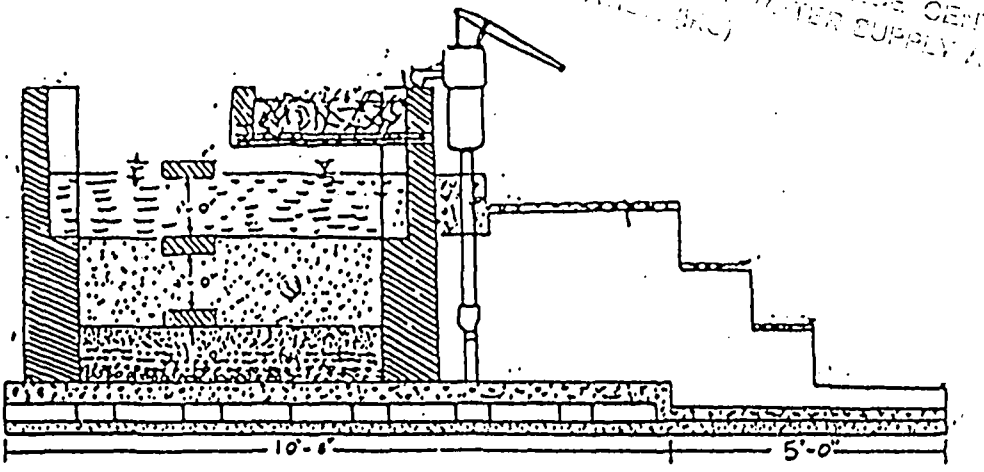
A REPORT ON THE POND SAND FILTER RESEARCH AND DEVELOPMENT PROGRAMME AT DACOPE



DPHE/UNICEF

KHULNA

July 1987

1. INTRODUCTION

There are certain areas in Bangladesh, particularly in the coastal belt, where neither Shallow, Very Shallow nor Deep Tubewells can be sunk with any hope of success. The reason is either that there are no aquifers available or that aquifers that are available yield water containing very high concentration of Chloride (i.e. Cl>1500 mg/l). The areas are located in the southern fringes of Khulna, Barisal and Patuakhali districts. For example Dacope Upazila under Khulna Sadar Sub-Division is an unsuccessful area.

The people of these areas mainly depend on water from artificially dug ponds, so called "sweet water ponds", which are replenished by rain water in the monsoon; but their number is not adequate and during the dry season the number of users will increase between 100 - 300%. The people generally use pond water for drinking and cooking purposes, but the water from these ponds is not safe for human consumption.

2. THE RESEARCH AND DEVELOPMENT PROGRAMME

2.1 Previous Work

In order to develop a system of purifying the pond water, a programme was taken up in 1984 under the supervision of DPHE-UNICEF-DANIDA R&D Project. The main objectives were:

a) To develop an effective means of obtaining safe water at an acceptable level of salinity.

b) To motivate the people to use filter water rather than using the pond directly.

A device known as the pond sand filter (PSF) was designed to purify the pond water.

In Dacope Upazila 12 experimental PSFs were constructed, being completed in October 1984.

This phase of the project had some success in achieving the first objective, but the second objective was not achieved, mainly due to the following reasons:

a) Low discharge, resulting in the users having to spend a long time collecting water, especially in the dry season when the number of users goes up. Inadequate discharge was due to:

- Filter size was too small.
- The sand used as filter media was too fine.
- High turbidity of pond water.

b) No beneficiary participation, resulting in lack of interest and the idea that DPHE, who built the filter, will also repair and maintain it.

c) Lack of motivation and awareness of beneficiaries.

d) Construction problems, like leakage of tank.

e) Short filter run, i.e. the period between two cleaning operations was too short.

2.2 Objectives of Final Phase of R&D Work on PSF

In June 1986, R&D work started again with specific objectives to:

a) increase the discharge

b) increase the filter run

c) involve the beneficiaries in the project as much as possible and motivate and educate them in the same time.

d) give continual support and advice for operation and maintenance.

e) monitor plant performance regularly.

f) achieve a final standard design by July 1987.

2.3 The Progress of R&D Work June 1986 - June 1987

First, the existing PSFs were studied and their performance monitored. By September 1986 the following recommendations were made:

a) To include a storage chamber for treated water to increase discharge.

b) To include a pre-filter chamber to reduce the turbidity of raw water.

c) To increase the size of the PSF. (If possible, related to the number of users).

d) To use a little coarser sand.

e) To stop disturbance of sand bed during hand pumping.

f) To use a bigger tap size.

g) To improve the floating system at the intake point.

h) To improve the drainage system around the PSF unit.

i) To increase platform size.

A new design was prepared, based on the above recommendations. In October 1986 preparations started for constructing new sand filters. It was decided to concentrate work in 2 out of the 8 unions of Dacope Upazila (i.e. Kamerkhola and Sutorkhali unions). This was to facilitate the work and because there were many requests for sand filters from these two unions, where tubewells were totally unsuccessful.

The preparation work was as follows:

a) Selecting new sites

b) Purchasing the necessary materials

c) Taking necessary steps to make sure that the materials were carried to the new site.

d) (The most important one) involving the beneficiaries from the very beginning.

In January, 1987 the construction work started and since that time 7 PSFs have been constructed, 6 in Khamerkhola and Sutorkhali and the seventh in Chalna Union close to the PHE Building, enabling us to monitor its performance on a regular basis.

The total number of users of these filters during the dry season is around 7,000, but during the rainy season the figure will drop.

After completing each filter, the problems experienced in construction, transport of materials, transport of staff, beneficiary participation, training of mason, etc. were studied and, after finding the right and acceptable solution, work was started on the next filter. By following this policy new features were added to the design or bad features eliminated from it. This helped to improve the performance of the filters at each stage, and also reduce the total cost.

As a result, by the end of May 1987, a final design was reached which is now ready for adoption as the standard design.

2.3 Further R&D Work

Although the design has been finalized, more experimental work could be done to improve filter performance further and, if possible, to bring the cost down. It is also necessary to obtain more data and information about the users and the performance of the filter. These experimental works are listed below:

a) To find out the number of users during the dry season and the monsoon.

b) To experiment with different types of materials in the pre-filter chamber to achieve the most effective reduction in the turbidity of the raw water before it enters into the sand filter.

c) To experiment with different thicknesses of sand layers for the main media, to find out the minimum required thickness for effective removal of bacteria.

3. DEVELOPMENT OF EARLIER DESIGNS

The research has involved three different types of filter:

a) Original design
b) Modified design
c) New design

3.1 Original Design

The filter is designed on the principle of gravity, slow sand filtration. The structure of the PSF is of brick masonry and its dimensions 4'x 4'x 6'.

Inside the filter there is a 3 feet layer of sand as the filter medium. Underneath there is a 1 foot layer of graded khoa (brick chips).

A handpump draws water from the pond through a pipe into the filter. The water trickles through the media bed and then rises from the bottom of the filter by hydrostatic pressure head up through a pipe to an outlet tap for public use.

Disadvantages

a) Discharge from the PSF was about 1/4 gallon/minute, totally inadequate to meet the demand of the local people; even after changing the filter media the discharge only increased to 1 gallon/minute.

b) Most ponds have high turbidity and after about one week a thick layer of clay forms on the surface of the sand, reducing the filtration rate and lowering the discharge rate. With this design, filtration only takes place while water is being drawn from the outlet. This means that while the PSF is not being used, the filter acts as a sedimentation tank and the suspended matter settles on the top of the top of the filter media, which becomes blocked even though no filtration is taking place.

c) Because of the low discharge, the people have no alternative but to use the pond water directly, defeating the whole purpose of the PSF.

Because of these disadvantages the majority of the original design PSFs are not operating and, of those operating, only a small minority of people are using them.

Advantages

a) The chloride and iron concentration of the filtered water is acceptable.

b) The physical appearance and turbidity of the filtered water is acceptable

c) The bacteriological quality of the filtered water is acceptable.

3.2 Modified Design

The only features added to the original design were a small outlet water chamber for the treated water and a perforated slab at the bottom of the filter bed to make the water flow more easily. The platform was also made slightly larger.

The mechanism is the same as for the original design, except that the water rises from the bottom of the filter by hydrostatic pressure through the outlet water chamber, which has an outlet tap for public use.

Disadvantages

a) The outlet water chamber reduced the filtration area.

b) The useful capacity of the water chamber is only 90 litres, and when this had been used, the PSF operated as the original design.

c) When the filter is not being used the water levels in the filter and the water chamber become the same. When filtration ceases, the PSF again acts as a sedimentation tank, causing premature blocking of the filter media.

d) When the filter has a low filtration rate, the water rises in the filter and, as the height of the outlet water chamber is lower than the filter, unfiltered water enters the outlet water chamber.

e) The outlet water chamber is so small that it is difficult to carry out cleaning and maintenance.

f) As the outer water chamber is not sealed at the top, there is a possibility that the filtered water becomes polluted again.

Advantages

a) The same as the advantages of the original design.

b) More people can use it because there is more storage.

c) Its platform is larger than the original design.

4. THE NEW DESIGN

4.1 Desired Improvements

During the initial surveys of existing sand filters, information was sought from the users on the type of improvements they would like to see. The main response was for a higher discharge rate and less waiting time. Therefore it was felt that a bigger size of filter was needed to increase the filtration rate and a bigger storage tank was needed to cater for peak demand periods. The capacity of the filter should also cater for increasing demand.

4.2 The Main Features

With this design the internal dimensions were increased to 5'x5' (formerly 4'x4') for the filter bed and 5'-10" x 5'-10" above the filter bed; the wall height is 5' (formerly 6'-3"). It has a small pre-filter chamber (1'-6" x 2'-6" x 9") beneath the outlet of the handpump.

It has a storage tank (3' x 4' x 5') for treated water, with an effective capacity of 1000 litres. The storage tank has a fixed cover with a manhole for access. Two 1/2" outlet taps are provided for the users.

The filter chamber has a lid consisting of wooden frame with corrugated iron sheet, hinged to a wall plate on one side and provided with a supporting prop. Both the filter chamber and storage tank have a wash out pipe (1-1/2" GI pipe with an end cap) which discharge onto the platform.

The area of the platform is about 28 sq. ft, which is three times larger than the original platforms.

The depth of the main filter bed varies between 1'-6" to 2'-6"; under the filter bed there is a 1' layer of graded khoa (brick chips).

4.3 Operating Mechanism of New Design

The water is drawn by a handpump through a pipe from the pond into the pre-filter chamber, which is packed with coconut fibre. Here the turbidity of the raw water is reduced as it flows across the chamber. The water flows out of the chamber through two holes (1-1/2" dia) on one side and falls into the main filter chamber; as it falls, the water is aerated, causing some iron to precipitate out of solution.

The water then trickles down through the filter bed, and bacteria are removed in a manner similar to a slow sand filter. The percentage of removal depends on how "mature" the filter is. After each cleaning, it usually takes several days before the full removal rate is reached, and the longer the filter run lasts the better the bacteria removal rate. This is why a pre-filter chamber is necessary to prevent premature clogging of the filter and to allow the PSF to achieve full performance.

As the water passes through the filter bed, organic matter is removed and turbidity reduced. The water passes down through the graded khoa (brick chips) and then rises by hydrostatic pressure from the bottom of filter through a 1-1/2" dia pipe into the storage tank. From that tank the treated water is delivered through two 1/2" CI taps for public use.

Advantages

a) It has a larger filter bed area increasing the rate of filtration.

b) It has been possible to reduce the height of the plant from 6 to 5 feet because it is no longer necessary to provide high freeboard above the filter bed to increase the discharge rate. With the storage tank, discharge is independent of filtration rate and the flow is continuous.

of pre-treatment

c) Longer filter runs can be achieved, because the storage tank enables the plant to provide a reasonable discharge, even at very low filtration rates.

d) It has a higher discharge rate.

e) It has a larger platform area.

f) The filter runs can be achieved because the pre-filter chamber reduces the turbidity of the raw water.

g). About 500 people can use the filter, compared to about 200.

Disadvantages

a) The cost is approximately double, although per capita cost is still only Tk. 30 (US$ 1).

b) It takes a longer time to fill the plant with water after each cleaning.

5. SITE SELECTION CRITERIA FOR POND SAND FILTERS

We have to look at two sets of criteria for selection purposes:

a) The community
b) The pond

5.1 Selection of Community

So far in this project the criteria for selection of community has been based on :

a) How much interest is shown by the community

b) The community's willingness and ability to fulfil the terms of the agreement (see Annex 3.)

It is worth mentioning that, since the economical capacity of each community differs, a flexible attitude was adopted towards each community as regards their financial input (see Annex 4).

5.2 Selection of Pond

In tubewell unsuccessful areas there are usually specific ponds where people collect their water, and these are not difficult to identify. However, the following criteria must be taken into consideration :

a) The salinity of the pond throughout the year must not exceeded 600 mg/l chloride.

b) The pond must be large enough to ensure that it will not dry out in the dry season, at the time of maximum use.

6. OPERATION AND MAINTENANCE OF POND SAND FILTER

6.1 Responsibility for Operation and Maintenance

Opertion and maintenance of the pond sand filter is done by the users themselves. Therefore, during the construction work, discussions should be held with the users as to how the plant operates and what is the benefit. It is important that users understand that they must pump whenever they draw water from the plant. When construction is complete a group meeting of all users should be held at the site to give instructions and demonstrations how to operate and maintain the plant. The users should select one Caretaker Family, usually living near the plant, who should receive special instructions in how to maintain and clean the plant. Each Caretaker Family is provided with wrenches to enable them to do minor repairs. If there is any major fault beyond the capacity of the Caretaker to solve, the DPHE tubewell mechanic should be informed.

6.2 Cleaning Procedure

a) Open the washout pipe and let the water level drop below sand level.

b) Scrape 3" of sand off the top of the filter bed.

c) Wash this sand on the platform.

d) Replace the sand back into the filter

e) Pump water into the filter

7. WATER QUALITY

It may be seen from Table 1 below that the chloride and iron concentrations in all sand filters tested are acceptable according to WHO International Standards (Cl max 600 mg/l, Fe max 1.0 mg/l); physical appearance, i.e. colour and turbidity of treated water, is also acceptable. Bacteriological quality of treated water is acceptable in all cases except at one site (Khalinagar) where the storage tank did not have a fixed cover and, furthermore, the plant had been cleaned only a few days before the sample was collected.

TABLE 1 : WATER QUALITY TEST RESULTS

Sl. No.	Location	Fe mg/l	Cl mg/l	Turbidity NTU	pH	Coliforms per 100 ml
Date of sample, 22 February 1987						
01	DPHE Pond	2.88	234	35.0	7.6	39
02	DPHE PSF	0.09	234	3.0	7.7	0
03	TTDC Pond	0.40	152	5.2	7.6	42
04	TTDC PSF	0.04	152	1.0	7.4	02
Date of sample, 8 April 1987						
05	Majhee Bari Pond	0.56	402	8.2	7.4	22
06	Majhee Bari PSF	0.46	402	3.9	7.6	01
07	Khalinagor Pond	0.61	127	11.5	8.2	30
08	Khalinagor PSF	0.08	122	2.4	8.0	05
09	Meghana Pond	3.06	483	43.0	7.6	40
10	Meghana PSF	0.33	483	4.4	7.8	02
11	DPHE Pond	1.54	274	17.0	7.9	26
12	DPHE PSF	0.08	274	2.1	7.7	03

low bacterial counts for surface water!

8. USER SURVEY OF POND SAND FILTER

To find out how many people are using the sand filter in Chalna and what their views are about it, a survey was carried out on Friday, 22nd of May 1987.

The survey started at 6.00 a.m. and finished at 7.30 p.m. It was noted that the users started using the filter at about 5.00 a.m. and continued up to 8.30 p.m.

8.1 The Questionnaire

In the survey the following questions were asked :

a) The age and sex of the users were noted.

b) How many family members do they have ?

c) How far do they have to walk to the PSF ?

d) For what purpose do they use the filter water ?

e) Are they carrying water for their own family, for hotel or restaurant or are they from a boat ?

f) Will they use the sand filter throughout the year or only during dry season ?

g) How many water jars do they use in a single day ?

h) What do they think about the quality of water ?

i) Do they have any complaints or suggestions ?

8.2 Temporary and Permanent Users

During the survey it was noted that there are two types of users, temporary and permanent, with temporary users outnumbering permanent by 2:1. Temporary users are those who normally use river water or other ponds except in the dry season when the river water becomes excessively saline or their regular pond dries up. In particular hotel and restaurant owners and boat people usually use river water and are therefore only temporary users of the sand filter.

8.3 Survey Results

The results of the survey were as follows:

a) The users were 84% female (67% adult, 17% girls) and 16% male (8.5% adult, 7.5% boys)

b) The total number of family members was 1,265. If the customers of restaurants and hotels are included, total number of beneficiaries is around 3,000 people.

c) The furthest walking distance was 1.5 miles, with an average of 0.5 mile.

d) 100% of users said they used the water for drinking, 80% for cooking and 13% for washing

e) 65.5% of users were carrying water for themselsves, 26% for hotels or restaurants and 8.5% for boat people.

f) Only 36% of users will use the sand filter throughout the year. 58.5% said they will use it only in the dry season and 5.5% did not reply.

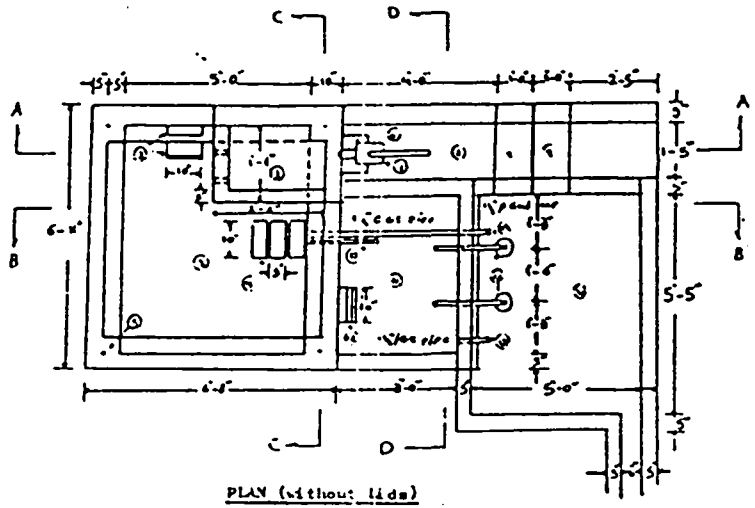
g) A total of 500 jars of water were taken from the sand filter during the period.

h) All the users reported that they were happy with the quality of water.

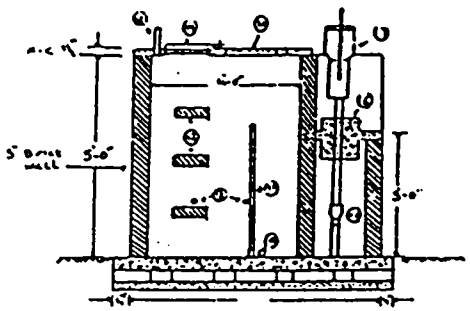
i) The main complaint was that there were too many users, and they have to wait a long time to draw water especially in the afternoon.

Annex 1

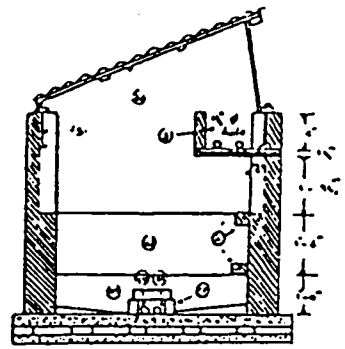
POND SAND FILTER



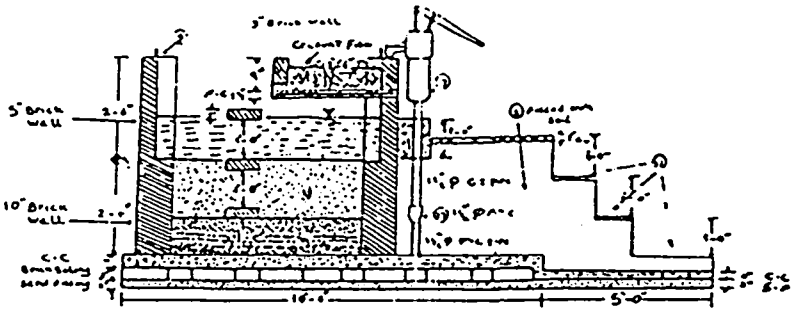
PLAN (without lids)



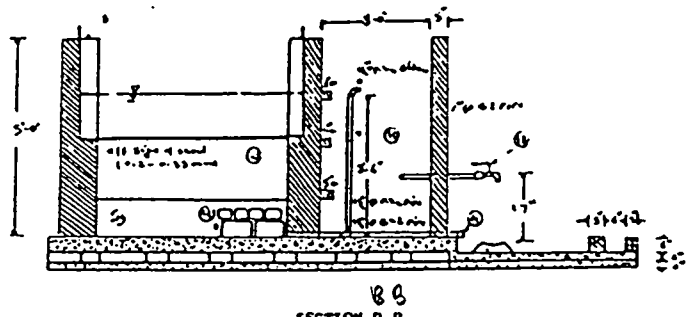
SECTION D-D (with the Fixed Cover)



SECTION C-C (with the Lid)



SECTION A-A



SECTION B-B

1 - SAND FILTER
2 - STEPS
3 - PRE-FILTER CHAMBER
4 - BRICK TUNNEL
5 - INLT
6 - CONCRETE PILLAR
7 - HANDPUMP
8 - RAISED PLATFORM
9 - STEPS
10 - CONNECTION PIPE (S.F. TO S.T.)
11 - STORAGE TANK
12 - STEPS
13 - GI TAPS
14 - S.F. WASHOUT PIPE
15 - S.T. WASHOUT PIPE
16 - PLATFORM
17 - PVC ADAPTOR
18 - VENT PIPE
19 - MANHOLE
20 - GI PIPE
21 - FIXED COVER
22 - S.F. LID
23 - SAND BED
24 - GARDEN MEDIA

Annex 2

SAMPLE COST OF POND SAND FILTER

Sl. No.	Description	Quantity	Unit	Unit Rate Tk.	Total Taka
	Special Purchase Items				
01.	Khoa	60	cft.	15	900
02.	First class brick	1,600	ea.	1,550/1,000	2,488
03.	Local sand	25	cft.	2	50
04.	Masonry sand	100	cft.	5	500
05.	Sylhet sand	75	cft.	15	1,125
06.	1-1/2" dia hose pipe	2	ft.	20	40
07.	1-1/2" GI cap	2	ea.	35	70
08.	1-1/2" PVC cap	1	ea.	6	6
09.	1-1/2" dia GI elbow	1	ea.	30	30
10.	1-1/2" dia. PVC elbow	2	ea.	8	16
11.	1" dia GI pipe	3	ft.	24	12
12.	Socket reducer 1" x 1/2"	2	ea.	25	50
13.	Manhole	1	eal	175	175
14.	Timber	1.4	cft.	125	175
15.	Hinge	4	ea.	6	24
16.	Nail	0.25	kg	60	15
17.	Plastic container	1	ea.	24	24
18.	1-1/2" dia PVC adaptor	1	ea.	25	25
19.	Solvent cement	1/2	tube	120	60
20.	Wire mesh	40	sft.	5	200
21.	Pipe wrench	1	ea.	140	140
			Sub-total:		6,125
	Items from Store				
22.	Cement	21	bag	100	2100
23.	Handpump	1	ea.	550	550
24.	PVC pipe (1-1/2" dia)	80	ft.	15	1,200
25.	1-1/2" dia. GI pipe	10	ft.	30	300
26.	1-1/2" dia. PVC strainer	3	ft.	30	90
27.	CGI sheet	42	sft.	30	1,260
28.	MS rod	8	ft.	5	40
29.	Multipurpose wrench	1	ea.	100	100
			Sub-total:		5,640
	Labour				
30.	Mason	10	day	80	800
31.	Helper	10	day	40	400
32.	Carrying cost	-	-	-	1,500
			Sub-total:		2,700
			Grand Total:		14,465

Note: Actual costs will vary from site to site.

Annex 3

AGREEMENT FOR CONSTRUCTING AN EXPERIMENTAL POND SAND FILTER

This is an agreement between Mr. _____ who represents _____ and DPHE/UNICEF.

This agreement has been signed with the understanding that it is an experimental project and its design in future may need some improvement.

Each signatory has agreed on the following conditions for constructing a Pond Sand Filter.

1. DPHE/UNICEF will be responsible for providing all necessary materials for constructing a sand filter.

2. Skilled labourers will be paid by DPHE/UNICEF.

3. The community must contribute Tk. 1000/= (Taka one thousand) only towards the construction of the sand filter in cash. This payment must be made to DPHE/UNICEF before construction.

4. The community should be prepared to carry the materials from the place specified by DPHE/UNICEF to the site of construction.

5. Community should provide sufficient unskilled labour as requested by DPHE/UNICEF.

In order to achieve the continued operation of the Sand Filter after its completion, each signatory has agreed upon the following conditions:

a. Mr _____ is the nominated caretaker and he is responsible for cleaning the filter and maintaining the Pond Sand Filter.

b. The Pond Sand Filter should be available to all the people in the community.

c. The community should arrange and bear the cost of minor repairs.

d. If the Pond Sand Filter needs a major repair within 12 month of construction, DPHE/UNICEF will provide the necessary materials but other cost must be borne by the community.

e. It is agreed by the community that, if DPHE/UNICEF wishes to improve the performance of the Pond Sand Filter it may be modified at the cost of DPHE/UNICEF.

f. For maintenance purposes DPHE/UNICEF will give one pipe wrench and one multiple purpose wrench to the caretaker.

g. Some additional materials will be given to the caretaker by DPHE/UNICEF for maintenance during the early stages of the Pond Sand Filter's operation.

Annex 4

CONTRIBUTIONS BY COMMUNITY TOWARDS CONSTRUCTION OF EXPERIMENTAL POND SAND FILTERS

Contribution / Sites	CASH (Taka)	Unskilled labour: All the Time	Unskilled labour: Some-time	Materials: Brick No.	Materials: Sand Cft.	Materials: Bamboo No.	Land for filter site: Public	Land for filter site: Private	Carrying Materials from: DPHE building in Chalna	Carrying Materials from: River site in chalna	Carrying Materials from: River site near the village	Food to Workers: Always	Food to Workers: Occasionally	Maintenance: By DPHE but paid by users	Maintenance: By care-takers
Khalinagar	950		✓	-	-	2	✓	-	-	-	-	-	✓	-	✓
Maji Bari	1,120	✓	-	-	-	1	-	✓	-	✓	-	✓	-	-	✓
Meghna	1,000	✓	-	-	-	1	-	✓	✓	-	-	✓	-	-	✓
Chalna	3,000	-	-	-	-	-	✓	-	-	-	-	-	-	✓	-
WAPDA	1,200	✓	-	350	50	1	✓	-	✓	-	-	-	-	-	✓
Jainagar	600	✓	-	-	20	1	✓	-	-	-	✓	✓	-	-	-

SB/CG/kb/psb
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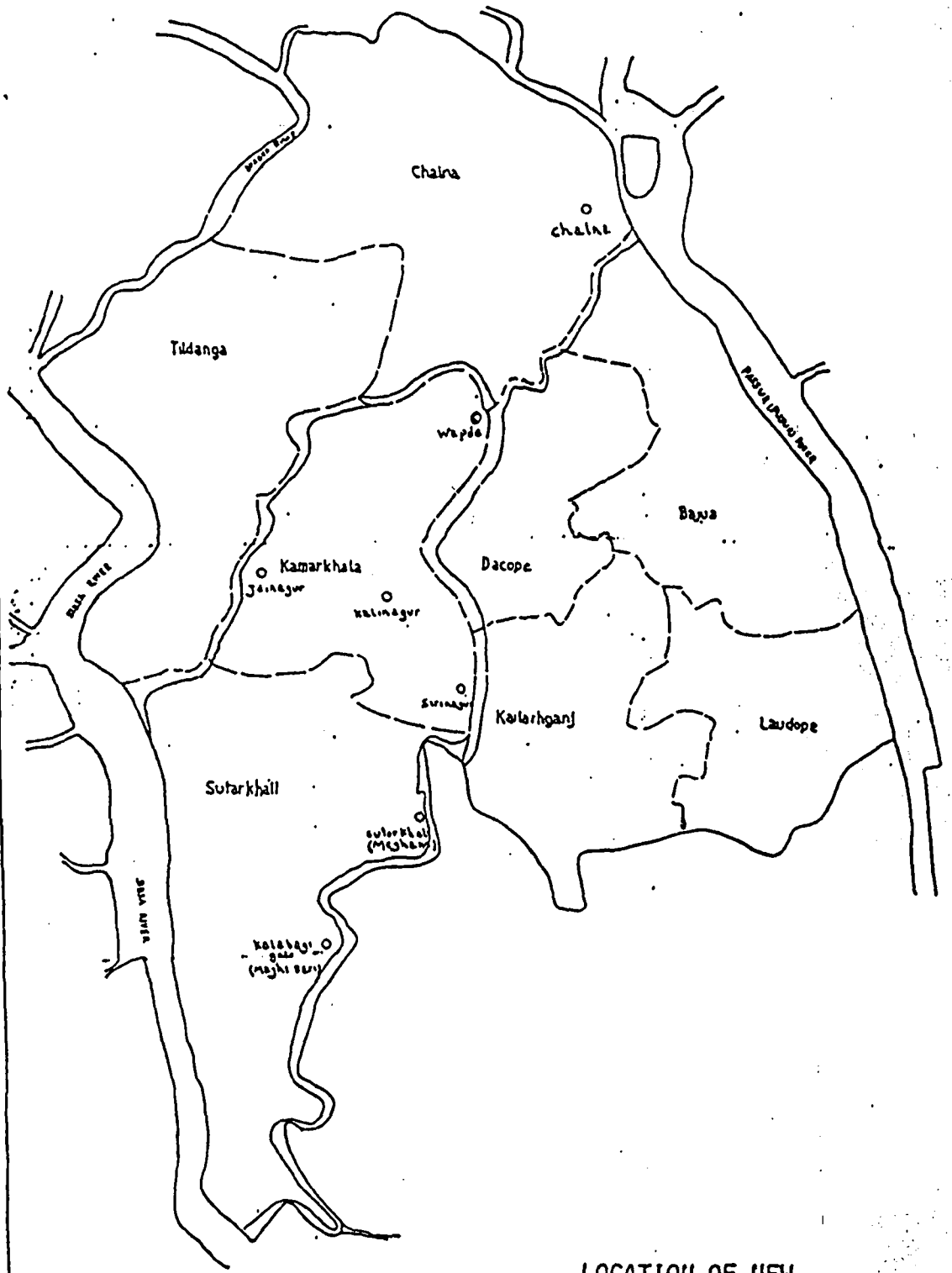
Annex 5

DACOPE UPAZILA - KHULNA



LOCATION OF NEW POND SAND FILTERS