphasised that in many cases, and particularly when used with the mini containerised filter units, the operating conditions for the pumps are far too severe for the types of pump used.

Table 9.2 - Defects of installations with Semi-Rotary Pumps

Place and Installation Date	Inspection Date	Defect	Amendment
Warali (Abu Ishreen) 22.2.82	12.3.82	The wooden stand loosened.	Replaced by a triangle iron stand on 15.3.82. It fitted.
	15.3.82	Leakage in the plastic connector.	
	15.7.82	The pump body broken.	
10 Nafie (Minor) 8.3.82	15.3.82	The pump jammed.	Lubrication.
	16.3.82	The delivery hose broken.	Replaced by a metallic pipe.
	16.3.82	The wooden stand broken.	Replaced by the triangle iron stand.
	19.4.82	The pump body broken.	Replaced by a new pump on 22.4.82.
	15.6.82	The body of the replaced pump broken.	

Table 9.3 Defects of installation with the Patay Double Acting Diaphragm Pumps

Place and Installation Date	Inspection Date	Type of Pump	Defect	Amendment
Wad El Amin (Minor)	18.7.82	DD70B 1"	Diaphragm damaged.	Replaced.
18.7.82	27.2.83		Small socket screw broken	Replaced.
10 Nafie (Minor) 1st Station	27.9.82	DD70B 1"	Pump base broken.	Replaced by a pump on 19.10.82.
26.4.82	20.10.82		Leakage in diaphragm of replaced pump at 1st station.	Replaced by a new diaphragm
2nd Station 17.11.82		DD70B 1"	Water shortage.	Additional pump installed.
3rd Station 29.11.82		DD70B 1"	Pump base broken.	Replaced by a new DD70B 1" pump on 27.5.82.
(Minor)5.5.82	8.6.82		Base and handle of replaced pump broken.	Replaced by a new DD70B 1" pump on 20.8.82.
2nd Station (Abu Ishreen) 20.8.82		DD120B 1"	Water shortage.	Additional pump installed.
Warali (Abu Ishreen)	2.11.82	DD70B 1"	Diaphragm damaged.	Replaced.
5.8.82	20.12.82	DD120B 1½"	Water shortage.	Additional pump installed.
Wad Bella (Minor) 1st Station 5.8.82	29.9.82	DD70B 1"	1st Station Pump base broken.	Replaced by a new DD70B 1" pump on 19.10.82.
2nd Station 7.8.82	6.8.83	DD70B 1"	Water shortage. 2nd Station. Pump handle socket broken.	Additional pump installed. Replaced by new DD70B 1" pump on 12.3.83.

The extremely high flow rates per unit area of filter material in the containerised units and the dense silt layer that clogs the filter cloth impose a very heavy load on the pump. The effect pumping against this load results in excessive wear and a reduced life of the pump.

The SWS Rower pump has been developed from the original Bangladesh version which was used as a low cost irrigation pump. SWS Ltd have improved this pump for use in small African communities. These pumps proved to be very reliable and out of 10 seen only one was out of order and this was due to vandalism. Some of the others had been operating maintenance-free for more than a year. The only areas where attention was needed were the rubber piston washer which needed replacement once a year, and the steel spout protection which sometimes became dislodged through excessive use and caused wear on the less durable plastic cylinder section.*

It has been argued that the open ended nature of the water outlet point could result in greater contamination of the water than the more enclosed spouts common on other hand pumps. The field results show little different between the bacteriological quality of water from a Patay pump unit and a Rower pump unit using the same source of water (see Chapter 10). It is understood that a spout arrangement is being designed by SWS Ltd and this may overcome some of the objections although it may also add new problems of its own in terms of durability.

Most people preferred to use the Patay pump rather than the Rower and this is probably due to the slightly more difficult or awkward operation of the Rower pump. This is an important consideration since the users' preferences will often determine whether a system is actually used or, as has been observed, ignored in preference to traditional methods of water collection.

Overall, however, the Rower pump performed very well and is considered as one of the most suitable low lift pumps for rural water supply.

*** It is possible that the samples seen without steel spouts were early models, manufactured without steel spouts.**

10 PERFORMANCE - MICROBIOLOGICAL

10.1 Introduction

The bacteriological data were collected and analysed to evaluate the microbiological performance of the SWS system. No attempt was made in the present study to detect actual disease pathogens. The laboratory procedures required are much more difficult to apply under field conditions, and the detection of these organisms is in any case very haphazard in the field, depending on the presence in the vicinity of persons who are actually infected with them. Rather, the microbiological field work concentrated on faecal coliforms, which are always present in the faeces of all warm blooded animals including Man, and whose removal by any given process gives a good indication of the degree to which other bacteria, including disease pathogens, will also be removed.

In the context of the membrane filtration method, organisms which produce acid from lactose after incubation at 44°C for 14 hours, are presumed to be faecal coliforms organisms. These organisms have a characteristic morphology and colour when grown on a selective medium. Not all of these can in fact be assumed to be of the species Escherichia coli which is exclusively of faecal origin. In hot climates other coliform organisms (eg Enterobacter spp.) may give similar reactions to E-coli but may be of lesser hygienic importance.

Representative faecal coliform colonies isolated on the membrane filters were therefore subcultured onto nutrient agar slopes for storage and transport back to the UK. Subsequent confirmatory tests on these were performed using the APl 20 Enterobacteriacae system. Over 93% of the faecal coliforms examined were found to be strains of Escherichia coli.

Although faecal coliforms were present in all the surface waters tested, the vagaries of their distribution in the environment meant that the numbers detected in different samples, even from the same source, varied widely, as is normal in studies of this kind. Ideally a large number of tests should be performed over a long period of time, but this is always difficult to achieve in practice.

The results of the bacteriological and physical water tests carried out in Zaire, Sudan and Nigeria, are recorded in Appendices B, C and D respectively. No field tests were carried out in Uganda, as no working sites were found. Intensive consecutive daily monitoring of sites was carried out in Sudan and these field results are recorded in Appendix E.

Table 10.1 summarises these results and Figures 10.1 and 10.2 show them graphically. Because of the very wide variation in values of faecal coliform counts and turbidity, geometric rather than arithmetic means have been used in the summaries and logarithmic scales for these quantities in the figures. A measure of the range of the results is indicated by one standard deviation of the mean, calculated on a logarithmic scale. On average 68% of the test results from a particular source will therefore have fallen within the range shown.

Table 10.1 - Summary of Bacteriological and Turbidimetric Performance

Source or Installation	(2) Mean Faecal Coliform Count/100ml	(2) Mean Turbidity JTU	Number of	
			Sources	Samples
Springs (Zaire)				
Unprotected	298	30	5	5
Protected:				
Traditionally	27	5	7	8
SWS: hillside	35	5	10	13
SWS: valley bottom	110	10	6	11
Mini Filters(Sudan)(1)				
Raw irrigation water	236	80	5	45
SWS units	116	35	5	58
Slow Sand Filter(Sudan)				
Raw irrigation water	493	120	1	9
Filtered water	10	<5	1	14
River Bed Units(Nigeria)				
Raw river water	4970	100	2	1
SWS units	1080	100	2	1
Tube Wells (Nigeria)				
SWS jetted wells	8	10	6	6
Other tube wells	10	15	5	5
Nearby rivers	>2000	65	3	3

(1) Values taken over 11 consecutive days.

(2) Geometric mean values.

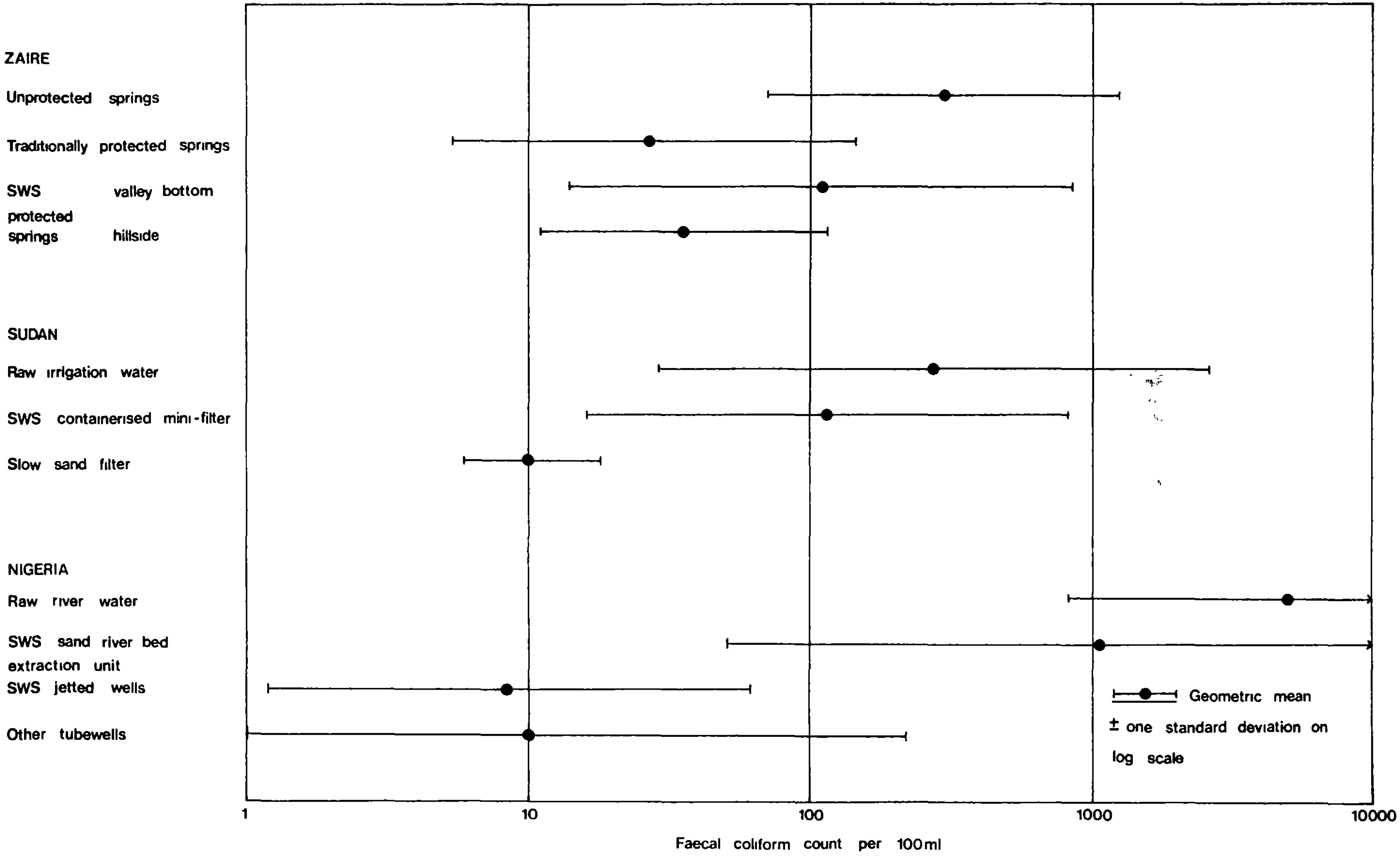


Figure 10.1 - Faecal coliform pollution in different water sources.

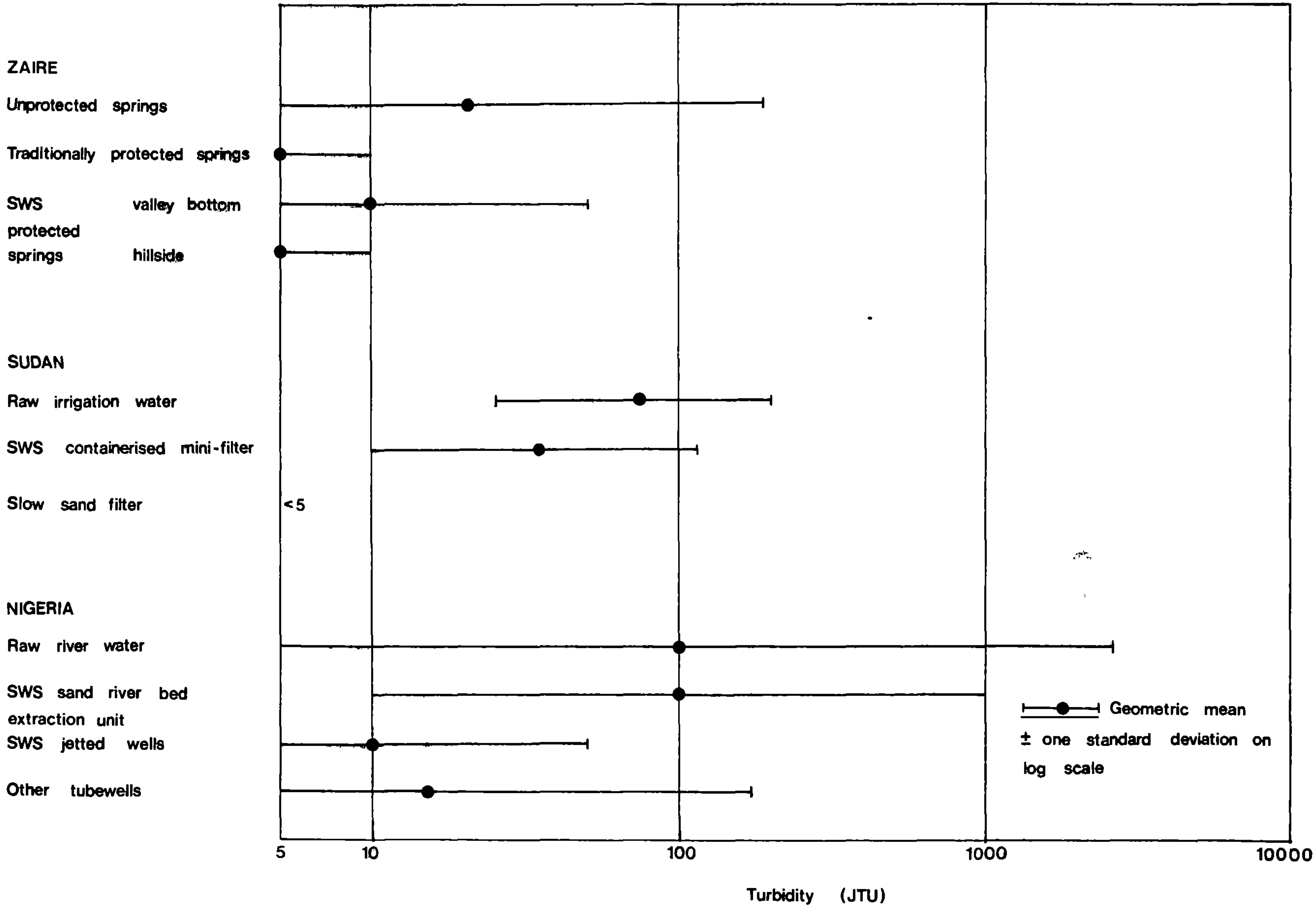


Figure 10.2 - Turbidity in different water sources.

Table 10.2 - Water Quality of Springs in Zaire

Site No	Name	No of Tests	Mean faecal Coliform Count per 100 ml	Mean Turbidity JTU
	Unprotected Springs			
-	Matete	1	30	15
-	Ngutu	1	210	40
-	Mdododo	1	1,050	350
-	Rubingo Kamuchali	1	883	<5
-	Boga Commercial Centre	1	400	<5
	Traditionally Protected Springs			
Z4	Buliki	1	50	<5
Z5	Komanda 2	1	90	15
Z7	Bogoro	2	10	<5
-	Gambili	1	390	<5
-	Kainana Mission	1	25	<5
-	Kainana Chief's	1	2	<5
-	Atekwa	1	11	<10
	SWS Protected Springs			
	(a) Valley Bottom			
Z1	Ndoya	1	8	<5
Z2	Matete	1	12	15
Z9	Boga Mission	5	543	<10
Z11	Chororo	1	1,260	200
Z13	Kahwa	2	281	<5
Z17	Mutega	1	98	<5
	(b) Hillside			
Z3	Komanda I	1	110	<10
Z6	Mdododo	2	166	<5
Z8	Berunga	1	60	<10
Z10	Raikakara	1	121	<5
Z12	Karbarole	2	5	<5
Z14	Kabaganzi 1	1	28	<5
Z15	Candip	2	20	<5
Z16	Kabaganzi 2	1	60	10
Z18	Kabalu	1	11	<5
Z19	Chekele	1	11	<5

10.2 SWS Spring Protection (Zaire)

The physical performance of this system is described in Section 9.1. In this case the SWS unit is not intended to function as a microbiological filter, as the spring is supposed to be protected from faecal pollution. Rather, its

purpose is to permit the passage of clean water without clogging of the outlet pipe by soil carried along it by the flow.

Of the 28 spring sources tested, 5 were unprotected springs, 7 traditionally protected and 16 SWS protected. The SWS protected springs consisted of 10 hillside and 6 valley bottom sources.

The mean faecal coliform counts for these sources covered a wide range, as will be seen from Table 10.2. From these results it would appear that, where natural sources are polluted, protection reduces pollution, and that protection is least effective with valley bottom sources.

10.3 SWS Containerised Mini Filters (Sudan)

Six SWS Mini Filter installations were examined in the Gezira, Sudan. Two of these incorporated double units. A slow sand filter constructed by the Blue Nile Health Project was also tested for comparison. The results are summarised in Table 10.3. In every case both the mean faecal colliform and turbidity in raw irrigation water were reduced by filtration. Generally, however, the reductions in the SWS systems were small and did not match up to the performance of the slow sand filter.

As will be seen from Table 10.3 the quality of the raw irrigation water varied extensively. At Shagra and Jubara the sources were tertiary irrigation channels (Abu Ishreens) - see Photos 3, and 5. At Tama and Wad el Amin the water came from Minor Canals - see Photo 2.

The results are shown in more detail in Table 10.4 and Figures 10.3 and 10.4, which present the mean results from the seven sites which were monitored intensively over the same period of 11 consecutive days. The field results of the intensive monitoring are given in Appendix E.

Table 10.3 - Water Quality of Filter Systems in the Gezira, Sudan

Site No	Name	No of Samples	Mean faecal coliform count/100ml		Mean Turbidity JTU	
			Raw Water	Filt'd Water	Raw Water	Filt'd Water
	Two-stage SWS Systems					
S1	Shagra (Rower pump)	) 9	>2000	582	35	15
S2	Shagra (Patay pump)	) 9	>2000	871	35	15
	Single-stage SWS Systems					
S3	Jubara (Patay pump)	) 10	>207	>185	70	35
S4	Jubara (Patay pump)	) 10	46	29	40	30
S5	Jubara (Rower pump)	) 10	40	15	40	25
S6	Tama (Patay pump)	10	947	361	285	240
S7	Wad el Amin	1	790	638	500	500
	Slow sand filter					
S7	Wad el Amin	14	493	10	120	<5

Since the SWS containerised Mini Filters in the Sudan had been installed in the context of a health project, one of whose specific objectives is the control of schistosomiasis, it is appropriate to note its performance in preventing transmission of this disease.

No tests of the filtered water for schistosome cercariae were carried out. Other research conducted in the Sudan[8] has shown that a negligible percentage of cercariae are filtered out by the fabric covering mat, 40% by a gravel filter medium, and 60% by sand and gravel together. It has been mentioned in Section 9.2 that snails were in fact found inside three of the six units observed, having either bypassed a badly fitting surface filter mat, or having been washed in during a previous maintenance. Many if not most of the cercariae shed by snails living in the unit will therefore still be present in the water abstracted from it. A similar proportion of cercariae present in canal water pumped through the unit are also likely to emerge at the pump outlet.

Table 10.4

Mean water quality at seven abstraction sites in the Sudan

Installation	Parameter	Consecutive Days										
		1	2	3	4	5	6	7	8	9	10	11
Raw Canal Water	Mean coliform count[a]	658	889	458	338	55	120	114	>1320	227	193	645
	Mean turbidity[b]	200	70	60	35	50	55	60	100	80	140	140
	Number of samples	1	3	5	6	6	5	6	6	5	6	5
Patay Pump Outflow	Mean coliform count[c]	400	510	180	483	75	81	199	1062	110	68	170
	Mean turbidity	200	100	50	25	25	30	30	50	30	90	90
	Number of samples	1	3	4	4	4	4	4	4	3	4	4
Rower Pump Outflow	Mean coliform count[d]	–	120	39	144	18	85	184	161	60	97	139
	Mean turbidity	–	60	10	10	20	15	10	10	20	30	45
	Number of samples	0	1	2	2	2	2	2	2	2	2	2
Total Outflow	Mean coliform count	400	355	108	323	47	82	194	566	86	77	159
	Mean turbidity	200	80	30	20	25	25	20	30	20	60	75
	Number of samples	1	4	6	6	6	6	6	6	5	6	6
Slow Sand Filter Outflow	Mean coliform count	–	24	8	9	18	7	12	13	8	4	–[e]
	Mean turbidity	–	<5	<5	<5	<5	<5	<5	<5	<5	<5	–
	Number of samples	–	1	1	1	2	2	2	2	2	1	–

Note : a. Geometric mean faecal coliform count/100ml sample.
b. Geometric mean turbidity measured in Jackson Turbidity Units.
c. 4 pumps tested each day.
d. 2 pumps tested each day.
c. Canal level fell below filter intake pipe.

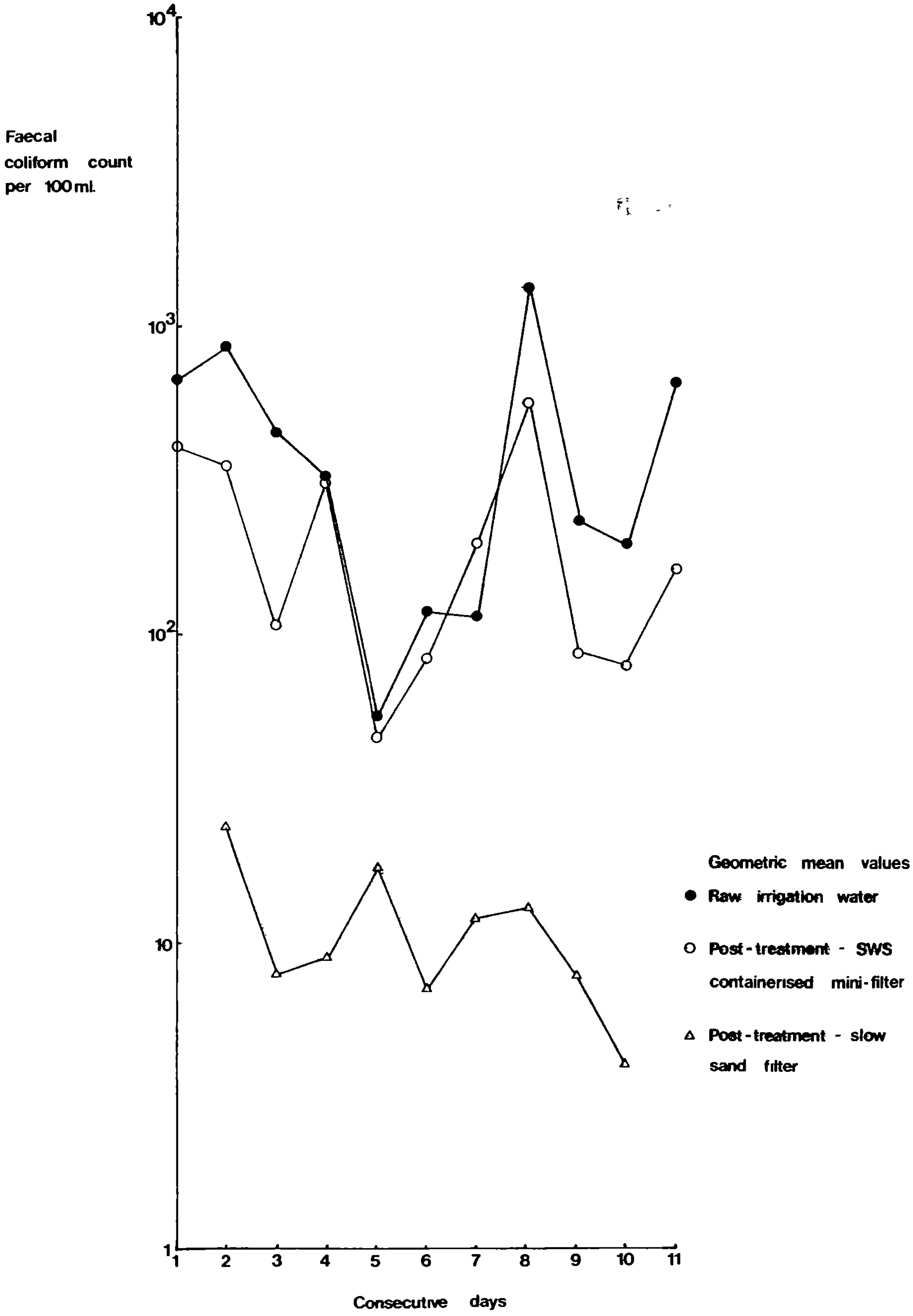


Figure 10.3 - Changes in coliform counts in irrigation water, Sudan.

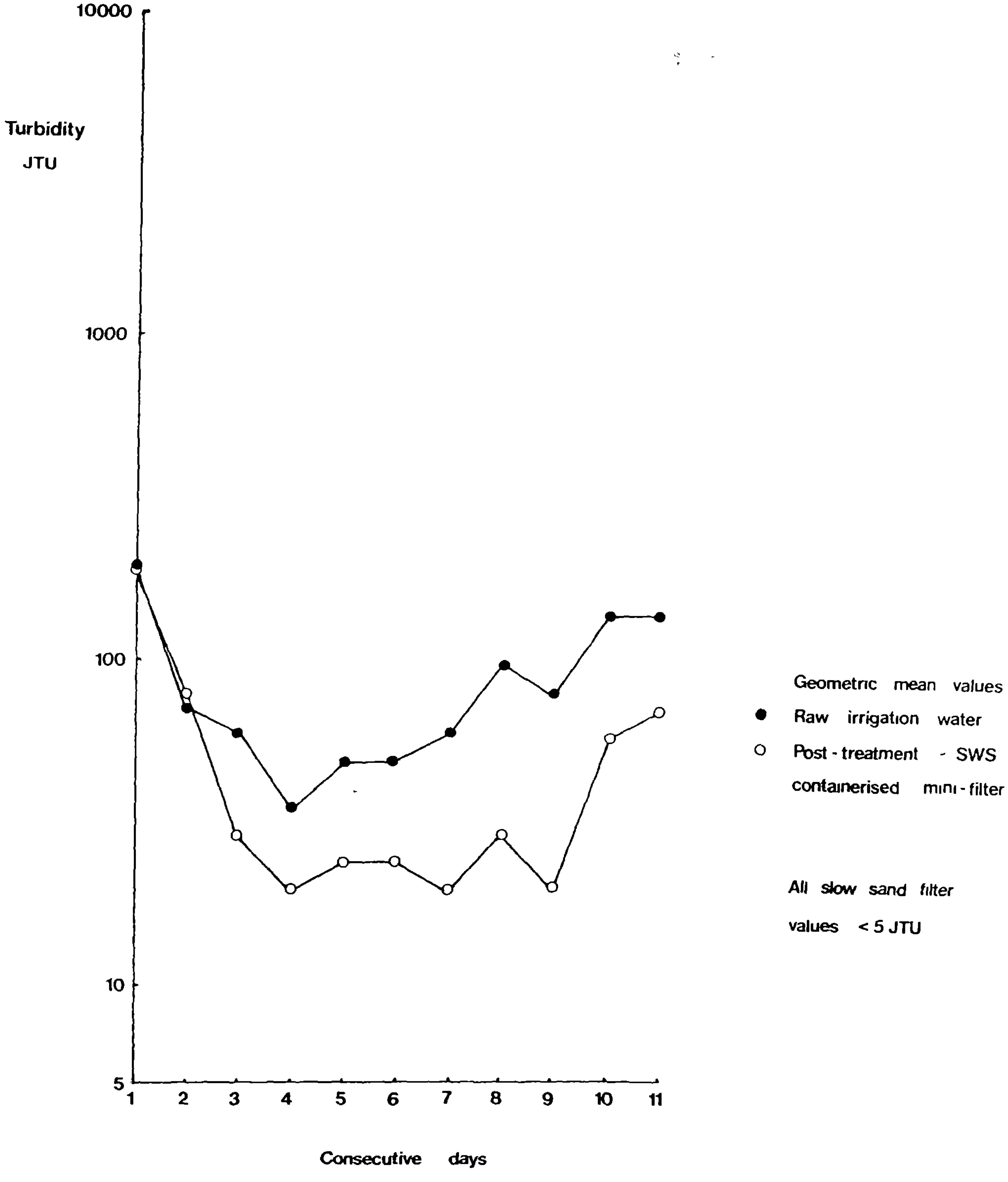


Figure 10.4 - Changes in turbidity in irrigation water, Sudan.

Most potentially waterborne pathogens, particularly bacteria, must be ingested in considerable numbers, typically in thousands, if they are to have any significant probability of causing infection. On the other hand, with helminths such as schistosomes, a single organism is sufficient. Thus, whereas a small number of faecal bacteria may be permissible in water, there is no safe level for schistosomes[11]. To be effective, therefore, schistosome removal should be complete.

Schistosome cercariae can be highly motile and are not reliably removed by sedimentation, even with coagulation. Rapid sand filtration is also ineffective although slow sand filtration will remove 99 - 99.9% if correctly operated. Chlorination at a sufficient dose effectively kills cercariae, and allowing water to stand for 48 hours (without further contamination) also renders cercariae non-infective.

10.4 SWS Sub Sand Bed River Units (Nigeria)

Only two of these units were examined in Plateau State, Nigeria, because, due to the field visit being made during the rainy season, many existing installations were not in use. The results from these two sites are given in Table 10.5.

Table 10.5 SWS Filter Systems in Nigeria

Site No	Name	No of Samples	Faecal coliform count/100ml		Turbidity JTU	
			Raw Water	Filt'd Water	Raw Water	Filt'd Water
N4	Barakesh	1	1,410	125	<10	20
N6	Marish	1	17,500	9,260	1,000	500

At both sites filtration produced a reduction in faecal coliform counts, the reduction being very much greater at Barakesh (N4). At Maresh (N6) sand was found in the filtrate, and the river was in flood at the time of testing.

10.5 Jetted Well Screens (Nigeria)

As with the SWS protected springs discussed above, the function of the well screen here is not to remove disease organisms but to hold back solid particles which would clog the well, as the groundwater should already be of good quality.

Table 10.6 presents results from six wells (3 to 7m deep) jetted with the SWS technique and, for comparison, from five other tube wells (15 to 20m deep) in the same area. The microbiological quality of the water was particularly poor at two sites (Hamdullahi and Kiyako 2), but the water at both of these was visibly very turbid, indicating some serious defect in the installation of the tubewell or the pump. At the other sites, wells of both kinds were producing water of relatively good quality, certainly much better than that of the adjacent rivers, which generally had over 2000 faecal coliforms/100ml. (Table 10.6).

The performance of jetted wells can therefore be considered satisfactory from the microbiological and public health point of view.

Table 10.6: Tube wells in Nigeria

Site No.	Name	Faecal coliforms/100ml	Turbidity JTU
	SWS Jetted Walls		
N.8	Lausa 1	1	<5
N.9	Lausa 2	29	75
N.10	Lausa 3	5	<5
N.11	Kiyako 1	17	<5
N.12	Gwaram	1	<5
N.13	Hamdullahi	150	>75
	Other Tubewells		
..	Maragwado	62	<5
..	Hago	0	<5
..	Kadume 1	0	<5
..	Kadume 2	11	<10
N.11	Kiyako 2	600	1000
	Nearby Rivers		
N.8, 9, 10	Lausa	>400	<5
N11	Kiyako	>2000	50
N12	Gwaram	9250	1000

10.6 Water Supplies at Boga Mission, Zaire

The water supplies at Boga Mission were subjected to intensive water quality monitoring over a period of six days, and the results are of interest as SWS units had been installed there in an unconventional way.

The arrangement of the water supply for the station is shown in Fig 10.5. Stream water flows by gravity into a collecting reservoir and then by pipe through a coarse filtering arrangement to supply the school and the mission houses. Apart from the coarse filtration, the school supply receives no treatment. The supply to the houses passes through an SWS Mini Filter buried in sand in a 200l drum and thence into a 'holding tank' consisting of a concrete chamber, filled with sand in which are buried SWS filter units in two pairs in parallel as shown in the diagram.

The results of the tests on water samples taken from the school supply at the base of the holding tank and at one of the mission houses are recorded in Appendix E and are plotted in Fig 10.6.

The faecal coliform concentrations in the water drawn from the holding tank and the supply to the house, which had passed through two consecutive SWS screens, one of which was buried in a sand filter medium, showed a slight improvement, never greater than one log cycle, over the quality of the raw water in the reservoir from which it had been drawn. However, this improvement was also evident in the water from the school supply, which had only passed through a coarse filter. The coarse filter cannot have been responsible for the difference, however slight, and the most probable explanation is that the retention time of the reservoir permitted a certain amount of die-off of the faecal bacteria in the water.

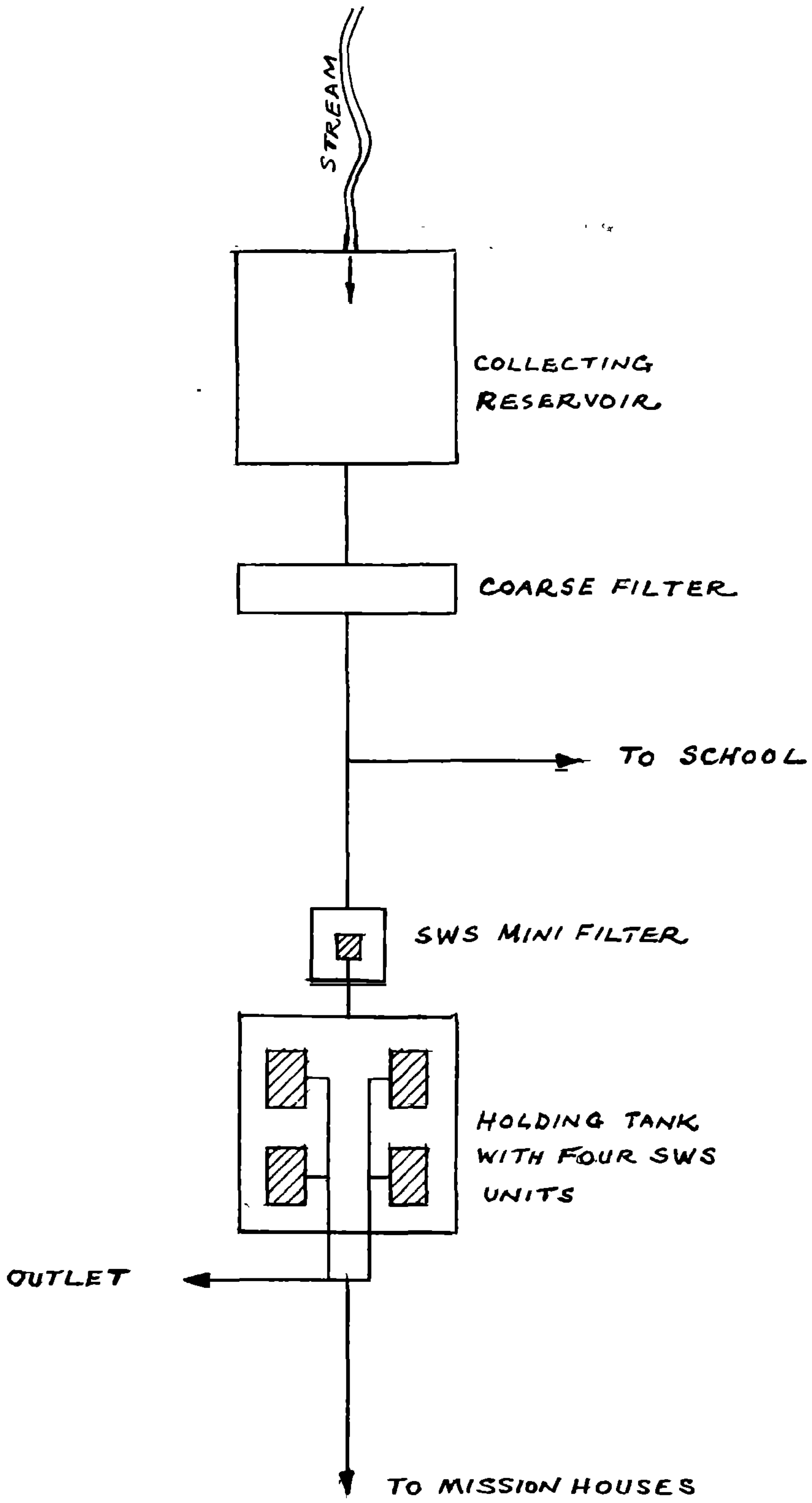


Figure 10.5 - Diagrammatic arrangement of water supply at Boga Mission, Zaire.

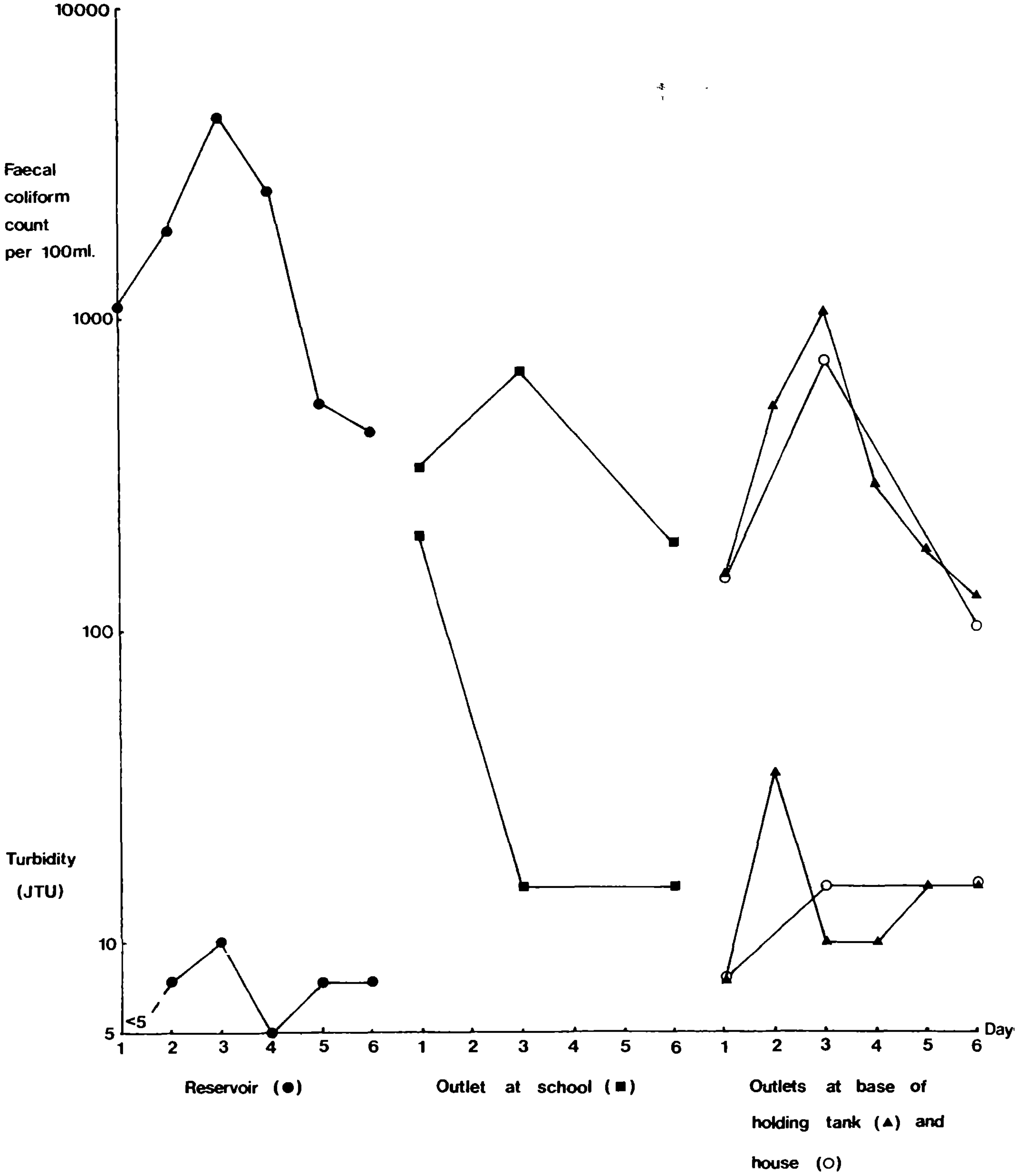


Figure 10.6 - Water quality at Boga Mission.

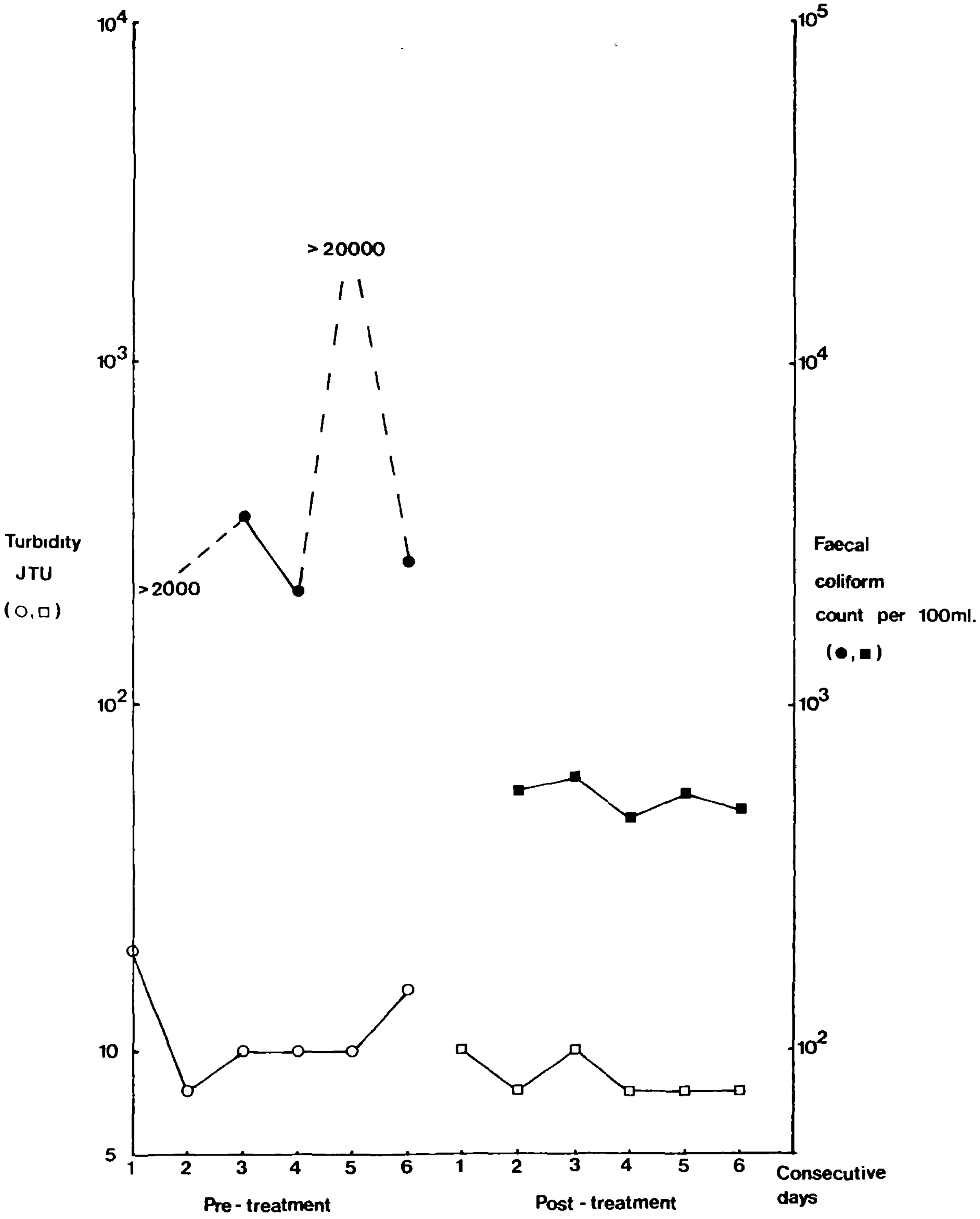


Figure 10.7 - Water quality at SWS mini filter installation (Z/9) near Boga Mission.

Both the filtered water and the school supply showed higher turbidities than the water in the reservoir. This may be due to a greater accretion of sediment or algae at the depth of the reservoir outlet than near the surface where the samples were collected. Overall, however, the results show little difference in the quality of the water which had passed through the SWS units and the water supplied to the school, which had not.

The results of monitoring another supply at a stream near to the mission (Site Z/9) are also given in Appendix E and are plotted graphically in Figure 10.7. An SWS Mini Filter had been buried in a stream bed under 0.7m of gravel, and the area covered over with coarser gravel. The observed performance at this site was slightly better than that noted in Section 10.3 above for SWS Mini Filters in the Sudan, with a typical reduction in faecal coliform count of about 85%, comparable with the performance of the better of two sub sand river bed units in Nigeria, which were essentially similar in their functioning.

10.7 Water Quality

While it can be seen from the foregoing sections that, wherever it was possible to test water before and after passing through SWS filtration units, the faecal coliform count in the water has been reduced by filtration. But the extent of these reductions has not always been significant in micro-biological terms. One difficulty in this type of assessment is to define significant pollution in relation to the health risks to the people using the water and the feasibility (particularly in terms of cost) of providing an improved supply.

Very large numbers of potential pathogens may be present in surface waters. Their survival in such an environment will depend upon such factors as temperature, pH and availability of nutrients. However it is not sufficient to rely solely on natural die-off during water storage to reduce contamination to significantly low levels. The probability that such organisms will cause infection if ingested is mainly a function of the infective dose which, for a given organism, is sufficient to cause disease (the number of organisms needed to infect 50% of healthy human volunteers varies from between $<10^2$ to $>10^7$), depending on a variety of host factors such as nutritional status, immunity and endemic illnesses.

This means that, whereas some members of the population would need to ingest a very large dose to become infected, others are susceptible to a very small one. On the other hand, a water source which on some occasions contains little faecal pollution and no pathogenic organisms at all may at other times contain them in very large amounts. This means that for a water treatment process to play a worthwhile role in controlling the transmission of waterborne infections, it must effect a very significant reduction in the number of faecal micro-organisms in the water; typically by several factors of ten.

Moreover, it must do so reliably if it is not to engender a false sense of security. This is particularly necessary at times of peak pollution, when the raw water is most likely to contain pathogens.

In the light of these considerations, and with reference to Tables 10.3 and 10.5 it can be said that none of the sites in the Sudan or in Nigeria produced a significant reduction. While the filtered water at some sites (such as S4 and S5) might be considered acceptable, this is essentially because the quality of the raw canal water at these sites was already relatively good. By comparison the slow sand filter in Sudan (S7) removed 98% of faecal coliforms from the water, and so provided reasonably safe water.

10.8 Water Contact

No systematic observations of water contact behaviour were made in the present study. Another study, conducted in the Sudan[7] found by such observation that water contact events were reduced by 80% in villages provided with SWS Mini Filters. However, the principal types of water contact activity which were reduced (water collection and hand washing) involved relatively short periods of water contact. Activities involving longer periods of immersion and therefore carrying a greater risk of infection, such as bathing and swimming, suffered a lesser reduction.

Epidemiological investigations accompanying the Sudan study mentioned above, although methodologically flawed, suggested that schistosomiasis transmission was also reduced. However, it should be pointed out that any abstraction method, such as a pump alone or even a shaduf or a windlass on a platform over the surface water, could have the same effect. The reduction in water contact then is not a benefit specific to the SWS system.

11. COST IMPLICATIONS

11.1 Cost Data

As much information as possible has been collected for the costs of the various systems examined in the four countries visited. The costs of SWS equipment have been obtained from the suppliers and these costs cover supply and air freight to an international airport in the country of delivery.

Local costs for these installations have been incurred in fees and charges for clearing equipment at the airport and transport to sites, in the purchase of local supplies and materials, and in labour and supervision for construction. In almost every case, installation has been undertaken with community participation in the provision of labour without charge for site work. The supervision of the installations has been provided either by Government Staff as part of their normal duties, or by Church organisations as part of their service to the community. As records are rarely kept of inputs of this kind, it has not been possible to quantify them in terms of cost. Local costs which are recorded are generally those which have involved cash payments for materials for construction, transport, hired labour and contract services.

11.2 Installation Costs

On the basis of the data available we have evaluated the installation costs for six different types of installation, four with SWS equipment and two without. Details of these evaluations are given in Appendix H and are summarised in Table 11.1. Figures for the average number of people served by the different systems have been derived from the field data sheets (Appendices B, C and D) from which it will be seen that there are wide variations for different sites with the same type of equipment.

Table 11.1 Installation Costs

These costs include the cost of imported equipment, transport of equipment and materials to site, locally purchased materials and services. The costs of local or agency labour and supervision are not included.

Costs in £ Sterling

Type of Installation	Av People Served	Av Cost	
		Total	Per Capita
1. Traditionally protected spring (Zaire)	550	9.00	0.02
2. SWS protected spring (Zaire)			
(a) Hillside, gravity	151	65.40	0.43
(b) Valley bottom, with pump	231	124.00	0.54
3. SWS sub sand river bed units (Zaire and Nigeria)	163	307.00	1.88
4. SWS Mini Containerised Unit (Sudan)			
(a) One stage	100	215.00	2.15
(b) Two stage	200	410.00	2.05
5. SWS jetted well with hand pump (Nigeria)	200	535.00	2.68
6. Slow sand filter with two hand pumps (Sudan)	100	1296.00	12.96

11.3 Protected Springs

Traditionally protected springs have been included as an illustration of what can be done at minimum cost with maximum local participation, under the specially favourable conditions in Eastern Zaire.

The major difference between the traditionally protected springs and the SWS protected springs in Zaire is the cost of the imported SWS equipment. Where the sources are in a valley bottom, the cost of a hand pump has to be included.

The local contribution for all protected spring works is considerable, in the form of labour for excavation and refilling with selected material.

11.4 SWS Sub Sand River Bed Units

Most of these were seen in Nigeria and one in Zaire. The major part of the cost for these is in the imported equipment. Local costs include transport to the site, the construction of a pump base, and labour for excavating and placing the unit in a river bed.

11.5 SWS Mini Containerised Units

These were examined in Sudan and again the major item in the cost is the imported equipment, labour only being required for assembling and placing the unit in the water source. Stands for the pumps and clamps for the filter mats are fabricated locally and the costs of these have been included. Costs have been evaluated for two types of system: a single stage system using one unit and a double stage system with two units.

11.6 SWS Jetted Wells

Costs for these have been included because they have been a popular and successful development in Kano State, Nigeria, where they were examined. Here only total costs per installation were available from the Kano Agricultural Rural Development Project. The work, which requires mechanical equipment for jetting and close supervision, was carried out as part of the project, under the management of project staff.

11.7 Slow Sand Filters

An evaluation of these small systems has been included because they are now being introduced in the Gezira region of Sudan as an acceptable alternative to the SWS mini containerised unit.

Although there is some local contribution in the provision of labour for excavation, the major part of the work, in masonry and concrete, involves cash expenditure. The total installation cost is very much greater than that for any of the SWS installations.

11.8 Per Capita Installation Costs

Table 11.1 shows per capita installation costs based on observed numbers of users. Because the observed numbers varied so widely and because in some cases an installation capable of supplying 200 people was serving a community of 20 or 30, a better comparison of per capita costs for the SWS installations is achieved on the basis of 200 people served by each unit. This is given in Table 11.2.

Table 11.2 Adjusted per Capita Installation Costs

Costs in £ Sterling

Type of Installation	People Served	Per Capita Cost
1. Traditionally protected spring	550	0.02
2. SWS protected spring		
(a) Hillside, gravity	200	0.33
(b) Valley bottom, with pump	200	0.62
3. SWS sub sand river bed unit	200	1.54
4. SWS Mini Containerised unit		
(a) One stage	200	1.08
(b) Two stage	200	2.05
5. SWS jetted well, hand pump	200	2.68
6. Slow sand filter, two hand pumps	200	6.48

11.9 Operation and Maintenance

It was impossible to obtain meaningful comparative figures for the annual costs of operating and maintaining the different systems.

Where spring water is available by gravity, or where supplies are drawn by hand pump operated by the consumers, there are no quantifiable operating costs. The costs of maintaining protected springs are usually very small, although after a number of years major rehabilitation may be necessary.

Experience from Nigeria has shown the maintenance costs for the SWS sub sand river bed units is low, and are estimated at about £15 per year to cover minor attention, such as the repair or replacement of a broken pump handle.

As has been described in Section 9.2(c) and Table 9.1, the SWS mini containerised units in Sudan have required frequent and extensive repairs. As the Blue Nile Health Project has been supplied with a large number of units and only a few have been installed, it has been easy to replace an existing faulty unit with a new one, discarding the faulty equipment without attempting to repair it. Any attempt to evaluate maintenance costs on this basis would be misleading. However, it must be concluded that experience from the Gezira in Sudan has demonstrated serious operation and maintenance problems.

The satisfactory operation and maintenance of slow sand filters may be no less problematical. There are many existing slow sand filters in Sudan which are not working properly, for the lack of simple maintenance. A tentative figure of £100 per year has been given for the maintenance costs of the new small slow sand filters being developed by the Blue Nile Health Project, but this clearly does not include the overhead management and supervision costs.

12. EVALUATION OF THE SWS FILTRATION SYSTEM

12.1 Introduction

The objectives of this investigation are to study the performance of SWS installations in order to evaluate the SWS filtration system in relation to capital cost, ease of installation, operation and performance (Section 3.1). Primarily therefore we are concerned with evaluating the system, and in so doing we need to answer the following questions:

1. Does the system improve the quality of water for the communities for which it is intended?

2. If there is an improvement, is it significant in relation to health?

3. How does it compare in terms of capital cost and ease of installation and operation with other alternative systems?

There has been a certain amount of confusion over what is understood by the SWS System and what is expected of SWS installations in operation. There has been further confusion in the minds of many of those involved in the operation of SWS installations, between system failures arising from the misuse of, or mechanical defects in hand pumps, and failures in the filtration process.

12.2 Previous Research in the United Kingdom

In 1976 and 1977 a Camp Unit was tested for 9 months in the river Ivel, Bedfordshire, UK, jointly by M. Hurst, microbiologist of the Agricultural Development and Advisory Service, Cambridge and D. Caddy of the Anglian Water Authority.

During this period weekly samples of river water before and after filtration were taken for chemical and microbiological analysis. These tests were carried out primarily to investigate the unit for agricultural applications. A copy of the investigators' report is included in Appendix I, together with a note by the authors on their research, in which they stated that total bacterial removal averaged 98%.

Further tests on a similar unit were carried out by Hurst for 8 months in 1980 at a trout farm in Hertfordshire. The results of this work are recorded in a note dated 29 April 1981, also in Appendix I.

During 1977 and 1978 investigations of camp units were carried out at the Department of Microbiology, University of Surrey. For two experiments units were tested in the bed of a lake consisting of black mud and silt into which a cubic yard of coarse sand had been placed. In a third experiment units were tested in various grades of sand in a plastic tank 0.6m deep. This work has been recorded in a report dated June 1978. Unfortunately a copy of the report, suitable for reproduction here, is not available. However, a note about this work from D. Wheeler of the University of Surrey, dated November 1983, is reproduced in Appendix I.

Experimental investigations on the more recently introduced Mini Containerised Unit have not been undertaken in the UK, and this unit was developed primarily for the Blue Nile Health Project in Sudan.

12.3 The SWS System

The original SWS system as incorporated in the Camp Unit and researched in the UK, consisted of a facility for extracting water from the saturated bed material of a sand-bed river, thereby making use of the natural granular material as a filter medium, and providing an alternative to raw and often highly polluted river water. This principle is described in Section 2.2, with installation specifications in Appendix F.

The use of a Mini filter buried in the sandy bed of a stream at Boga (Z9) in Zaire and six of the sites visited in Nigeria (N1 to N4, N6, N7) are applications of the original system. The six jetted wells in Nigeria (N8 to N13), extracting water from the sandy beds of rivers, are adaptations of the same principle. The device described as a Mini Filter is in fact a small stainless steel slotted screen, which per se has no filtration function, but which, when properly embedded in a filter medium, is a component of a filtration system.

In all these arrangements biological filtration occurs over an indeterminate but extensive contact area, and the flow of water to the extraction point is regulated by its movement through a large volume of filter medium. The use of the Minifilter in spring protection in Zaire serves a different purpose, as the spring water can be assumed to be of good quality and needing no further filtration.

The uses of the Mini Filter buried at a shallow depth in the bed of a stream (Fig 2.2(a) and (b)) or in a small container (Fig 2.2(c) and in the Gezira, Sudan) are departures from the original system.

12.4 Microbiological Performance

The microbiological performance of SWS systems was measured at 16 sites in Zaire, Sudan and Nigeria, comprising:

3 buried river-bed units (Z9, N4, N6). 7 containerised mini units (S1 - S7) 1 compound unit at Boga Mission, Zaire (Z9). 5 jetted wells beside flowing rivers (N8 - N13).

It was unfortunate that the visit to Nigeria was made during the wet season when several river-bed units were either not in use or removed from river beds for safety, and only two operational systems could be tested. At all the other SWS sites in Zaire and Nigeria, which were either spring sources or groundwater sources, only the outflow of the installations was tested.

At Boga Mission in Zaire the water supply arrangements are complex (Fig 10.5), and it was impossible to isolate and test single SWS units. Overall, the tests showed that the water supplied to the school which was taken off before the group of SWS units had an average faecal coliform count of 345 per 100ml, while that which had passed through the units had average counts of 290 at exit from holding tank and 225 at one of the house supplies. The improvement therefore was so small as to be negligible in bacteriological terms.

The SWS mini containerised system as used in the Sudan differs from the original SWS system in several important respects:

(a) The unit is placed in the stream on the bed of the channel and not buried below the bed.

(b) The contact area between raw water and the filter medium is reduced from an extended area of stream bed above the buried chamber (2 to $3m^2$), to the plan area of the chamber itself (about $0.09m^2$).

(c) The corresponding volume of filter medium in use is reduced from about $1m^3$ to $0.03m^3$.

(d) Layers of fabric matting are introduced into the chamber to compensate for the loss of granular filter medium.

The systems as used in the Sudan incorporate the following additional changes which depart from SWS Ltd's specifications for these mini containerised units:

(e) The chambers are filled with gravel and not sand.

(f) One layer of fabric matting in the chamber immediately above the screen is omitted.

(g) The two layers of fabric matting at the top of the chamber are above and not in contact with the filter medium.

By so drastically reducing the contact area and volume of the filter medium, a very serious reduction in filtering performance can only be expected. This has been borne out by the results from the seven sites in Sudan (Table 10.3). Although in fact the mean faecal coliform count at each of these sites was reduced by filtration, performance was erratic and at five of the sites the reductions left unacceptably high levels of pollution. These findings are corroborated to a large extent by an investigation carried out by Sadiq Abdel Basit and Denver Brown[12], of the Blue Nile Health Project.

At the three sites where SWS units were buried in the sandy beds of rivers, the reductions in faecal coliform counts per 100ml were:

		Raw Water	Filtered	%
Z9	Boga Mission	>3,800	540	85
N4	Barakesh	1,410	125	91
N6	Marish	17,500	9,260	47

At the time of testing N6 the river was in flood and sand was being pumped through the system (see sect. 10.4). This suggests that the river bed was unstable under flood conditions and that the unit was not properly buried, which could account for the poor performance.

If the results from N6 are discarded, the remaining two results may have some significance. However, the bacteriologists take the view that the results from these sites are sufficient to show that the system does not reliably produce water of acceptable quality nor, in the light of the considerations in Section 10.7 above, a worthwhile improvement in relation to the quality of the raw water. Even if conditions at the sites visited were exceptionally poor, the results show that in such conditions the system cannot be relied upon. And it is under conditions of the grossest pollution that the reliability of water treatment system is most necessary.

12.5 Physical Performance

The investigations of SWS units in spring protection installations in Zaire provided an opportunity for a comparison between gravity flow and pumped systems. On the whole the gravity systems on hillside springs are trouble free, and the pumped systems on valley-bottom springs require attention from time to time due to pump breakages.

The units which had been installed in Ngora District, Uganda, were abandoned because, according to reports, they had not worked properly and the pumps broke down and could not be repaired. Apart from a prevailing lack of interest, one cause for their failure may have been their location in silty-clay lake bed material beneath static water.

The mini containerised units in Sudan have given much trouble in use, and require frequent attention and maintenance. Most of these problems arise from the design and installation features listed in Section 12.4 above. When pumps are applied to these systems and water is forced through a confined filter body, fine material quickly accumulates at the contact surfaces, causing clogging and increasing the resistance to pumping. Extra physical effort on the hand pumps increases wear on the pumps, leading to mechanical breakdown. Thus what

appear to be mechanical failures due to design defects in the pumps may, in fact, be failures due to overloading the pumps, caused by design defects in the filtration system.

12.6 Operation

An indisputable advantage of the SWS system is its simplicity and ease of operation. Where a gravity supply is feasible, operation is automatic. In the more common situations where the water is extracted by a hand pump, no special skills are required and the system can be worked without supervision.

12.7 Installation

It is clear from the results of this study that installation of SWS systems is easy and can be undertaken in remote locations without difficulty. The components can be transported across country by foot or on bicycles, and systems can therefore be installed at sites where there is no access for road vehicles.

Installation requires no special skills and can be undertaken by unskilled labour with hand tools. But it is essential that it is carried out under informed supervision. Once the system has been installed it is important that the installation is lodged in the care of a responsible local person or authority, so that maintenance and repairs may be undertaken as necessary. It was found that this was generally done in Zaire and Nigeria, but not in Sudan where the Blue Nile Health Project undertook overall responsibility.

12.8 Capital Cost

The computed capital cost of an SWS sub sand bed river installation to serve 200 people is £307 compared with a slow sand filter for the same number of people at £1,296, representing per capita costs of £1.54 and £6.48 respectively (Table 11.2).

12.9 Alternatives

A possible alternative to the SWS system is some equipment which is being marketed by Ideas Development Limited of Worcester, England, consisting of prefabricated filtration systems incorporating sand and gravel as the filter medium together with "specially designed" filter cartridges. Information about these sytems has come to hand very recently, in the form of brief trade literature and specifications, without dimensions, through-put capacity or treatment characteristics. A unit described as the "Waterpak II", which can be placed on the bed of a stream or channel and from which water is extracted by pumping appears to be very similar to the SWS containerised mini-filter. The ex-works price of this unit is quoted as £350 per single unit, and £48 for a replacement filter cartridge. If it is designed to serve a small community of up to 200 people, its cost is of the same order as the SWS mini-filter.

Other possibilities include various methods for treatment by chlorination, (which are usually ruled out on grounds of cost and the difficulties of maintaining supplies of chemicals), and the slow sand filter. The slow sand filter tested in the Gezira, Sudan, gave an acceptable microbiological performance (Table 10.3), but the equivalent capital cost is over four times that of an SWS sub-bed unit. This particular slow sand filter was operating under optimum conditions, under the close technical supervision of the trained staff of the Blue Nile Health project. Not all slow sand filters in Sudan are working satisfactorily, and some are not working at all, as a recent review[13] of slow sand filters at refugee settlements in the Eastern Region has demonstrated.

The hand dug well is a common method for reaching water in river bed aquifers, but takes time to construct and usually requires masonry lining which can be expensive. Examples of rapid methods using light mechanical equipment are the jetted wells (Sect. 2.3), hand-boring as developed on the Morogoro Project in Tanzania and light weight power drilling as used on the ODA sponsored Livulezi Project in Malawi.

12.10 Conclusions

During the field work of this investigation some 38 SWS installations were examined in Zaire, Sudan and Nigeria, and some abandoned sites in Uganda.

These installations consisted of four principal types: spring protection, surface water containerised units, sandy river bed units and shallow tube wells beside sand bed rivers: in addition one open well system and one complex system with units buried in sand in chambers were exmamined. In some cases it was not possible to monitor and test the systems because the installations wre not in use. The number of each type tested and not tested are given in Table 12.1.

Table 12.1 - Quantities of different types of SWS installation examined

Type SWS Installation	Tested	Out of use not tested	Total examined
I Spring protection	14	..	14
II Surface water containerised units	7	2	9
III Sandy river bed units	3	4	7
IV Shallow tube wells beside sand bed rivers	6	..	6
V Unit in open well	..	1	1
VI Units buried in sand in chambers in water treatment complex	1	..	1
	31	7	38

At the spring protection sites (Zaire), as spring water is usually good quality, there is no filtering process and the SWS equipment is used as an improved water collecting system.

The investigations of the surface water containerised units used in the Sudan have demonstrated that their performance as filters is far from satisfactory. There are certain fundamental defects in the design of the equipment, and the installation of the units had not complied with the supplier's specifications. In their present form they cannot be considered as suitable filtration systems.

Although 7 sandy river bed units were examined only 3 were tested: one in Zaire and two in Nigeria. Of these three, two showed some significant improvement to the quality of raw water.

The shallow tube wells, drawing water from sandy river bed aquifers, produced water of generally acceptable quality.

It has been concluded in the preceding sections that the advantages of SWS technology, with regard to spring protection and tubewell installation, can be assessed on cost and engineering grounds alone.

With regard to the surface water abstraction units, however (the SWS containerised Mini Filter and the SWS sub sand river bed unit) the situation is more complex, as there is no comparably cheap and simple technology for surface water abstraction. While their microbiological performance is poor, it might be observed that, considering the low cost of the units, this performance is cheap at the price. Alternatively, the real appreciation of the units by the users might suggest that the units have major benefits which justify their installation, whatever their microbiological performance.

Some of the users' appreciation may be attributed to the illusion of lower turbidity when water is taken from a river or canal to be viewed in a glass, and some to the official recognition which a settlement acquires in the Gezira when it has an improved water supply. But these do not reflect objective benefits peculiar to the SWS system.

The objective benefits of improved rural water supply in developing countries can be summed up as:

(i) savings in time and effort spent collecting water

(ii) health improvements.

Since the SWS units are installed in rivers and canals which are already in use as water sources, and the pump is immediately adjacent to them, time-saving benefits do not occur.

Health improvements, on the other hand, can result from:

(a) Improvements in water quality
(b) Increase in quantity of water used
(c) Reduction in contact with surface water.

Water quality and water quantity have been discussed in Sections 10.7 and 10.8. This study has found limited improvement in the microbiological quality of water from the SWS units. There was some reduction in water contact in villages provided with SWS units in Sudan.

No increase was observed in the quantity of water used, nor was one to be expected as the new water source (the pump) was no closer to the houses of the users than the old source (the river or canal). No reduction in water-washed transmission of disease will therefore have resulted.

From the results of these investigations, it is clear that while the various SWS systems always produced some reduction in the faecal coliform counts of the raw water passing through them, these reductions were frequently insignificant in bacteriological terms, and the systems were therefore held to be of little value in the pursuit of public health. Even when the improved quality of the water approaches acceptability, it is still regarded as "unsafe" because it could give consumers a false sense of security.

While accepting the logic of these arguments, it is important also to take account of the fact that there are many thousands of small communities in Africa and elsewhere in the developing world whose only source of water, now and in the foreseeable future, is polluted surface water. Some communities will, undoubtedly, benefit from water supply improvement programmes, but these will be a favoured few because of the vast number of people in need, and because of the limited financial resources available for both implementation and operation and maintenance.

The rural water supply authorities in many developing countries are struggling to maintain their services in the face of acute shortages of local funding and foreign exchange, of technical staff, vehicles and spare parts. Budgets for recurrent expenditure are cut to a bare minimum and funds for new works are often non-existent unless provided through a foreign aid programme.

Thus for a great many communities, insistence on water of a quality which is bacteriologically acceptable is hypothetical. In real terms, some improvement, may often be better than no improvement. Dr. Richard Feachem, in a recent work on water and sanitation in developing countries[14], approaches the question of bacteriological acceptability by taking into account the fact that if an option, though desirable is unattainable, some relaxation in standards of acceptability may be legitimate.

In the light of this it could be said that as the SWS filtration system, as originally designed to extract water from below the bed of a sandy river, does produce water which is measurably better than the raw river water, and at a cost which is at least one quarter of that of an equivalent capacity slow sand filter, it has achieved something worthwhile. Unlike the mini containerised units, which had no independent scientific testing in the UK, the sub sand river bed units were tested fairly thoroughly by scientific bodies in the UK. On the basis of this earlier work and several years of field use, only a small amount of further research would be needed to identify more precisely the weaknesses in these existing systems and to establish specific design parameters for hydraulic performance.

12.11 Recommendations

This report has demonstrated that although the original SWS systems does go some way towards providing a simple, cheap, easily managed low-cost improved water supply, it has some serious limitations which could be overcome.

There is a need for some limited further research into the design features of the SWS sub sand river bed system on the following lines:

1. Investigations into the hydraulic characteristics of the buried unit in river bed material, with flow-path studies in different grades of granular material and under different pumping heads, in order to define the conditions under which the system will and will not function satisfactorily.

2. Investigations into design modifications to prevent over-pumping, causing excessive pore velocities in the filter medium and clogging at the water/sand interface.

3. Investigations into the depth to which the unit must be buried in a river bed to ensure adequate cover under all conditions of river flow, including floods.

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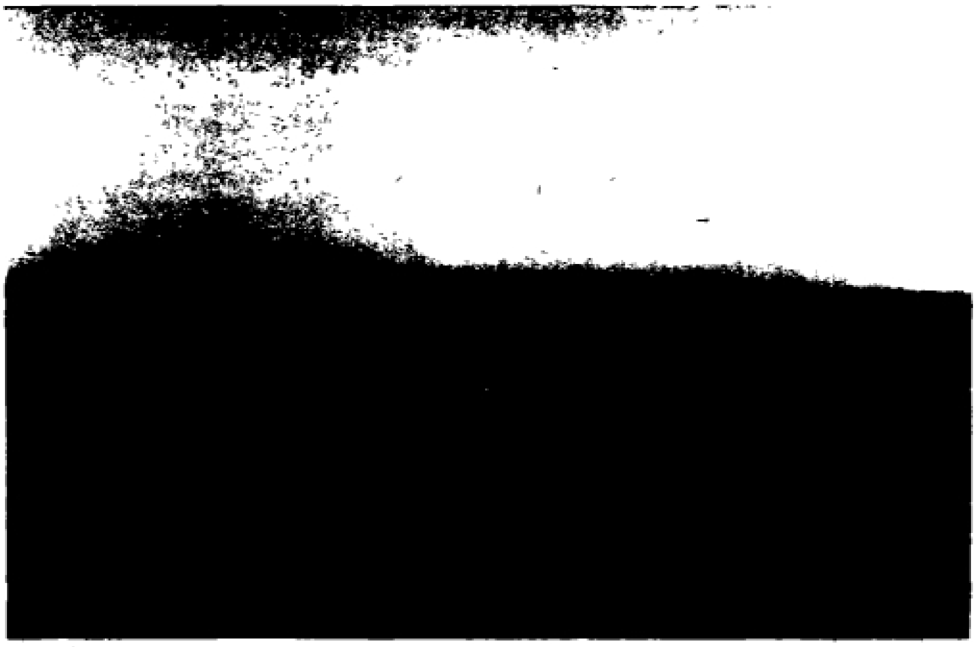
1. SWS Protected spring at Bogoro, Zaire, May 1985.

2. Removing SWS mini container for maintenance, and Patay pump, at Tama, Sudan, June 1985.

3. Rower pump and mini container at Jubara, Sudan, June 1985.

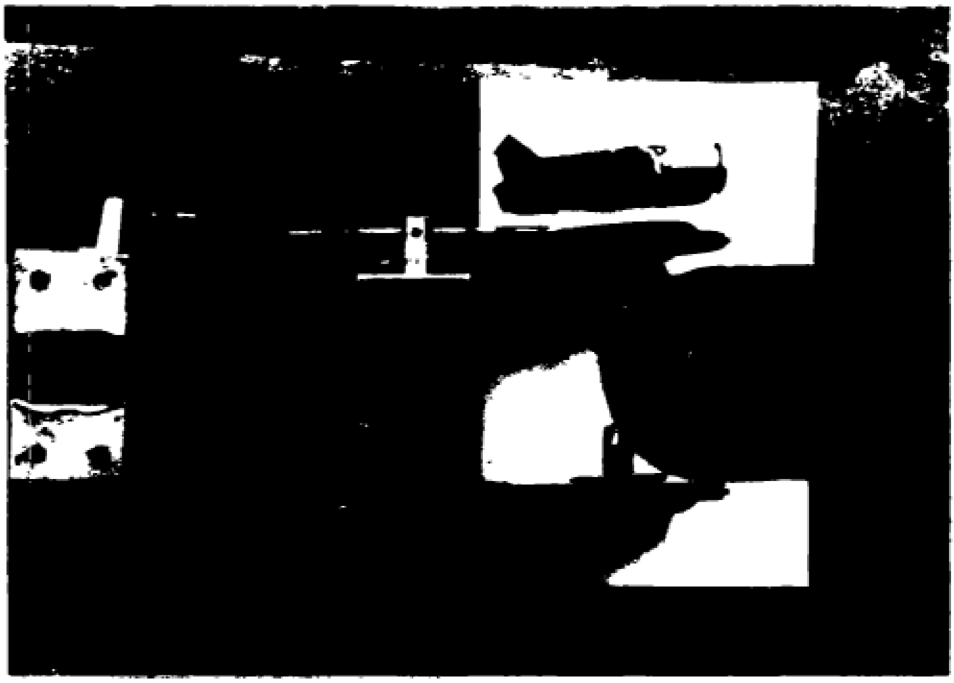
4. Filter mat on mini container, about to be changed, Jubara, Sudan, June 1985.



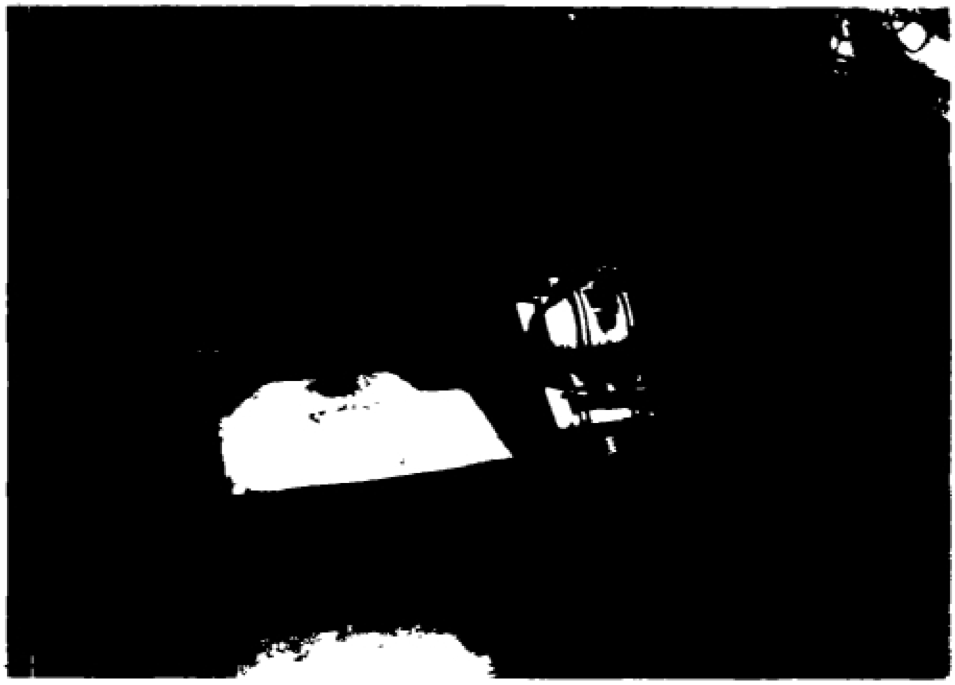
5. 'Abu Ishreen' channel at Jubara, Sudan, June 1985.

6. SWS double filtration system with Patay and Rower pumps at Shagara, Sudan, June 1985.

7. Slow sand filter with Patay and Rower pumps at Wad el Amin, Sudan, June 1985.



8. Damaged components of a DD70 Patay pump: wear at handle aperture, fractured linkages and torn diaphragm: at Boga, Zaire, May 1985.



9. SWS sand bed river unit, prior to installation at Barakesh, Nigeria, July 1985.

10. OXFAM - del Agua water testing kits: vanity case type[l] with separate mains charger; A2 type[r] with filtration assembly [in front], common to both types.

APPENDIX A - ITINERARIES OF FIELD VISITS

Dates	Departure	Mode of Travel	Arrival	No of Days	Nature of Work
8-9/5	London	Plane	Nairobi		
9-10/5				2	Preparatory.
11/5	Nairobi	Plane	Nyankunde		
11-15/5				5	Field work at six sites in Nyankunde vicinity. Training and demonstrations of field water testing equipment.
16/5	Nyankunde	Car	Boga		Two sites visited en route.
16-23/5				8	Field work at 9 sites in Boga Region. Intensive bacteriological tests over a period of 5 days.
23/5	Boga	Car	Bunia		Two sites visited en route.
24/5	Bunia	Plane	Nairobi		
2-26/5				2	Preparatory
26/5	Nairobi	Plane	Entebbe		
				4	Contact with Water Development Department, transport arrangements, collecting information on progress of SWS systems in Uganda.
31/5	Entebbe	Car	Ngora		
1-3/6				3	Inspection of previous sites.
3/6	Ngora	Car	Entebbe		Visit to Tororo en route to see possible SWS activity.
4-5/6				2	Finalising arrangements with Water Development Department, communication with people interested in the implementation of SWS systems.
5/6	Entebbe	Plane	Nairobi		
6-11/6				7	Nigerian visa arrangements. Preparatory work.
12/6	Nairobi	Plane	Khartoum		
12-14/6				3	Contact with British Embassy, Blue Nile Health Project transport arrangements.
15/6	Khartoum	Car	Hasaheisa & return		Visit to local Blue Nile Health Project offices, accommodation arrangements
15-19/6				5	Preparatory, information gathering, Nigerian Visa applications, waiting for end of Ramadan holiday.
20/6	Khartoum	Car	Abu Usher		(Field work in Gezira region. Six sites tested (intensively, three other sites visited. (Comparisons taken with alternatives. Training (and demonstrations given for field water testing (equipment.
20/6-1/7				11	
2/7	Abu Usher	Car	Khartoum		
2-4/7				2	Travel arrangements.
4-5/7	Khartoum	Plane	London		
5-16/7				12	Nigerian visas, travel arrangements, preparatory work for report.
17/7	London	Plane	Kano	1	
18/7	Kano	Plane	Jos		
18-28/7				11	Field work in Plateau State visiting 7 sites. Demonstration of field equipment.
29/7	Jos	Car	Kano		
29-6/7				9	Field work in Kano State visiting SWS installations in three areas.
7-8/7	Kano	Plane	London		

APPENDIX B : FIELD DATA SHEETS - ZAIRE

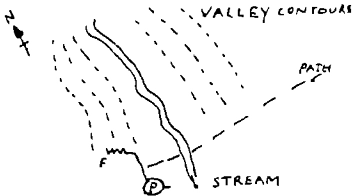
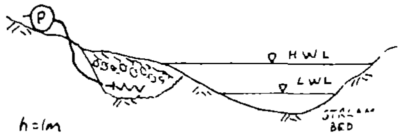
Ref No	Location/Site Name	Type of Installation
Z/1	Ndoya	SWS protected spring - valley bottom
Z/2	Matete	"
Z/3	Komanda 1	SWS protected spring - hillside
Z/4	Buliki	Traditionally protected spring - hillside
Z/5	Komanda 2	" "
Z/6	Modododo	SWS protected spring - hillside
Z/7	Bogoro	Traditionally protected spring - hillside
Z/8	Berunga	SWS protected spring - hillside
Z/9	Boga Mission	" - valley bottom
Z/10	Rakaikara	" - hillside
Z/11	Chororo	" - valley bottom
Z/12	Karbarole	" - hillside
Z/13	Kahwa	" - valley bottom
Z/14	Kabaganzi 1	" - hillside
Z/15	Candip	" - hillside
Z/16	Kabaganzi 2	" - hillside
Z/17	Mutega	" - valley bottom
Z/18	Kabalu	" - hillside
Z/19	Chekele	" - hillside

UK OVERSEAS DEVELOPMENT ADMINISTRATION - PROJECT R3957

Gifford and Partners, Consulting Engineers, in association with The London School of Hygiene and Tropical Medicine

EVALUATION OF SWS FILTER SYSTEMS

FIELD DATA SHEET

<table>
<tr><td>Serial No: Z/1</td><td>Name:
NDOYA (MAGUTABA)</td><td>Long. 29° 53'
Lat. 1° 58'</td><td>Visit Date(s):
13/5/85</td></tr>
<tr><td colspan="2">Location Sketch Map

d = 50
d = Average walking distance to water collection point (m)</td><td colspan="2">Sketch of Installation

h = 1m
h = Operating head (m)</td></tr>
</table>

1. INSTALLATION

Date of Installation : 25/10/84

Installed by : T ROUS & COMMUNITY WORKERS

Has the equipment been installed in accordance with supplier's instructions? YES

Remarks:

Description of Source

Alternative Source : MUDDY STREAM, OTHER SWS INSTALLATION

Quantity Restrictions/Variations: SAID TO BE AN ALL YEAR SUPPLY

Quality/Pollution : NONE, EXCEPT WHEN STREAM IS IN FLOOD

INSTALLATION (Cont.)

Filter

One or two stage? 1

Type and size of screen MINI FILTER

Filter Chamber made of : NONE

Dimensions : /

Filter medium : UNWASHED GRAVEL, 8mm MAX SIZE (NO DEVELOPMENT OF FILTER MEDIUM)

Covered with : LARGE STONES & SOIL TOPPING

Connections from Filter

Pipe Dia : 1"

Pipe Length : 2m

Pipe Material : PLASTIC

Pump

Type : PATAY

Size : /

Mark : DD70

Delivery Arrangements

SINGLE FLEXIBLE OUTLET PIPE

General Remarks

1) FILTER LOCATED BENEATH PATH AND THE STREAM NEEDS TO BE CROSSED TO GAIN ACCESS.

2) THE PUMP SHOWS NO SIGNS OF WEAR AND IS USED VERY SENSIBLY.

2. PERFORMANCE

In working order (yes/no) YES

Filter Chamber(s) : N/A

Piping : OK

Delivery : OK

Remarks : PUMP HANDLE KEPT BY "AGENT DE SANTE", SOME LOCALS HAVE IMPROVISED THEIR OWN HANDLES.

---

3. DEMOGRAPHY

User population : WET SEASON 50
DRY SEASON 400
Main Occupation : SUBSISTANCE FARMERS

Water Collection Times : MORNING & EVENING, NO QUEING

Methods : HAND CARRIED CONTAINER

Containers used : 20 LITRE METAL CONTAINER

Average Usage : (1/p/day) 20 1/day FOR DRINKING/COOKING ONLY THE NEARBY STREAM IS USED FOR WASHING ETC.

---

4. MAINTENANCE

Has the installation worked satisfactorily since installation? (yes/no) YES

Any periods of breakdown? (details) NO

Causes of breakdown /

Who undertakes repairs? /

Who finances these repairs? /

Comments : NOTE 1) THE WEAR ON THE PATHS, THE WASTE WATER CHANNEL SIZE SUBSTANTIATE THE STATED POPULATION NUMBER

---

5. PHYSICAL/CHEMICAL WATER QUALITY

	Details	Raw Water	Filtered Water
1.	Average Counts Faecal Coliform/100ml	170	8
2.	Number of Samples	1	1
3.	Colour		Clear
4.	Odour		Odourless
5.	Temperature ^{o}C		25
6.	pH		6.7
7.	Turbidity, JTU		< 5
8.	Conductivity $\mu s/cm$		607
9.	Comments		

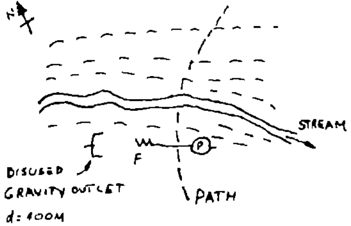
UK OVERSEAS DEVELOPMENT ADMINISTRATION - PROJECT R3957

Gifford and Partners, Consulting Engineers, in association
with The London School of Hygiene and Tropical Medicine

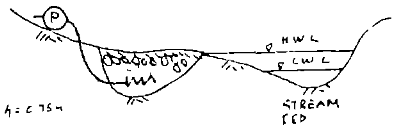
EVALUATION OF SWS FILTER SYSTEMS

FIELD DATA SHEET

<table>
<tr><td>Serial No: Z/2</td><td>Name: MATETE</td><td>Long. $29^{\circ} 53'$
Lat. $1^{\circ} 58'$</td><td>Visit Date(s): 13/5/85</td></tr>
<tr><td colspan="2">Location Sketch Map



d = Average walking distance to water collection point (m)</td><td colspan="2">Sketch of Installation



h = Operating head (m)</td></tr>
</table>

1. INSTALLATION

Date of Installation : 18/10/84

Installed by : T. ROUS & COMMUNITY WORKERS

Has the equipment been installed in accordance
with supplier's instructions? YES

Remarks: EXISTING GRAVITY OUTLET OUT OF USE BECAUSE ITS LEVEL IS TOO HIGH.

Description of Source

Alternative Source : STREAM NEARBY

Quantity Restrictions/Variations: IN THE DRY SEASON THE FLOW IS SUFFICIENT FOR DRINKING PURPOSES ONLY

Quality/Pollution : NONE, EXCEPT THE STREAM AT H.W.L.

INSTALLATION (Cont.)

Filter

One or two stage? 1

Type and size of screen MINI

Filter Chamber
made of : /

Dimensions : /

Filter medium : GRAVEL 8mm SIZE

Covered with : LARGE STONES, SOIL COVERING

Connections from Filter

Pipe Dia :1"

Pipe Length : 1m

Pipe Material : PLASTIC (GREEN FLEXIBLE TYPE)

Pump

Type : ROWER PUMP

Size :

Mark :

Delivery Arrangements

General Remarks

1) THE ROWER PUMP NEEDED THE PISTON RUBBER WASHER TO BE REVITALISED BY MANIPULATING IT BACK AND FORTH. ONCE THIS HAD BEEN DONE THE PUMPED PERFORMANCE SATISFACTORILY.

2. PERFORMANCE

In working order (yes/no) YES

Filter Chamber(s) : /

Piping : YES

Delivery :YES

Remarks : RUBBER SEAL ON PISTON OF ROWER PUMP NEEDS TO BE REVITALISED.

---

3. DEMOGRAPHY

User population :150-250 PEOPLE DEPENDING ON TIME OF YEAR

Main Occupation :SUBSISTANCE FARMERS

Water Collection Times :MORNING/EVENING

Methods :HAND CARRIED CONTAINERS

Containers used : PLASTIC "BEDON"

Average Usage : (1/p/day) 20 1/per day

---

4. MAINTENANCE

Has the installation worked satisfactorily since installation? (yes/no) NO

Any periods of breakdown? (details)ONLY ONCE AT THE TIME OF OUR VISIT

Causes of breakdown RUBBER PISTON RING WASHER NEEDS ATTENTION

Who undertakes repairs? T. ROUS HAD TO ATTEND TO THE RUBBER WASHER AFTER LOCAL ATTEMPTS HAD FAILED TO SOLVE THE PROBLEM

Who finances these repairs? /

Comments :

---

5. PHYSICAL/CHEMICAL WATER QUALITY

	Details	Raw Water	Filtered Water
1.	Average Counts Faecal Coliform/100ml		12
2.	Number of Samples		1
3.	Colour		Pale buff
4.	Odour		-
5.	Temperature °C		25
6.	pH		5.6
7.	Turbidity, JTU		15
8.	Conductivity μs/cm		97
9.	Comments		

UK OVERSEAS DEVELOPMENT ADMINISTRATION - PROJECT R3957

Gifford and Partners, Consulting Engineers, in association
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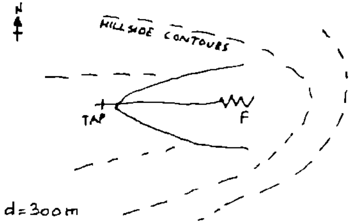
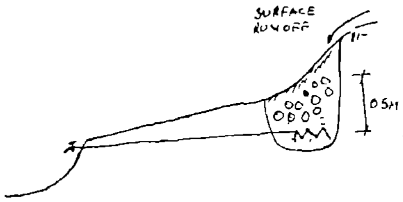
EVALUATION OF SWS FILTER SYSTEMS

FIELD DATA SHEET

<table>
<tr><td>Serial
No:Z/3</td><td>Name:
KOMANDA 1</td><td>Long. 29° 43'
Lat. 1° 55'</td><td>Visit Date(s):
13/5/85</td></tr>
<tr><td colspan="2">Location Sketch Map

d = Average walking distance to water collection point (m)</td><td colspan="2">Sketch of Installation

h = Operating head (m)</td></tr>
</table>

1. INSTALLATION

Date of Installation : MID JUNE 1983

Installed by : T. ROUS & COMMUNITY WORKERS

Has the equipment been installed in accordance
with supplier's instructions? YES

Remarks:

Description of Source

Alternative Source : 1 OTHER PROTECTED SOURCE 2km
3 UNPROTECTED SOURCES WITHIN 1km
Quantity Restrictions/Variations: DRIES UP IN THE DRY SEASON

Quality/Pollution : NONE, EXCEPT SURFACE INFILTRATION

INSTALLATION (Cont.)

Filter

One or two stage? 1

Type and size of screen MINI FILTER

Filter Chamber
made of : /

Dimensions : /

Filter medium : SMALL STONES SURROUNDED BY CHARCOAL

Covered with : LARGE STONES & SOIL COVERING

Connections from Filter

Pipe Dia : 1"

Pipe Length : 10m

Pipe Material : 9m PLASTIC, LAST 1m GALVANISED IRON

Pump GRAVITY

Type :

Size :

Mark :

Delivery Arrangements

1 TAP WHICH SERVES TO ALLOW THE SPRING TO STORE WATER IN DRY SEASON

General Remarks

THE WET SEASON SPRING HAS A CONSIDERABLE OVERFLOW AND THE TAP COLLECTION POINT BECOMES VERY MUDDY.

2. PERFORMANCE

In working order (yes/no) YES

Filter Chamber(s) : /

Piping : YES

Delivery :YES

Remarks :

---

3. DEMOGRAPHY

User population : 600 PEOPLE DRY SEASON, MANY LESS DURING WET SEASON

Main Occupation : SUBSISTANCE FARMERS

Water Collection Times : MORNING (DURING DRY SEASON SOURCE NEEDS TO FILL UP DURING THE NIGHT)
Methods :HAND CARRIED CONTAINERS

Containers used :"BEDON"

Average Usage : (l/p/day) /

---

4. MAINTENANCE

Has the installation worked satisfactorily since installation? (yes/no) YES

Any periods of breakdown? (details) NO

Causes of breakdown

Who undertakes repairs?

Who finances these repairs?

Comments :

---

5. PHYSICAL/CHEMICAL WATER QUALITY

	Details	Raw Water	Filtered Water
1.	Average Counts Faecal Coliform/100ml		110
2.	Number of Samples		1
3.	Colour		Clear
4.	Odour		-
5.	Temperature ^{o}C		27
6.	pH		5.7
7.	Turbidity, JTU		<10
8.	Conductivity μs/cm		84
9.	Comments		

UK OVERSEAS DEVELOPMENT ADMINISTRATION - PROJECT R3957

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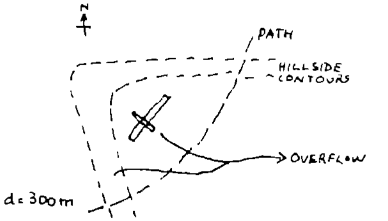
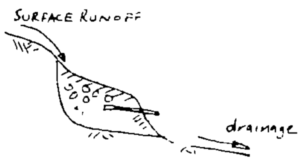
EVALUATION OF SWS FILTER SYSTEMS

FIELD DATA SHEET

Serial No: 2/4	Name: BULIKI	Long. 29° 46' Lat. 1° 54'	Visit Date(s): 13/5/85
Location Sketch Map  d = Average walking distance to water collection point (m)		Sketch of Installation  h = Operating head (m)	

1. INSTALLATION

Date of Installation : SEPT 1983

Installed by : LOCAL COMMUNITY UNAIDED BY EXTERNAL ASSISTANCE

Has the equipment been installed in accordance
with supplier's instructions? /

Remarks: TRADITIONALLY PROTECTED SPRING

Description of Source

Alternative Source : NEAREST ALTERNATIVE SOURCE 400m AWAY

Quantity Restrictions/Variations: NONE REPORTED

Quality/Pollution : NONE EXCEPT SURFACE INFILTRATION

INSTALLATION (Cont.)

Filter

One or two stage? N/A

Type and size of screen /

Filter Chamber
made of : /

Dimensions : / TRADITIONALLY PROTECTED SOURCE

Filter medium : EARTH

Covered with : SOIL & VEGETATION

Connections from ~~Filter~~ SPRING SOURCE

Pipe Dia : 4"

Pipe Length : 0.5m

Pipe Material : BAMBOO

Pump GRAVITY

Type :

Size :

Mark :

Delivery Arrangements

BAMBOO PIPE OUTFLOW

General Remarks

2/A

2. PERFORMANCE

In working order (yes/no) YES

Filter Chamber(s) : /

Piping : /

Delivery : /

Remarks :

---

3. DEMOGRAPHY

User population : 600 PEOPLE (DEPENDING ON TIME OF YEAR), RESTAURANT & SMALL TOWN/VILLAGE CENTER
Main Occupation : FARMER

Water Collection Times : EVENING & MORNING

Methods : CONTAINERS

Containers used : "BEDON"

Average Usage : (l/p/day) 40 l/day/house = 8 l/p/day
DISCHARGE RATE: 2 gallons/minute

---

4. MAINTENANCE

Has the installation worked satisfactorily since installation? (yes/no) YES

Any periods of breakdown? (details) NO

Causes of breakdown

Who undertakes repairs?

Who finances these repairs?

Comments :

---

5. PHYSICAL/CHEMICAL WATER QUALITY

	Details	Raw Water	Filtered Water
1.	Average Counts Faecal Coliform/100ml		50
2.	Number of Samples		1
3.	Colour		Clear
4.	Odour		Odourless
5.	Temperature °C		24.7
6.	pH		6.2
7.	Turbidity, JTU		<5
8.	Conductivity µs/cm		140
9.	Comments		

UK OVERSEAS DEVELOPMENT ADMINISTRATION - PROJECT R3957

Gifford and Partners, Consulting Engineers, in association
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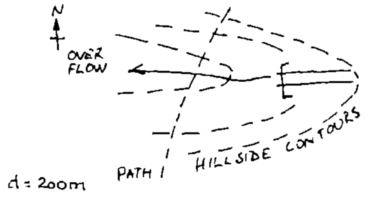
EVALUATION OF SWS FILTER SYSTEMS

FIELD DATA SHEET

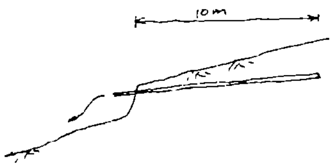
Serial No: Z/5	Name: KOMANDA 2	Long. 29° 46' Lat. 1° 56'	Visit Date(s): 13/5/85

Location Sketch Map



d = Average walking distance to water collection point (m)

Sketch of Installation



h = Operating head (m)

1. INSTALLATION

Date of Installation : MID JUNE 1983

Installed by : T. ROUS & LOCAL COMMUNITY

Has the equipment been installed in accordance with supplier's instructions? /

Remarks: TRADITIONALLY PROTECTED SPRING

Description of Source

Alternative Source : NONE

Quantity Restrictions/Variations: NONE

Quality/Pollution : NONE

INSTALLATION (Cont.)

Filter

One or two stage? /

Type and size of screen /

Filter Chamber made of : / TRADITIONALLY PROTECTED SOURCE

Dimensions : /

Filter medium : LARGE ROCKS

Covered with : SOIL

Connections from SPRING SOURCE

Pipe Dia : 2x½" OUTLETS Pipe Length : 10m

Pipe Material : PLASTIC

Pump GRAVITY

Type :

Size :

Mark :

Delivery Arrangements

General Remarks

GOOD STONEY BASIN FOR COLLECTION

2/5

2. PERFORMANCE

In working order (yes/no) YES

Filter Chamber(s) : /

Piping : YES

Delivery :YES

Remarks :

---

3. DEMOGRAPHY

User population :500 IN DRY SEASON, MANY LESS IN WET SEASON

Main Occupation :SUBSISTANCE FARMING

Water Collection Times :MORNING & EVENINGS

Methods : HAND CARRIED CONTAINERS

Containers used : PLASTIC CANS (BEDON)

Average Usage : (1/p/day)8-10 1/p/day FOR DRINKING PURPOSES ONLY

---

4. MAINTENANCE

Has the installation worked satisfactorily since installation? (yes/no)YES

Any periods of breakdown? (details) YES - FOR A FEW DAYS

Causes of breakdown PIPES GET BLOCKED AND SPRING NEEDS TO BE REDUG

Who undertakes repairs? LOCAL USERS

Who finances these repairs?LOCAL USERS

Comments :AN SWS SCREEN WITH A GRAVEL BED MIGHT WELL PREVENT BLOCKAGE OF THE PIPE

---

5. PHYSICAL/CHEMICAL WATER QUALITY

	Details	Raw Water	Filtered Water
1.	Average Counts Faecal Coliform/100ml		90
2.	Number of Samples		1
3.	Colour		Buff
4.	Odour		Slightly earthy
5.	Temperature ^oC		25
6.	pH		6
7.	Turbidity, JTU		15
8.	Conductivity $\mu s/cm$		114
9.	Comments		

UK OVERSEAS DEVELOPMENT ADMINISTRATION - PROJECT R3957

Gifford and Partners, Consulting Engineers, in association
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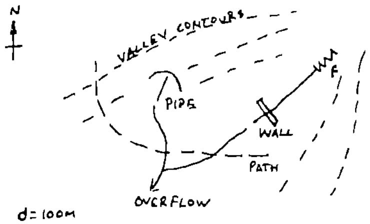
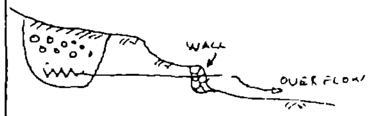
EVALUATION OF SWS FILTER SYSTEMS

FIELD DATA SHEET

<table>
<tr><td>Serial No:Z/6</td><td>Name:
MDODODO</td><td>Long. 30° 01'
Lat. 1° 57'</td><td>Visit Date(s):
14/5/85 and 15/5/85</td></tr>
<tr><td colspan="2">Location Sketch Map


d=100M
d = Average walking distance to water collection point (m)</td><td colspan="2">Sketch of Installation


h = Operating head (m)</td></tr>
</table>

1. INSTALLATION

Date of Installation : FEB 1985

Installed by : NYANKUNDE HEALTH TEAM

Has the equipment been installed in accordance
with supplier's instructions?

Remarks:

Description of Source

Alternative Source : NEAREST 2km AWAY

Quantity Restrictions/Variations: NONE REPORTED

Quality/Pollution : FIELDS ADJACENT TO SPRING

INSTALLATION (Cont.)

Filter

One or two stage? 1

Type and size of screen MINI

Filter Chamber
made of : /

Dimensions : /

Filter medium : SAND, GRAVEL 10mm SIZE

Covered with : THIN LAYER OF EARTH

Connections from Filter

Pipe Dia : 1"   Pipe Length : 10m

Pipe Material : PLASTIC, THE LAST ½m BEING GALVANISED IRON

Pump

Type :

GRAVITY

Size :

Mark :

Delivery Arrangements

General Remarks

2/6

2. PERFORMANCE

In working order (yes/no) YES

Filter Chamber(s) : /

Piping : OK

Delivery : OK

Remarks :

---

3. DEMOGRAPHY

User population : NOT KNOWN

Main Occupation : FARMER

Water Collection Times :EVENING/MORNING

Methods :CONTAINER CARRIED BY HAND

Containers used : 'BEDON'

Average Usage : (l/p/day) NOT KNOWN

---

4. MAINTENANCE

Has the installation worked satisfactorily since installation? (yes/no) YES

Any periods of breakdown? (details) NO

Causes of breakdown

Who undertakes repairs?

Who finances these repairs?

Comments :

5. PHYSICAL/CHEMICAL WATER QUALITY

	Details	Raw Water	Filtered Water	
			14.5.85	15.5.85
1.	Average Counts Faecal Coliform/100ml		70	394
2.	Number of Samples		1	1
3.	Colour		Clear	Clear
4.	Odour		-	-
5.	Temperature °C		23.4	24
6.	pH		5.8	6.1
7.	Turbidity, JTU		< 5	<5
8.	Conductivity μs/cm		400	412
9.	Comments		Rainfall previous evening	

UK OVERSEAS DEVELOPMENT ADMINISTRATION - PROJECT R3957

Gifford and Partners, Consulting Engineers, in association
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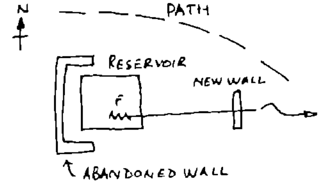
EVALUATION OF SWS FILTER SYSTEMS

FIELD DATA SHEET

Serial No:Z/7	Name: BOGORO 1	Long. 30° 17' Lat. 1° 56'	Visit Date(s): 16/5/85 and 24/5/85

Location Sketch Map



d= 500 M

d = Average walking distance to water collection point (m)

Sketch of Installation

h = Operating head (m)

1. INSTALLATION

Date of Installation : 26/10/84

Installed by : T. ROUS & LOCAL COMMUNITY

Has the equipment been installed in accordance
with supplier's instructions?

Remarks: TRADITIONALLY PROTECTED SOURCE WITH RESERVOIR

Description of Source

Alternative Source : 1 OTHER PROTECTED SOURCE 500m AWAY

Quantity Restrictions/Variations: ALL YEAR SUPPLY

Quality/Pollution : SPRING LIABLE TO OVERFLOW

INSTALLATION (Cont.)

Filter

One or two stage?

Type and size of screen

Filter Chamber
made of : TRADITIONALLY PROTECTED SOURCE

Dimensions :

Filter medium :

Covered with :

Connections from Filter

Pipe Dia : 1"

Pipe Length : 10m

Pipe Material : GALVANISED IRON

Pump

GRAVITY

Type :

Size :

Mark :

Delivery Arrangements

General Remarks

REASONABLY GOOD BUT TENDANCY TO FLOOD

2. PERFORMANCE

In working order (yes/no) YES

Filter Chamber(s) : /

Piping :OK

Delivery : OK

Remarks : THE OLD SYSTEM HAD THE OUTLET PIPE TOO HIGH. NEW OUTLET WORKS SATISFACTORILY

---

3. DEMOGRAPHY

User population :500+ DEPENDING ON TIME OF YEAR

Main Occupation :FARMERS/SOME COMMERCE IN BOGORO

Water Collection Times :MORNING/EVENING

Methods :HAND CARRIED CONTAINERS

Containers used :BEDON

Average Usage : (l/p/day)8 l/p/day

---

4. MAINTENANCE

Has the installation worked satisfactorily since installation? (yes/no) YES

Any periods of breakdown? (details)NO

Causes of breakdown

Who undertakes repairs?

Who finances these repairs?

Comments :

5. PHYSICAL/CHEMICAL WATER QUALITY

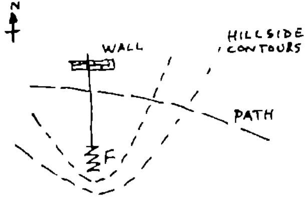
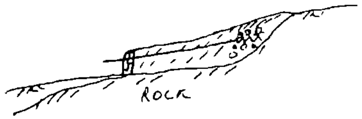
	Details	Raw Water	Filtered Water	
			16.5.85	24.5.85
1.	Average Counts Faecal Coliform/100ml		3	33
2.	Number of Samples		1	1
3.	Colour		Clear	Clear
4.	Odour		-	-
5.	Temperature °C		23.6	-
6.	pH		6.2	<6.8
7.	Turbidity, JTU		<5	<5
8.	Conductivity µs/cm		129	-
9.	Comments			

UK OVERSEAS DEVELOPMENT ADMINISTRATION - PROJECT R3957

Gifford and Partners, Consulting Engineers, in association
with The London School of Hygiene and Tropical Medicine

EVALUATION OF SWS FILTER SYSTEMS

FIELD DATA SHEET

<table>
<tr><td>Serial
No: Z/8</td><td>Name:
BERUNGA</td><td>Long. 30° 17'
Lat. 1° 56'</td><td>Visit Date(s):
16/5/85</td></tr>
<tr><td colspan="2">Location Sketch Map

d=300M
d = Average walking distance to water collection point (m)</td><td colspan="2">Sketch of Installation

h = Operating head (m)</td></tr>
</table>

1. INSTALLATION

Date of Installation : OCTOBER 1984

Installed by : T. ROUS & COMMUNITY

Has the equipment been installed in accordance
with supplier's instructions? YES

Remarks:

Description of Source

Alternative Source : SEE Z/7

Quantity Restrictions/Variations: NONE

Quality/Pollution : SURFACE INFILTRATION

INSTALLATION (Cont.)

Filter

One or two stage? 1

Type and size of screen MINI

Filter Chamber
made of : /

Dimensions : /

Filter medium : SAND, GRAVEL(8mm), LARGE STONES

Covered with : SOIL

Connections from Filter

Pipe Dia : 1" Pipe Length : 10m

Pipe Material : PLASTIC

Pump Type :

GRAVITY Size :

Mark :

Delivery Arrangements

General Remarks

2. PERFORMANCE

In working order (yes/no) YES

Filter Chamber(s) : /

Piping : OK

Delivery :OK

Remarks :

---

3. DEMOGRAPHY

User population : 400 DRY SEASON, LESS DURING WET SEASON

Main Occupation : SUBSISTANCE FARMERS

Water Collection Times : MORNING & EVENING

Methods : HAND CARRIED CONTAINERS

Containers used : "BEDON"

Average Usage : (l/p/day) ?

---

4. MAINTENANCE

Has the installation worked satisfactorily since installation? (yes/no) NO

Any periods of breakdown? (details) YES

Causes of breakdown FILTER GETS BLOCKED

Who undertakes repairs? LOCAL USERS

Who finances these repairs? /

Comments : THE BLOCKING PROBLEMS ARE OVERCOME BY BLOWING UP THE OUTFLOW PIPE

---

5. PHYSICAL/CHEMICAL WATER QUALITY

	Details	Raw Water	Filtered Water
1.	Average Counts Faecal Coliform/100ml		60
2.	Number of Samples		1
3.	Colour		Pale buff
4.	Odour		Slightly vegy
5.	Temperature °C		22.3
6.	pH		5.7
7.	Turbidity, JTU		<10
8.	Conductivity μs/cm		44
9.	Comments		

UK OVERSEAS DEVELOPMENT ADMINISTRATION - PROJECT R3957

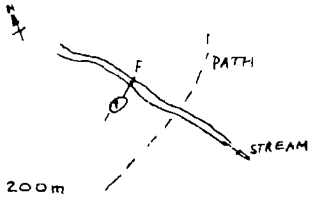
Gifford and Partners, Consulting Engineers, in association with The London School of Hygiene and Tropical Medicine

EVALUATION OF SWS FILTER SYSTEMS

FIELD DATA SHEET

Serial No: Z/9	Name: BOGA MISSON	Long. 29° 58' Lat. 1° 33'	Visit Date(s): 17/5/85

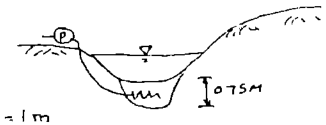
Location Sketch Map



d < 200m

d = Average walking distance to water collection point (m)

Sketch of Installation



h = 1m

h = Operating head (m)

1. INSTALLATION

Date of Installation : MAY 1983

Installed by : T. ROUS & COMMUNITY

Has the equipment been installed in accordance with supplier's instructions? YES

Remarks:

Description of Source

Alternative Source : SEVERAL IN THE LOCALITY

Quantity Restrictions/Variations: NONE

Quality/Pollution : SURFACE INFILTRATION FROM CULTIVATED FIELDS

INSTALLATION (Cont.)

Filter

One or two stage? 1

Type and size of screen MINI FILTER

Filter Chamber / made of :

Dimensions : /

Filter medium : SMALL GRAVEL APPROX 0.7m IN DEPTH

Covered with : LARGE STONES

Connections from Filter

Pipe Dia : 1"

Pipe Length : ?

Pipe Material : PLASTIC

Pump

Type : PATAY

Size :

Mark :DD70

Delivery Arrangements

SINGLE FLEXIBLE GREEN PIPE

General Remarks

OVERFLOW FROM DISCHARGE IS DIRECTED INTO THE STREAM

2/9

2. PERFORMANCE

In working order (yes/no) YES

Filter Chamber(s) : /

Piping : OK

Delivery :OK

Remarks :

---

3. DEMOGRAPHY

User population : 15

Main Occupation : FARMERS/MISSION/HOSPITAL

Water Collection Times : MORNING & EVENING

Methods :HAND CARRIED CONTAINERS

Containers used :"BEDON"

Average Usage : (l/p/day)

---

4. MAINTENANCE

Has the installation worked satisfactorily since installation? (yes/no) NO

Any periods of breakdown? (details) YES

Causes of breakdown PATAY PUMP BROKEN AND NOW REPLACED

Who undertakes repairs? T ROUS

Who finances these repairs? MISSION

Comments :

---

5. PHYSICAL/CHEMICAL WATER QUALITY

Intensive study site: see Appendix E.

UK OVERSEAS DEVELOPMENT ADMINISTRATION - PROJECT R3957

Gifford and Partners, Consulting Engineers, in association
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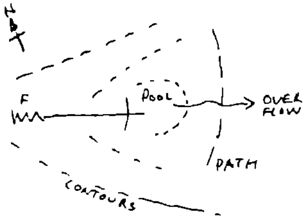
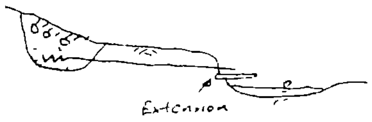
EVALUATION OF SWS FILTER SYSTEMS

FIELD DATA SHEET

<table>
<tr><td>Serial No: Z/10</td><td>Name: RAKAIKARA</td><td>Long. 29° 58'
Lat. 1° 33'</td><td>Visit Date(s): 17/5/85</td></tr>
<tr><td colspan="2">Location Sketch Map

d = Average walking distance to water collection point (m)</td><td colspan="2">Sketch of Installation

h = Operating head (m)</td></tr>
</table>

1. INSTALLATION

Date of Installation : NOVEMBER 1983

Installed by : T. ROUS & COMMUNITY

Has the equipment been installed in accordance
with supplier's instructions?

Remarks:

Description of Source

Alternative Source : RESERVOIR AT MISSION

Quantity Restrictions/Variations: VERY LOW DURING DRY SEASON

Quality/Pollution : NEARBY FIELDS

INSTALLATION (Cont.)

Filter

One or two stage? 1

Type and size of screen MINI

Filter Chamber
made of : /

Dimensions : /

Filter medium : GRAVEL QUITE FINE

Covered with : LARGE STONES/EARTH

Connections from Filter

Pipe Dia : 1"

Pipe Length : 5m

Pipe Material : PLASTIC

Pump

GRAVITY

Type :

Size :

Mark :

Delivery Arrangements

General Remarks

Z/10

2. PERFORMANCE

In working order (yes/no) YES

Filter Chamber(s) : /

Piping : THIS IS BROKEN, AN EXTENSION HAS BEEN MADE WITH BANANA LEAVES
Delivery :OK

Remarks :

---

3. DEMOGRAPHY

User population : 30

Main Occupation : FARMERS

Water Collection Times : MORNING & EVENING

Methods : BEDON CARRIED BY HAND

Containers used : BEDON

Average Usage : (l/p/day) 5 l/p/day DRINKING ONLY

---

4. MAINTENANCE

Has the installation worked satisfactorily since installation? (yes/no) YES

Any periods of breakdown? (details) NO

Causes of breakdown /

Who undertakes repairs? /

Who finances these repairs? /

Comments : BROKEN OUTLET PIPE REPLACED BY A BANANA LEAF EXTENSION

---

5. PHYSICAL/CHEMICAL WATER QUALITY

	Details	Raw Water	Filtered Water
1.	Average Counts Faecal Coliform/100ml		121
2.	Number of Samples		1
3.	Colour		Buff
4.	Odour		-
5.	Temperature °C		22.8
6.	pH		5.8
7.	Turbidity, JTU		<5
8.	Conductivity μs/cm		57
9.	Comments		

UK OVERSEAS DEVELOPMENT ADMINISTRATION - PROJECT R3957

Gifford and Partners, Consulting Engineers, in association
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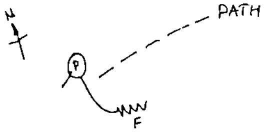
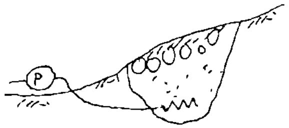
EVALUATION OF SWS FILTER SYSTEMS

FIELD DATA SHEET

<table>
<tr><td>Serial No: Z/11</td><td>Name: CHORORO</td><td>Long. 29° 58'
Lat. 1° 35'</td><td>Visit Date(s): 18/5/85</td></tr>
<tr><td colspan="2">Location Sketch Map


d=100M
d = Average walking distance to water collection point (m)</td><td colspan="2">Sketch of Installation


h=0.8m
h = Operating head (m)</td></tr>
</table>

1. INSTALLATION

Date of Installation : JANUARY 1983

Installed by : T. ROUS & COMMUNITY

Has the equipment been installed in accordance with supplier's instructions? YES

Remarks:

Description of Source

Alternative Source : SEVERAL

Quantity Restrictions/Variations: NONE REPORTED

Quality/Pollution : RAINY SEASON

INSTALLATION (Cont.)

Filter

One or two stage? 1

Type and size of screen MINI

Filter Chamber made of : /

Dimensions : /

Filter medium : QUITE FINE SAND

Covered with : STONES & EARTH

Connections from Filter

Pipe Dia : 1" Pipe Length : 3m

Pipe Material : PVC

Pump

Type : ROWER

Size :

Mark :

Delivery Arrangements

General Remarks

1) THE PUMP IS QUITE HARD TO USE WHICH MAY INDICATE CLOGGING

2) IT IS SAID THE WATER GETS CLOUDY, DURING THE RAINY SEASON

2. PERFORMANCE

In working order (yes/no) YES

Filter Chamber(s) : /

Piping : OK

Delivery : OK

Remarks : /

---

3. DEMOGRAPHY

User population : 5 HOUSES, 6 PEOPLE IN EACH

Main Occupation : FARMER

Water Collection Times : EVENING & MORNING

Methods : HAND CARRIED CONTAINERS

Containers used : "BEDON"

Average Usage : (l/p/day) 10 l/p/day

---

4. MAINTENANCE

Has the installation worked satisfactorily since installation? (yes/no) NO

Any periods of breakdown? (details) YES (FOR 1 WEEK)

Causes of breakdown A PATAY PUMP WAS ORIGINALLY INSTALLED AND BROKE DOWN WITHIN ONE WEEK

Who undertakes repairs? T. ROUS

Who finances these repairs? MISSION FUNDS

Comments :

---

5. PHYSICAL/CHEMICAL WATER QUALITY

	Details	Raw Water	Filtered Water
1.	Average Counts Faecal Coliform/100ml		1260
2.	Number of Samples		1
3.	Colour		Buff
4.	Odour		Vegy
5.	Temperature °C		23
6.	pH		5.7
7.	Turbidity, JTU		200
8.	Conductivity μs/cm		142
9.	Comments		

UK OVERSEAS DEVELOPMENT ADMINISTRATION - PROJECT R3957

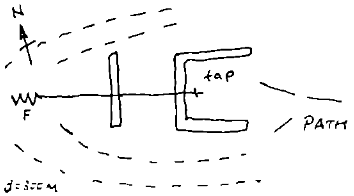
Gifford and Partners, Consulting Engineers, in association with The London School of Hygiene and Tropical Medicine

EVALUATION OF SWS FILTER SYSTEMS

FIELD DATA SHEET

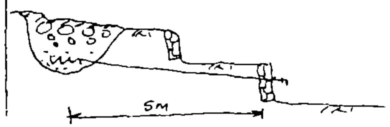
Serial No: Z/12	Name: KARBAROLE	Long. 29° 58' Lat. 1° 35'	Visit Date(s): 18/5/85 and 19/5/85

Location Sketch Map



d = Average walking distance to water collection point (m)

Sketch of Installation



h = Operating head (m)

1. INSTALLATION

Date of Installation : FEBRUARY 1983

Installed by : T. ROUS & COMMUNITY

Has the equipment been installed in accordance with supplier's instructions? YES

Remarks:

Description of Source

Alternative Source : NONE NEARBY

Quantity Restrictions/Variations: NONE REPORTED

Quality/Pollution : NONE

INSTALLATION (Cont.)

Filter

One or two stage? 1

Type and size of screen MINI FILTER

Filter Chamber made of : /

Dimensions : /

Filter medium : A CONSIDERABLE QUANTITY OF FINE GRAVEL- LESS THAN 8mm SIZE

Covered with :

Connections from Filter

Pipe Dia : 1"

Pipe Length : 5m+

Pipe Material : PLASTIC , LAST METRE GALVANISED IRON

Pump

GRAVITY

Type :

Size :

Mark :

Delivery Arrangements

General Remarks

1 HOUR STORAGE AVAILABLE IN THE FILTER MEDIUM DURING THE DRY SEASON

2. PERFORMANCE

In working order (yes/no) YES

Filter Chamber(s) : /

Piping : OK

Delivery : OK

Remarks :

---

3. DEMOGRAPHY

User population : 17 HOUSES, MORE DURING DRY SEASON

Main Occupation : FARMERS/HOSPITAL WORK

Water Collection Times : MORNING & EVENING

Methods : HAND CARRIED "BEDON"

Containers used : "BEDON"

Average Usage : (l/p/day) 20 l/p/day

---

4. MAINTENANCE

Has the installation worked satisfactorily since installation? (yes/no) YES

Any periods of breakdown? (details) NO

Causes of breakdown

Who undertakes repairs?

Who finances these repairs?

Comments :

5. PHYSICAL/CHEMICAL WATER QUALITY

	Details	Raw Water	Filtered Water	
			18.5.85	19.5.85
1.	Average Counts Faecal Coliform/100ml		6	5
2.	Number of Samples		1	1
3.	Colour		Clear	Clear
4.	Odour		-	-
5.	Temperature °C		23.8	-
6.	pH		6.1	6.1
7.	Turbidity, JTU		<5	<5
8.	Conductivity μs/cm		112	120
9.	Comments			

UK OVERSEAS DEVELOPMENT ADMINISTRATION - PROJECT R3957

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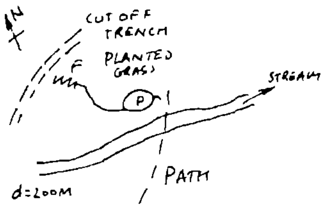
EVALUATION OF SWS FILTER SYSTEMS

FIELD DATA SHEET

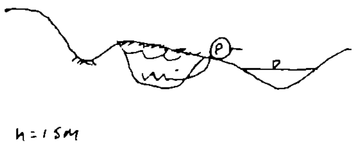
Serial No:Z/13	Name: KAHWA	Long. 29 °59 ' Lat. 1 °34 '	Visit Date(s): 10/5/85 and 19/5/85

Location Sketch Map



d = Average walking distance to water collection point (m)

Sketch of Installation



h = Operating head (m)

1. INSTALLATION

Date of Installation : MARCH 1983

Installed by : T. ROUS & COMMUNITY

Has the equipment been installed in accordance with supplier's instructions?

Remarks:

Description of Source

Alternative Source : STREAM

Quantity Restrictions/Variations: NO

Quality/Pollution : STREAM OVERFLOW

INSTALLATION (Cont.)

Filter

One or two stage? 1

Type and size of screen MINI

Filter Chamber made of : /

Dimensions : /

Filter medium : GRAVEL APPROX 8mm SIZE

Covered with : LARGE STONES

Connections from Filter

Pipe Dia : 1"

Pipe Length : 2m

Pipe Material : PLASTIC

Pump

Type : ROWER

Size :

Mark :

Delivery Arrangements

General Remarks

1) A CONCRETE STAND IS PROVIDED TO REST BUCKETS ON AND TO DIVERT WASTE WATER TO STREAM

2) POSSIBLE OVERFLOW OF STREAM TO POLLUTE SPRING SOURCE AFTER HEAVY RAIN

2. PERFORMANCE

In working order (yes/no) YES

Filter Chamber(s) : /

Piping : OK

Delivery : OK

Remarks :

---

3. DEMOGRAPHY

User population : 10 HOUSES - 60 PEOPLE

Main Occupation : FARMERS/CHURCH WORKERS

Water Collection Times : EVENING/MORNING

Methods :HAND CARRIED CONTAINERS

Containers used : "BEDON"

Average Usage : (l/p/day) 12 l/p/day

---

4. MAINTENANCE

Has the installation worked satisfactorily since installation? (yes/no) NO

Any periods of breakdown? (details) YES, FOR A SHORT PERIOD - SIX MONTHS AFTER INSTALLATION

Causes of breakdown PATAY PUMP BREAKDOWN

Who undertakes repairs? T. ROUS REPLACED PATAY PUMP WITH THE ROWER PUMP

Who finances these repairs? MISSION FUNDS

Comments :

---

5. PHYSICAL/CHEMICAL WATER QUALITY

	Details	Raw Water	Filtered Water	
			18.5.85	19.5.85
1.	Average Counts Faecal Coliform/100ml		660	120
2.	Number of Samples		1	1
3.	Colour		Clear	Clear
4.	Odour		-	-
5.	Temperature °C		23.7	-
6.	pH		6.13	5.8
7.	Turbidity, JTU		<5	<5
8.	Conductivity μs/cm		-	175
9.	Comments			

UK OVERSEAS DEVELOPMENT ADMINISTRATION - PROJECT R3957

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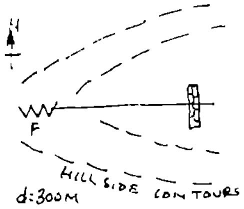
EVALUATION OF SWS FILTER SYSTEMS

FIELD DATA SHEET

Serial No: Z/14	Name: KABAGANZI 1	Long. 29° 56' Lat. 1° 35'	Visit Date(s): 20/5/85

Location Sketch Map



d = Average walking distance to water collection point (m)

Sketch of Installation

h = Operating head (m)

1. INSTALLATION

Date of Installation : OCTOBER 1983

Installed by : T. ROUS

Has the equipment been installed in accordance with supplier's instructions? YES

Remarks:

Description of Source

Alternative Source : ANOTHER SWS 500m + AWAY

Quantity Restrictions/Variations: LESS FLOW DURING DRY SEASON

Quality/Pollution : CULTIVATION RUN OFF

INSTALLATION (Cont.)

Filter

One or two stage? 1

Type and size of screen MINI

Filter Chamber made of : /

Dimensions : /

Filter medium : GRAVEL & SAND

Covered with : EARTH, LARGE STONES

Connections from Filter

Pipe Dia : 1"

Pipe Length : 6m

Pipe Material : PLASTIC & GALVANISED

Pump

Type : GRAVITY

Size :

Mark :

Delivery Arrangements

General Remarks

1) TAP INSTALLED BY VILLAGER LEFT OPEN ON OUR VISIT. PERHAPS THE RESERVOIR EFFECT OF FILTER MEDIUM IS USED ONLY DURING DRY SEASON

2) MUDDY OUTLET POINT

2/14

2. PERFORMANCE

In working order (yes/no) YES

Filter Chamber(s) : N/A

Piping : OK

Delivery : OK

Remarks :

---

3. DEMOGRAPHY

User population : 3 HOUSES

Main Occupation : FARMERS/SCHOOL TEACHER

Water Collection Times : MORNING & EVENING

Methods : CARRYING BEDON

Containers used : BEDON

Average Usage : (l/p/day) 60-90 l/house/day

---

4. MAINTENANCE

Has the installation worked satisfactorily since installation? (yes/no) YES

Any periods of breakdown? (details) NO BUT WOODEN DAM PROTECTION IS BREAKING UP

Causes of breakdown

Who undertakes repairs?

Who finances these repairs?

Comments :

---

5. PHYSICAL/CHEMICAL WATER QUALITY

	Details	Raw Water	Filtered Water
1.	Average Counts Faecal Coliform/100ml		28
2.	Number of Samples		1
3.	Colour		Clear
4.	Odour		-
5.	Temperature ^{o}C		22.3
6.	pH		4.4
7.	Turbidity, JTU		<5
8.	Conductivity $\mu s/cm$		35
9.	Comments		

UK OVERSEAS DEVELOPMENT ADMINISTRATION - PROJECT R3957

Gifford and Partners, Consulting Engineers, in association
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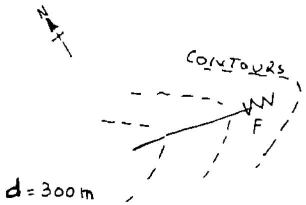
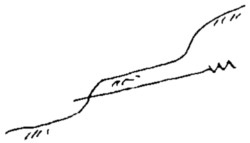
EVALUATION OF SWS FILTER SYSTEMS

FIELD DATA SHEET

<table>
<tr><td>Serial No: Z/15</td><td>Name: CANDIP</td><td>Long. 29° 56'
Lat. 1° 35'</td><td>Visit Date(s): 20/5/85 and 22/5/85</td></tr>
<tr><td colspan="2">Location Sketch Map


d = Average walking distance to water collection point (m)</td><td colspan="2">Sketch of Installation

h = Operating head (m)</td></tr>
</table>

1. INSTALLATION

Date of Installation : NOVEMBER 1983

Installed by : T. ROUS

Has the equipment been installed in accordance with supplier's instructions? YES

Remarks:

Description of Source

Alternative Source : NEAREST SOURCE 500m

Quantity Restrictions/Variations: PRONE TO DRY OUT

Quality/Pollution : CULTIVATION RUN OFF

INSTALLATION (Cont.)

Filter

One or two stage? 1

Type and size of screen MINI

Filter Chamber made of : /

Dimensions : /

Filter medium : GRAVEL & STONES & SAND

Covered with : EARTH/STONES

Connections from Filter

Pipe Dia : 1"

Pipe Length : 85m

Pipe Material : P.V.C.

Pump

Type : GRAVITY

Size :

Mark :

Delivery Arrangements

General Remarks

1) P.V.C. PIPE STOPPED WITH BANANA TO STOP SOURCE DRYING OUT, WHICH IS PREFERRED TO A TAP FOR THE REASON THAT CHILDREN CANNOT OPERATE A TAP, OR REMEMBER TO TURN IT OFF

2. PERFORMANCE

In working order (yes/no) YES

Filter Chamber(s) : /

Piping : OK

Delivery :OK

Remarks :

---

3. DEMOGRAPHY

User population : 5 HOUSES

Main Occupation : FARMERS

Water Collection Times : MORNING & EVENING

Methods : "BEDON" CARRIED BY HAND

Containers used : "BEDON"

Average Usage : (1/p/day) DISCHARGE RATE = 0.251/sec

---

4. MAINTENANCE

Has the installation worked satisfactorily since installation? (yes/no) YES

Any periods of breakdown? (details) NO

Causes of breakdown

Who undertakes repairs?

Who finances these repairs?

Comments :

---

5. PHYSICAL/CHEMICAL WATER QUALITY

	Details	Raw Water	Filtered Water	
			20.5.85	22.5.85
1.	Average Counts Faecal Coliform/100ml		5	69
2.	Number of Samples		1	1
3.	Colour		Clear	Clear
4.	Odour		-	-
5.	Temperature ^{o}C		22.3	22.9
6.	pH		5.6	-
7.	Turbidity, JTU		5	<5
8.	Conductivity μs/cm		51	-
9.	Comments			

UK OVERSEAS DEVELOPMENT ADMINISTRATION - PROJECT R3957

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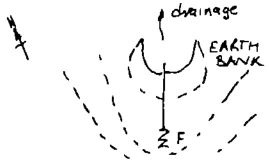
EVALUATION OF SWS FILTER SYSTEMS

FIELD DATA SHEET

Serial No: Z/16	Name: KABAGANZI 2	Long. 29° 56' Lat. 1° 36'	Visit Date(s): 20/5/85

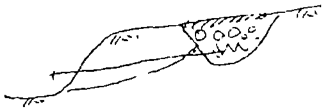
Location Sketch Map



d = 300+M

d = Average walking distance to water collection point (m)

Sketch of Installation



h = Operating head (m)

1. INSTALLATION

Date of Installation : DECEMBER 1983

Installed by : T. ROUS & COMMUNITY

Has the equipment been installed in accordance with supplier's instructions? YES

Remarks:

Description of Source

Alternative Source : 800m AWAY

Quantity Restrictions/Variations: NONE

Quality/Pollution : LIGHT CULTIVATION IN RUN OFF AREA

INSTALLATION (Cont.)

Filter

One or two stage? 1

Type and size of screen MINI

Filter Chamber made of : /

Dimensions : /

Filter medium : GRAVEL NO SAND, SAND BLOCKED FILTER SO REMOVED.

Covered with : EARTH STONES

Connections from Filter

Pipe Dia : 1"

Pipe Length : ?

Pipe Material : PVC & GALVANISED IRON

Pump

GRAVITY

Type :

Size :

Mark :

Delivery Arrangements

1 TAP

General Remarks

2/16

2. PERFORMANCE

In working order (yes/no) YES

Filter Chamber(s) : /

Piping : OK

Delivery : OK

Remarks :

---

3. DEMOGRAPHY

User population : 5 HOUSES

Main Occupation : FARMER/SCHOOL

Water Collection Times : EVENING & MORNING

Methods : CARRYING BEDON

Containers used : "BEDON"

Average Usage : (l/p/day) 15 l/p/day

---

4. MAINTENANCE

Has the installation worked satisfactorily since installation? (yes/no) YES

Any periods of breakdown? (details) NO

Causes of breakdown

Who undertakes repairs?

Who finances these repairs?

Comments :

---

5. PHYSICAL/CHEMICAL WATER QUALITY

	Details	Raw Water	Filtered Water
1.	Average Counts Faecal Coliform/100ml		60
2.	Number of Samples		1
3.	Colour		Clear
4.	Odour		-
5.	Temperature °C		22
6.	pH		5.0
7.	Turbidity, JTU		10
8.	Conductivity μs/cm		57
9.	Comments		

UK OVERSEAS DEVELOPMENT ADMINISTRATION - PROJECT R3957

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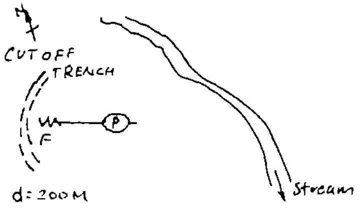
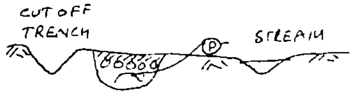
EVALUATION OF SWS FILTER SYSTEMS

FIELD DATA SHEET

Serial No: Z/17	Name: MUTEGA	Long. 29° 56' Lat. 1° 37'	Visit Date(s): 22/5/85

Location Sketch Map	Sketch of Installation
	
d = Average walking distance to water collection point (m)	h = Operating head (m)

1. **INSTALLATION**

Date of Installation : ?

Installed by : T. ROUS & COMMUNITY

Has the equipment been installed in accordance with supplier's instructions? YES

Remarks:

Description of Source

Alternative Source : STREAM

Quantity Restrictions/Variations: NONE REPORTED

Quality/Pollution : NONE

INSTALLATION (Cont.)

Filter

One or two stage? 1

Type and size of screen CAMP UNIT

Filter Chamber made of : GRP

Dimensions : 300mmx300mm

Filter medium : GRAVEL

Covered with : LARGE STONES/EARTH

Connections from Filter

Pipe Dia : 1"

Pipe Length : ?

Pipe Material : PLASTIC

Pump

Type : ROWER PUMP

Size :

Mark :

Delivery Arrangements

General Remarks

DELIVERY OK

2/17

2. **PERFORMANCE**

In working order (yes/no) YES

Filter Chamber(s) : YES

Piping : YES

Delivery : YES

Remarks :

---

3. **DEMOGRAPHY**

User population : 20+

Main Occupation : CHIEF & RETINUE

Water Collection Times : AM & PM

Methods : CARRYING BEDON

Containers used : BEDON

Average Usage : (l/p/day) 20 l/p/day

---

4. **MAINTENANCE**

Has the installation worked satisfactorily since installation? (yes/no) YES

Any periods of breakdown? (details) NO

Causes of breakdown

Who undertakes repairs?

Who finances these repairs?

Comments :

---

5. **PHYSICAL/CHEMICAL WATER QUALITY**

	Details	Raw Water	Filtered Water
1.	Average Counts Faecal Coliform/100ml		98
2.	Number of Samples		1
3.	Colour		Clear
4.	Odour		-
5.	Temperature ^{o}C		23.7
6.	pH		7.2
7.	Turbidity, JTU		<5
8.	Conductivity $\mu s/cm$		
9.	Comments		

UK OVERSEAS DEVELOPMENT ADMINISTRATION - PROJECT R3957

Gifford and Partners, Consulting Engineers, in association
with The London School of Hygiene and Tropical Medicine

EVALUATION OF SWS FILTER SYSTEMS

FIELD DATA SHEET

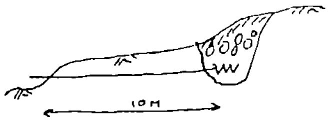
Serial No: 2/18	Name: KABALU	Long. 30° 06' Lat. 1° 47'	Visit Date(s): 23/5/85

Location Sketch Map

d: 300 M

d = Average walking distance to water collection point (m)

Sketch of Installation



h = Operating head (m)

1. INSTALLATION

Date of Installation : 4/4/85

Installed by : LOCAL COMMUNITY

Has the equipment been installed in accordance
with supplier's instructions?

Remarks:

Description of Source

Alternative Source : NONE

Quantity Restrictions/Variations: NONE

Quality/Pollution : LIGHT CULTIVATION

INSTALLATION (Cont.)

Filter

One or two stage? 1

Type and size of screen MINI

Filter Chamber made of : /

Dimensions : /

Filter medium : SAND

Covered with : LARGE STONES & EARTH

Connections from Filter

Pipe Dia : 1"

Pipe Length : 10m

Pipe Material : GALVANISED & PVC

Pump

Type : GRAVITY

Size :

Mark :

Delivery Arrangements

General Remarks

2/18

2. PERFORMANCE

In working order (yes/no) YES

Filter Chamber(s) : N/A

Piping : YES

Delivery : YES

Remarks :

---

3. DEMOGRAPHY

User population : 18 HOUSES

Main Occupation : FARMERS

Water Collection Times : MORNING & EVENING

Methods : BEDON CARRIED BY HAND

Containers used : BEDON 201

Average Usage : (1/p/day) 10 1/p/day 0.21/sec discharge

---

4. MAINTENANCE

Has the installation worked satisfactorily since installation? (yes/no) YES

Any periods of breakdown? (details) NO

Causes of breakdown

Who undertakes repairs?

Who finances these repairs?

Comments : LITTLE BLACK BUGS ARE REPORTED IN THE WATER

---

5. PHYSICAL/CHEMICAL WATER QUALITY

	Details	Raw Water	Filtered Water
1.	Average Counts Faecal Coliform/100ml		11
2.	Number of Samples		1
3.	Colour		Clear
4.	Odour		-
5.	Temperature ^{o}C		-
6.	pH		-
7.	Turbidity, JTU		<5
8.	Conductivity $\mu s/cm$		-
9.	Comments		

UK OVERSEAS DEVELOPMENT ADMINISTRATION - PROJECT R3957

Gifford and Partners, Consulting Engineers, in association
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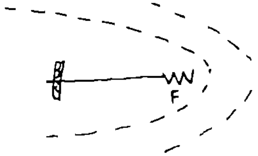
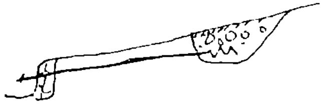
EVALUATION OF SWS FILTER SYSTEMS

FIELD DATA SHEET

<table>
<tr><td>Serial No: Z/19</td><td>Name: CHEKELE</td><td>Long. 30° 06'
Lat. 1° 47'</td><td>Visit Date(s): 23/5/85</td></tr>
<tr><td colspan="2">Location Sketch Map

d=200
d = Average walking distance to water collection point (m)</td><td colspan="2">Sketch of Installation

h = Operating head (m)</td></tr>
</table>

1. INSTALLATION

Date of Installation : APRIL 1985

Installed by : LOCAL COMMUNITY

Has the equipment been installed in accordance
with supplier's instructions?

Remarks:

Description of Source

Alternative Source : NONE

Quantity Restrictions/Variations: TAP TO CONSERVE FOR DRY SEASON

Quality/Pollution : LIGHT CULTIVATION

INSTALLATION (Cont.)

Filter

One or two stage? 1

Type and size of screen MINI

Filter Chamber
made of : /

Dimensions : /

Filter medium : SAND

Covered with : LARGE STONES/EARTH

Connections from Filter

Pipe Dia : 1" Pipe Length : 10m

Pipe Material : PVC & GALVANISED IRON

Pump

Type :

Size : GRAVITY

Mark :

Delivery Arrangements

General Remarks

2/19

2. PERFORMANCE

In working order (yes/no) YES

Filter Chamber(s) : N/A

Piping : YES

Delivery : YES

Remarks :

---

3. DEMOGRAPHY

User population : 15 HOUSES +

Main Occupation : FARMERS

Water Collection Times : MORNING & EVENING

Methods : CARRYING BEDON BY HAND

Containers used : 201 BEDON

Average Usage : (l/p/day)

---

4. MAINTENANCE

Has the installation worked satisfactorily since installation? (yes/no) YES

Any periods of breakdown? (details) NO

Causes of breakdown

Who undertakes repairs?

Who finances these repairs?

Comments :

---

5. PHYSICAL/CHEMICAL WATER QUALITY

	Details	Raw Water	Filtered Water
1.	Average Counts Faecal Coliform/100ml		11
2.	Number of Samples		1
3.	Colour		Clear
4.	Odour		Odourless
5.	Temperature ^{o}C		-
6.	pH		<6.8
7.	Turbidity, JTU		<5
8.	Conductivity $\mu s/cm$		-
9.	Comments		

APPENDIX C : FIELD DATA SHEETS - SUDAN

Ref No	Location/Site Name	Type of Installation
S/1	Shagra 1	SWS mini containerised unit - double filtration
S/2	Shagra 2	SWS mini containerised unit - double filtration
S/3	Jubara 1	SWS mini containerised unit
S/4	Jubara 2	"
S/5	Jubara 3	"
S/6	Tama	"
S/7	Wadelamin	"
S/8	Ashara Nafi	"
S/9	Warali	"

UK OVERSEAS DEVELOPMENT ADMINISTRATION - PROJECT R3957

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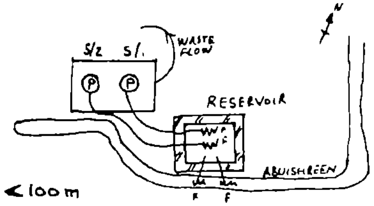
EVALUATION OF SWS FILTER SYSTEMS

FIELD DATA SHEET

Serial No: S/1	Name: SHAGRA 1	Long. 33° 15' Lat. 14° 47'	Visit Date(s): 22/6 - 1/7/85

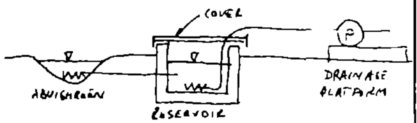
Location Sketch Map



d < 100 m

d = Average walking distance to water collection point (m)

Sketch of Installation



h < 1 m

h = Operating head (m)

1. INSTALLATION

Date of Installation : 1982

Installed by : BLUE NILE HEALTH PROJECT

Has the equipment been installed in accordance with supplier's instructions?

Remarks:

Description of Source

Alternative Source : RAW WATER FROM FIELD DITCH OR REMOTE CANAL

Quantity Restrictions/Variations: FIELD DITCH OFTEN DRY

Quality/Pollution : GROSS SURFACE POLLUTION

INSTALLATION (Cont.)

Filter

One or two stage? 2 STAGE IN SERIES, WITH RESERVOIR 1.2 x 2.4 x 1.5m DEEP

Type and size of screen MINI

Filter Chamber made of : POLYTHENE

Dimensions : 18" x 12" x 12"

Filter medium : 3mm GRAVEL

Covered with : 3 LAYERS OF FILTERMAT CLAMPED TO THE RIM

Connections from Filter

Pipe Dia : 1"

Pipe Length : 2m

Pipe Material : PVC

Pump

Type : ROWER

Size :

Mark :

Delivery Arrangements

QUITE NEAT

General Remarks

1) DRAINAGE PLATFORM WITH PIPED DRAINAGE LEADING BACK TO FIELD DITCH

2) A RESERVOIR COVER WAS BEING CONSTRUCTED DURING THE VISIT.

5/1

2. PERFORMANCE

In working order (yes/no) YES

Filter Chamber(s) : YES

Piping : YES

Delivery : YES

Remarks :

---

3. DEMOGRAPHY

User population : 300/500

Main Occupation : AGRICULTURAL LABOURERS

Water Collection Times : MORNING & EVENING

Methods : HAND CONTAINERS

Containers used : 201 JERRY CAN

Average Usage : (l/p/day) 101/p/day DRINKING PURPOSES ONLY

---

4. MAINTENANCE

Has the installation worked satisfactorily since installation? (yes/no)NO

Any periods of breakdown? (details) YES, RECORDS ONLY AVAILABLE FROM DECEMBER 1984

Causes of breakdown CLOGGING OF FILTER MATS

Who undertakes repairs? B.N.H.P. ENGINEERING UNIT

Who finances these repairs? B.N.H.P.

Comments : UNIT CONTINUED TO FUNCTION DURING EVALUATION PERIOD

---

5. PHYSICAL/CHEMICAL WATER QUALITY

Intensive study site: see Appendix E.

UK OVERSEAS DEVELOPMENT ADMINISTRATION - PROJECT R3957

Gifford and Partners, Consulting Engineers, in association
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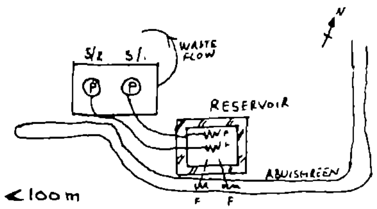
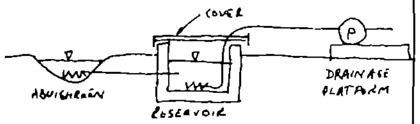
EVALUATION OF SWS FILTER SYSTEMS

FIELD DATA SHEET

<table>
<tr><td>Serial
No: S/2</td><td>Name:
SHAGRA 2</td><td>Long. 33° 15'
Lat. 14° 47'</td><td>Visit Date(s):
22/6 - 1/7/85</td></tr>
<tr><td colspan="2">Location Sketch Map

d < 100m
d = Average walking distance to water collection point (m)</td><td colspan="2">Sketch of Installation

h < 1m
h = Operating head (m)</td></tr>
</table>

1. **INSTALLATION**

Date of Installation : 1982

Installed by : BLUE NILE HEALTH PROJECT

Has the equipment been installed in accordance
with supplier's instructions?

Remarks:

Description of Source

Alternative Source :RAW WATER FROM FIELD DITCH OR REMOTE CANAL

Quantity Restrictions/Variations:FIELD DITCH, ONE OFTEN DRY

Quality/Pollution : GROSS SURFACE POLLUTION

INSTALLATION (Cont.)

Filter

One or two stage? 2 STAGE IN SERIES, WITH RESERVOIR 1.2 x 2.4 x 1.5m DEEP

Type and size of screen MINI

Filter Chamber
made of : POLYTHENE

Dimensions : 18" x 12" x 12"

Filter medium : 3mm GRAVEL

Covered with : 3 LAYERS OF FILTERMAT CLAMPED TO RIM

Connections from Filter

Pipe Dia :1" Pipe Length :2m

Pipe Material : PVC

Pump

Type : PATAY

Size : DD120

Mark :

Delivery Arrangements

General Remarks

COMMENTS AS S/1

S/2

2. PERFORMANCE

In working order (yes/no) AS S/1

Filter Chamber(s) :

Piping :

Delivery :

Remarks :

---

3. DEMOGRAPHY

User population : 300/500

Main Occupation : AGRICULTURAL LABOURERS

Water Collection Times : MORNING & EVENING

Methods : HAND CONTAINERS

Containers used : 201 JERRY CANS

Average Usage : (l/p/day) 101/p/day DRINKING PURPOSES ONLY

---

4. MAINTENANCE

Has the installation worked satisfactorily since installation? (yes/no) NO

Any periods of breakdown? (details) YES, RECORDS ONLY AVAILABLE FROM DECEMBER 1984

Causes of breakdown CLOGGING OF FILTERMATS - PUMP BREAKDOWN

Who undertakes repairs? B.N.H.P. ENGINEERING UNIT

Who finances these repairs? B.N.H.P.

Comments :
UNITS CONTINUED TO FUNCTION DURING EVALUATION

---

5. PHYSICAL/CHEMICAL WATER QUALITY

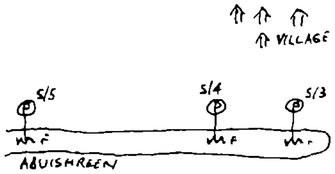
Intensive study site: see Appendix E.

UK OVERSEAS DEVELOPMENT ADMINISTRATION - PROJECT R3957

Gifford and Partners, Consulting Engineers, in association
with The London School of Hygiene and Tropical Medicine

EVALUATION OF SWS FILTER SYSTEMS

FIELD DATA SHEET

<table>
<tr><td>Serial
No:S/3</td><td>Name:
JUBARA 1</td><td>Long. 33° 12'
Lat. 14° 48'</td><td>Visit Date(s):
22/6 - 1/7/85</td></tr>
<tr><td colspan="2">Location Sketch Map

d< 100M
d = Average walking distance to water collection point (m)</td><td colspan="2">Sketch of Installation

h< 0 5M
h = Operating head (m)</td></tr>
</table>

1. INSTALLATION

Date of Installation : 1982

Installed by : B.N.H.P.

Has the equipment been installed in accordance
with supplier's instructions?

Remarks:

Description of Source

Alternative Source : RAW WATER FROM FIELD DITCHES OR REMOTE CANALS

Quantity Restrictions/Variations: FIELD DITCHES ARE OFTEN DRY

Quality/Pollution : GROSS SURFACE POLLUTION

INSTALLATION (Cont.)

Filter

One or two stage? 1

Type and size of screen MINI

Filter Chamber made of : POLYTHENE

Dimensions : 18" x 12" x 12"

Filter medium : 3mm GRAVEL

Covered with : 3 LAYERS OF FILTERMAT

Connections from Filter

Pipe Dia : 1"

Pipe Length : 1½m

Pipe Material : PVC

Pump

Type : PATAY

Size : DD120

Mark :

Delivery Arrangements

General Remarks

WASTE WATER IS NOT DIRECTED BUT SITUATION SEEMS QUITE OK IN DRY SEASON

5/3

2. PERFORMANCE

In working order (yes/no) YES

Filter Chamber(s) : YES

Piping : A SMALL SPLIT ON INTAKE HOSE

Delivery : YES

Remarks :

---

3. DEMOGRAPHY

User population : 150

Main Occupation : AGRICULTURAL LABOURERS

Water Collection Times : MORNING & EVENING

Methods : HAND CARRIED CONTAINERS

Containers used : 201 - 51 CONTAINERS

Average Usage : (1/p/day) 8-101/p/day

---

4. MAINTENANCE

Has the installation worked satisfactorily since installation? (yes/no) NO

Any periods of breakdown? (details) YES, FREQUENT

Causes of breakdown
HOSE SPLIT
- FILTERMAT CLOGGED
- PUMP BREAKDOWN
- FILTERMAT BY-PASSED

Who undertakes repairs? B.N.H.P. ENGINEERING UNIT

Who finances these repairs? B.N.H.P.

Comments : SEE PHOTOGRAPHS OF MAINTANCE PROCEDURES
THE FILTER MAT BECAME DARKAND SILT LADEN WITHIN A DAY OF OPERATION. IT WAS SEEN TO HEAVE IN AND OUT WITH PUMPING

5. ~~PHYSICAL/CHEMICAL WATER QUALITY~~

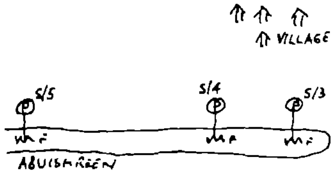
Intensive study site: see Appendix E.

UK OVERSEAS DEVELOPMENT ADMINISTRATION - PROJECT R3957

Gifford and Partners, Consulting Engineers, in association
with The London School of Hygiene and Tropical Medicine

EVALUATION OF SWS FILTER SYSTEMS

FIELD DATA SHEET

<table>
<tr><td>Serial
No:S/4</td><td>Name:
JUBARA 2</td><td>Long. 33° 12'
Lat. 14° 48'</td><td>Visit Date(s):
26/6 - 1/7/85</td></tr>
<tr><td colspan="2">Location Sketch Map

d< 100M
d = Average walking distance to water collection point (m)</td><td colspan="2">Sketch of Installation

h< 05M
h = Operating head (m)</td></tr>
</table>

1. **INSTALLATION**

Date of Installation : 1982

Installed by : B.N.H.P.

Has the equipment been installed in accordance
with supplier's instructions?

Remarks:

Description of Source

Alternative Source :RAW WATER FROM FIELD DITCHES OR REMOTE CANALS

Quantity Restrictions/Variations: FIELD DITCH (ABU ISHREEN IS OFTEN DRY)

Quality/Pollution : ANIMAL, HUMAN CONTACT

INSTALLATION (Cont.)

Filter

One or two stage? 1

Type and size of screen MINI

Filter Chamber
made of : POLYTHENE

Dimensions : 18" x 12" x 12"

Filter medium : GRAVEL - 3mm SIZE

Covered with : 3 LAYERS OF FILTERMAT

Connections from Filter

Pipe Dia : 1½" Pipe Length : 2m

Pipe Material : PVC (GREEN)

Pump

Type : PATAY

Size : DD120

Mark :

Delivery Arrangements

PUMP HELD IN STAND

General Remarks

DRAINAGE LEFT TO RANDOM

2. PERFORMANCE

In working order (yes/no) NO

Filter Chamber(s) : YES

Piping : YES

Delivery : YES

Remarks : DIAPHRAGM ON PUMP NEEDED REPLACING

---

3. DEMOGRAPHY

User population : SEE S/3

Main Occupation :

Water Collection Times :

Methods :

Containers used :

Average Usage : (1/p/day)

---

4. MAINTENANCE

Has the installation worked satisfactorily since installation? (yes/no) NO

Any periods of breakdown? (details) YES - FREQUENT

Causes of breakdown DIAPHRAGM ON PUMP NEEDED REPLACEMENT AND WAS REPLACED ON 22/6

Who undertakes repairs? B.N.H.P.

Who finances these repairs? B.N.H.P.

Comments : FILTERMAT HAD MOVED OUT OF PLACE DESPITE A WELL FITTED CLAMP. CLOGGING OF THE MAT AND VIGOUROUS PUMPING MAY HAVE DISLODGED IT.

- 23/6 CHILD OBSERVED GETTING WATER DIRECT FROM THE ABU ISHREEN
- FILTERMAT ALREADY COVERED WITH ALGAE AND SILT

5. PHYSICAL/CHEMICAL WATER QUALITY

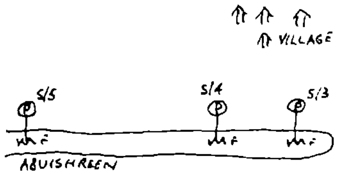
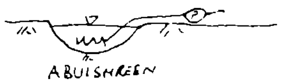
Intensive study site: see Appendix E.

UK OVERSEAS DEVELOPMENT ADMINISTRATION - PROJECT R3957

Gifford and Partners, Consulting Engineers, in association
with The London School of Hygiene and Tropical Medicine

EVALUATION OF SWS FILTER SYSTEMS

FIELD DATA SHEET

<table>
<tr><td>Serial
No:S/5</td><td>Name:
JUBARA 3</td><td>Long. 33° 12'
Lat. 14° 48'</td><td>Visit Date(s):
22/6 - 1/7/85</td></tr>
<tr><td colspan="2">Location Sketch Map

d< 100M
d = Average walking distance to water collection point (m)</td><td colspan="2">Sketch of Installation

h< 0 5M
h = Operating head (m)</td></tr>
</table>

1. INSTALLATION

Date of Installation : 1984

Installed by : B.N.H.P.

Has the equipment been installed in accordance with supplier's instructions? YES

Remarks:

Description of Source

Alternative Source : RAW WATER FROM WATER COURSE

Quantity Restrictions/Variations: WATER COURSE SHUT OFF BY IRRIGATION PRACTISE

Quality/Pollution : SEVERE CONTAMINATION BY ANIMALS & HUMANS

INSTALLATION (Cont.)

Filter

One or two stage? 1

Type and size of screen MINI

Filter Chamber made of : POLYTHENE

Dimensions : 18" x 12" x 12"

Filter medium : GRAVEL 2mm SIZE

Covered with : 3 LAYERS OF FILTERMAT

Connections from Filter

Pipe Dia : 1½"

Pipe Length : 2m

Pipe Material : PVC GREEN

Pump

Type : ROWER PUMP

Size :

Mark :

Delivery Arrangements

PUMP SEEMS SET IN STURDILY. LOWER DELIVERY ARRANGEMENT A BIT AWKWARD

General Remarks

S/5

2. PERFORMANCE

In working order (yes/no) YES

Filter Chamber(s) : YES

Piping : YES

Delivery : YES

Remarks :

3. DEMOGRAPHY

User population : SEE S/3

Main Occupation :

Water Collection Times :

Methods :

Containers used :

Average Usage : (l/p/day)

4. MAINTENANCE

Has the installation worked satisfactorily since installation? (yes/no) NO

Any periods of breakdown? (details) YES, SEVERAL TIMES

Causes of breakdown
CLOGGING FILTERMATS

Who undertakes repairs? B.N.H.P.

Who finances these repairs? B.N.H.P.

Comments :
- FILTERMATS CLEANED AND TOP ONE REPLACED ON 22/6
- PEOPLE TEND TO PREFER TO USE THE PATAY PUMPS, THIS ONE WAS ALSO SITED FURTHER AWAY BY THE VILLAGE ITSELF
- THE FILTERMAT IS CONSISTENTLY CLEANER THAT THE OTHERS INDICATING LESS USAGE

5. ~~PHYSICAL/CHEMICAL WATER QUALITY~~

Intensive study site: see Appendix E.

UK OVERSEAS DEVELOPMENT ADMINISTRATION - PROJECT R3957

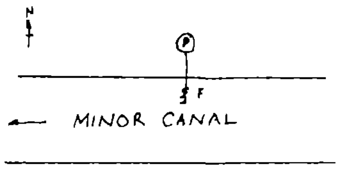
Gifford and Partners, Consulting Engineers, in association with The London School of Hygiene and Tropical Medicine

EVALUATION OF SWS FILTER SYSTEMS

FIELD DATA SHEET

Serial No:S/6	Name: TAMA	Long. 33° 10' Lat. 14° 52'	Visit Date(s): 21/6 - 1/7/85

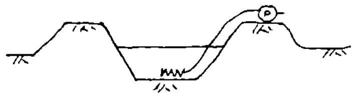
Location Sketch Map



d = 30m

d = Average walking distance to water collection point (m)

Sketch of Installation



h = 2m

h = Operating head (m)

1. INSTALLATION

Date of Installation : 1984

Installed by : B.N.H.P.

Has the equipment been installed in accordance with supplier's instructions? YES

Remarks:

Description of Source

Alternative Source : MINOR CANAL

Quantity Restrictions/Variations:LESS SEVERE THAN ABU ISHREEN.

Quality/Pollution : ANIMAL/HUMAN CONTAMINATION SEVERE

INSTALLATION (Cont.)

Filter

One or two stage? 1

Type and size of screen MINI

Filter Chamber made of : POLYTHENE

Dimensions : 18" x 12" x 12"

Filter medium : SMALL SIZED GRAVEL 2mm

Covered with : 3 LAYERS FILTERMAT

Connections from Filter

Pipe Dia : 1½"

Pipe Length : 3m+

Pipe Material : PVC GREEN

Pump

Type : PATAY

Size : DD120

Mark :

Delivery Arrangements

General Remarks

SMALL CONCRETE SLAB TO REST BUCKETS ON.

5/6

2. PERFORMANCE

In working order (yes/no) YES

Filter Chamber(s) : YES

Piping : YES

Delivery : YES

Remarks :

---

3. DEMOGRAPHY

User population : 50+

Main Occupation : AGRICULTURAL LABOURERS

Water Collection Times : MORNING & EVENING

Methods : HAND CARRIED CONTAINERS

Containers used : PLASTIC JERRY CANS, BUCKETS

Average Usage : (l/p/day) ?

---

4. MAINTENANCE

Has the installation worked satisfactorily since installation? (yes/no) NO

Any periods of breakdown? (details) YES

Causes of breakdown DIAPHRAGM OF PUMP REQUIRED REPLACEMENT

Who undertakes repairs? B.N.H.P.

Who finances these repairs? B.N.H.P.

Comments : SNAILS FOUND IN GRAVEL.

---

5. ~~PHYSICAL/CHEMICAL WATER QUALITY~~

Intensive study site: see Appendix E.

UK OVERSEAS DEVELOPMENT ADMINISTRATION - PROJECT R3957

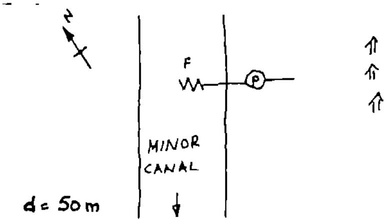
Gifford and Partners, Consulting Engineers, in association
with The London School of Hygiene and Tropical Medicine

EVALUATION OF SWS FILTER SYSTEMS

FIELD DATA SHEET

Serial No: S/7	Name: WADELAMIN	Long. ° ' Lat. ° ' (Map unavailable)	Visit Date(s): 29/6/85

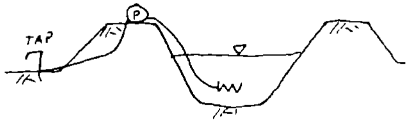
Location Sketch Map



d = 50m

d = Average walking distance to water collection point (m)

Sketch of Installation



h: 2M

h = Operating head (m)

1. INSTALLATION

Date of Installation : 1982

Installed by : A. FENWICK

Has the equipment been installed in accordance with supplier's instructions? YES

Remarks:

Description of Source

Alternative Source : RAW CANAL WATER

Quantity Restrictions/Variations: NONE

Quality/Pollution : ANIMAL/HUMAN CONTACT WITH CANAL

INSTALLATION (Cont.)

Filter

One or two stage? 1

Type and size of screen MINI

Filter Chamber made of : POLYTHENE

Dimensions :

Filter medium : 3-5mm GRAVEL

Covered with : 3 LAYERS OF FILTER MAT

Connections from Filter

Pipe Dia : 1½-1" Pipe Length : 3m

Pipe Material : GREEN PVC HOSE

Pump

Type : PATAY

Size : DD120

Mark : OLD TYPE (SOCKET WORN)

Delivery Arrangements

General Remarks

A BIT MESSY BUT NO WORSE THAN NORMAL

S/7

2. PERFORMANCE

In working order (yes/no) YES

Filter Chamber(s) : YES

Piping : YES

Delivery : YES

Remarks :

---

3. DEMOGRAPHY

User population : 100?

Main Occupation : AGRICULTURAL LABOURERS

Water Collection Times : MORNING AND EVENING

Methods : HAND CARRIED CONTAINERS

Containers used : PLASTIC JERRY CAN, BUCKETS

Average Usage : (l/p/day) ?

---

4. MAINTENANCE

Has the installation worked satisfactorily since installation? (yes/no) NO

Any periods of breakdown? (details) YES

Causes of breakdown

PUMP CLOGGING OF FILTERMAT

Who undertakes repairs?

LOCAL HEALTH WORKER

Who finances these repairs?

B.N.H.P.

Comments : THE INSTALLATION WE SAW HAD BEEN RESTORED FOR OUR VISIT. THE FILTERMAT AND BOX HAD BEEN REPLACED. THE PUMP HOWEVER HAD BEEN THERE FOR SOME TIME.

---

5. PHYSICAL/CHEMICAL WATER QUALITY

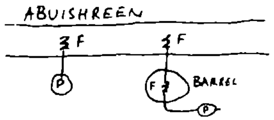
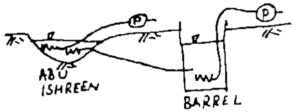
	Details	Raw Water	Filtered Water
1.	Average Counts Faecal Coliform/100ml	790	638
2.	Number of samples		1
3.	Colour		Muddy brown
4.	Odour		-
5.	Temperature °C		27.0
6.	pH		-
7.	Turbidity, JTU	500	500
8.	Conductivity μs/cm		-
9.	Comments		

UK OVERSEAS DEVELOPMENT ADMINISTRATION - PROJECT R3957

Gifford and Partners, Consulting Engineers, in association
with The London School of Hygiene and Tropical Medicine

EVALUATION OF SWS FILTER SYSTEMS

FIELD DATA SHEET

<table>
<tr><td>Serial
No: S/8</td><td>Name:
ASHARA NAFI</td><td>Long. 33° 1'
Lat. 15° 10'</td><td>Visit Date(s):
29/6/85</td></tr>
<tr><td colspan="2">Location Sketch Map

d=50M
d = Average walking distance to water collection point (m)</td><td colspan="2">Sketch of Installation

h = 1M
h = Operating head (m)</td></tr>
</table>

1. INSTALLATION

Date of Installation : 1982

Installed by : A. FENWICK

Has the equipment been installed in accordance with supplier's instructions? YES

Remarks:

Description of Source

Alternative Source : RAW WATER FROM ABU ISHREEN

Quantity Restrictions/Variations: ABU ISHREEN DRIES UP

Quality/Pollution : HUMAN/ANIMAL CONTACT,

INSTALLATION (Cont.)

Filter

One or two stage? 1 x 2

Type and size of screen MINI

Filter Chamber made of : POLYTHENE

Dimensions :

Filter medium : GRAVEL 3-5mm

Covered with : FILTERMATS

Connections from Filter

Pipe Dia : Pipe Length :

Pipe Material :

Pump

Type : DD120 DD70

PUMP BASE BROKEN DD70

Size :

Mark :

Delivery Arrangements

General Remarks

S/8

2. **PERFORMANCE**

In working order (yes/no) NO

Filter Chamber(s) : DERILICT

Piping : /

Delivery : /

Remarks :

---

3. **DEMOGRAPHY**

User population : 200+

Main Occupation : AGRICULTURAL LABOURERS

Water Collection Times : MORNING & EVENING

Methods : HAND CARRIED CONTAINERS

Containers used : PLASTIC JERRY CANS, BUCKETS

Average Usage : (l/p/day) /

---

4. **MAINTENANCE**

Has the installation worked satisfactorily since installation? (yes/no) YES

Any periods of breakdown? (details) YES

Causes of breakdown FLUCTUATING SUPPLY OF WATER, LACK OF CONCERTED MAINTANCE

Who undertakes repairs? LOCAL HEALTH WORKER OCCASIONALLY MAINTAINS THE SYSTEMS

Who finances these repairs?

Comments : ONE OF THE CONTAINERS HAD ITS FILTERMAT BROKEN. 3 MONTH INTERVAL BETWEEN FILTERMAT CLEANING. THE MAT ITSELF NOW ROTTEN (6 MONTHS OLD)

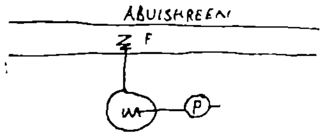
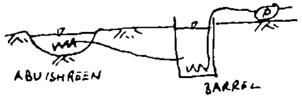
5. **PHYSICAL/CHEMICAL WATER QUALITY**

UK OVERSEAS DEVELOPMENT ADMINISTRATION - PROJECT R3957

Gifford and Partners, Consulting Engineers, in association with The London School of Hygiene and Tropical Medicine

EVALUATION OF SWS FILTER SYSTEMS

FIELD DATA SHEET

<table>
<tr><td>Serial No:S/9</td><td>Name:
WARALI</td><td>Long. 15° 03'
Lat. 33° 07'</td><td>Visit Date(s):
29/6/85</td></tr>
<tr><td colspan="2">Location Sketch Map

d = 50 m
d = Average walking distance to water collection point (m)</td><td colspan="2">Sketch of Installation

h = 1 m
h = Operating head (m)</td></tr>
</table>

1. INSTALLATION

Date of Installation : 1982

Installed by : A. FENWICK

Has the equipment been installed in accordance with supplier's instructions?

Remarks:

Description of Source

Alternative Source : ABU ISHREEN

Quantity Restrictions/Variations:ABU ISHREEN DRIES UP

Quality/Pollution : ANIMAL/HUMAN CONTACT

INSTALLATION (Cont.)

Filter

One or two stage? 2

Type and size of screen MINI

Filter Chamber made of : POLYTHENE

Dimensions : 18" x 12" x 12"

Filter medium : ROAD GRAVEL 3-5mm SIZE

Covered with : 3 LAYERS FILTERMAT

Connections from Filter

NO PUMPS - RESERVOIR FULL

Pipe Dia :

Pipe Length :

Pipe Material :

Pump

Type :

Size :

Mark :

Delivery Arrangements

INSTALLATION ABANDONED

General Remarks

2. PERFORMANCE

In working order (yes/no) NO

Filter Chamber(s) : YES

Piping : NO

Delivery :

Remarks :

3. DEMOGRAPHY

User population : 200+

Main Occupation : AGRICULTURAL LABOURERS

Water Collection Times : MORNING & EVENING

Methods : HAND CARRIED CONTAINER

Containers used : JERRY CAN, BUCKETS

Average Usage : (l/p/day) /

4. MAINTENANCE

Has the installation worked satisfactorily since installation? (yes/no) NO

Any periods of breakdown? (details) YES, INSTALLATION NOW ABANDONED

Causes of breakdown FLUCTUATING WATER SUPPLY, LACK OF CONCERTED MAINTANCE

Who undertakes repairs? A LOCAL HEALTH WORKER HAS IN THE PAST MADE SOME REPAIRS

Who finances these repairs?

Comments :

5. ~~PHYSICAL/CHEMICAL WATER QUALITY~~

APPENDIX D : FIELD DATA SHEETS - NIGERIA

Ref No	Location/Site Name	Type of Installation
N/1	Angwrae	SWS sandy river bed extration unit
N/2	Sambo	"
N/3	Jarawan	"
N/4	Barakesh	"
N/5	Mbar	SWS shallow well installation
N/6	Marish	SWS sandy river bed extraction unit
N/7	Wuya	"
N/8	Lausa 1	SWS jetted well screen
N/9	Lausa 2	"
N/10	Lausa 3	"
N/11	Kiyako	"
N/12	Gwaram	"
N/13	Hamdullahi	"

UK OVERSEAS DEVELOPMENT ADMINISTRATION - PROJECT R3957

Gifford and Partners, Consulting Engineers, in association
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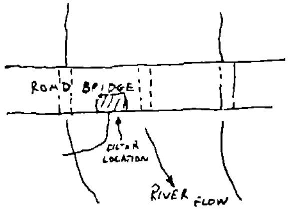
EVALUATION OF SWS FILTER SYSTEMS

FIELD DATA SHEET

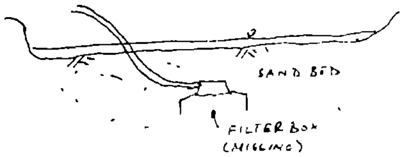
Serial No: N/1	Name: ANGWRAE	Long. 9° 12' Lat. 9° 52'	Visit Date(s): 19/7/85

Location Sketch Map



d = Average walking distance to water collection point (m)

Sketch of Installation



h = Operating head (m)

1. INSTALLATION

Date of Installation : 12/7/85

Installed by : D JOY

Has the equipment been installed in accordance with supplier's instructions? YES

Remarks: FILTER BOX MISSING PRESUMED STOLEN

Description of Source

Alternative Source : RAW RIVER WATER

Quantity Restrictions/Variations: NO DRY SEASON SURFACE FLOW
SUB SURFACE FLOW 0.5m DEEP

Quality/Pollution : SURFACE CONTAMINATION

INSTALLATION (Cont.)

Filter

FILTER BOX MISSING

One or two stage? 1

Type and size of screen VILLAGE UNIT

Filter Chamber made of : FIBRE GLASS

Dimensions :

Filter medium : COARSE SAND

Covered with : /

Connections from Filter

NONE

Pipe Dia :

Pipe Length :

Pipe Material :

Pump

NONE

Type :

Size :

Mark :

Delivery Arrangements

General Remarks

N/1

2. PERFORMANCE

In working order (yes/no) NO

Filter Chamber(s) :

Piping :

Delivery :

Remarks :

---

3. DEMOGRAPHY

User population : INDETERMINATE - LOCAL FARMERS & NOMADS

Main Occupation : NOMADS & SUBSISTANCE FARMERS

Water Collection Times : /

Methods : /

Containers used : /

Average Usage : (l/p/day) /

---

4. MAINTENANCE

Has the installation worked satisfactorily since installation? (yes/no) NO

Any periods of breakdown? (details) YES, SEVERAL INSTALLATIONS HAVE BEEN MADE ALL OF WHICH HAVE BEEN STOLEN

Causes of breakdown

Who undertakes repairs?

Who finances these repairs?

Comments : NO EVIDENCE OF HOSE. THIS COULD BE BECAUSE RECENT FLOOD BURYING IT OR IT MAY HAVE BEEN STOLEN AS WAS THE PREVIOUS ONE. PRODDING AND DIGGING INDICATED THAT IT HAD PROBABLY BEEN STOLEN (1 WEEK AFTER INSTALLATION). THE PUMP WAS REMOVED DELIBERATLY AFTER REPEATED THEFTS.

5. PHYSICAL/CHEMICAL WATER QUALITY

UK OVERSEAS DEVELOPMENT ADMINISTRATION - PROJECT R3957

Gifford and Partners, Consulting Engineers, in association
with The London School of Hygiene and Tropical Medicine

EVALUATION OF SWS FILTER SYSTEMS

FIELD DATA SHEET

Serial No: N/2	Name: SAMBO	Long. ° ' Lat. ° ' (Map unavailable)	Visit Date(s): 19/7/85
Location Sketch Map d = Average walking distance to water collection point (m)		Sketch of Installation INSTALLATION NOT IN USE DURING WET SEASON h = Operating head (m)	

1. INSTALLATION

Date of Installation :

Installed by :

Has the equipment been installed in accordance with supplier's instructions?

Remarks:

Description of Source

Alternative Source :

Quantity Restrictions/Variations:

Quality/Pollution :

INSTALLATION (Cont.)

Filter

One or two stage?

Type and size of screen

Filter Chamber made of :

Dimensions :

Filter medium :

Covered with :

Connections from Filter

Pipe Dia :

Pipe Length :

Pipe Material :

Pump

Type :

Size :

Mark :

Delivery Arrangements

General Remarks

N/2

2. PERFORMANCE

In working order (yes/no)

Filter Chamber(s) :

Piping :

Delivery :

Remarks :

---

3. DEMOGRAPHY

User population :

Main Occupation :

Water Collection Times :

Methods :

Containers used :

Average Usage : (l/p/day)

---

4. MAINTENANCE

Has the installation worked satisfactorily since installation? (yes/no)

Any periods of breakdown? (details)

Causes of breakdown

Who undertakes repairs?

Who finances these repairs?

Comments :

---

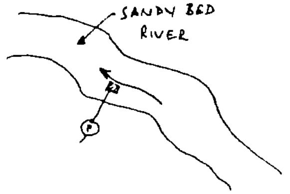
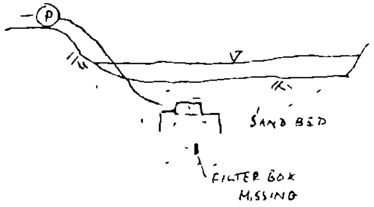
5. PHYSICAL/CHEMICAL WATER QUALITY

UK OVERSEAS DEVELOPMENT ADMINISTRATION - PROJECT R3957

Gifford and Partners, Consulting Engineers, in association
with The London School of Hygiene and Tropical Medicine

EVALUATION OF SWS FILTER SYSTEMS

FIELD DATA SHEET

<table>
<tr><td>Serial
No: N/3</td><td>Name:
JARAWAN</td><td>Long. 9° 12'
Lat. 9° 52'</td><td>Visit Date(s):
19/7/85</td></tr>
<tr><td colspan="2">Location Sketch Map

d = 200M+
d = Average walking distance to water collection point (m)</td><td colspan="2">Sketch of Installation

h = Operating head (m)</td></tr>
</table>

1. INSTALLATION

Date of Installation : 1985

Installed by : D JOY & SCHOOL

Has the equipment been installed in accordance
with supplier's instructions? YES

Remarks:

Description of Source

Alternative Source : NONE

Quantity Restrictions/Variations: WATER DROPS BELOW SURFACE DURING THE DRY SEASON

Quality/Pollution : SURFACE CONTAMINATION

INSTALLATION (Cont.)

Filter

FILTER MISSING (PRESUMED STOLEN)

One or two stage?

Type and size of screen

Filter Chamber
made of :

Dimensions :

Filter medium :

Covered with :

Connections from Filter

Pipe Dia : 1½"

Pipe Length : 5m

Pipe Material : PVC (GREEN)

Pump

FOOTVALVE BROKEN SO PUMP INOPERATIVE

Type : ROWER

Size :

Mark :

Delivery Arrangements

General Remarks

THE ROWER PUMP AND HOSE WERE IN PLACE BUT THE FILTER BOX WAS MISSING

N/3

2. PERFORMANCE

In working order (yes/no) NO

Filter Chamber(s) : MISSING

Piping : YES

Delivery : OK

Remarks :

---

3. DEMOGRAPHY

User population : SCHOOLS & SOME LOCAL FARMERS

Main Occupation : STUDENTS & SUBSISTANCE FARMERS

Water Collection Times : ALL DAY

Methods : HAND CARRIED CONTAINERS

Containers used : VARIED

Average Usage : (l/p/day) ?

---

4. MAINTENANCE

Has the installation worked satisfactorily since installation? (yes/no) NO

Any periods of breakdown? (details) YES

Causes of breakdown FOOT VALVE BROKEN IN PUMP

Who undertakes repairs? D JOY

Who finances these repairs? UNITED FAITH TABERNACLE COLLEGE

Comments : THIS SYSTEM IS USED MOST DURING THE DRY SEASON WHEN THE WATER LEVEL FALLS BENEATH THE SAND BED AND THE ONLY ALTERNATIVE METHOD IS TO DIG SHALLOW HOLES TO THE WATER TABLE.

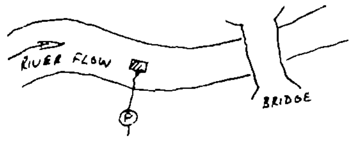
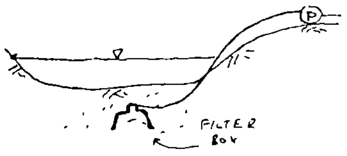
5. PHYSICAL/CHEMICAL WATER QUALITY

UK OVERSEAS DEVELOPMENT ADMINISTRATION - PROJECT R3957

Gifford and Partners, Consulting Engineers, in association
with The London School of Hygiene and Tropical Medicine

EVALUATION OF SWS FILTER SYSTEMS

FIELD DATA SHEET

Serial No:N/4	Name: BARAKESH	Long. ° ' Lat. ° ' (Map unavailable)	Visit Date(s): 21/7/85
Location Sketch Map  d= 300 M d = Average walking distance to water collection point (m)		Sketch of Installation  h ~ 2M h = Operating head (m)	

1. INSTALLATION

Date of Installation : 21/7/85

Installed by : D JOY & COMMUNITY

Has the equipment been installed in accordance with supplier's instructions? YES

Remarks:
INSTALLATION MADE DURING VISIT

Description of Source

Alternative Source : NONE

Quantity Restrictions/Variations: THE RIVER DOES NOT DRY OUT

Quality/Pollution : SURFACE POLLUTION

INSTALLATION (Cont.)

Filter

One or two stage? 1

Type and size of screen VILLAGE UNIT

Filter Chamber
made of : FIBRE GLASS

Dimensions :

Filter medium : GRAVEL 10mm+, FINE SAND

Covered with : /

Connections from Filter

Pipe Dia : 1½" Pipe Length : 3m

Pipe Material : PVC

Pump

Type : PATAY

Size : DD120

Mark :

Delivery Arrangements

THE PUMP BASE NEEDS TO BE HELD MORE STABLE

General Remarks

EXTENSIVE DEVELOPMENT WAS NECESSARY TO BRING THE TURBIDITY OF THE WATER DOWN TO AN ACCEPTABLE LEVEL. AFTER 20 MINUTES THE TURBIDITY HAD REDUCED TO 30JTU (RIVER WATER 10JTU) THE PUMP BROKE STOPPING FURTHER DEVELOPMENT.

2. PERFORMANCE

In working order (yes/no) YES - UNTIL PUMP HANDLE FAILURE

Filter Chamber(s) : YES

Piping : YES

Delivery : YES

Remarks :

---

3. DEMOGRAPHY

User population : 125

Main Occupation : FARMERS

Water Collection Times : MORNING, EVENING

Methods : HAND CARRIED CONTAINERS

Containers used : BUCKETS MAINLY

Average Usage : (l/p/day) /

---

4. MAINTENANCE

Has the installation worked satisfactorily since installation? (yes/no) NO

Any periods of breakdown? (details) YES

Causes of breakdown PUMP HANDLE BROKE

Who undertakes repairs? D JOY

Who finances these repairs? D JOY

Comments : THE PUMP IS UNDER EXTREME STRESS DURING DEVELOPMENT, AND EVEN UNDER NORMAL USAGE WHEN THE IMPOSED FLOW RATE OF THE PUMP CAUSES THE WATER TO MOVE AT FAST VELOCITIES THROUGH THE SAND, RESULTING IN HIGH HEADLOSS AND CONSEQUENT STRAIN ON THE PUMP.

5. PHYSICAL/CHEMICAL WATER QUALITY

	Details	Raw Water	Filtered Water
1.	Average Counts Faecal Coliform/100ml	1410	125
2.	Number of samples	1	1
3.	Colour	clear	clear
4.	Odour	-	-
5.	Temperature °C	24.4	24.0
6.	pH	6.8	-
7.	Turbidity, JTU	<10	20
8.	Conductivity μs/cm	-	-
9.	Comments		

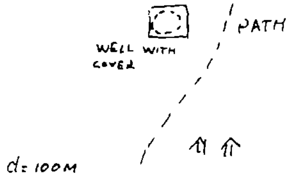
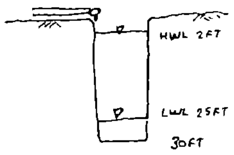
UK OVERSEAS DEVELOPMENT ADMINISTRATION - PROJECT R3957

Gifford and Partners, Consulting Engineers, in association
with The London School of Hygiene and Tropical Medicine

EVALUATION OF SWS FILTER SYSTEMS

FIELD DATA SHEET

Serial No: N/5	Name: MBAR	Long. ° ' Lat. ° '	Visit Date(s): 22/7/85

Location Sketch Map	Sketch of Installation
	 FILTER SYSTEM NOT IN USE
d = Average walking distance to water collection point (m)	h = Operating head (m)

1. INSTALLATION

Date of Installation : 1984

Installed by : D.JOY & COMMUNITY

Has the equipment been installed in accordance with supplier's instructions? NOT IN USE

Remarks:

Description of Source

Alternative Source : RIVER 2km AWAY

Quantity Restrictions/Variations: IN THE DRY SEASON WATER SHORTAGE ACUTE

Quality/Pollution : SURFACE IN FLOW

INSTALLATION (Cont.)

Filter

NOT IN USE

One or two stage?

Type and size of screen

Filter Chamber
made of :

Dimensions :

Filter medium :

Covered with :

Connections from Filter

NOT IN USE

Pipe Dia :

Pipe Length :

Pipe Material :

Pump

Type :

Size :

Mark :

Delivery Arrangements

General Remarks

N/S

2. PERFORMANCE

NOT IN USE

In working order (yes/no)

Filter Chamber(s) :

Piping :

Delivery :

Remarks :

3. DEMOGRAPHY

User population : 300

Main Occupation : FARMERS

Water Collection Times : MORNING & EVENING (DRY SEASON)

Methods : HAND CARRIED CONTAINERS

Containers used :

Average Usage : (l/p/day) 10l/p/day DRINKING & WASHING

4. MAINTENANCE

Has the installation worked satisfactorily since installation? (yes/no)

Any periods of breakdown? (details)

Causes of breakdown

Who undertakes repairs?

Who finances these repairs?

Comments : SUPPLIED EQUIPMENT CONSISTED OF A FILTER SCREEN AND DD70 PUMP WITH HOSE. THIS SCREEN WAS USED DIRECTLY IN THE WELL AND ALSO PUT IN A BUCKET OF SAND AND SUSPENDED BELOW THE WATER SURFACE.

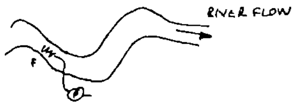
5. PHYSICAL/CHEMICAL WATER QUALITY

UK OVERSEAS DEVELOPMENT ADMINISTRATION - PROJECT R3957

Gifford and Partners, Consulting Engineers, in association
with The London School of Hygiene and Tropical Medicine

EVALUATION OF SWS FILTER SYSTEMS

FIELD DATA SHEET

<table>
<tr><td>Serial No: N/6</td><td>Name:
MARISH</td><td>Long. 9° 10'
Lat. 9° 25'</td><td>Visit Date(s):
24/7/85</td></tr>
<tr><td colspan="2">Location Sketch Map

d=200M
d = Average walking distance to water collection point (m)</td><td colspan="2">Sketch of Installation

h= 2M
h = Operating head (m)</td></tr>
</table>

1. INSTALLATION

Date of Installation : JULY 1985

Installed by : D.JOY

Has the equipment been installed in accordance
with supplier's instructions? YES

Remarks:

Description of Source

Alternative Source : RAW RIVER WATER

Quantity Restrictions/Variations: NONE REPORTED

Quality/Pollution : SURFACE CONTAMINATION

INSTALLATION (Cont.)

Filter

One or two stage? 1

Type and size of screen VILLAGE UNIT

Filter Chamber
made of : GRP

Dimensions :

Filter medium : FINE SAND

Covered with : /

Connections from Filter

Pipe Dia : 1½

Pipe Length : 5m

Pipe Material : PVC

Pump

Type : PATAY

Size : DD120

Mark :

Delivery Arrangements

General Remarks

PUMP WAS STORED IN CHIEF'S HOUSE TO GUARD AGAINST VANDALISM. A PERMANENT CONCRETE STAND IS BEING MADE. THE PUMP IS TAKEN DOWN TO THE RIVER IN THE MORNING AND EVENING FOR GENERAL USAGE.

N/6

2. PERFORMANCE

In working order (yes/no) YES

Filter Chamber(s) : YES

Piping : OK

Delivery : OK

Remarks : 1mm + PARTICLES OF SAND BEING PUMPED THROUGH EVEN AFTER 10 MINUTES CONTINUOUS PUMPING

3. DEMOGRAPHY

User population : 1000+

Main Occupation : SUBSISTANCE FARM

Water Collection Times :

Methods :

Containers used :

Average Usage : (1/p/day)

4. MAINTENANCE

Has the installation worked satisfactorily since installation? (yes/no) YES

Any periods of breakdown? (details) NO

Causes of breakdown

Who undertakes repairs?

Who finances these repairs?

Comments : MANY UNITS HAVE BEEN REPORTED TO HAVE BEEN VANDALISED IN OTHER AREAS.

5. PHYSICAL/CHEMICAL WATER QUALITY

	Details	Raw Water	Filtered Water
1.	Average Counts Faecal Coliform/100ml	17,500	9260
2.	Number of samples	1	1
3.	Colour	Muddy	Muddy
4.	Odour	vegy	vegy
5.	Temperature °C	24.9	24.2
6.	pH	7.0	6.4
7.	Turbidity, JTU	1000	500
8.	Conductivity μs/cm	-	-
9.	Comments		

UK OVERSEAS DEVELOPMENT ADMINISTRATION - PROJECT R3957

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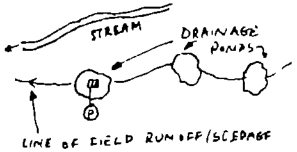
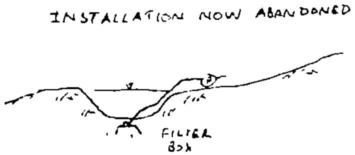
EVALUATION OF SWS FILTER SYSTEMS

FIELD DATA SHEET

<table>
<tr><td>Serial
No: N/7</td><td>Name:
WUYA</td><td>Long. 9° 18'
Lat. 9° 36'</td><td>Visit Date(s):
25/7/85</td></tr>
<tr><td colspan="2">Location Sketch Map

d = Average walking distance to water collection point (m)</td><td colspan="2">Sketch of Installation

h = Operating head (m)</td></tr>
</table>

1. INSTALLATION

Date of Installation : 6/4/85

Installed by : D. JOY & COMMUNITY

Has the equipment been installed in accordance
with supplier's instructions? PUMP KEPT IN CHIEF'S HOUSE

Remarks:

Description of Source

Alternative Source : NO (JUST OTHER PONDS)

Quantity Restrictions/Variations: DRIES UP IN DRY SEASON

Quality/Pollution : SURFACE, FIELD CULTIVATION (FERTILISER)

INSTALLATION (Cont.)

Filter

One or two stage? 1 INSTALLATION NOW ABANDONED

Type and size of screen VILLAGE UNIT

Filter Chamber
made of : GRP

Dimensions :

Filter medium : IMPORTED SAND

Covered with :

Connections from Filter

Pipe Dia : 1½ Pipe Length :

Pipe Material : PVC

Pump

Type : PATAY

PUMP NOW NOT IN USE

Size : DD120

Mark :

Delivery Arrangements

General Remarks

SUCTION HOSE SPLIT

N/7

2. PERFORMANCE

INSTALLATION ABANDONED

In working order (yes/no) NO

Filter Chamber(s) : NO

Piping : NO

Delivery :

Remarks :

---

3. DEMOGRAPHY

User population : 400

Main Occupation : FARMERS

Water Collection Times : MORNING & EVENING

Methods : HAND CARRIED CONTAINERS

Containers used : BUCKETS

Average Usage : (l/p/day) 301/p/day DRINKING, WASHING, DOMESTIC

---

4. MAINTENANCE

Has the installation worked satisfactorily since installation? (yes/no) NO

Any periods of breakdown? (details) YES, AFTER A MONTH - AT THE FIRST RAINS

Causes of breakdown FILTER BLOCKED

Who undertakes repairs? NONE UNDERTAKEN

Who finances these repairs?

Comments : THE FILTER BECAME BLOCKED AFTER THE FIRST RAINS BROUGHT SILT FROM NEARBY CULTIVATED FIELDS. THE FILTER WAS REPORTED NOT TO IMPROVE THE TURBIDITY OF THE WATER WHEN THE RAW WATER WAS TURBID.

5. PHYSICAL/CHEMICAL WATER QUALITY

UK OVERSEAS DEVELOPMENT ADMINISTRATION - PROJECT R3957

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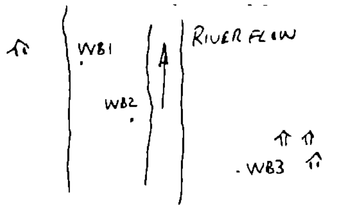
EVALUATION OF SWS FILTER SYSTEMS

FIELD DATA SHEET

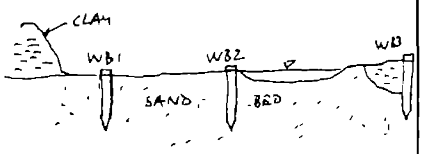
Serial No:	Name:		Visit Date(s):
N/8, 9,10	LAUSA	Long. 8° 39' Lat. 11° 24'	31/7/85

Location Sketch Map



d = Average walking distance to water collection point (m)

Sketch of Installation



h = Operating head (m)

1. INSTALLATION

Date of Installation : 1982

Installed by : KANO AGRICULTURAL RURAL DEVELOPMENT AUTHORITY

Has the equipment been installed in accordance with supplier's instructions? YES

Remarks:
N/8 = WB/1
N/9 = WB/2
N/10 = WB/3

Description of Source

Alternative Source : RAW RIVER WATER

Quantity Restrictions/Variations: NONE, RIVER FALLS BELOW BED LEVEL DURING DRY SEASON

Quality/Pollution : OPEN POLLUTION

INSTALLATION (Cont.)

Filter

One or two stage? 1 JETTED WELL SCREEN 2"

Type and size of screen ABS PLASTIC

Filter Chamber made of :

Dimensions :

Filter medium :

Covered with :

Connections from Filter

Pipe Dia : 2"

Pipe Length : 0-2m

Pipe Material : PVC

Pump

	WB1	WB2	WB3
Type :	GRILLOT	HONDA	ROWER
Size :	/	2" 600l/min	/
Mark :	/	/	/

Delivery Arrangements

DELIVERY WAS MADE DIRECTLY FROM PUMP OUTLET

General Remarks

2. PERFORMANCE

In working order (yes/no) YES

Filter Chamber(s) : /

Piping : YES

Delivery : YES

Remarks : IN VERY GOOD WORKING ORDER

---

3. DEMOGRAPHY

User population : 800+ PEOPLE SERVED BY WB1, WB2

Main Occupation : FARMERS

Water Collection Times : MORNING & EVENING

Methods : HAND CARRIED CONTAINERS

Containers used : CALABASH, BUCKET

Average Usage : (l/p/day) /

---

4. MAINTENANCE

Has the installation worked satisfactorily since installation? (yes/no) YES

Any periods of breakdown? (details) GRILLOT PUMP ON WB1 HAD HAD HANDLE REPLACED

Causes of breakdown /

Who undertakes repairs? KNARDA

Who finances these repairs? KNARDA

Comments :

---

5. PHYSICAL/CHEMICAL WATER QUALITY

	Details	Raw Water River	Filtered Water		
			N/8	N/9	N/10
1.	Average Counts Faecal Coliform/100ml	> 2000	1	29	5
2.	Number of samples	1	1	1	1
3.	Colour	clear	clear	buff	clear
4.	Odour	-	-	-	-
5.	Temperature °C	29.9	29.4	29.8	29.7
6.	pH	6.9	< 6.8	6.8	6.9
7.	Turbidity, JTU	<5	<5	75	<5
8.	Conductivity µs/cm	-	-	-	-
9.	Comments				

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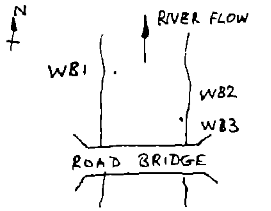
EVALUATION OF SWS FILTER SYSTEMS

FIELD DATA SHEET

Serial No: N/11	Name: KIYAKO	Long. 9 ° 30' Lat. 11 ° 24'	Visit Date(s): 1/8/85

Location Sketch Map



d = Average walking distance to water collection point (m)

Sketch of Installation

h = Operating head (m)

1. INSTALLATION

Date of Installation : 1983

Installed by : KNARDA

Has the equipment been installed in accordance with supplier's instructions? YES

Remarks: THIS IS THE SITE OF THREE 'WASHBORES', WB/1, 2 AND 3 SHOWN IN THE SKETCH.

Description of Source

Alternative Source : RAW RIVER WATER

Quantity Restrictions/Variations: LOW SURFACE FLOW DURING DRY SEASON

Quality/Pollution : SURFACE CONTAMINATION

INSTALLATION (Cont.)

Filter

JETTED WELL SCREEN ABS PLASTIC 2"

One or two stage?

Type and size of screen

Filter Chamber made of :

Dimensions :

Filter medium :

Covered with :

Connections from Filter

Pipe Dia : 2"

Pipe Length : 2m

Pipe Material : PVC

Pump

Type : HONDA

Size : 2" (6001/min)

Mark : /

Delivery Arrangements

General Remarks

THE PUMP WAS STORED NEARBY AND STORED FOR ALL WASHBORES.

N/11

2. PERFORMANCE

In working order (yes/no) WB1, WB3 - NO, WB2-YES

~~Filter Chamber(s)~~ :

Piping : WB2 NO, OTHERS YES

Delivery : YES

Remarks :

---

3. DEMOGRAPHY

User population : 1000+

Main Occupation : FARMERS

Water Collection Times : /) - AS PER IRRIGATION SCHEDULE

Methods : /)

Containers used :

Average Usage : (l/p/day)

---

4. MAINTENANCE

Has the installation worked satisfactorily since installation? (yes/no) NO

Any periods of breakdown? (details) - SPLIT SUCTION HOSE (WB1)
- HOSE BLOCKED WITH MUD (WB2)

Causes of breakdown

Who undertakes repairs? KNARDA

Who finances these repairs? KNARDA

Comments :

---

5. PHYSICAL/CHEMICAL WATER QUALITY

	Details	Raw Water River	Filtered Water WB/1
1.	Average Counts Faecal Coliform/100ml	> 2000	17
2.	Number of Samples	1	1
3.	Colour	Buff	Clear
4.	Odour	-	-
5.	Temperature °C	33.0	30.0
6.	pH	7.6	6.8
7.	Turbidity, JTU	50	< 5
8.	Conductivity μs/cm		
9.	Comments		

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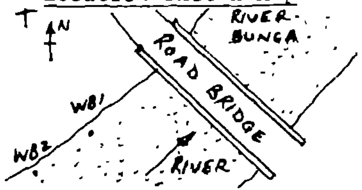
EVALUATION OF SWS FILTER SYSTEMS

FIELD DATA SHEET

Serial No:N/12	Name: GWARAM	Long. ° ' Lat. ° '	Visit Date(s): 1/8/85
Location Sketch Map  d = Average walking distance to water collection point (m)		Sketch of Installation h = Operating head (m)	

1. **INSTALLATION**

Date of Installation :

Installed by : KNARDA

Has the equipment been installed in accordance with supplier's instructions?

Remarks: Two 'washbores', WB1 AND WB 2

Description of Source JETTED WELL

Alternative Source : RAW RIVER WATER

Quantity Restrictions/Variations:

Quality/Pollution :

INSTALLATION (Cont.)

Filter

One or two stage?

Type and size of screen

Filter Chamber made of :

Dimensions :

Filter medium :

Covered with :

Connections from Filter

Pipe Dia : Pipe Length :

Pipe Material :

Pump

Type : HONDA

Size :

Mark :

Delivery Arrangements

General Remarks

N/12

2. PERFORMANCE

In working order (yes/no)

Filter Chamber(s) :

Piping :

Delivery :

Remarks :

---

3. DEMOGRAPHY

User population :

Main Occupation :

Water Collection Times :

Methods :

Containers used :

Average Usage : (l/p/day)

---

4. MAINTENANCE

Has the installation worked satisfactorily since installation? (yes/no)

Any periods of breakdown? (details)

Causes of breakdown

Who undertakes repairs?

Who finances these repairs?

Comments :

---

5. PHYSICAL/CHEMICAL WATER QUALITY

	Details	Raw Water River	Filtered Water WB 2
1.	Average Counts Faecal Coliform/100ml	9250	1
2.	Number of Samples	1	1
3.	Colour	Muddy	Clear
4.	Odour	-	-
5.	Temperature °C	30.0	29.0
6.	pH	7.0	7.0
7.	Turbidity, JTU	1000	<5
8.	Conductivity μs/cm		
9.	Comments		

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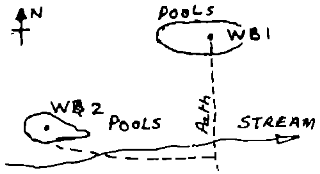
EVALUATION OF SWS FILTER SYSTEMS

FIELD DATA SHEET

<table>
<tr><td>Serial
No:N/13</td><td>Name:
HAMDULLAHI</td><td>Long. ° '
Lat. ° '</td><td>Visit Date(s):
1/8/85</td></tr>
<tr><td colspan="2">Location Sketch Map

d = Average walking distance to water collection point (m)</td><td colspan="2">Sketch of Installation

h = Operating head (m)</td></tr>
</table>

1. INSTALLATION

Date of Installation :

Installed by : KNARDA

Has the equipment been installed in accordance with supplier's instructions?

Remarks: TWO 'WASHBORES' WB1 AND WB 2

Description of Source JETTED WELL

Alternative Source :

Quantity Restrictions/Variations:

Quality/Pollution :

INSTALLATION (Cont.)

Filter

One or two stage?

Type and size of screen

Filter Chamber
made of :

Dimensions :

Filter medium :

Covered with :

Connections from Filter

Pipe Dia : Pipe Length :

Pipe Material :

Pump

Type : HONDA

Size :

Mark :

Delivery Arrangements

General Remarks

N/13

2. PERFORMANCE

In working order (yes/no)

Filter Chamber(s) :

Piping :

Delivery :

Remarks :

---

3. DEMOGRAPHY

User population :

Main Occupation :

Water Collection Times :

Methods :

Containers used :

Average Usage : (l/p/day)

---

4. MAINTENANCE

Has the installation worked satisfactorily since installation? (yes/no)

Any periods of breakdown? (details)

Causes of breakdown

Who undertakes repairs?

Who finances these repairs?

Comments :

5. PHYSICAL/CHEMICAL WATER QUALITY

	Details	Raw Water	Filtered Water WB 2
1.	Average Counts Faecal Coliform/100ml		150
2.	Number of Samples		1
3.	Colour		Buff
4.	Odour		Nil
5.	Temperature ^{o}C		
6.	pH		
7.	Turbidity, JTU		> 75
8.	Conductivity $\mu s/cm$		
9.	Comments		Turbidity too dark to measure

APPENDIX E : WATER QUALITY DATA AT INTENSIVE STUDY SITES

Country and Ref No	Location/Site Name	Type of Installation
ZAIRE		
Z/9	Boga Mission (stream)	SWS Mini Filter
-	Boga Mission	Combination SWS
SUDAN		
S/1	Shagra 1	SWS Mini containerised unit - double filtration.
S/2	Shagra 2	" "
S/3	Jubara 1	SWS Mini containerised unit
S/4	Jubara 2	" "
S/5	Jubara 3	" "
S/6	Tama	" "
S/7	Wad el Amin	Horizontal slow sand filter.

5. PHYSICAL/CHEMICAL WATER QUALITY

COUNTRY /SITE Zaire BOGA MISSION (STREAM)
TYPE OF INSTALLATION SWS PROTECTED
SITE NUMBER· Z/9

		DAY					
PARAMETER		1	2	3	4	5	6
DATE / TIME		mid afternoon 17/5/85	Midday 18/5/85	midmorning 19/5/85	midmorning 20/5/85	7 30 21/5/85	midmorning 22/5/85
WEATHER		SUNNY	SUNNY	SUNNY	SUNNY	SUNNY	DRIZZLE
NUMBER OF SAMPLES		—	1	1	1	1	1
FAECAL COLIFORM COUNT /100mL	PRE TREATMENT	—	>2000	3700	2150	>20,000	2,630
	POST TREATMENT	—	575	627	465	555	507
COLOUR	PRE TREATMENT	buff	buff	clear	buff	buff	buff
	POST TREATMENT	clear	clear	clear	clear	clear	clear
ODOUR	PRE TREATMENT	—	—	—	—	—	—
	POST TREATMENT	—	—	—	vegy	—	—
TEMPERATURE	PRE TREATMENT	22	25	22	22	20	22
	POST TREATMENT	23	25	23	22	21	22
pH	PRE TREATMENT	6.7	6.7	6 4	6 4	6.4	6 7
	POST TREATMENT	6 0	6.2	6 2	6 1	6 1	6 6
TURBIDITY	PRE TREATMENT	20	<10	10	10	10	15
	POST TREATMENT	10	<10	10	<10	<10	<10
CONDUCTIVITY	PRE TREATMENT	81	-	35	57	58	47
	POST TREATMENT	23	60	100	94	124	120

5. PHYSICAL/CHEMICAL WATER QUALITY

COUNTRY /SITE Zaire BOGA MISSION
TYPE OF INSTALLATION SWS MINI-FILTER
SITE NUMBER –

		DAYS					
PARAMETER		1	2	3	4	5	6
DATE /TIME /WEATHER		AFTERNOON 17/5/85 SUNNY	AFTERNOON 18/5/85 SUNNY	MIDDAY 19/5/85 SUNNY	MIDDAY 20/5/85 SUNNY	MORNING 21/5/85 SUNNY	MORNING 22/5/85 DRIZZLE
NUMBER OF SAMPLES		4	2	4	2	2	4
FAECAL COLIFORM COUNT/100ML	RESERVOIR	1090	1910	4500	2550	533	432
	OUTLET AT SCHOOL	320	–	676	–	–	190
	HOLDING TANK	155	515	1050	300	190	125
	OUTLET AT HOUSE	148	–	757	–	–	102
COLOUR	RESERVOIR	buff	buff	pale buff	pale buff	buff	buff
	OUTLET AT SCHOOL	dark brown (silty)	–	silty	–	–	pale buff
	HOLDING TANK	buff	buff	pale buff	buff	buff	buff
	OUTLET AT HOUSE	buff	–	buff	–	–	silty
ODOUR	RESERVOIR	–	–	earthy	–	earthy	earthy
	OUTLET AT SCHOOL	–	–	–	–	–	–
	HOLDING TANK	–	–	–	–	–	–
	OUTLET AT HOUSE	–	–	–	–	–	–
TEMPERATURE	RESERVOIR	24	23	24	23	21	24
	OUTLET AT SCHOOL	24	–	24	–	–	24
	HOLDING TANK	23	24	23	24	22	24
	OUTLET AT HOUSE	24	–	24	–	–	24
pH	RESERVOIR	6 5	8.2	6.4	6.5	6.2	6 6
	OUTLET AT SCHOOL	6 2	–	6.2	–	–	6.8
	HOLDING TANK	6.3	6 6	6 2	6 6	6 1	6.5
	OUTLET AT HOUSE	6 3	–	6 4	–	–	6.8
Turbidity	RESERVOIR	<5	<10	10	5	<10	<10
	OUTLET AT SCHOOL	200	–	15	–	–	15
	HOLDING TANK	<10	35	10	10	15	15
	OUTLET AT HOUSE	<10	–	15	–	–	15
CONDUCTIVITY	RESERVOIR	520	–	42	56	50	48
	OUTLET AT SCHOOL	48	–	46	–	–	48
	HOLDING TANK	68	–	68	67	79	60
	OUTLET AT HOUSE	64	–	66	–	–	69

PHYSICAL/CHEMICAL WATER QUALITY

COUNTRY /SITE Sudan SHAGRA
TYPE OF INSTALLATION SWS CONTAINERISED MINI-FILTER
SITE NUMBERS · S/1 - Rower pump delivery, S/2 - Patay pump delivery.

PARAMETER		DAYS										
		1	2	3	4	5	6	7	8	9	10	11
DATE /TIME /WEATHER		–	11 00 22/6/85 SUNNY	[illegible]00 23/6/85 OVERCAST	10 00 24/6/85 SUNNY	14 00 25/6/85 SUNNY	15.00 26/6/85 SUNNY	13 00 27/6/85 SUNNY	11 00 28/6/85 WINDY	11 00 29/6/85 WINDY	11.00 30/6/85 SUNNY	19 00 1/7/85 WINDY
NUMBER OF SAMPLES		–	4	4	4	3	4	4	4	3	3	4
FAECAL COLIFORM COUNT /100mL	CANAL	–	–	9600	2940	<50	>400	>2000	>2000	>2000	6700	>20,000
	RESERVOIR	–	>200	5300	850	60	15	210	2000	–	–	>200
	S/2 PATAY PUMP	–	–	1090	1750	220	360	1980	2050	610	1100	700
	S/1 ROWER PUMP	–	–	30	2070	170	1440	1250	2000	237	1900	450
COLOUR	CANAL	–	Buff	Buff	pale buff	slightly opaque	slightly opaque	pale buff	buff	buff	Buff	Buff
	RESERVOIR	–	Buff	Buff	pale buff	clear	buff	pale buff	buff	–	–	Buff
	S/2 PATAY PUMP	–	pale brown	Buff	pale buff	clear	buff	pale buff	buff	slightly opaque	Buff	opaque
	S/1 ROWER PUMP	–	pale buff	Buff	pale buff	clear	buff	pale buff	buff	slightly opaque	Buff	opaque
ODOUR	CANAL	–										
	RESERVOIR	–		NO ODOUR								
	S/2 PATAY PUMP	–										
	S/1 ROWER PUMP	–										
TEMPERATURE	CANAL	–	28·5	29·5	27	28	–	–	–	–	–	–
	RESERVOIR	–	30·5	29·5	29	–	–	27	–	–	–	–
	S/2 PATAY PUMP	–	26	29·5	30	25	–	–	–	–	–	–
	S/1 ROWER PUMP	–	28 8	30 0	33	–	–	–	–	–	–	–
pH	CANAL	–	7 0	7 0	6·9	7·9	–	8·0	–	–	–	7·9
	RESERVOIR	–	6·9	7 0	6·9	8·0	–	8 0	–	–	–	7·9
	S/2 PATAY PUMP	–	6 9	7·0	6 9	8·2	–	8·0	–	–	–	7·8
	S/1 ROWER PUMP	–	6 9	6 9	7 0	8 0	–	7 6	–	–	–	7·7
TURBIDITY	CANAL	–	100	30	20	30	30	30	30	10	40	100
	RESERVOIR	–	100	<20	15	<10	10	15	10	–	–	100
	S/2 PATAY PUMP	–	100	20	15	<10	10	15	<10	5	30	20
	S/1 ROWER PUMP	–	75	15	15	10	10	10	10	5	25	20

PHYSICAL/CHEMICAL WATER QUALITY

COUNTRY /SITE Sudan JUBARA
TYPE OF INSTALLATION SWS CONTAINERISED MINIFILTER
SITE NUMBERS: S/3, S/4, S/5

PARAMETER			DAYS										
			1	2	3	4	5	6	7	8	9	10	11
DATE /TIME /WEATHER			–	1 00 22/6/85 SUNNY	15 00 23/6/85 OVERCAST	11.30 24/6/85 SUNNY	13 30 25/6/85 SUNNY	14 30 26/6/85 SUNNY	13·30 27/6/85 SUNNY	10 00 28/6/85 WINDY	MIDDAY 29/6/85 WINDY	MIDDAY 30/6/85 SUNNY	11 00 1/7/85 SUNNY
NUMBER OF SAMPLES			–	5	5	6	6	5	6	6	6	6	6
FAECAL COLIFORM COUNT /100ml	S/3	CANAL	–	1800	100	1830	40	18	169	>2000	890	25	82
		PATAY PUMP	–	620	100	2520	30	118	192	>2000	220	11	89
	S/4	CANAL	–	–	–	50	20	–	0	1500	20	7	>2000
		PATAY PUMP	–	560	<10	93	7	6	33	155	<10	7	50
	S/5	CANAL	–	2600	33	25	<10	5	20	221	30	10	73
		ROWER PUMP	–	120	50	10	2	5	27	13	15	5	43
COLOUR	S/3	CANAL	–	buff	buff	buff	buff	buff	buff	muddy	muddy	muddy	muddy
		PATAY PUMP	–	buff	buff	buff	buff	buff	buff	muddy	muddy	buff	buff
	S/4	CANAL	–	buff	buff	buff	buff	buff	slightly muddy	buff	muddy	muddy buff	muddy buff
		PATAY PUMP	–	buff	buff	pale buff	buff	buff	buff	buff	buff	buff	buff
	S/5	CANAL	–	buff	buff	buff	buff	buff	slightly muddy	slightly muddy	muddy	buff	buff
		ROWER PUMP	–	buff	pale buff	pale buff	buff	buff	clear	pale buff	muddy	buff	buff
ODOUR			–		NO ODOUR								
TEMPERATURE	S/3	CANAL	–	29	32	–	–	–	–	–	–	–	–
		PATAY PUMP	–	–	34	–	–	–	–	–	–	–	–
	S/4	CANAL	–	29	–	–	29	–	28	–	–	–	–
		PATAY PUMP	–	29	33	–	29	–	28	–	–	–	–
	S/5	CANAL	–	29	32	28	–	–	–	–	–	–	–
		ROWER PUMP	–	27	32	27	–	–	–	–	–	–	–
pH	S/3	CANAL	–	6·9	7·0	7 0	8 0	–	8 0	–	–	–	9 0
		PATAY PUMP	–	–	7 0	6 9	7 9	–	8 0	–	–	–	8·6
	S/4	CANAL	–	6 9	–	6 8	8 0	–	8 0	–	–	–	8 9
		PATAY PUMP	–	7 0	7 0	6 8	8 0	–	8 0	–	–	–	9·2
	S/5	CANAL	–	6·9	7 0	7 0	7 9	–	8 0	–	–	–	9·1
		ROWER PUMP	–	6 9	6 9	7 0	8 6	–	8 0	–	–	–	8 9
TURBIDITY	S/3	CANAL	–	50	75	50	50	40	50	200	100	100	100
		PATAY PUMP	–	–	30	30	20	30	25	75	75	20	75
	S/4	CANAL	–	50	–	15	35	–	30	20	75	100	100
		PATAY PUMP	–	50	50	10	25	15	10	20	30	100	100
	S/5	CANAL	–	50	30	15	30	30	30	40	100	75	100
		ROWER PUMP	–	50	<10	<10	40	20	<10	<10	75	30	100

PHYSICAL/CHEMICAL WATER QUALITY

COUNTRY /SITE Sudan TAMA
TYPE OF INSTALLATION SWS CONTAINERISED MINIFILTER
SITE NUMBER . S/6

		DAYS										
PARAMETER		1	2	3	4	5	6	7	8	9	10	11
DATE /TIME		MIDDAY 21/6/85	MIDDAY 22/6/85	17 30 23/6/85	11 30 24/6/85	13 00 25/6/85	17 00 26/6/85	15 00 27/6/85	MIDDAY 28/6/85	13.30 29/6/85	13 30 30/6/85	9.00 1/7/85
WEATHER		SUNNY	SUNNY	OVERCAST	SUNNY	SUNNY	SUNNY	SUNNY	WINDY	WINDY	SUNNY	SUNNY
NUMBER OF SAMPLES		2	1	2	2	2	2	2	2	a	2	2
FAECAL COLIFORM COUNT/100mL	CANAL	658	–	1267	>2000	733	>2000	490	>2000		550	467
	POST TREATMENT	400	383	967	133	675	172	124	>2000		250	267
COLOUR	CANAL	dark brown	brown	brown	brown	buff	brown	muddy brown	muddy brown.		very muddy	muddy
	POST TREATMENT	dark brown	brown	brown	buff	buff	brown	muddy brown	muddy brown		very muddy	muddy
ODOUR	CANAL	No odour										
	POST TREATMENT											
TEMPERATURE	CANAL	27	–	30	–	–	–	25	27		–	–
	POST TREATMENT	27	–	30	–	–	–	–	27		–	–
pH	CANAL	7 0	–	7 0	–	7 8	–	–	–		–	7 8
	POST TREATMENT	7 0	–	7 0	–	7 8	–	7 6	–		–	7 8
TURBIDITY	CANAL	200	250	180	200	130	200	300	500		1000	500
	POST TREATMENT	200	200	180	100	130	150	200	500		1000	500

Note a Area inaccessable ~ water logged , canal overflowing .

PHYSICAL/CHEMICAL WATER QUALITY

COUNTRY /SITE Sudan WAD - EL-AMIN CAMP
TYPE OF INSTALLATION HORIZONTAL SLOW SAND FILTER WITH PRE-FILTRATION
SITE NUMBER: S/7

		DAYS										
PARAMETER		1	2	3	4	5	6	7	8	9	10	11
DATE /TIME /WEATHER		–	MIDDAY 22/6/85 SUNNY	17 00 23/6/85 COOL WINDY	11 00 24/6/85 SUNNY	15 00 25/6/85 SUNNY	16 00 26/6/85 SUNNY	14 00 27/6/85 SUNNY	11 30 28/6/85 WINDY	13 00 29/6/85 WINDY	13 00 30/6/85 SUNNY	11 00 1/7/85 SUNNY
NUMBER OF SAMPLES		–	3	3	3	4	4	4	4	4	2	–
FAECAL COLIFORM COUNT/100mL	CANAL	–	150	500	110	96	350	675	>2000	570	8100	a
	ROUGHNING FILTER	–	19	54	9	37	1	54	80	28	BED DRY	
	PATAY PUMP	–	–	8	9	21	7	11	9	5	4	
	ROWER PUMP	–	24	–	–	16	7	12	19	14	WOULD NOT LIFT WATER	
COLOUR	CANAL	–	slightly opaque	opaque	buff	buff	buff	opaque	brown muddy	Brown muddy	Brown muddy	
	ROUGHNING FILTER	–	clear	clear	clear	clear	clear	slightly opaque	clear	dark buff	–	
	PATAY PUMP	–	–	clear	clear	clear	clear	clear	clear	clear	clear	
	ROWER PUMP	–	clear	–	–	clear	clear	clear	clear	clear	–	
ODOUR	CANAL	–										
	ROUGHNING FILTER	–			No	odour						
	PATAY PUMP	–										
	ROWER PUMP	–										
TEMPERATURE	CANAL	–	–	28	28	28	–	27	–	–	–	
	ROUGHNING FILTER	–	–	28	–	–	–	–	–	–	–	–
	PATAY PUMP	–	–	28	28	25	–	25	–	–	–	
	ROWER PUMP	–	28 0	–	–	–	–	–	–	–	–	
pH	CANAL	–	–	7 0	7·6	7 8	–	–	–	–	–	
	ROUGHNING FILTER	–	–	7 0	8·2	7·6	–	7·8	–	–	–	
	PATAY PUMP	–	–	7 0	–	7 8	–	7·6	–	–	–	
	ROWER PUMP	–	7·8	–	–	7·8	–	7 6	–	–	–	
TURBIDITY	CANAL	–	50	60	40	75	75	100	500	500	300	
	ROUGHNING FILTER	–	<10	35	15	<5	<5	15	<5	50	–	
	PATAY PUMP	–	–	<5	<5	<5	<5	<5	<5	<5	<5	
	ROWER PUMP	–	<5	–	–	<5	<5	<5	<5	<5	–	

Note a Canal level below intake pipe. Slow sand filter beds and tank dried out

APPENDIX F - SPECIFICATIONS FOR SWS INSTALLATIONS

I. MINI FILTERS AT SPRINGS

Installation

1. A large hole or trench should be dug into the eye of the spring and lined with stones or gravel.

2. The Mini Filter fastened firmly to a length of armoured hose, is placed on the bed of stones and covered by 2 -5mm gravel to depth of about 150mm, followed by at least 300mm sand (0.5 - 2.0mm). If sand is in ample supply this layer can usefully be deeper. Soil, followed by turf or other vegetation should be added to make a stable profile.

3. If storage is required large stones can be used above the sand formation.

4. A tap may be used at the outlet so that water can be stored in the permeable material. This will require the provision of an overflow.

5. A retaining wall may be necessary depending on the site.

6. The installation should be developed and stabilised by stopping and releasing the flow until the turbidity is reduced to an acceptable level.

7. If the profile of the ground allows a shallow diversion ditch should be made above the spring to cut off direct entry of surface water and prevent erosion of disturbed surface soil.

Maintenance

Little maintenance is likely to be needed. If there are signs of blocking this may be overcome by blowing air back into the pipe; if not, the installation will have to be dug up and redone.

II. MINI FILTER CONTAINERISED SYSTEM

Installation

1. Fill the bottom quarter of the tank with 2 - 5mm gravel making sure that the Mini Filter is covered. Place on this one layer of filter matting. Fill to near the top of the tank with 0.5 - 2.0mm sand.

2. Place two layers of filter matting on the sand and secure by clamp, grid and several large stones.

3. The container should be placed with its intake zone well below (at least 300mm) the water surface and above the bottom sludge, if possible away from the bank to avoid concentration of schistosome cercariae. In deeper water it may be better to suspend it from stakes.

4. Pumping rate should not exceed 75g/ft^2/hr or 3,600 l/m^2/hr.

5. Reservoirs and secondary filters etc. can be used to reduce the effective flow rate and increase filtration performance.

Maintenance

Normal maintenance requires only changing the filter matting when flow is reduced - after up to 13 weeks. The top layer, full of silt, is taken for washing: a fresh clean piece is placed on the sand and the partly dirty piece on top.

At longer intervals the container is taken ashore and the sand is removed, washed in the cleanest available water and replaced. A handful of dirty sand should be kept to mix with it to "seed" the biological filter.

If work in the water is done at sunrise the risk of bilharzia infection is minimised. After any maintenance the water should be pumped to waste for at least 10 minutes to stabilise the system.

III. SUB-SAND BED RIVER EXTRACTION UNIT

Installation

If a power-driven pump is available the potential site can be surveyed in a few minutes by using a jetting pipe and the best point chosen. If the bed has much silt and organic debris it should be jetted over an area of at least 3.0 x 3.0m to remove as much as possible.

1. A large hole is dug in the sand bed of the river deep enough to leave the top of the unit at least 300mm below the bed surface when refilled. If there is no surface flow the filter should be buried deeper with its top below the minimum dry season groundwater level.

2. The hole is back-filled with the excavated sand, leaving a slight mound over the filter. If the *in situ* sand is uniformly fine several loads of coarser material (1.0 -5.0mm) should be placed in, under and around the filter to increase potential flow.

3. Development of the system is most important and this is done by pumping. A stop/start routine, if necessary with one or two brief spells of back pumping, evacuates the fine material to stabilise the bed. (It is important to

study the detailed instruction note provided with the hardware.) Development is best done with a small power pump, but it can also be done by hand pumping.

Maintenance

Little maintenance is needed. Any blocking is normally confined to the surface 50mm and this is cleared by gently raking. If the bed is thought to be clogged up the filter can be dug up and reinstalled.

APPENDIX G : THE FIELD EVALUATION OF THE OXFAM DEL-AGUA PORTABLE WATER TESTING KIT

by N P Cox, London School of Hygiene and Tropical Medicine

INTRODUCTION

The Role of the Portable Water Testing Kit in Water Surveillance

Conventional water analysis requires water sample collection and transportation to a processing laboratory. This has two important disadvantages. The first is the time delay which can result from such a procedure. It is desirable to report and act on data within the shortest period of time. The second is the risk of deterioration of samples during prolonged transportation. On-site analysis using a portable water test kit overcomes these problems and also allows data collection under difficult conditions where laboratory facilities are lacking or non-existent.

The Need for a New Water Testing Kit

Commercial water test kits that are currently available have still to be fully developed to meet the needs of water surveillance programmes in developing countries. There is a need for an inexpensive water test kit that is easy to use and to maintain whilst using inexpensive and readily available consumable items.

The Del-Agua Water Testing Kit

This water testing kit, which has been developed at the Department of Microbiology, University of Surrey, with funds from Oxfam, measures five important parameters from the 60+ listed in 'Guidelines for Drinking Water Quality' (WHO 1984).

These are:

(i) faecal coliform count using the membrane filtration method.

(ii) turbidity using a turbidity tube (range 5-2000JTU).

(iii) chlorine residual (range 0.1-3.0mg/l)) using
) a
(iv) pH (range 6.8-8.2)) comparator

(v) combined conductivity (range 0-20,000 uS/cm) and temperature probe using an electronic meter.

In addition, the physical parameters of odour, taste and colour can be recorded.

Three versions of the kit are currently available:

(1) The A2 Model - A rectangular aluminium box 540mm x 220mm x 280mm, constructed at the University of Surrey and weighing 13Kg, including a mains electricity charger.

(2) The Adapted Delsey Vanity Case - An adapted polypropylene ladies' vanity case, 370mm x 230mm x 240mm, weighing 10Kg, excluding an external mains charger.

(3) The Paqualab - A more expensive de luxe model containing electronic metering and two incubators capable of housing up to 60 petri-dishes.

The first two versions are shown in Photo No 10. A list of the main components of the kits is given in Annex G-I. The components of each kit vary according to their availability and are constantly beiong modified and updated with experience by the University of Surrey research group. Further information about these kits and about opportunities for training in their use can be obtained from Mr Andrew Rickard, Surrey Aqua Biotechnologies, University of Surrey, Guildford, GU2 5XH, England.

Two A2 model kits were supplied to the SWS Evaluation Team at a cost of £1,000 each, without consumable materials and chemicals, which cost a further £330 for about 3 months investigations. A list of consumable items is given in Annex G-II.

The A2 models were tested in Zaire, Uganda and Sudan. On the return of the team to England after the Sudan and before leaving for Nigeria, one of the A2 models was exchanged for a Delsey vanity case model, which was tested in Nigeria. The Paqualab kit was not tested in these investigations.

Wherever possible during the field work, people who showed an interest were encouraged to use the kits. Only a basic requirement in literacy and numeracy is required to operate these kits but it is also desirable to have some background knowledge of bacteriology to enable the correct precautions to be taken when sampling, and to correctly interpret the results obtained. For this reason, training in water analysis is given at Surrey University.

A2 MODEL

This kit had the disadvantage of being bulky and tiring to carry although in many instances local assistance was provided. Part of the increased weight was due to the non-removable mains charger. It had the obvious advantage of being very sturdy, withstanding both the traumas of air transportation and handling and the very bumpy overland journeys. However the components inside the lid of the kit could have been more securely fastened as these often became detached during transit. This kit was the prototype model and will soon be unavailable except if specially requested.

Bacteriological Performance

Water samples were collected using a sterile water sampling cup.

Faecal coliform counts were performed using the membrane filtration method (HMSO Report No 71, 1982). This was clearly described in the instruction booklet provided with the kit. The capacity of the incubator allowed only ten samples per kit per day to be processed. The incubator (powered by internal batteries) was switched on for two consecutive 14hr incubation periods, after which time it was recharged from an external power supply (mains or car battery; leads supplied). However, whenever possible it was run directly from the mains. It would have been useful to have had a simple voltmeter incorporated to indicate when the internal batteries were low or fully charged. The incubator is set at 44°C and had good thermal insulation.

Sterilisation of the filtration assembly consisting of the water sample cup, filter funnel and bronze membrane support, is performed easily and efficiently in the field using methanol/formaldehyde. Care had to be taken when igniting the methanol since the flame was not easily apparent in daylight and the filtration assembly becomes too hot to hold. The assembly is ready to use again after a fifteen minute delay, to allow for complete sterilisation.

Physical Performance

(i) Turbidity is measured using a plastic turbidity tube and is straightforward to use provided that there is sufficient overhead light. Measuring turbidity in bad lighting conditions, for example, in the shade of a tree or at dusk, will give incorrect values.

(ii) Chlorine residual can be measured using a colour comparator. However, on this field study this test was not routinely required except to demonstrate the method using "Puritabs".

(iii) pH was initially measured with a pH probe but this was later abandoned in favour of the comparator method. The pH probe was less robust than the other probes in the kit and consequently became damaged. On the other hand the pH comparator method (using phenol red indicator tablets) was simple to use and reliable, although only a narrow range is covered.

(iv) Conductivity and Temperature Probes. These worked satisfactorily. However the black electronic meter box suffered from a defect common to electronic devices in hot climates in that prolonged exposure to the sun gave erratic readings. Such readings may be identified when reading temperatures but may not be apparent when measuring conductivities.

DELSEY VANITY CASE

This type was much easier to carry since it was smaller and less heavy than the aluminium type. The mains charger is carried separately, although it is not necessary to carry the charger when sampling the sites. The kit withstood the traumas of both air and land journeys. The components inside were securely fastened.

Bacteriological Performance

This is again performed by membrane filtration. The notable exception here though is that 16 samples per kit per day can be processed for 5 consecutive 14hr incubation periods, (a record must be kept) after which time the internal batteries must be recharged. An indicator light on the charging unit shows when the batteries are fully charged.

Physical Performance

A modified conductivity probe and temperature probe was available with this kit (which performed satisfactorily) whilst the pH probe had been deleted in favour of the comparator/phenol red method.

CONCLUDING REMARKS

Both kits performed very well, considering the amount of rough handling they received, but overall the vanity case type was preferred simply because it was lighter to carry and more samples could be processed per day.

ANNEX G-I

Main Components of the Del-Agua Portable Water Test Kits

The list applies to both the A2 model and Vanity Case types of test kit, except where indicated.

1. Carrying case with 44°C incubator.
2. Aluminium petri-dishes with carrier.
3. Storage box with charger lead (Vanity Case type, VCT).
4. Mains electric and motor vehicle charge leads.
5. Turbidity tubes x 2.
6. Conductivity and temperature meter (VCT).
   Conductivity, temperature and pH meter (A2 model).
7. Conductivity probe.
8. Temperature probe.
9. pH probe (A2 model).
10. Chlorine residual and pH comparator.
11. Stainless steel sample cup and recovery wire.
12. Stainless steel vacuum flask.
13. Stainless steel filter funnel and locking collar.
14. Aluminium filter assembly base.
15. Upper and lower "O" rings.
16. Bronze membrane support.
17. Stainless steel forceps.
18. Suction pump.
19. Lighter.
20. Absorbent pad dispenser.
21. Autoclaveable polypropylene bottles x 3.
22. Metal methanol dispenser.
23. Cleaning brush.
24. Carrying case keys (VCT).
25. Padlock and keys (A2 model).

ANNEX G-II

Consumable Items

These are required by both the A2 model and Vanity Case types of water test kit and can be purchased in any quantity required from the University of Surrey.

1. Membrane filters 47mm diameter, nominal pore size 0.45um.

2. Absorbent pads, same diameter as membranes, approximately 1mm thick.

3. Membrane broth in pre-weighed sachets.

4. Methanol.

5. DPD1 and DPD3 reagents in foil-wrapped pastilles.

6. Phenol red reagent in foil-wrapped pastilles.

7. Disposable tissues or clean cloth.

8. Disposable gloves.

9. Daily report sheets.

   In addition 1 ml and 10 ml pipettes (either sterile disposable or glass autoclaveable) and sterile Ringers diluent may be required if 1 ml or 10 ml samples (i.e. from grossly contaminated surface water) are to be processed.

APPENDIX H - COST DATA

1. Traditionally Protected Spring (Zaire)

Ref: Section 5.2 and Appendix B.

Gravity system without pump.

Cost of purchases for a typical installation, as provided by a local engineer, Eastern Zaire:

	£
Galvanised iron outlet pipe and cement for retaining wall	6
Transport of materials to site	3
Construction in local materials with local labour and supervision	-
Total	9

Maximum number of people supplies at sites visited:

Z/4	600
Z/5	500
	1,100
Average per site	550

Purchase cost per capita : £0.016

2. SWS Protected Spring (Zaire)

Ref: Section 2.2, 5.2 and Appendix B.

Three systems : (a)i Hillside gravity, with masonry retaining wall.

(a)ii Hillside gravity, without masonry wall

(b) Valley bottom with hand pump.

Cost of purchases:	(a)i £	(a)ii £	(b) £
Landed at Bunia Airport			
SWS Mini-filter, 10m of 1-in armoured hose, clips and bolts	50	50	50
Hand pump	-	-	50

Local Costs

Clearance at airport and transport to site	9	9	20
Galvanised pipe and cement	10	4	4
Local labour for construction and supervision	-	-	-
	69	63	124
Number of sites visited	4	6	5
Total costs	£276	£378	£620
Total maximum people served	800	710	1155

Hillside	(a)	(b)	Total
Cost	£69	63	
No sites	4	6	10
Total Cost	£276	£378	£654
People served	800	710	1510

Av people per site = 151
Av per capita = 0.43

Valley Bottom

Total Cost = £620
Total people = 1,155
Av people per site = 231
Cost per capita = 0.54

3. SWS Sub Sand River Bed Units (Zaire and Nigeria)

Ref: Section 2.2, 8.2 and Appendices B and D.

Cost of purchases (Nigeria) :	£
Landed at Kano Airport	
SWS filter pack consisting of GRP box container, 3m of 1½-in armoured hose, hand pump, hose clips and accessories	300
Local Costs	
Clearance at airport and transport to site	5
Cement for pump base	2
Labour for installation and supervision	-
Total	307

Maximum number of people supplied at 4 sites visited (Z/17, N/3, 4, 7) = 650

Average number of people per site = 163

Average per capita cost = £1.88

4. SWS Mini Containerised Unit (Sudan)

Ref: Section 2.2, 7.2 and Appendix C.

Two types : (a) Single stage, with pump.

(b) Two stage, gravity to reservoir and pump.

(a) Single Stage	£
Landed at Khartoum Airport	
SWS PVC box container, mini filter, hose pipe, pump, clips and accessories	200
Local Costs	
Clearance at airport and transport to site	5
Fabrication of steel stand for pump and clamps for filter mat	10
Labour and supervision for installation	-
	215
Number of installations visited (S/3, 4, 5, 6, 7, 8, 9)	7
Total population supplied	700
Average number of people per installation	100
Average per capita cost	£2.15

(b) Two Stage	£
Landed at Khartoum Airport	
2 SWS PVC box containers, 2 mini filters, hose pipe, pump, clips and accessories	350

Total population supplied : 400 from 2 units (S/1, 2)

therefore No per unit = 200

Local Costs

Clearance at airport and transport to site	5
Fabrication of steel stand for pump and clamps for filter mats	15
Bricks, sand, cement and pipes for reservoir	40
	£410
Average per capita cost	£2.05

5. SWS Jetted Well with Hand Pump (Nigeria)

Ref : Section 2.2, 8.2 and Appendix D.

Cost per installation complete, supplied by the Kano Agricultural and Rural Development Project	£535
Maximum number of people supplied per unit	200

6. Slow Sand Filter (Sudan)

A schedule of costs for a slow sand filter constructed at Wad el Amin Camp, Gezira, for a community of 100 is attached at Annex H/a. This work was undertaken by the Blue Nile Health Project in 1984/85, with Project staff providing skilled labour and supervision, and the community providing labour for excavation. The cost to the project is given as LS3659, equivalent in mid 1985 to £1,196. To this must be added the cost of two hand pumps at £100, giving a total of £1,296.

APPENDIX I - PREVIOUS U.K. TEST DATA

I/a - 'Treatment of Water by SWS filter unit', by M.J. Hurst, Agricultural Development and Advisory Service, Cambridge, 1977.

I/b - 'Applying the SWS unit in the UK', by Donald Caddy and Mike Hurst.

I/c - 'Studies on SWS water filtration units', by M.J. Hurst, Agricultural Development and Advisory Service Microbiology Department, Cambridge, April 1981.

I/d - 'Sub-sand water abstraction'. a personal Communication from David Wheeler, Department of Microbiology, University of Surrey to P. Stern, Gifford and Partners, November 1983.

APPENDIX I/a

AGRICULTURAL DEVELOPMENT & ADVISORY SERVICE

TREATMENT OF WATER BY THE SWS FILTER UNIT

M J HURST, CAMBRIDGE

INTRODUCTION

The SWS Unit is manufactured by Sea Water Supplies Ltd. of Skegness, Lincs. The unit was initially developed for the recovery of clean sea water from beach wells for aquarium purposes, but has since proven to have a much wider range of application.

The unit was first encountered during a search of equipment suitable for the prevention of blockage in trickle filter irrigation nozzles. Such nozzles have a very fine capillary bore and become easily blocked by particulate matter or microbial growth. Initial studies of the unit demonstrated its potential for a wider range of uses than first envisaged. A unit was installed at a site owned by the Anglian Water Authority and the opportunity was taken to carry out a joint investigation. The Water Authority carried out chemical analysis whilst this department undertook microbiological analysis.

THE UNIT

The unit comprises a heavy duty fibre glass box of 60 x 30 cm cross sectional area. The box is buried inverted in the gravel/sand and contains a slotted septum which keeps the upper part of it free from gravel. An outlet fitting is situated at one end above the false ceiling to take the connecting hose to the pump. Figure 2 demonstrates that water has to pass through the river bed and the gravel inside the unit itself before being removed by the pump. Should the b of the water course be of the incorrect kind then an artificial bed of gravel/ coarse sand can be created.

I/a-2

Once a unit has been installed it becomes necessary to 'develop' the supply. This done by running the pump for a short while and switching off and on when the water becomes clear. The water first pumped contains large numbers of fine mud particles from the interstitial spaces of the gravel. Switching on and off has the effect of further disturbing the bed so that more sediment is released. This process is repeated for a number of hours until the water remains clear when the pump is switched off and on. With the bed thus stabilised the unit can be run for a considerable period. So far we have encountered no blockage problems as the river used is quite fast flowing and tends to scour the bed.

SITE

Preliminary bacteriological results from temporary installations were encouraging and when an opportunity arose to conduct a joint investigation with the Anglian Water Authority on a permanent site over a lengthy period, it was quickly taken up. The site was on the River Ivel at Tempsford in Bedfordshire. The Ivel is a tributary of the River Ouse and carries a consdderable amount of sewage discharge (70% of flow) from the developing town of Biggleswade. At the point of sampling the Ivel is fast flowing approximately 1 metre deep over a gravel bed.

SAMPLING

Samples were taken on a weekly basis although failure of the pump necessitated a three month interlude. Sampling duties were shared with the Anglian Water Authority. Bacteriological samples were taken aseptically into sterile 550 ml B.T bottles and tested within four hours. Separate large samples were taken for chemical analyses. Two samples were taken on each visit one after treatment from the outlet of the pump and the other from the river just upstream of the unit. This sample was taken by wading from 0.25 metre above the river bed using a weighted bottle with its bung removable by thread.

TESTING

(a) (Bacteriological)

The waters were dilution plated and the dilutions examined as follows:-

(i) Bacteria total count on Nutrient Agar (Oxoid) at 22°C for 72hrs and 37°C for 48hr

(ii) Coli-aerogenes organisms MaConkey No.3 Agar (Oxoid) at 37°C suspect colonies (dark red) picked off at 24 and 48 hrs and subcultured.

(iii) E. coli type I suspect colonies from (ii) innoculated into Lactose Ricinoleate Broth (Oxoid) and examined for gas production after 24 and 48 hrs at 44°C

(b) Chemical

Chemical tests were as follows:- Suspended solids, B.O.D. Ammoniacal nitrogen, nitrate nitrogen, ~~allcalunty~~ ALKALINITY, total hardness, calcium, magnesium, sodium, potassium, anionic detergents, phosphate, boron, chloride, sulphate, dissolved silica, iron, zinc, copper nickel, chromium, cadmium and lead.

RESULTS

(a) Bacteriological

Bacteriological results are detailed in figure I. Removal of bacteria by the filter was more efficient than expected. The mean removals were 98.4%, 98.05%, 98.8% and 98.8%) for counts at 22°, 37°C and of coli - aerogenes and E. coli organisms respectively. The results are particularly favourable if one considers that flexible bellows type hosing was used for all piping and that the interiors of these were far from clean. Good though results are the unit cannot be relied on to produce bacteriologically potable water and E. coli I was recovered at levels of up to 500 organisms per 100mls on occasions.

(b) Chemical

Full chemical results are not yet available. However the initial nine samples did consistently yield some quite surprising and significant results.

TEST	MEAN REMOVAL %
Suspended solids	71
B.O.D	49
Ammoniacal nitrogen	71
Nitrate nitrogen	12
Anionic detergents	18
Phosphate	21
Iron	59

DISCUSSION

The good results obtained indicate a number of potential uses for the unit.

Uses envisaged at the moment are:-

1. The filtration of raw water from rivers, streams etc. to prevent the blockage of trickle irrigation units. Such units become blocked by either small sand particles or by the growth of microorganisms especially iron bacteria. The unit considerably reduces suspended solids and as a bonus may cut down on the amount of iron present in the water.
2. The unit could facilitate the use of open water sources for use for glasshouse irrigation. Usually the occurrence of Phytopthora and Pythium species militates against the use of such sources. The unit should considerably reduce the risk of the transmission of these agents to nursery seedlings.
3. The unit has the effect of clearing water of sediment and thus increasing its transmission of ultra violet light. If the unit is used in conjunction with an ultra violet lamp the production of water suitable for the irrigation of young seedlings or salad crops is possible from quite heavily contaminated water.
4. Interest has been aroused in the possibilities of using the unit in conjunction with a U/V lamp and a charcoal filter as an emergency source of water for human use. There has been considerable interest from developing countries on this aspect.

5. It may prove possible to utilise the unit to aid the recovery of water for re-use in vegetable washing - particularly for root crops.

The idea of using a gravel filter to abstract water is not new and devices utilising the beds of rivers have been designed before. However, the SWS differs from such units is that it is exceedingly simple, easy to install and relatively cheap, (£160 including pump). It is anticipated that it will find considerable use within the field of agriculture.

It is intended to continue the experiment on at least two sites. At one of these the unit will be connected to a Havovia ultraviolet lamp to ascertain the final quality of water obtainable from the joint use of these two items of equipment.

CONCLUSION

The treatment of raw river water with the SWS unit produced water of greatly improved microbiological quality and encourages further investigation into potential roles for the unit in agriculture.

ACKNOWLEDGEMENTS

My thanks are due to Dr D Caddy of the Anglian Water Authority for his cooperation, Mr G Cansdale of Sea Water Supplies for the loan of the unit, to Mr E Slater of the Cambridge Laboratory for carrying out the lions share of the field work and to the staff of the Cambridge Laboratory for their assistance.

M J Hurst
ADAS Microbiology Department Cambridge
September 1977

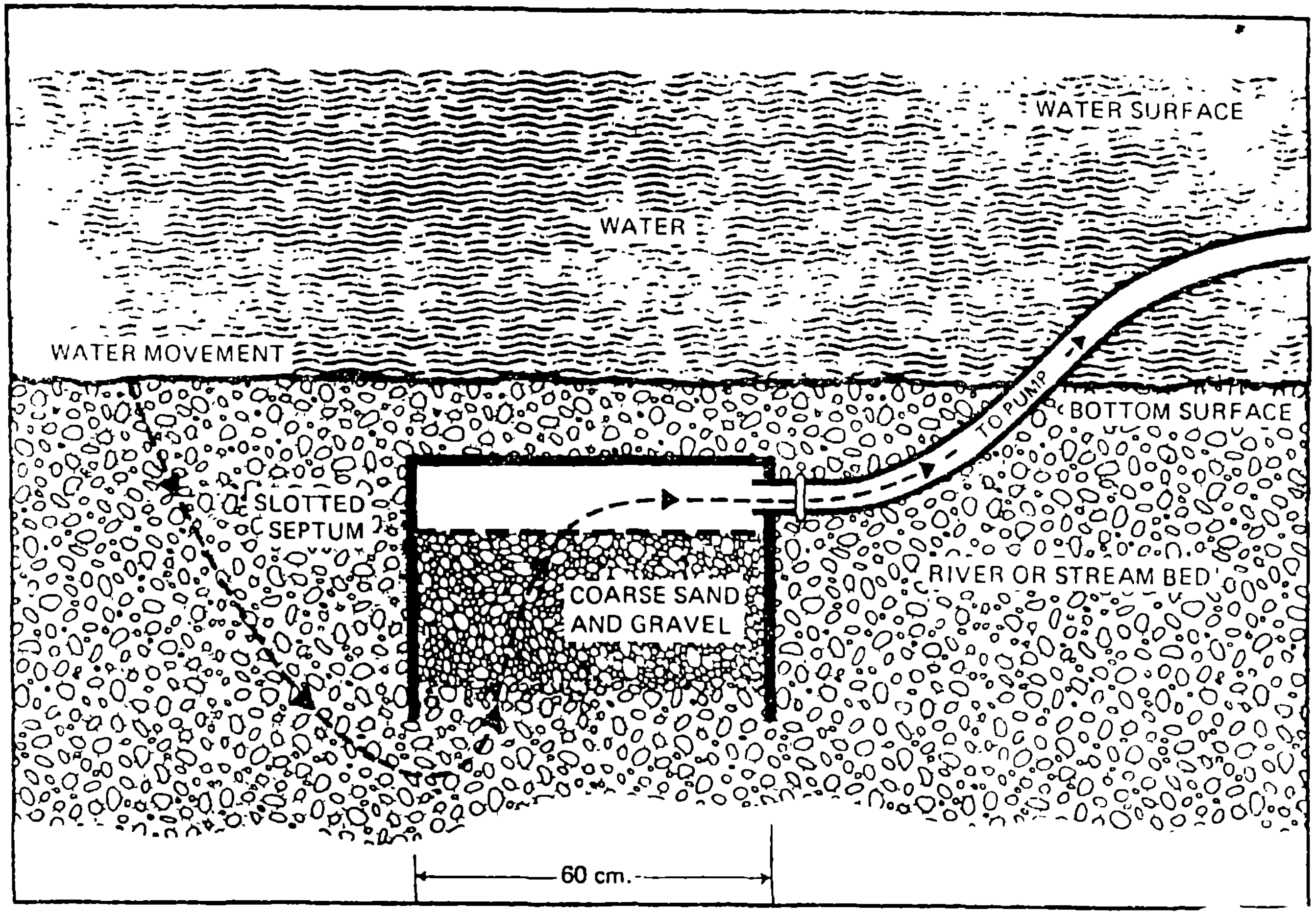
INVESTIGATION INTO THE EFFICIENCY OF THE SWS FILTER UNIT AT TEMPSFORD, BEDS

Date	Count at 22°C per ml			Count at 37°C per ml			Coli-aerogenes organisms at 37°C per ml			E coli type 1 per ml 44°C		
	b	a	% reduction	b	a	% reduction	b	a	% reduction	b	a	% reduction
20. 9.76	13,400	79	99.41	206	22	89.32	45	0	100	45	0	100
27. 9.76	8,600	460	94.65	2,000	310	84.5	65	5	92.3	33	3	90.9
4.10.76	22,400	1170	94.78	12,100	165	98.64	280	6	97.86	50	5	90.0
11.10.76	7,900	159	97.99	33,200	140	99.58	64	0	100	51	0	100
18.10.76	14,700	91	99.38	12,300	29	99.76	100	3	97.0	30	0	100
25.10.76	12,300	540	95.61	17,100	24	99.86	56	0	100	50	0	100
2.11.76	28,500	115	99.60	1,960	45	97.7	670	2	99.7	469	1	99.79
8.11.76	11,700	92	99.21	4,700	21	99.55	490	0	100	392	0	100
15.11.76	18,600	87	99.53	9,100	67	99.26	66	0	100	46	0	100
21. 2.77	70,000	2,160	96.91	18,100	490	97.29	241	4	98.34	241	2	99.17
28. 2.77	18,200	170	99.07	8,500	52	99.39	108	5	95.39	65	0	100
4. 3.77	34,000	990	97.09	29,000	600	97.93	85	2	97.65	77	2	97.41
7. 3.77	18,300	50	99.73	13,000	107	99.17	209	1	99.52	146	0	100
14. 3.77	49,000	124	99.75	25,700	44	99.83	174	1	99.43	104	0	100
21. 3.77	83,000	134	99.84	22,100	64	99.71	187	0	100	168	0	100
28. 3.77	31,000	84	99.73	13,600	102	99.25	230	1	99.57	207	0	100
18. 4.77	32,700	121	99.63	18,300	35	99.81	144	0	100	86	0	100
26. 4.77	77,000	490	99.36	21,800	550	97.48	123	0	100	86	0	100
2. 5.77	28,100	52	99.81	19,200	29	99.85	330	0	100	13	0	100
9. 5.77	48,000	1,630	96.61	15,400	42	99.73	119	0	100	60	0	100
16.5.77	24,800	116	99.53	25,200	62	99.75	169	0	100	118	0	100
13.6.77	82,000	1,940	97.63	70,000	223	99.68	113	5	97.35	22	1	95.45

b = before filtration a = after filtration

FIG 2

SWS FILTER UNIT - DIAGRAM OF INSTALLATION



	Total Count at 22° C (Nos/ml)	Total Count at 37° C (Nos/ml)	Coli-aerogenes at 37° C (Nos/ml)	E. coli type at 44°C (Nos/ml	pH	Suspended solids at 105° C (mg/l	Suspended solids at 500° C (mg/l)	BOD (5-day) (mgO_2/l)	Ammoniacal Nitrogen (mgN/l)	Total oxidised Nitrogen (mgN/l	Anionic detergent (mg/l)	Dissolved phosphate (mg/P/l)	Total iron (mg/l)	Total copper (mg/l)	Total lead (mg/l)
RAW WATER QUALITY															
Maximum	83,000	70,000	670	469	8.4	50	32	Over 10	1.50	19.9	0.34	3.2	10.0	0.05	0.09
Mean	33,393	17,844	185	116	8.07	12.3	5.7	3.4	0.59	13.28	0.09	1.46	1.24	0.0175 → 0.019	0.04
Median	23,600	16,250	133	71	8.05	9.25	3.0	3	0.45	12.85	0.08	1.325	0.625 → 0.58	0.01	0.04
Minimum	7,900	200	45	13	7.8	2	less than 1.0	less than 1.0	less than 0.5	9.6	0.03	0.22	0.16	less than 0.01	0.02
Samples	22	22	22	22	12	24	24	24	24	24	24	24	20	20	20
FILTRATE QUALITY															
Maximum	2160	600	6	5	8.2	4	1.5	5	0.56	14.3	0.11	2.58	0.58	0.05	0.06
Mean	493	147	2	1	7.72	1.8 → 2.0	0.2 → 1.0	1.3 → 1.6	0.11 → 0.12	10.0	0.052 → 0.053	1.00	0.16	0.012 → 0.015	0.032
Median	129	63	1	0	7.8	2	less than 1	1	0.08	10.05	0.04	0.98	0.145	0.01	0.03
Minimum	50	21	0	0	7.3	less than 1	less than 1	less than 1	less than 0.05	7.1	less than 0.02	0.09	0.04	less than 0.01	0.02
Samples	22	22	22	22	12	24	24	24	24	24	24	24	20	20	20
PERCENTAGE REDUCTION															
Maximum	99.8	99.9	100	100	0.6*	100	100	100	100	46.7	108	70.3	98.3	100	77.8
Mean	97.8	98.0	98.8	98.8	0.4*	76.8 → 78.3	50.2 → 94.0	40.7 → 58.4	72.6 → 74.1	23.27	38.27 → 41.06	38.2	76.15	15.2 → 36.7	20.1
Median	99.15	99.55	99.65	100	0.32*	78.25 → 82.85	67 → 100	50 → 66.7	79.2	25	36.75 → 38.75	37.65	74.15	0 → 20	16.7
Minimum	89.8	84.5	92.3	90	0.1*	42.9	0	0	- 20	1.6	9.1	- 9	55.7	0	0
Samples	22	22	22	22	12	24	24	24	24	24	24	24	20	20	20

* Percentage Reduction in pH is expressed as pH differ[illegible]

APPENDIX I/b

APPLYING THE S.W.S. UNIT IN THE U.K.

By Donald Caddy and Mike Hurst

After 10 days' pumping to stabilise an S.W.S. installation in the River Ivel at Tempsford, Bedfordshire, a weekly programme of sampling and analysis was maintained to study its performance as a continuous water treatment system, over a period of seven months.

Removal through the system of Escherichia coli, Type 1, was 99%, while total bactorial removal averaged 98%. Nitrification and dentrification occurred in excess of 70% and 20% respectively and percentage reductions in 5 day Biochemical Oxygen Demand, orthophosphate, anionic detergent, total iron and suspended solids were as follows:- 49%, 38% 76% and 76% respectively.

"Development" of the bed took one hour, after which the unit was pumped continuously at 29m^3/d. The extent of the river bed utilised in the filtration process was indicated by tracer studies which in turn suggested that the filtration rate was no more than 4m/d, a rate similar to that used for traditional slow sand filtration in the water supply industry.

The river water, comprising about 40% sewage effluent under conditions of dry- weather flow, contained a mean concentration of 5.7 mg suspended solids/l which was reduced on treatment by an average of 79%. 76 /
On eleven occasions when the concentration of suspended solids exceeded 14 mg/l the removal was on average 95%. The filtrate contained a mean concentration of some 2 mg suspended solids/l, irrespective of river conditions.

The average reduction in the ammonia concentration was from 0.60 to 0.12 mg ammoniacal nitrogen/l, while marked dentrification was evident from the loss of total oxidised nitrogen from 13.3 to 10.0 mg nitrogen/l, most probably linked with the utilisation of inorganic nitrato- and for nitro- oxygen for oxidation of local benthic substrate.

Taken together, our initial results provide strong evidence that the system is capable of operating as a unit of biochemical treatment at pumping rates of about 5% and 10% of that specified by the manufacturer. It should be noted, however, that "conservative" substances such as chloride sulphate, sodium and potassium were not apparently affected by the process.

More research is necessary in order to assess the suitability of given sites for operation of sub benthic filtration using the S.W.S. unit and local variables such as flow, depth, width of stream, pumping rates and the particles-size and nature of the bed, should be studied further.

However, the encouraging results obtained so far suggest a number of possible applications.

1. In irrigation of salad crops and soft fruit where there is a disease risk from raw river water coming in contact with the surface of the fruit. This would be of particular importance in "pick-your-own" enterprises. Levels of potential bacterial pathogens of sewage origin could be reduced to acceptable levels.

2. Blockage of trickle irrigation systems due to sand particles would be substantially reduced.

3. The S.W.S. system would remove plant spores from river water which could then be used for intensive green house operations, reducing seedling loss.

4. In fish farming operations using a pumped river source, the risk to fish from suspended solids, ammonia and water-borne disease, could be minimised. Purification results in a loss of dissolved oxygen in the water, but this would be a small price to pay for clean water and can be injected economically using low pressure coarse-bubble aeration.

5. Could be used to increase the suitability of water for treatment by small scale physiochemical systems such as: chlorination - reduction of chlorine demand; U/V treatment - reduction of turbidity; activated carbon - reduction of clogging; reverse osmosis - increased membrane life.

Acknowledgement

D.E.C. wishes to thank the Director of Scientific Services of the Anglian Water Authority for his permission to publish. The views expressed are those of the authors and not necessarily of the Anglian Water Authority. Both authors thank their colleagues for advice and assistance.

APPENDIX I/c

Agricultural Development & Advisory Service
Microbiology Department Cambridge

Studies on SWS water filtration units

Site	West Mill Trout Farm West Mill Road Ware Herts	Site 1	just upstream of road bridge - filtered water feeding sales holding tanks

Table 1 Count at 22°C - Site 1

Date	Raw Water	Filtered Water	% Change
21/4/80	11,300	550	-95.1
28/4/80	2,690	161	-94.0
6/5/80	11,200	1,800	-83.9
12/5/80	11,800	75	-99.3
19/5/80*	1,620	7,600	*
27/5/80*	9,000	13,900	*
2/6/80	1,810	28	-98.4
9/6/80	5,800	16	-99.7
16/6/80	10,100	31	-99.7
23/6/80	8,200	172	-97.9
30/6/80	1,260	39	-96.9
7/7/80	17,900	140	-99.2
21/7/80	11,600	97	-99.9
28/7/80	5,300	77	-98.5
4/8/80	10,900	63	-99.4
11/8/80	7,900	690	-91.3
18/8/80	2,330	22	-99.1
26/8/80	8,100	128	-98.4
2/9/80	10,100	2,720	-73.1
8/9/80	6,600	1,500	-77.3
15/9/80	12,300	97	-99.2
22/9/80	2,170	32	-98.5
29/9/80	10,300	39	-99.6
6/10/80	8,100	48	-99.4
13/10/80	7,700	8	-99.9
20/10/80	9,900	36	-99.6
2/12/80*	4,100	5,900	*
15/12/80	5,300	29,900	*
Mean	8,140	357	95.6

* These samples were taken when the unit had been displaced and their results are included to show the effects of this.

I/c-2.

Site 1 **Table 2**

Bacterial Count at 37°C

Date	Raw Water	Filtered Water	% Change
21/4/80	51	15	-70.6
28/4/80	89	21	-76.4
6/5/80	940	22	-97.7
12/5/80	39	2	-94.8
19/5/80*	281	640*	
27/5/80*	172	201*	
2/6/80	71	3	-95.8
9/6/80	123	2	-98.4
16/6/80	620	6	-99.0
23/6/80	910	22	-97.6
30/6/80	136	10	-92.6
7/7/80	360	21	-94.2
21/7/80	133	40	-69.9
28/7/80	1,030	5	-99.5
4/8/80	650	43	-93.4
11/8/80	720	225	-68.7
18/8/80	1,120	26	-97.7
26/8/80	185	11	-94.1
2/9/80	640	300	-53.1
8/9/80	1,020	93	-90.9
15/9/80	1,570	3	-99.8
22/9/80	580	40	-93.1
29/9/80	810	5	-99.4
6/10/80	167	4	-97.6
13/10/80	410	2	-99.5
20/10/80	266	3	-98.9
2/12/80*	123	152*	
15/12/80*	139	136*	
Mean	526	385	-92.8

* Unit displaced

I/c-3

~~Site 1~~ Table 3

Coli aerogenes organisms $37^{o}C$

Date	Most probable no/100 mls		% Change
	Raw Water	Filtered Water	
21/4/80	170	50	-70.6
28/4/80	450	25	-94.4
6/5/80	350	110	-68.6
12/5/80	110	0	-100
19/5/80*	1,600	1,600	
27/5/80*	3,500	900	
2/6/80	550	5	-99.1
9/6/80	2,250	8	-99.6
16/6/80	1,700	17	-99.0
23/6/80	1,700	80	-95.3
30/6/80	700	70	-90.0
7/7/80	5,500	130	-97.6
21/7/80	400	50	-87.5
28/7/80	2,250	45	-98.0
4/8/80	5,500	250	-95.5
11/8/80	2,500	350	-86.0
18/8/80	9,000	50	-99.4
26/8/80	3,500	35	-99.9
2/9/80	5,500	9,000	+63.6
8/9/80	1,600	900	-43.7
15/9/80	1,400	35	-97.5
22/9/80	1,700	35	-97.9
29/9/80	1,600	5	-99.7
6/10/80	1,600	11	-99.3
13/10/80	550	11	-98.0
20/10/80	5,500	8	-99.9
2/12/80	900	900*	
15/12/80	5,500	1,600*	
Mean	2,337	470	-79.9

* Unit displaced

Site 1 **Table 4**

E coli type 1

Date	Most probable no/100 mls		% Change
	Raw Water	Filtered Water	
21/4/80	25	4	-84
28/4/80	20	13	-35
6/5/80	35	20	-42.9
12/5/80	50	0	-100
19/5/80*	550	250	
27/5/80*	13	25	
2/6/80	130	0	-100
9/6/80	200	0	-100
16/6/80	250	5	-97.5
23/6/80	1,700	6	-99.7
30/6/80	170	0	-100
7/7/80	1,500	50	-98.0
21/7/80	250	5	-98.0
28/7/80	350	8	-97.7
4/8/80	1,100	4	-96.0
11/8/80	1,600	350	-78.1
18/8/80	1,600	50	-96.9
26/8/80	225	2	-99.1
2/9/80	900	110	-87.8
8/9/80	550	45	-91.8
15/9/80	130	4	-96.9
22/9/80	350	0	-100
29/9/80	1,400	0	-100
6/10/80	350	2	-99.4
13/10/80	350	0	-100
20/10/80	3,500	2	-99.9
2/12/80	900	550*	
15/12/80	5,500	1,600*	
Mean	739	28	-96.2

* Unit displaced

Site I Table 5

% Transmittance of Ultra Violet Light at 254 nm

Date	Raw Water	Filtered Water	Change
21/4/80	61.9	67.1	+5.2
28/4/80	51.4	79.4	+28.0
6/5/80	55.0	72.6	+17.6
12/5/80	53.0	78.5	+25.5
19/5/80	52.1	52.1*	0*
27/5/80	70.0	70.6*	-0.6*
2/6/80	62.1	77.8	+15.7
9/6/80	53.1	78.0	+24.9
16/6/80	44.3	77.6	+33.3
23/6/80	43.7	75.0	+31.3
30/6/80	41.0	70.3	+29.3
7/7/80	45.5	71.3	+25.8
21/7/80	64.0	72.4	+8.4
28/7/80	57.5	72.8	+15.3
4/8/80	53.9	70.3	+16.4
11/8/80	65.3	70.8	+5.5
18/8/80	60.3	71.8	+11.5
26/8/80	66.1	79.1	+13.0
2/9/80	48.8	71.0	+22.2
8/9/80	56.5	58.6	+2.1
15/9/80	45.8	72.1	+26.3
22/9/80	50.4	65.9	+15.5
29/9/80	46.2	72.1	+25.9
6/10/80	57.5	77.6	+20.1
13/10/80	20.0	74.5	+54.5
20/10/80	28.8	71.5	+42.7
2/12/80	61.0	59.6*	-1.4
15/12/80	53.7	56.2*	2.5

* unit displaced

I/c-6

Table 6 **Site 1** **Water Temperature ^{o}F**

Date	Raw	Filtered	Difference
6/5/80	50	50	0
12/5/80	56	50	-6
2/6/80	57	56	-1
9/6/80	63	55	-8
16/6/80	63	55	-8
23/6/80	59	59	0
30/6/80	60	57	-3
7/7/80	60	58	-2
21/7/80	59.5	59	-0.5
28/7/80	65	62	-3
4/8/80	66	65	-1
18/8/80	63	63	0
26/8/80	59.5	59	-0.5
15/9/80	62	62	0
22/9/80	64	62.5	-1.5
29/9/80	58	61	+3
6/10/80	54	52	-2
13/10/80	48	50	+2

Table 7 **Site 1**

Date	Suspended Solids mg/litre		% Difference
	Raw	Filtered	
15/9/80	26.0	0.66	-97.5
22/9/80	12.6	2.6	-79.4
29/9/80	60.0	0.3	-99.5
6/10/80	18.8	0	-100
13/10/80	41.6	0	-100
20/10/80	44.8	0	-100
(2/12/80)*	(76.0)	(4.8)	(-93.7)
(15/12/80)*	(28.4)	(5.2)	(-81.7)
Mean	34.0	0.59	-98.3

* Unit displaced

Remarks Site 1 Overall the results are encouraging and begin to approach the results obtained in our first trial. The numbers of bacteria have been reduced considerably. E coli type I - an indication together with coli-aerogenes organisms of faecal type contamination was reduced significantly although not altogether. On two occasions it was noted that the unit had been disturbed in its bed. This is confirmed by the sudden onset of poor results for a 2 week period in each case.

It has been suggested that the unit at this site was tapping an underground stream. The results obtained would lend weight to this theory. In particular the transmittance of ultraviolet light through the water is increased by filtration to an extent I have never encountered before. Whilst turbidity of water has some effect on this reading it is mainly affected by dissolved material. Thus a marked difference in readings suggests one thing - different waters. It is also worth noting that when the unit was displaced the U/V readings became similar for both waters.

M J Hurst
Microbiologist

29 April 1981

USE OF SWS UNIT AND HANOVIA U/V LAMP AT TEMPSFORD

I/C-8

	Count 22°C/ml					Count 37° C/ml					Coliforms URB 37°C/ml					E coli I/ml					Coliforms MPN/100 ml					E. coli I MPN /100 ml				
Date	R	F	$\%_1$	U/V	$\%_2$	R	F	$\%_1$	U/V	$\%_2$	R	F	$\%_1$	U/V	$\%_2$	R	F	$\%_1$	U/V	$\%_2$	R	F	$\%_1$	U/V	$\%_2$	R	F	$\%_1$	U/V	$\%_2$
25/7	11300	1560	86.2	41	97.4	16800	1040	93.8	14	98.7	87	0	100	0	-	70	0	100	0	-										
7/9	29000	390	98.7	264	32.4	4100	60	98.5	59	1.7	69	3	95.7	1	66	48	1	52	0	100										
20/9	9600	330	96.6	179	45.8	5700	148	97.4	83	43.9	29	2	93.1	0	100	11	0	100	0	100										
28/9	7200	190	97.4	128	32.7	9600	135	98.6	102	24.5	24	2	91.7	0	100	5	0	100	0	100										
4/10	8500	47	99.4	33	29.8	180	20	88.9	10	50	129	0	100	0	-	52	0	100	0	100										
11/10	13700	132	99.0	155	+17.4	10600	51	99.5	32	41.8	101	0	100	0	-	61	0	100	0	100	1800+	35	98.1*	25	28.5	1800+	11	99.4*	8	27
18/10	14800	52	99.6	63	+21.2	2350	18	99.2	25	+38.9	261	0	100	0	100	209	0	100	0	100	1800+	17	99.1*	8	52.9	1800+	9	99.6*	5	37
25/10	17800	126	99.3	176	+39.7	8100	126	98.4	45	64.3	190	4	97.9	0	0	95	0	100	0	100	1800+	50	97.2*	50	0	1800+	17	99.1*	20	+18
31/10	13900	5200	62.6	116	97.8	88000	580	99.5	7	98.8	360	5	98.6	0	100	72	0	100	0	100	1800+	50	97.2*	0	100	1800+	5	99.7*	0	100
21/11	24800					7500					780					156					1800+					350				
13/12	413000	7300	98.2	1600	78.1	5300	102	98.1	14	86.3	620	17	97.3	0	100	124	3	97.6	0	100	1800+	900	50.0*	0	100	900	110	87.8	0	100
19/12	41000	920	97.8	3	99.7	11400	194	98.3	26	86.6	2080	34	98.4	0	100	62	7	88.7	0	100										
3/1	93000	177	99.8	12	93.3	16900	31	99.8	3	90.3	2600	3	99.8	0	100	1040	0	100	0	100	1800+	35	98.1*	0	100	1800+	7	99.6*	0	100
10/1	22500	560	97.5	9	98.4	6600	49	99.3	15	69.4	2060	1	99.9	0	100	1030	0	100	0	100	1800+	17	99.1*	0	100	1600+	0	100	0	-
17/1	49000	1080	97.8	48	95.6	6100	390	99.4	16	95.9	560	46	91.8	0	100	392	0	100	0	100	1800+	250	86.1*	2+	99.2	1800+	250	86.1*	2	99.2
30/1	61000	540	99.1	68	87.4	3100	54	98.3	9	83.3	1080	8	99.3	0	100	432	0	100	0	100	1800+	80	95.6*	17	78.7	1800+	25	98.6*	8	68
13/2	9800	410	95.8	115	72.0	2000	65	96.7	34	47.7	140	130	7.2	1	99.2	84	52	381	0	100	1800+	250	86.1*	17	93.2	1800+	130	92.8*	8	93.8
20/2	34800	500	98.6	141	71.8	11600	158	98.6	86	47.6	2430	33	98.7	3	91.0	97	3	97.1	0	100	1800+	170	90.6*	7	95.9	350	17	95.1	0	-
27/2	52000	174	99.6	29	83.3	23000	82	99.6	47	42.7	1140	11	99.0	3	72.8	114	0	100	0	100	1600	35	97.8	7	80	20	2	90	0	100
6/3	30500	410	98.7	43	89.5	7300	63	99.1	15	76.2	2330	2	99.9	3	+33	0	0	100	0	100	1800+	35	98.1*	0	100	5	0	100	0	-
13/3	120000	210	99.8	6	97.2	8300	39	99.5	1	97.5	2280	2	99.9	0	100	0	0	100	0	100	1800+	11	99.4*	0	100	550	2	99.6	0	100
20/3	55000	530	99.0	20	96.2	25100	121	99.5	5	95.9	3100	5	99.8	0	100	0	0	100	0	100	1800+	70	96.1*	2	97.1	55	9	83.6	2	77.8
3/4	105000	490	99.5	2	99.6	18300	84	99.5	7	91.7	4000	9	99.8	0	100	800	1	99.9	0	100	1800+	13	99.3*	0	100	900	5	99.4	0	100
10/4	120000	263	99.8	26	90.1	17900	113	99.4	60	47	8300	9	99.9	0	100	0	0	100	0	100	1800+	11	99.4*	0	100	15	2	86.7	0	100
17/4	14100	135	99.0	15	88.9	6800	66	99.0	6	91	1240	11	99.1	0	100	124	0	100	0	100	1800+	25	98.6*	0	100	550	0	100	0	-

Code R = Raw water
G = Filtered water
U/V = water after U/V and filtration
$\%_1$ = % reduction
$\%_2$ = further reduction by U/V

Horizontal lines indicate where system was cleaned out

* indicates minimum reduction

APPENDIX I/d

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ext 873

From the Department of Microbiology

DW/MH

-5 DEC 1983

30th November, 1983

Mr. P. Stern
Gifford and Partners
Consulting Civil and Structural
Engineers.
Carlton House,
Ringwood Road, Woodlands
Southampton, SO4 2HT

Dear Peter,

Sub-sand water abstraction

Charles Kerr telephoned today to discuss the position of the water panel regarding the Cansdale sub-sand abstraction unit.

My feeling, and that of Barry Lloyd is that in none but the most exceptional circumstances can the unit provide reliably disease-free water fromcontaminated surface waters on its own. We have operated the units in a careful and well managed fashion, at low flow rates, and with a positive displacement, smooth action pump (i.e. not by surging flow). Thus we feel we have given the units every chance of behaving optimally. However, even in these circumstances, the units can only offer a finite improvement in bacteriological quality, and whilst water which has been thus filtered may appear of much higher clarity, it can still contain bacterial levels far in excess of what might be considered 'safe' even by the most pragmatic standards.

For this reason, we consider the unit best suited for use as a prefilter. With one or two reservations we consider sub-sand abstraction to be an excellent means of clarification in preparation for other processes e.g. slow sand filtration. The main reservation in this context is that where the abstraction bed is subject to chronic or even intermittent high loads of organic pollution, the wrong kind of micro-flora may become established in the sand creating a fermentation which liberates gas in large quantities. This inevitably reduces the availability of clarified water. A side effect of this fermentation is a reduction in the dissolved oxygen content of the water which might inhibit the efficiency of downstream processes such as S.S.F.

.../2...

I/d - 2

I enclose some graphs from our first O.D.A. report (typed axis) and others from our next report (under preparation, axis not typed). The former represent winter operating conditions i.e. water temperatures less than 10°C, the latter represent summer conditions i.e. water temperatures in excess of 10°C. I hope they demonstrate the finite nature of the improvements which can be expected in water quality from sub-sand abstraction. Regression lines are plotted both against days of filter run and against build-up of vacuum pressure (a measure of the degree of blockage of the filter bed).

With best wishes.

Yours sincerely,

David Wheeler
Research Officer.

cc. Charles Kerr.

Results and Discussion

The results of microbiological analysis on the five indicator groups have been substantially simplified by relating results for total coliforms, faecal streptococci and 37°C and 20°C plate counts to faecal coliform density reductions for each test undertaken. The relationships between the various groups for both stages of the process: primary and secondary filtraion, are depicted (Figures 2 and 3). Regression lines have been omitted where the relationship was of low statistical significance.

Hereafter, all optional and experimental observations are related only to the faecal coliform counts.

a) Raw Water Quality

The severity of the challenge applied to the dual sand filtration system can best be described with reference to raw water quality at the test rig site. Figures 4, 5 and 6 demonstrate the variation in bacteriological quality, turbidity and temperature of the water during the experimental period. The site (Plate 1) is a pond served by run-off from playing fields and agricultural land. The pond receives direct but intermittent faecal pollution from a small population of farm animals and a constant faecal input from a stable colony of ducks and geese which inhabit the pond area.

Figure 7 depicts the precipitation throughout the period of experimentation, and as might be expected, the pattern of variation in turbidity follows this very closely. There is a similar correlation between the fluctuations in bacteriological quality and turbidity.

b) Primary Filtration

The performance of the primary filter is depicted chronologically (Figures 8,9 and 10) with reference to filter run length in days and the head loss accumulation (expressed as increase in vacuum pressure).

Although a decline in performance is noticeable when samples are taken immediately following backwashing of the primary units, both in terms of bacterial and turbidity removal, the general trend of increasing efficiency is marked, both during individual runs and more generally throughout the experimental programme.

1/d-4

backwashing with a pump, followed by alternating application and cessation of a vacuum pressure is sufficient to condition the sub-sand abstraction bed. In this case, where water abstraction is effected by pumping, the cleaning and grading of the sand need not be so efficient since high head losses can be overcome by an efficient pump.

However, the slow sand filter relies on gravity percolation and needs a much higher degree of cleaning if the requisite flow is to be obtained.

A simple but effective <u>in situ</u> washing and grading technique has been developed. Figure 25 shows not only how the silt content may be reduced to a negligible proportion, but also how the grading of the sand in the upper portion of the bed can be improved to such a degree that it falls substantially into the optimal range for slow sand filtration.

Plate 2 shows this process in operation, the principle feature of the cleaning technique being the application of a head of primary treated water for the backwashing process.

ii) <u>Primary Filter Maintenance</u>

The necessity for backwashing of the primary units arose when the overall head loss reached a level where strain was imposed on the abstraction pump - typically at a vacuum pressure between 20 and 25 inches of mercury.

As previously mentioned, this was manifested by a tendancy towards cavitation, or surging in the action of the pump.

By this time (after an average 8 days of filtration) the silt content of the sand bed was quite high, and the deposited clay formed a packed, cemented layer for an area up to 2 metres away from the primary abstraction unit.

Three methods of cleaning have been tried:

1) Backwashing by reversing the direction of the pump, using raw pond water, and 'spading' around the unit for two periods of 10 minutes to loosen and release the penetrated silt (Plate 3).

2) Backwashing from a header tank containing primary filtered water (the available head of water was approximately 4 metres), and 'spading' for two periods of 10 minutes (Plate 4).

3) Skimming : whilst the abstraction pump is switched off the top 2 cms. of silt and sand is carefully removed and discarded away from the unit.

Methods 1 and 2 are most efficiently carried out when there is a reasonable cross-flow of raw water to carry away resuspended silt. Method 3 requires that the overlying water does not exceed 20 cms in depth and that there is some means of replacing or cleaning the silted-up sand (in the first two techniques the washed sand settles in place).

Method 1 has been employed in most cases, and the effectiveness of the technique in reducing the silt content of the abstraction bed is depicted in Table 2.

TABLE 2 Efficiency of pumped backwash technique (MONO GH pump; volume of water consumed : 1M^3 per bed; 20 minutes cleaning per bed), measured in reduction of silt content (%) of primary unit abstraction beds.

	Mean volumetric silt proportion in top 2cms of sand bed (%)			
	5 Minutes Test		24 Hour Test	
	Before backwash	After backwash	Before backwash	After backwash
OM from unit	34.7	3.2	23.2	4.7
1M from unit	38.3	13.4	24.7	8.8

Head loss reduction : from 25" to 2" Hg vacuum pressure.

Samples of sand (skimmed from the bed surface to a depth of 2cms) both before and after the washing process were taken directly above and at a distance of 1m away from each abstraction unit.

Method 2 has been used once only and its effectiveness is described in Table 3. Also see Appendix 2.

I/d-6

TABLE 3 Efficiency of gravity backwash technique (4M head of water; volume of water consumed : 1.5 M^3 per bed; 20 minutes cleaning per bed), measured in reduction of silt content (%) of primary unit abstraction beds.

	Mean volumetric silt proportion in top 2cms of sand bed (%)			
	5 Minute Test		24 Hours Test	
	Before backwash	After backwash	Before backwash	After backwash
OM from unit	46.8	11.3	28.3	6.9
1M from unit	46.0	11.3	26.2	10.4

Head loss reduction: from 27" to 2.2" Hg vacuum pressure

Method 3 (skimming) has been tried on two occasions, and its effectivenes limited by the relative difficulty of skimming underwater. Its application was followed by lower than normal reductions in head loss (Table 4), which led to shorter than normal subsequent filter runs.

TABLE 4 Efficiency of skimming technique (20 minutes skimming per bed to a depth of approximately 2cms) measured in reduction of silt content (%) of primary unit abstraction beds.

Mean volumetric silt proportion in top 2cms of sand bed (%)			
5 Minute Test		60 Minute Test	
Before backwash	After backwash	Before backwash	After backwash
37.9	34.8	22.4	21.7
35.6	26.9	17.0	16.9

Head loss reduction : from 18.5" to 6.0" Hg vacuum pressure.

One further technique to be tried is vigorous raking without backwash. It is likely that a good cross-flow of water will be a pre-requisite for this method in order that the resuspended silt does not settle directly onto the filter beds.

The results of the primary filter cleaning techniques suggest that both pumped and gravity flow backwash were very effective in reducing the silt content of the abstraction beds. There was little difference in efficiency, and the methods were of equal simplicity. Skimming proved somewhat less efficient - probably as a result of the difficulty in seeing which areas had been skimmed and which had not.

iii) Secondary Filter Maintenance

a) Cleaning of the secondary filters became necessary when the flow rate of 3 litres per minute per unit (equivalent to 22.5 cms/h) could no longer be maintained by daily adjustment of the outlet tap. This coincided with a total head loss of approximately 50cms.

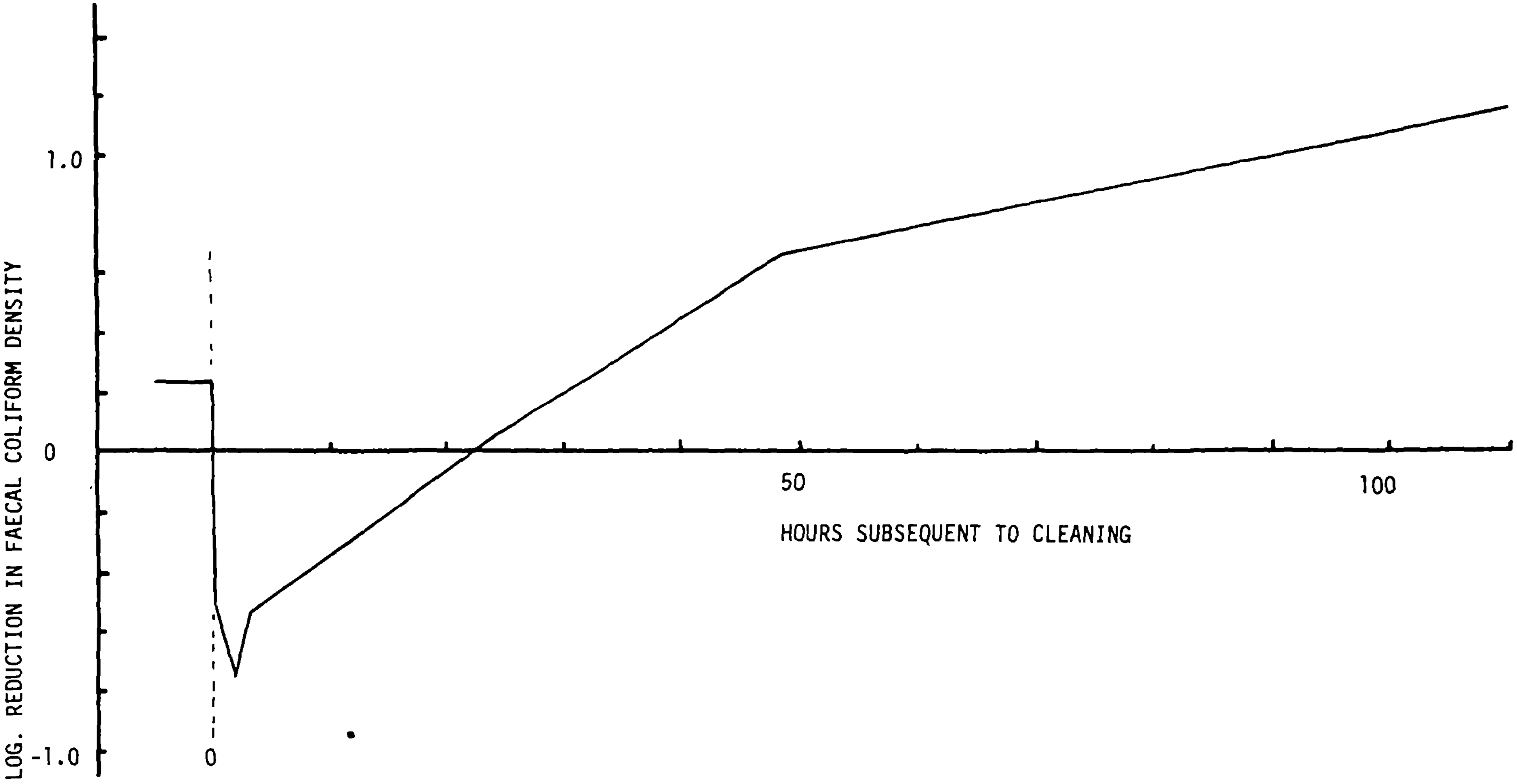
As with the sub-sand abstraction beds, the main purpose of filter cleaning is to remove silt plus the unwanted microbial biomass normally associated with the 'schmutzdecke' of the slow sand filtration process. The average length of secondary filter runs was significantly longer than the primary filter runs, and this is vital if the continuity of the process is to be maintained. Nevertheless, it is desirable to further improve filter run length, and this will largely rest on the selection of appropriate filter fabrics.

b) Filter Fabric Selection and Maintenance

The original intention of the filter fabrics was to retain all of the silt in the SSF supernatent water so that filter cleaning could be limited to fabric removal, washing and replacement, thereby avoiding any disturbance of the sand bed. However, it has been observed that even with multiple layers of appropriate fabric, silt penetration still occurred. The reason for this becomes obvious when the size range of particulate matter is taken into account. The overwhelming majority of suspended silt particles are less than 5µ in diameter. Evidently, no fabric would be capable of 'sieving-out' these particles. However, Table 5 demonstrates that these particles are trapped in the fabric, and furthermore whatever the medium, fabric type or sand, a similar distribution of silt sizes tends to deposit.

I/d-8

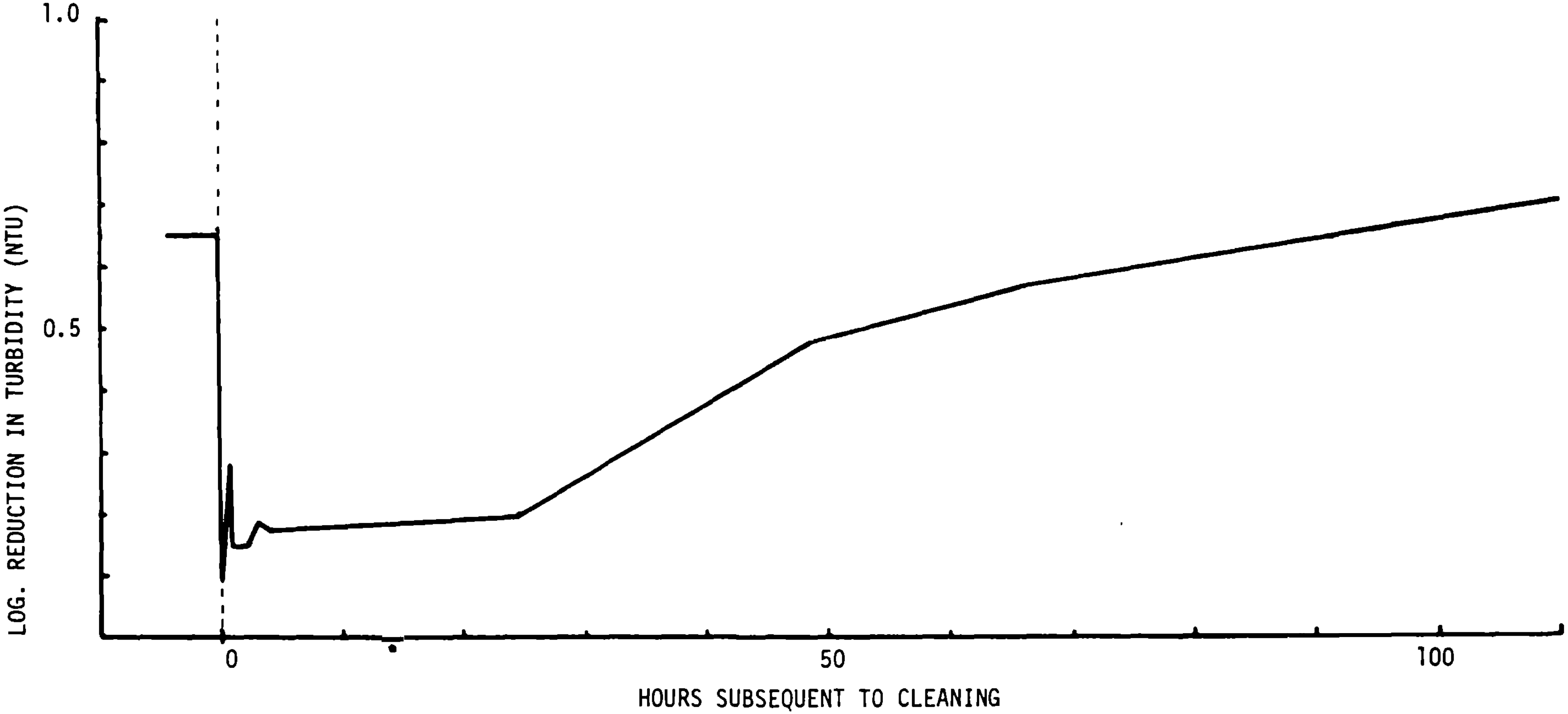
igure 11



Effect of cleaning (pumped backwash) on Primary filtration unit efficiency: Faecal coliform reductions.

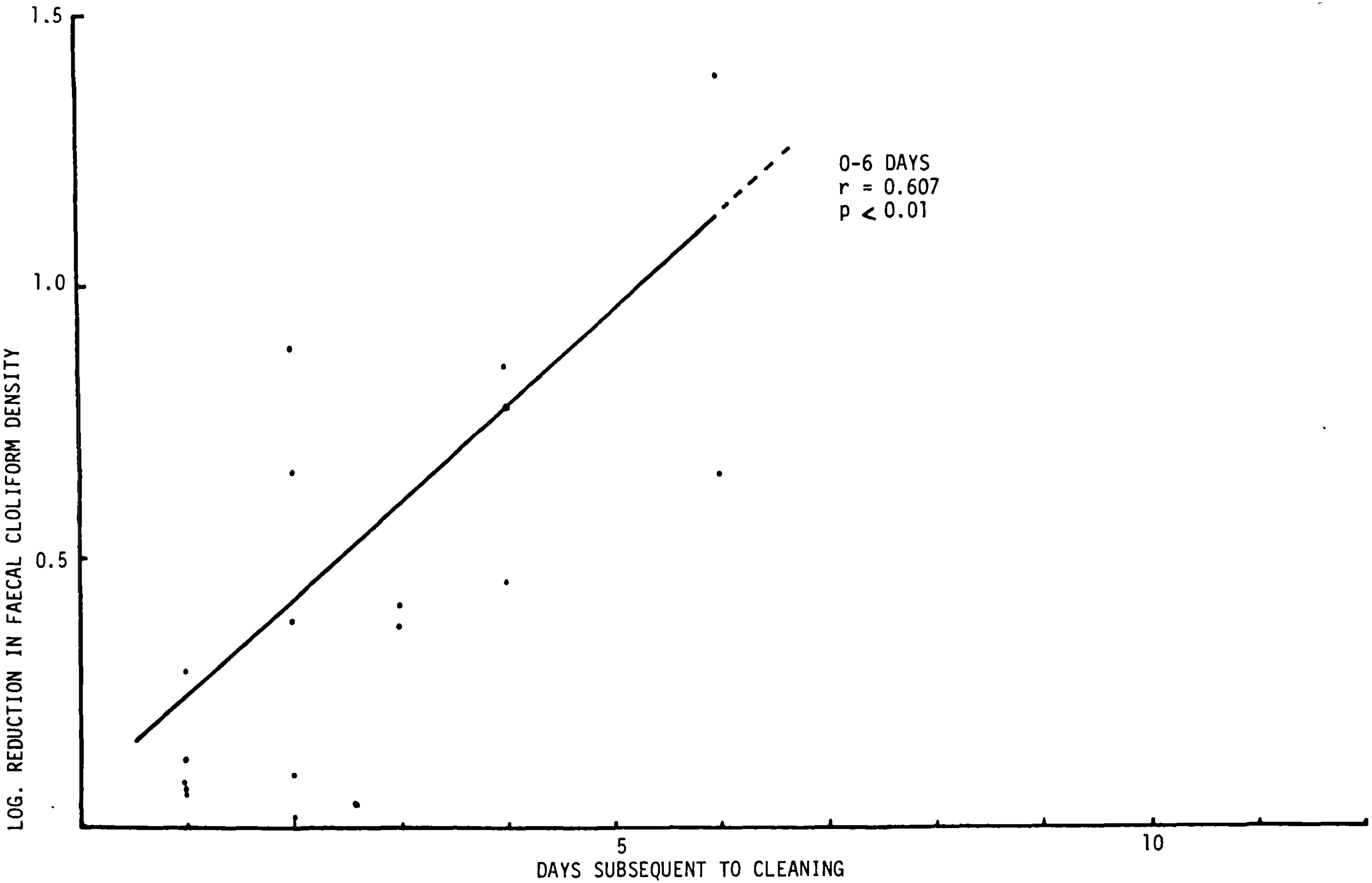
gure 12

4/d-10



Effect of cleaning (pumped backwash) on Primary filtration unit efficiency: Turbidity reduction.

gure 13

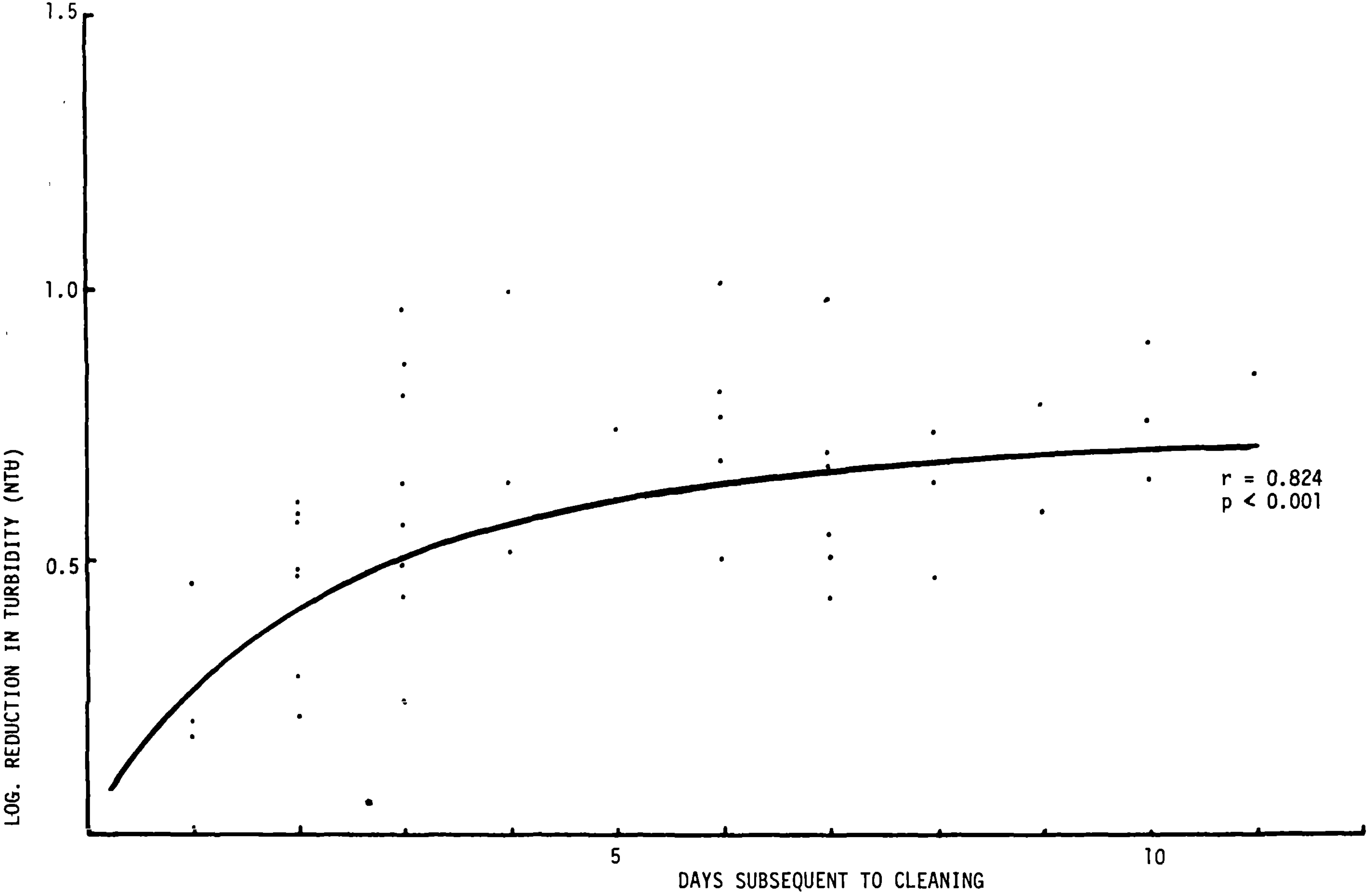


Performance of Primary filtration units: Faecal coliform reductions

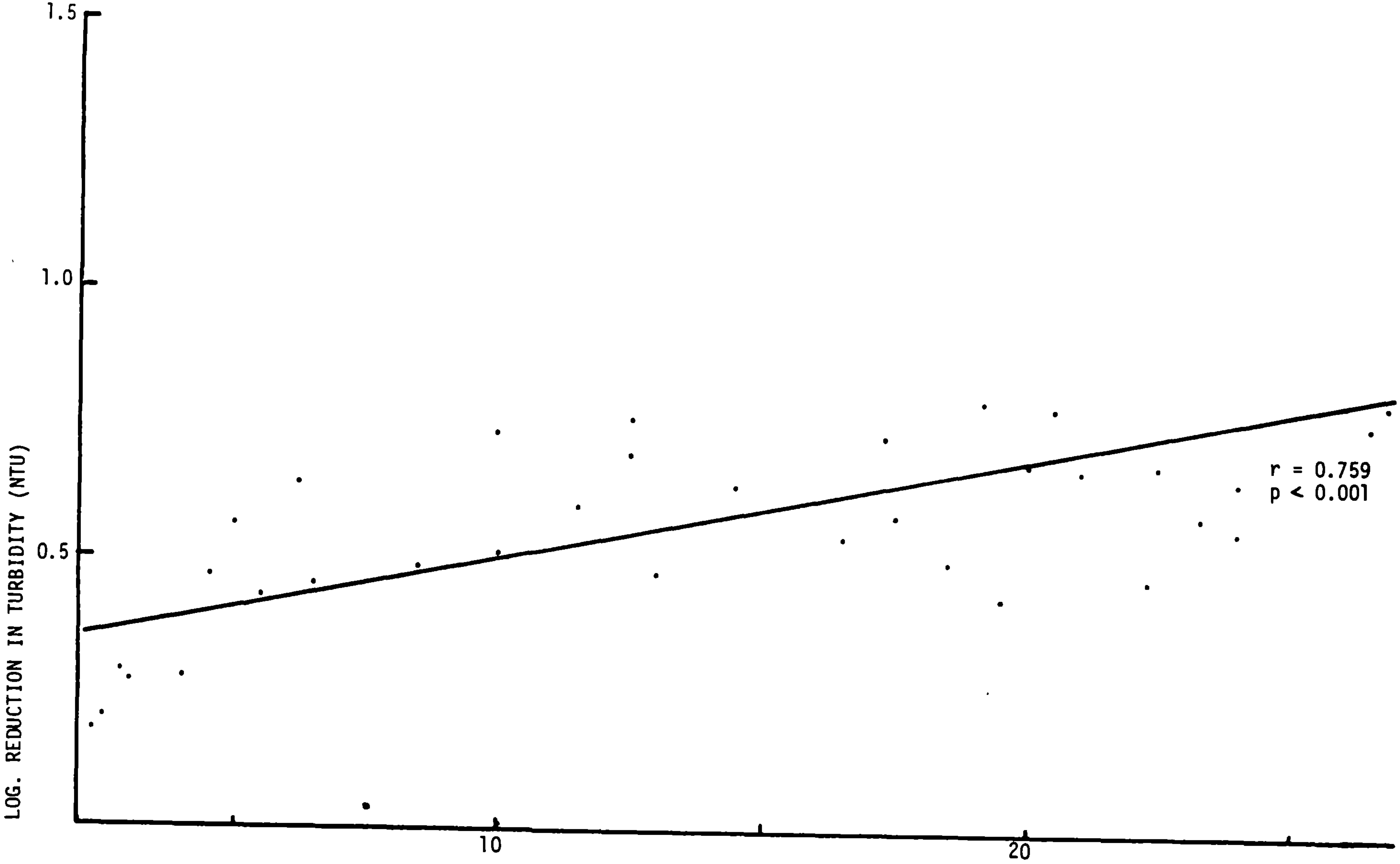
I/d-11

igure 14

I/d-12

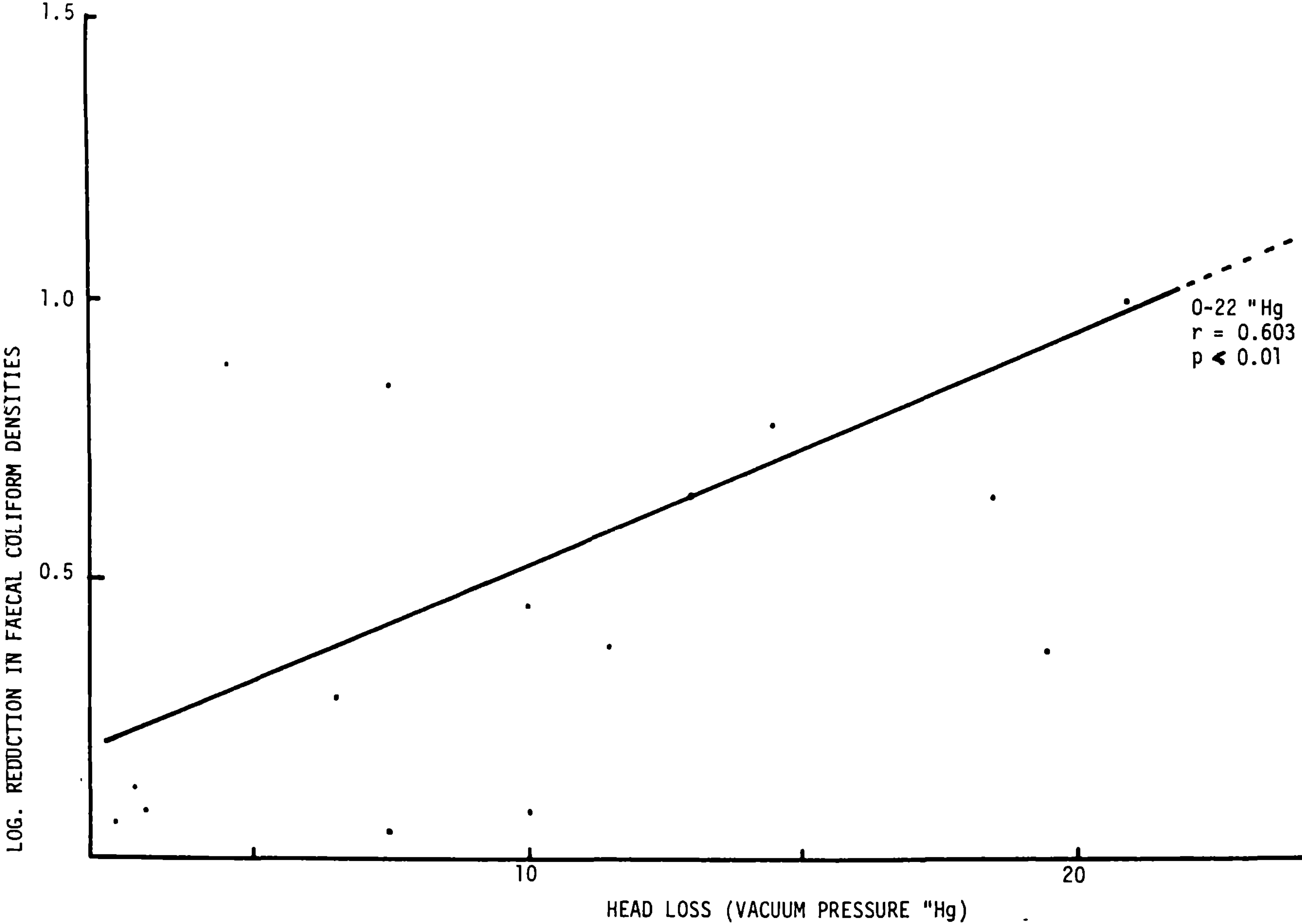


Performance of Primary filtration units: Turbidity reductions.



Performance of Primary filtration units: Turbidity reductions.

igure 16



Performance of Primary filtration units: Faecal coliform reductions

Appendix 2

Draft schedules for maintenance of primary sub-sand abstraction units.

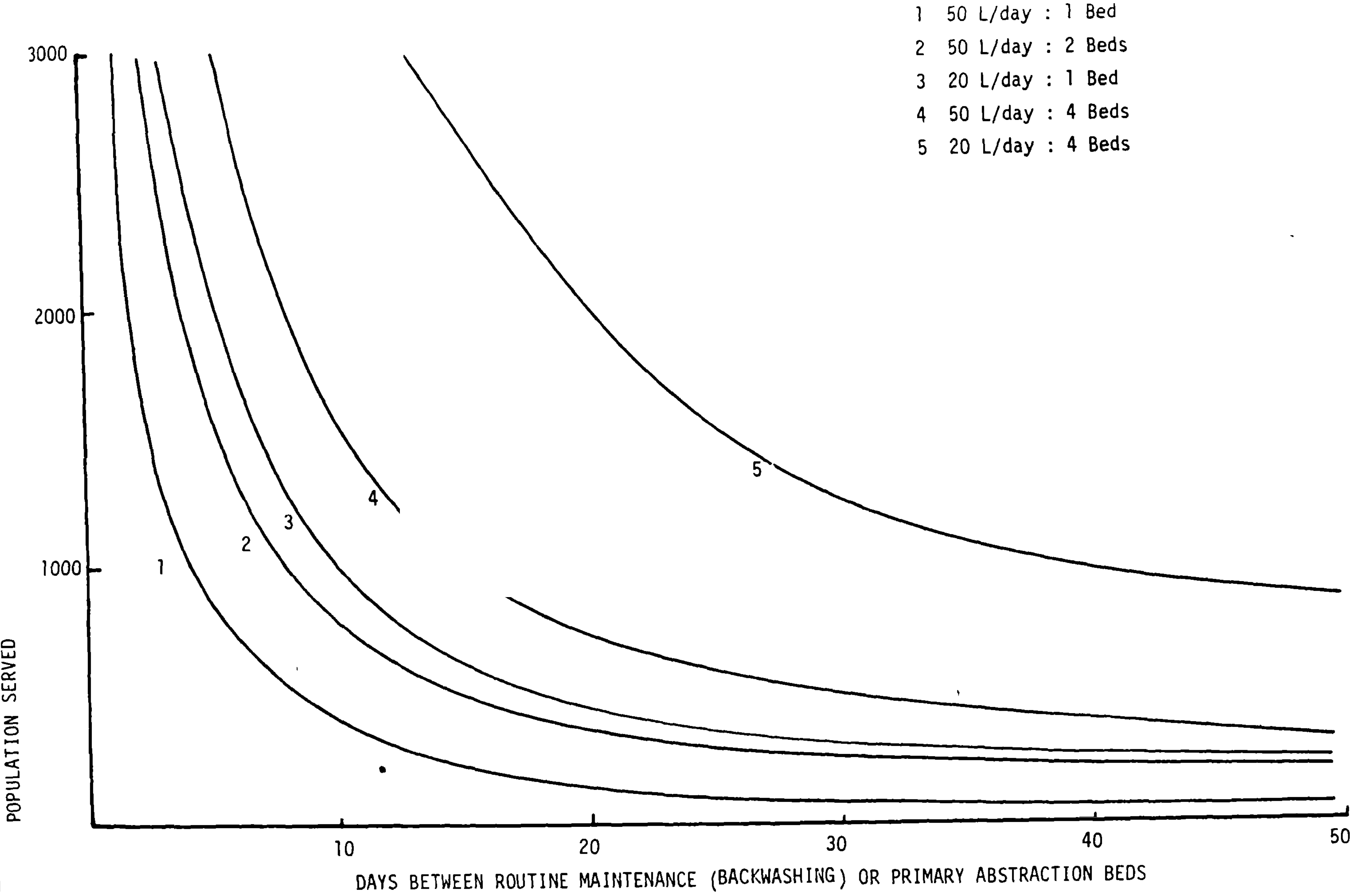
On empirical evidence, the expected filter run length for primary units operated continuously at $1M^3/h$, mean raw water turbidity 20-30 NTU, is 8 days. This assumes provision of a pump which can overcome a head loss on the suction side of up to 25" Hg. Under these circumstances, the effective capacity of one abstraction bed is approximately $200M^3$ before packing or clogging renders the bed blocked.

Figure A1 illustrates examples of maintenance schedules for populations of up to 3000 based on a per capita provision of 20 litres and 50 litres per day, for 1, 2 or 4 abstraction beds.

Higher influent turbidities would shift the curves to the left, lower turbidities to the right. New techniques for mitigating the effect of high influent turbidities are under evaluation.

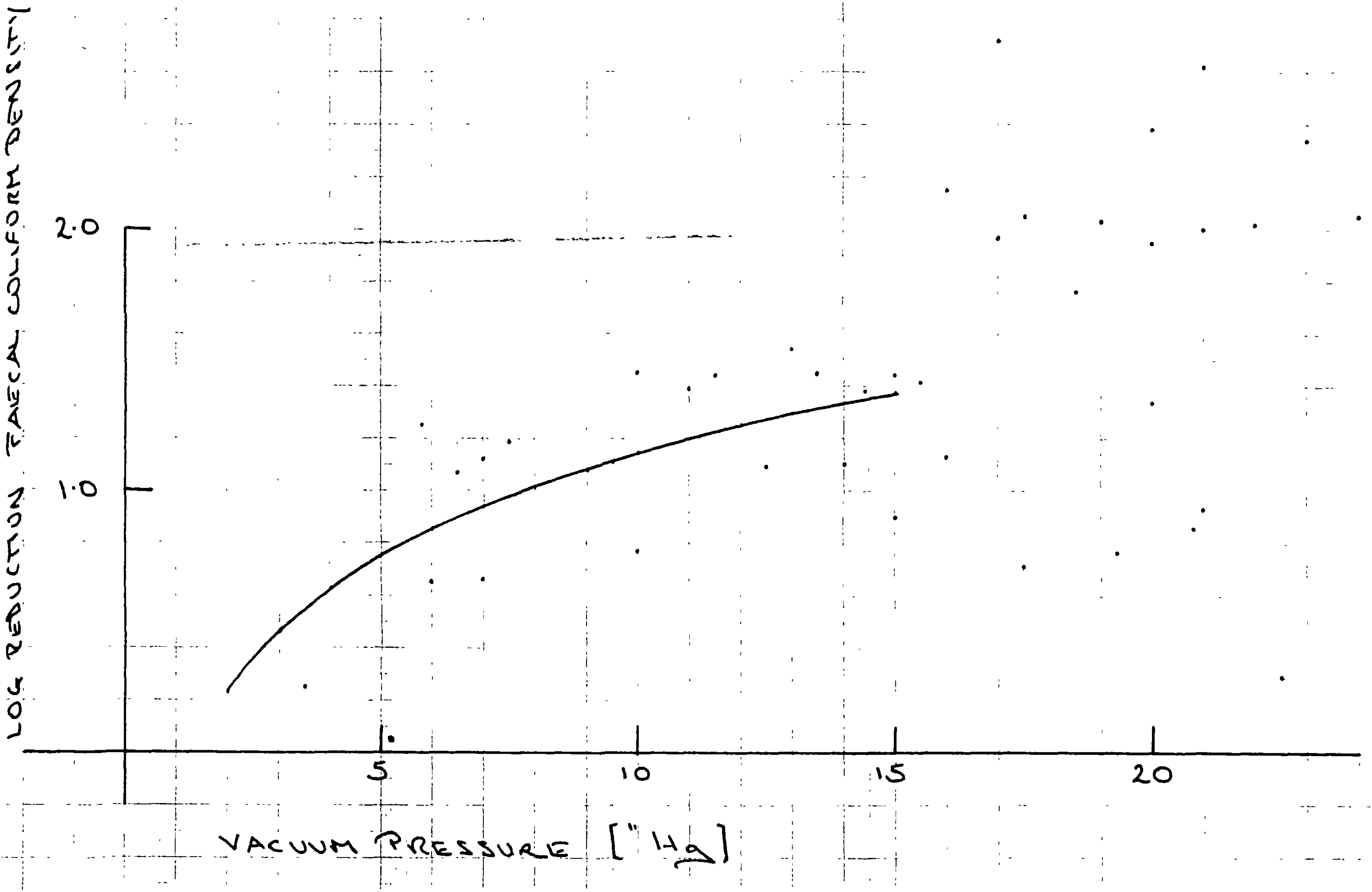
Evidently, under most circumstances a weekly or biweekly cleaning schedule can be arranged. The most efficient methods of backwashing employ either a pump, or sufficient head of stored water to deliver $3\text{-}5M^3$ water per hour back through the bed. The key to the process is the velocity of upward flow and although this cannot be accurately calculated, empirical evidence suggests that a velocity of approximately 0.25 M/h is insufficient but that approximately 0.75 M/h is (these figures are based on an estimated effective bed area of $4M^2$).

The use of stored water is particularly attractive since this overcomes the need for the facility to reverse the direction of the abstraction pump and can be accomplished with a simple bypass to the abstraction units. It has been demonstrated that a head of less than 4M, even with a 25M, 1.5" ID delivery hose, achieved efficient cleaning.



Maintenance schedule for sub-sand abstraction units: 200m^3 per filter run per bed; 8 days per filter run: flow rate 1m^3/h; mean influence turbidity 20-30 NTU

PRIMARY FILTRATION EFFICIENCY



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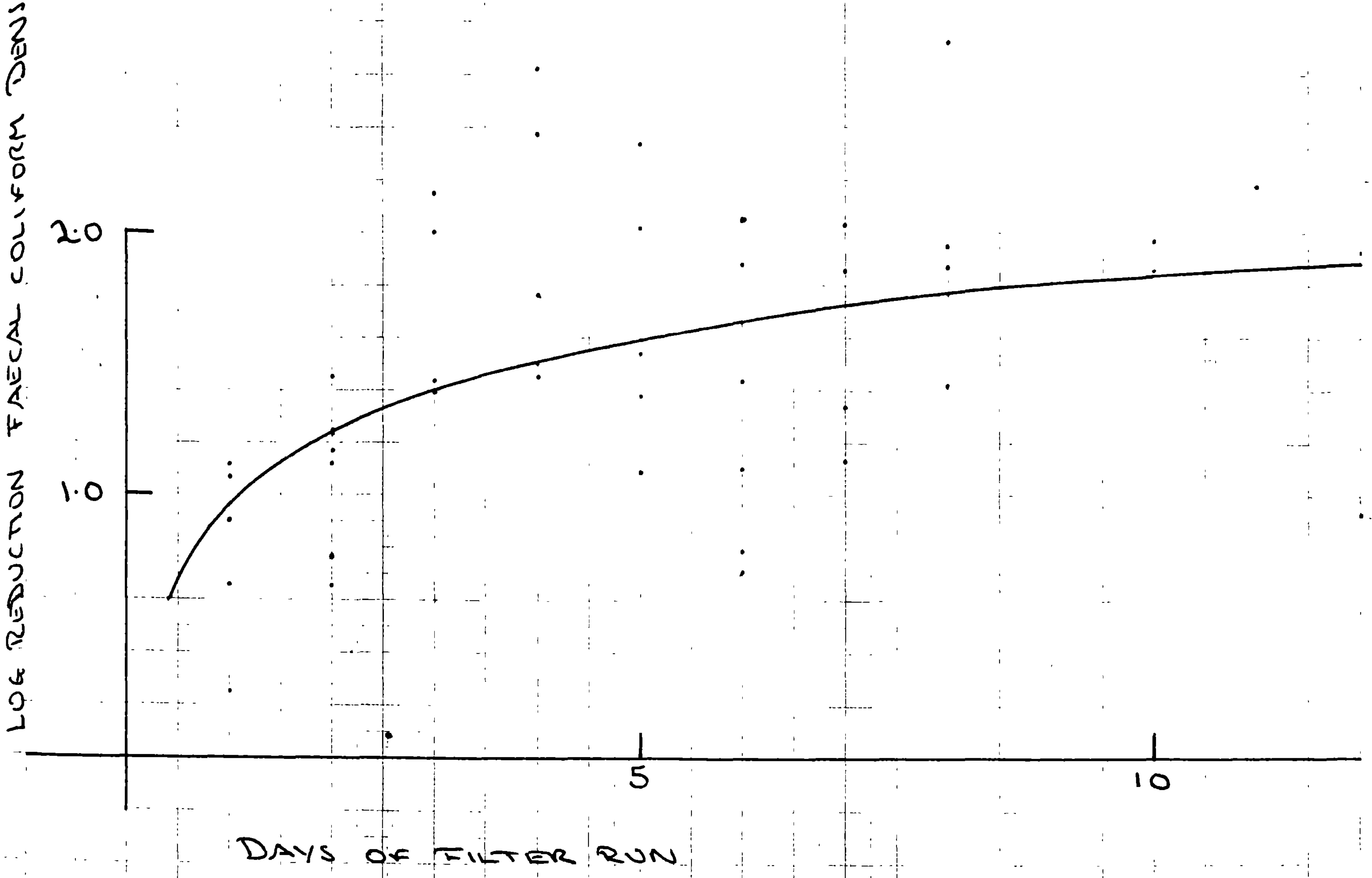

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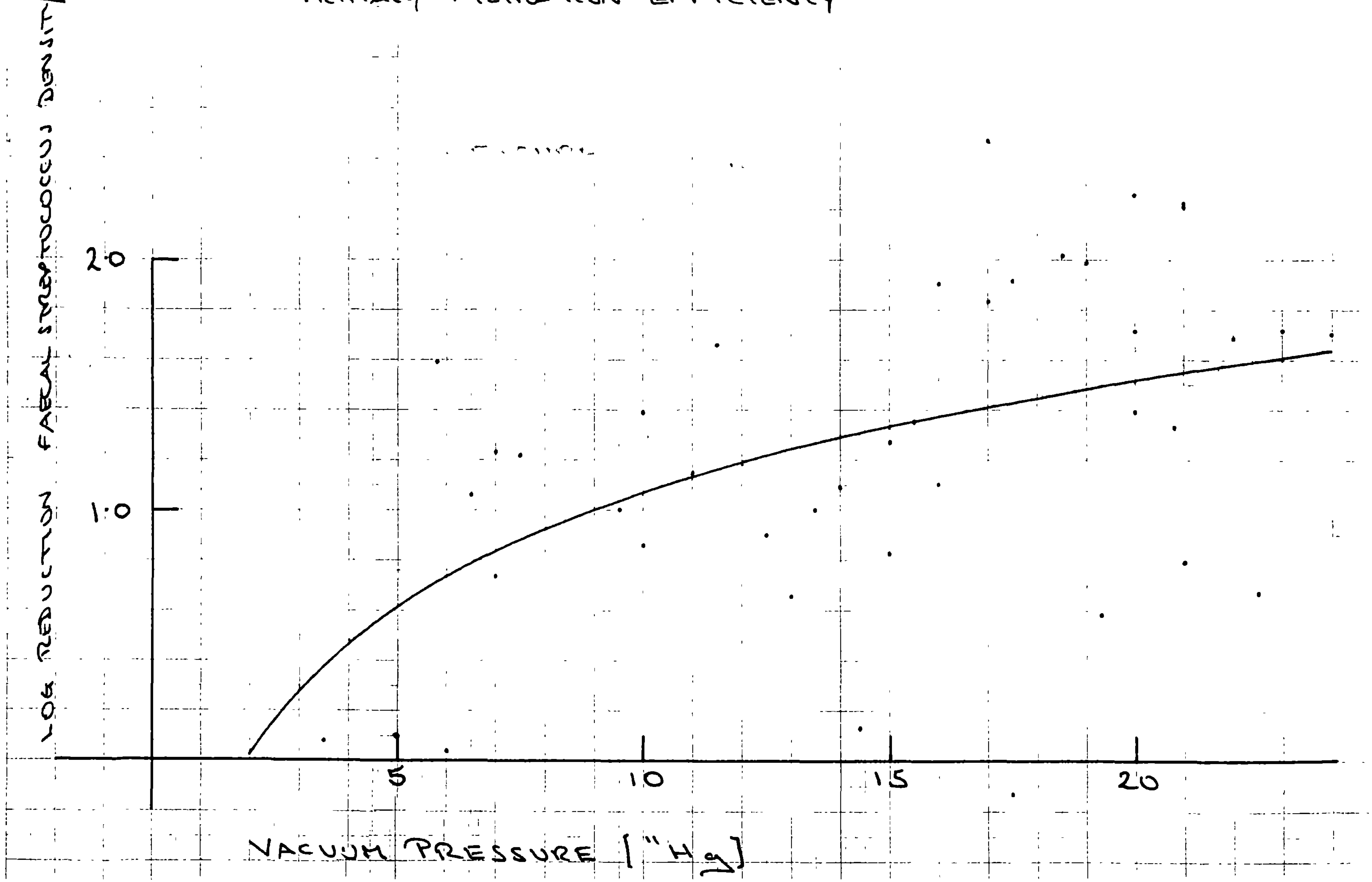

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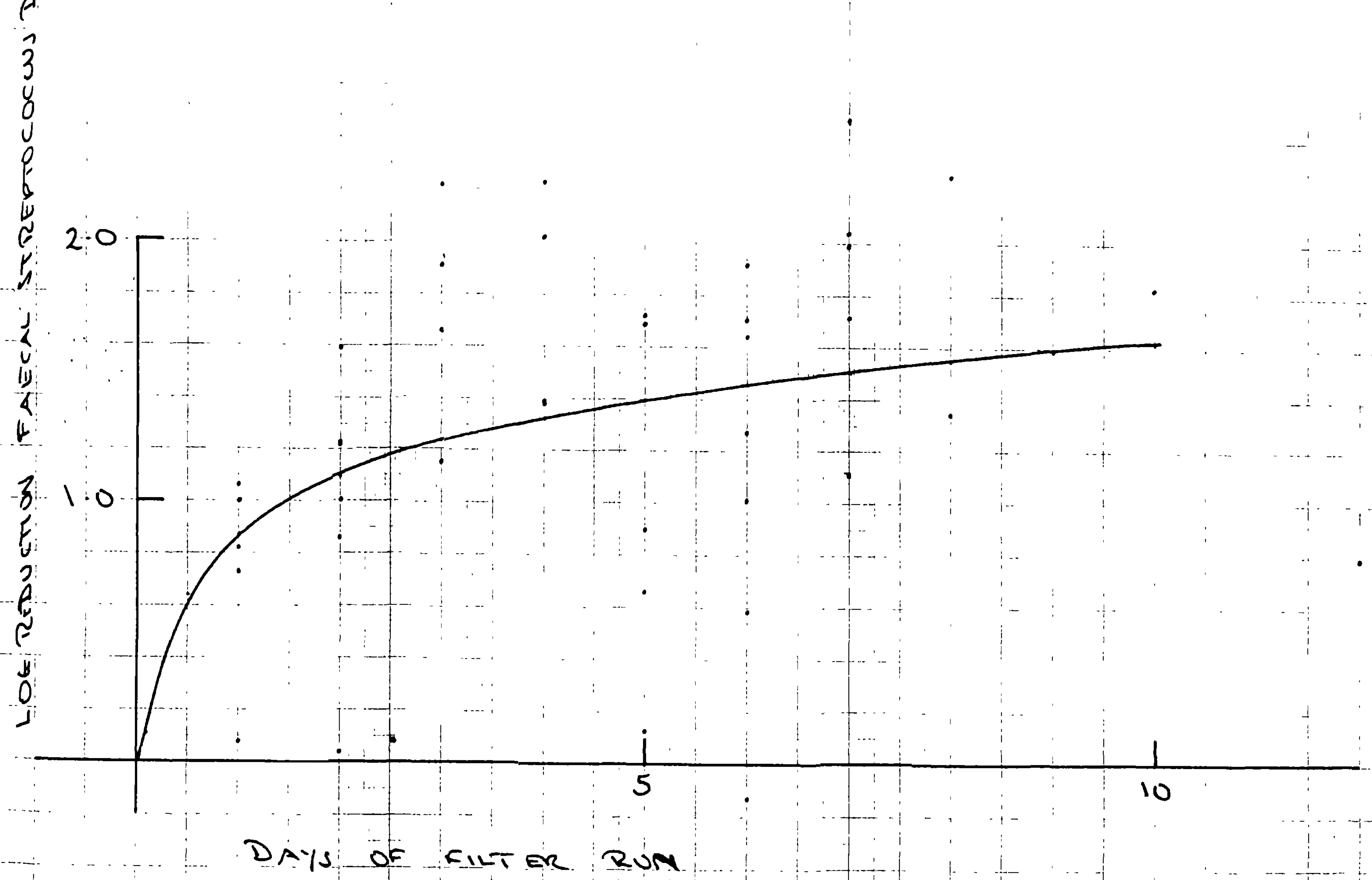

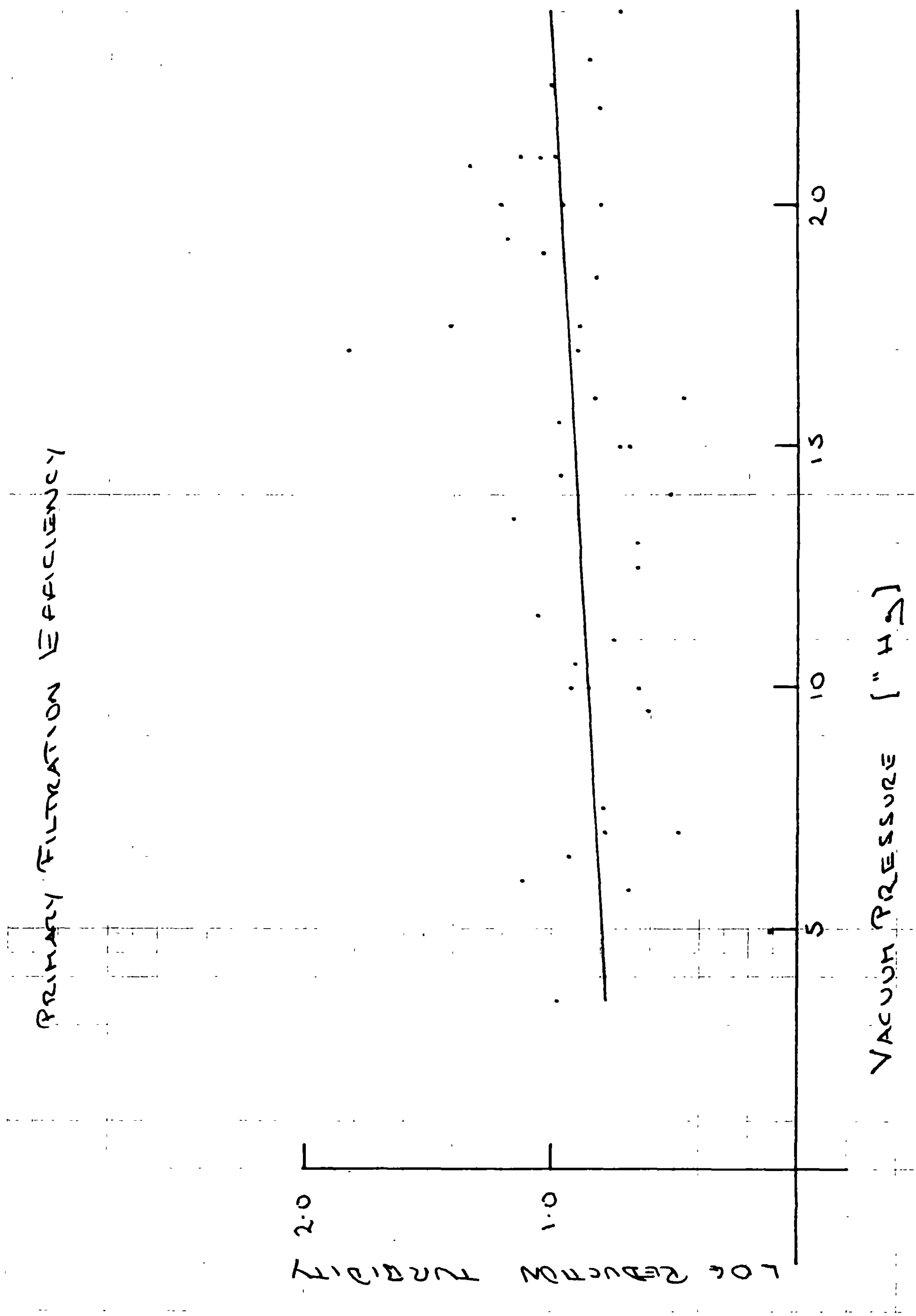

PRIMARY FILTRATION EFFICIENCY

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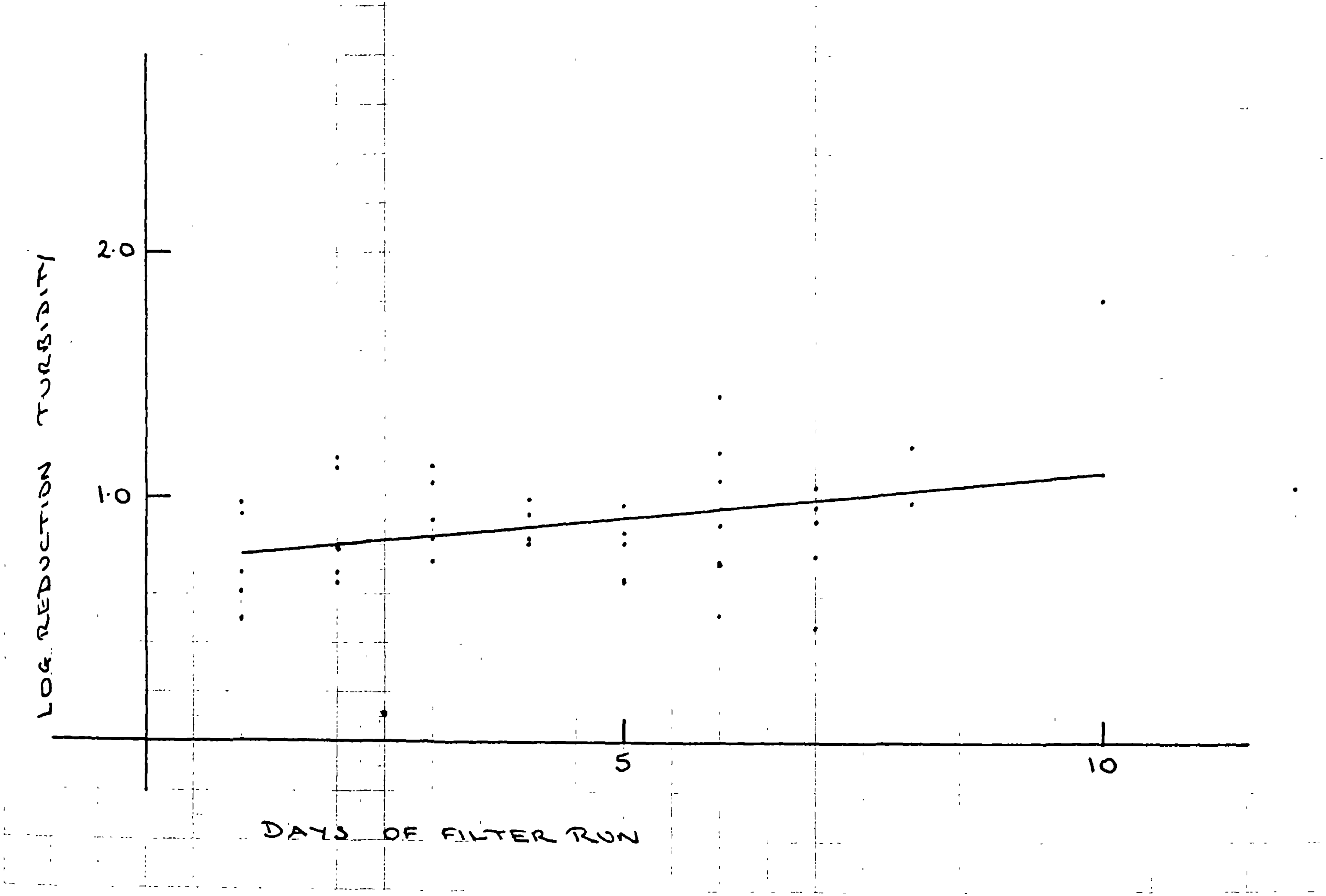
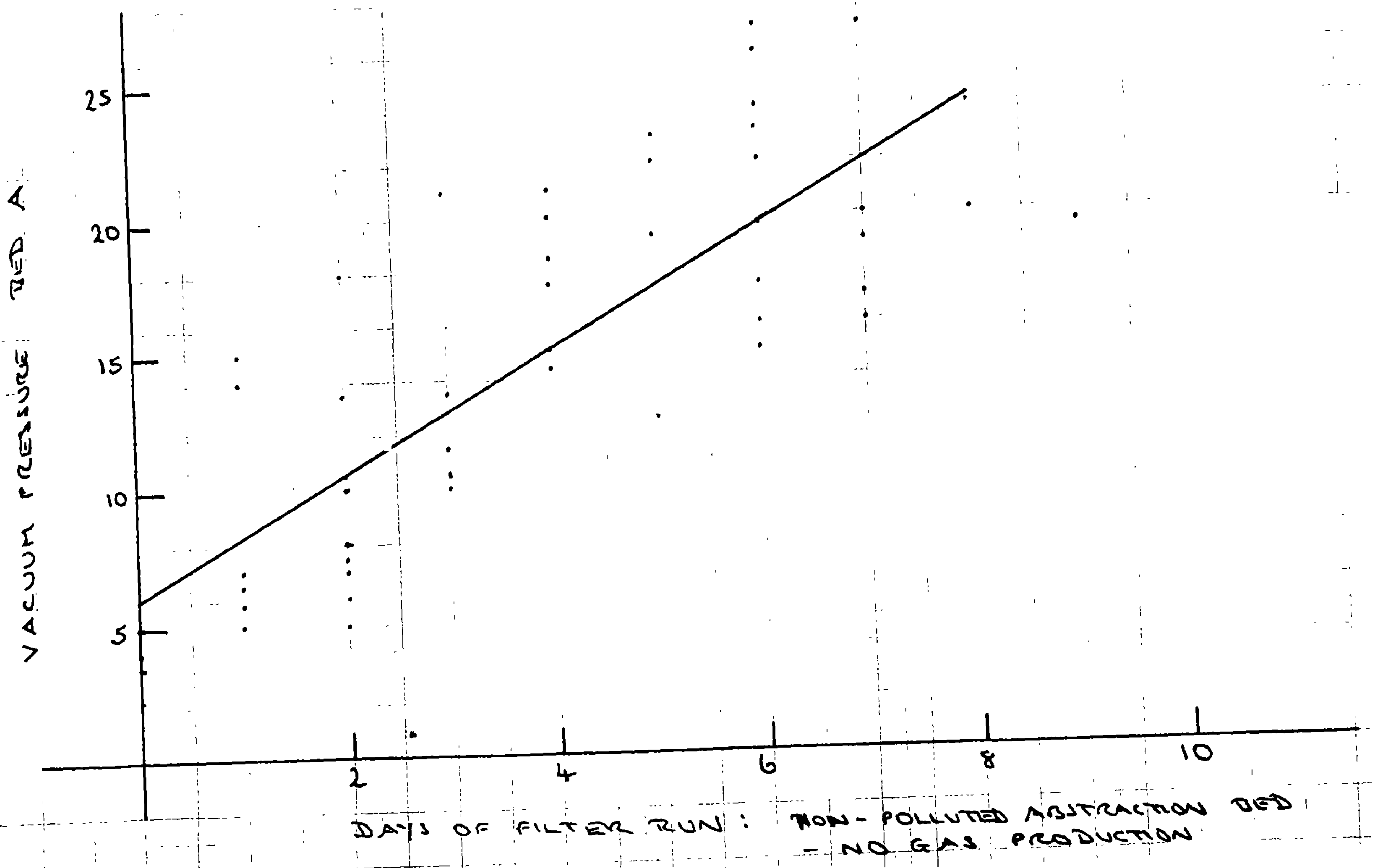
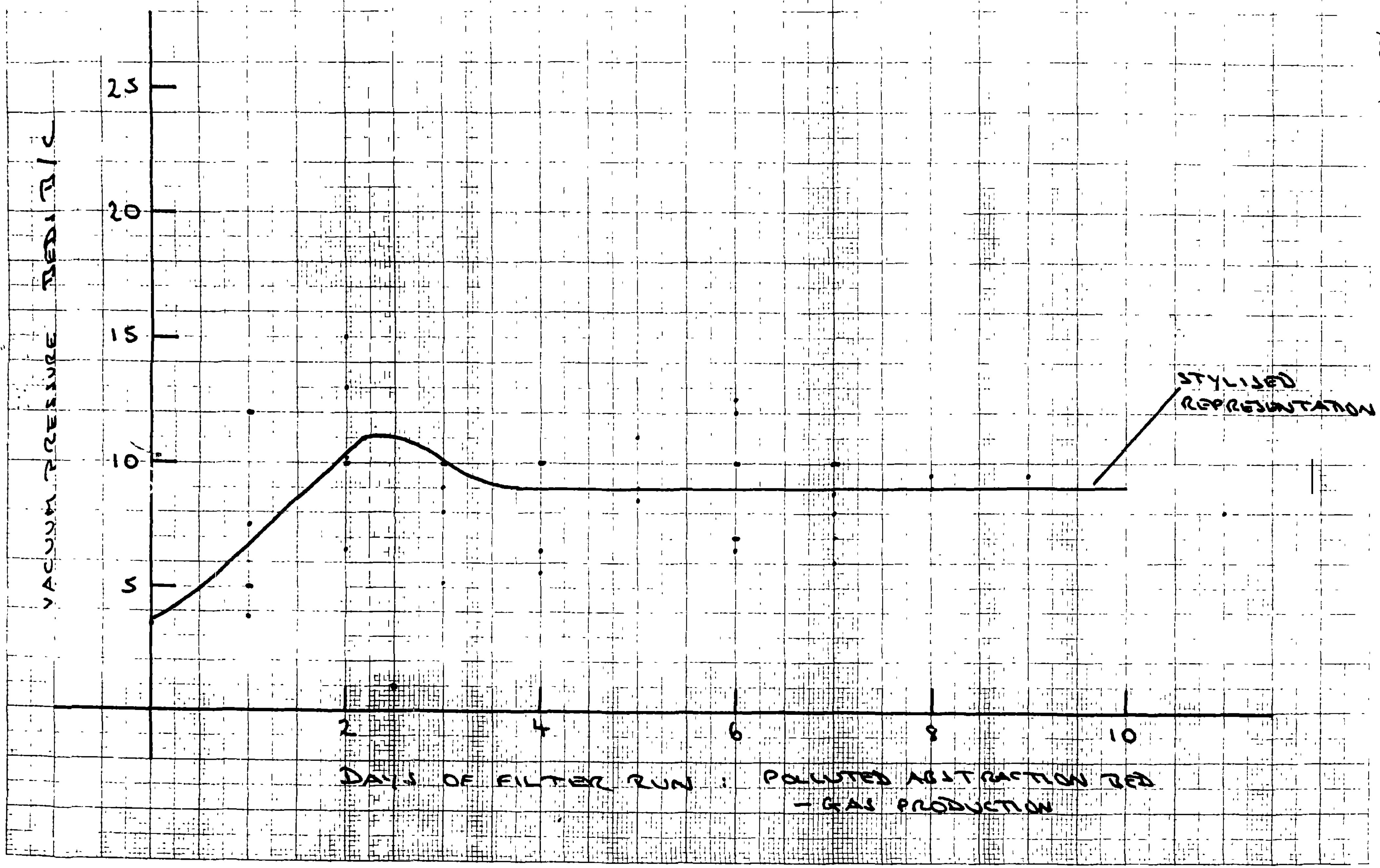


PRIMARY FILTRATION




VACUUM PRESSURE BED II/C
25
20
15
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8
10
DAYS OF FILTER RUN : POLLUTED ABSTRACTION BED - GAS PRODUCTION
STYLISED REPRESENTATION