

Phase II

71  
IRC 80

71  
IRC 80

CSP component.

INTERIM REPORT

ON

SLOW SAND FILTRATION RESEARCH PROJECT

Project  
undertaken  
by

Thailand Provincial Waterworks Authority  
(Formerly Rural Water Supply Division,  
Department of Health)

Project  
sponsored  
by

WHO International Reference Centre  
for Community Water Supply  
The Hague, THE NETHERLANDS

RECEIVED  
COMMUNITY WATER SUPPLY  
SECTION

| CONTENTS                                       | PAGE |
|------------------------------------------------|------|
| 1. Project Background                          | 1    |
| 1.1 History                                    | 1    |
| 1.2 Selection of the Demonstration Villages    | 2    |
| 2. Purposes of the Study                       | 3    |
| 2.1 Objectives                                 | 3    |
| 2.2 Scope                                      | 3    |
| 3. Description of the Study Programme          | 4    |
| 3.1 Project Site Selection                     | 4    |
| 3.2 Criteria under Study                       | 4    |
| 3.2.1 Pre-Construction Phase                   | 4    |
| 3.2.2 Operation and Maintenance Phase          | 4    |
| 3.3. Monitoring and Evaluation                 | 4    |
| 3.3.1 Technical Aspect                         | 4    |
| 3.3.2 Non-Technical Aspect                     | 5    |
| 4. Progress Report of the Communities Selected | 6    |
| 4.1 Ban Bangloa Village, Singhburi Province    | 6    |
| 4.1.1 Background Information                   | 6    |
| 4.1.2 Climate                                  | 10   |
| 4.1.3 Occupation and Income                    | 10   |
| 4.1.4 Education                                | 11   |
| 4.1.5 Water and Sanitation                     | 11   |
| 4.1.6 Participation                            | 12   |
| 4.1.7 Description of the treatment Plant       | 13   |
| 4.1.8 Engineering Design Criteria              | 13   |
| 4.1.9 Progress Work to Date                    | 18   |
| 4.1.10 Construction Cost Breakdown             | 20   |
| 4.2 Ban Thadindam Village, Lopburi Province    | 22   |
| 4.2.1 Background Information                   | 22   |
| 4.2.2 Climate                                  | 22   |
| 4.2.3 Occupation and Income                    | 22   |
| 4.2.4 Education                                | 22   |
| 4.2.5 Water and Sanitation                     | 22   |
| 4.2.6 Participation                            | 24   |

CONTENTS

PAGE

|       |                                                    |    |
|-------|----------------------------------------------------|----|
| 4.2.7 | Description of Treatment Plant at<br>Ban Thadindam | 25 |
| 4.2.8 | Progress Work to Date                              | 30 |
| 4.2.9 | Construction Cost Breakdown                        | 32 |
|       | Annex                                              |    |
| 1.    | Questionnaires on KAP Test                         | 33 |
| 2.    | Raw Water Characteristics                          | 39 |
| 3.    | Engineering Design Criteria                        | 41 |

\*\*\*\*\*

## PROGRESS REPORT ON SLOW SAND FILTRATION RESEARCH PROJECT

### 1. PROJECT BACKGROUND

History

The Royal Thai Government has developed the community portable water supply project since 1966. The project activity is responsible by the Rural Water Supply Division, Department of Health, to assist the community size of 500-5,000 people. By last May 1979, about 550 systems have been constructed, serving 1.6 million people, representing about 5 percent of the rural population. The type of treatment employed varies according to the quality of the raw water sources. It is apparent that main problem of using the surface water as sources of water supply depends upon the turbidity of the water, therefore the most common treatment employed has been the conventional rapid sand filtration process in which chemicals are used to coagulate and flocculate the turbidity for further sedimentation and filtration. It is rather complicated system which requires well trained operators.

Deep well water is another source of water used. The treatment of deep well water involves simple chlorination to complicated systems of aeration followed by rapid or slow sand filtration process. In all instances, the treated water is subjected to chlorination before it is supplied to consumers through the pipes system. Though the slow sand filtration system has more advantages in its simplicity of operation and maintenance than rapid sand filtration system, there are still many factors that influence the choice of the slow sand filtration system. For example, the turbidity of the raw water before filtration is conventionally limited to below 30 mg/l, and high initial construction cost of the slow sand filter. As the result, at present only about 5 % of the total number of the existing water supply systems in Thailand employing the slow sand filtration system.

The use of slow sand filter for water treatment in Thailand is rather limited due to the reasons mentioned above until recently. Starting in 1978, the International Reference Centre of the Netherlands (IRC) has sponsored the Rural Water Supply Division of the Department of Health to undertake the field study and research programme on the slow sand filter, through which three plants are being selected for assistance as demonstration projects. In addition, the Asian Institute of Technology (AIT) has recommended the use of pre-treatment technique, namely the horizontal-flow coarse material prefiltration. The main advantage of the pre-filter is recommended for its capability in reduction of suspended solids prevailing in raw water to a certain extent.

The purpose of the Project undertaken by the Rural Water Supply Division therefore are to review and evaluate the design criteria, the performance of the slow sand filtration systems under actual field operation, its maintenance problems, its benefits and debenefits, the related health impacts and socio-economic problems.

Selection of the  
Demonstration  
Villages

A preliminary survey has been done to select the demonstration villages in the Rural Water Supply Region 1, which located in central area of Thailand, northerly direction of Bangkok. The main reasons for selection all demonstration projects in the central area are the conveniences of the Project staffs to monitor and follow up the Projects, as the main laboratory is also in Bangkok.

At present two villages have already been selected as demonstration villages. Another is being considered since the community participation and contribution is still not ready, as one main criteria for the selection has been the community participation. The two villages selected are as followed :-

1. Ban Bangloa, Singhburi Province
2. Ban Thadindam, Lopburi Province

## 2. PURPOSES OF THE STUDY

### Objectives

The main objective of this study is to evaluate and develop the criteria of applying and promoting the use of slow sand filtration in developing countries; and also to determine whether such system would be appropriate to the local conditions, circumstances and the needs. The study research is to include technical as well as non-technical nature such as social culture and economic factors through the actual field trail of the demonstration plants. It is hoped that the results and field data information collected through the project will serve as a guideline in propagating and promoting the application of slow sand filtration in this country as well as in other developing countries and would serve to correct various pit-falls which have hampered the progress of the Rural Water Supply Programme.

### Scope

The Slow Sand Filtration Research Project has been planned to investigate the function of the slow sand filter with regard to the technical and non-technical aspects, which will also involve :-

1. The attitude of the villagers towards the acceptance of the water supply scheme.
2. The socio-economic capability of the villages in relation to Project operation and maintenance.
3. The performance of both pre-filters and filters with respect to the engineering design criteria.
4. The impact of the raw water quality especially turbidity which may have upon the filter run.
5. The training programme to be given to the operator that has been selected from the local people.

3. DESCRIPTION OF THE STUDY PROGRAMME

Project Site  
Selection

In conjunction with the IRC programme, three field sites for the construction as demonstration are to be selected. However, at present the construction for two communities have been initiated, the third one is under the consideration.

Criteria  
Under Study  
Pre-Construction  
Phase

The following study will be carried out during various stages :-

During this phase the health education programme has been implemented to the selected villages by various means through the local health workers and sanitarians of the Provincial Health Bureau. Village meeting, leaflet distribution were given to them. Health movies was also shown at the village gatherings in the evening, which aims to educate them on the importance and the benefit of piped water supply and on the means of transmitting the water-bourne diseases. In addition, the personal and door to door interview was also made in order to collect individual family information related to health and socio-economic conditions of the communities. The questionnaires on the knowledge, attitude and practice on water supply were made, and results are shown in the Annex.

Operation and  
Maintenance  
Phase

This is the most important and the final stage which determine the success or failure of the project. Various components and criteria involving both technical and non-technical nature will be studied so as to determined the appropriateness of the design assumption.

Monitoring and  
Evaluation

The study will be set up following by appropriate monitoring and evaluation procedures so that specifically the following aspects among many others be evaluated.

Technical  
Aspect

The study will aim at :-

a) to determine whether the proposed horizontal flow

pre-filter is feasible or appropriate for the slow sand filtration treatment under actual field previously studied in AIT pilot plant; this phase of the study will be carried out in conjunction with AIT,

b) to determine whether the chemical coagulation is needed or necessary to enhance such prefiltration operation,

c) to evaluate the effectiveness of the pre-filter by so-called "roughing filter" and to compare to other pretreatment process such as holding reservoirs which also would be employed in the demonstration systems,

d) to determine whether the recommended WHO/SEARO design of the slow sand filter is appropriate and to compare it to our present design, various aspects will be compared: the underdrain system design, the flow rate control systems, the ease of the construction, operation and maintenance as well as their costs as being judged by the local circumstances,

e) to determine whether such systems can be operated and maintained by the local village operators as will be recruited by the local communities themselves and will be trained specifically for the purpose,

f) to carry out a long-term monitoring and follow up of each system with regards to their qualities and clearing their problems.

Non-Technical  
Aspect

It is realized that the non-technical aspect, many times, appears to be equally important or even more so than the technical one. Often this aspect has been left out to the design engineer and technician to fulfill this need. As a result, a rather nominal attention is given to this aspect and failure often follows primarily due to the overlook of this fact. Some examples of the basic cultural, economic and social aspects which will be determined are :-



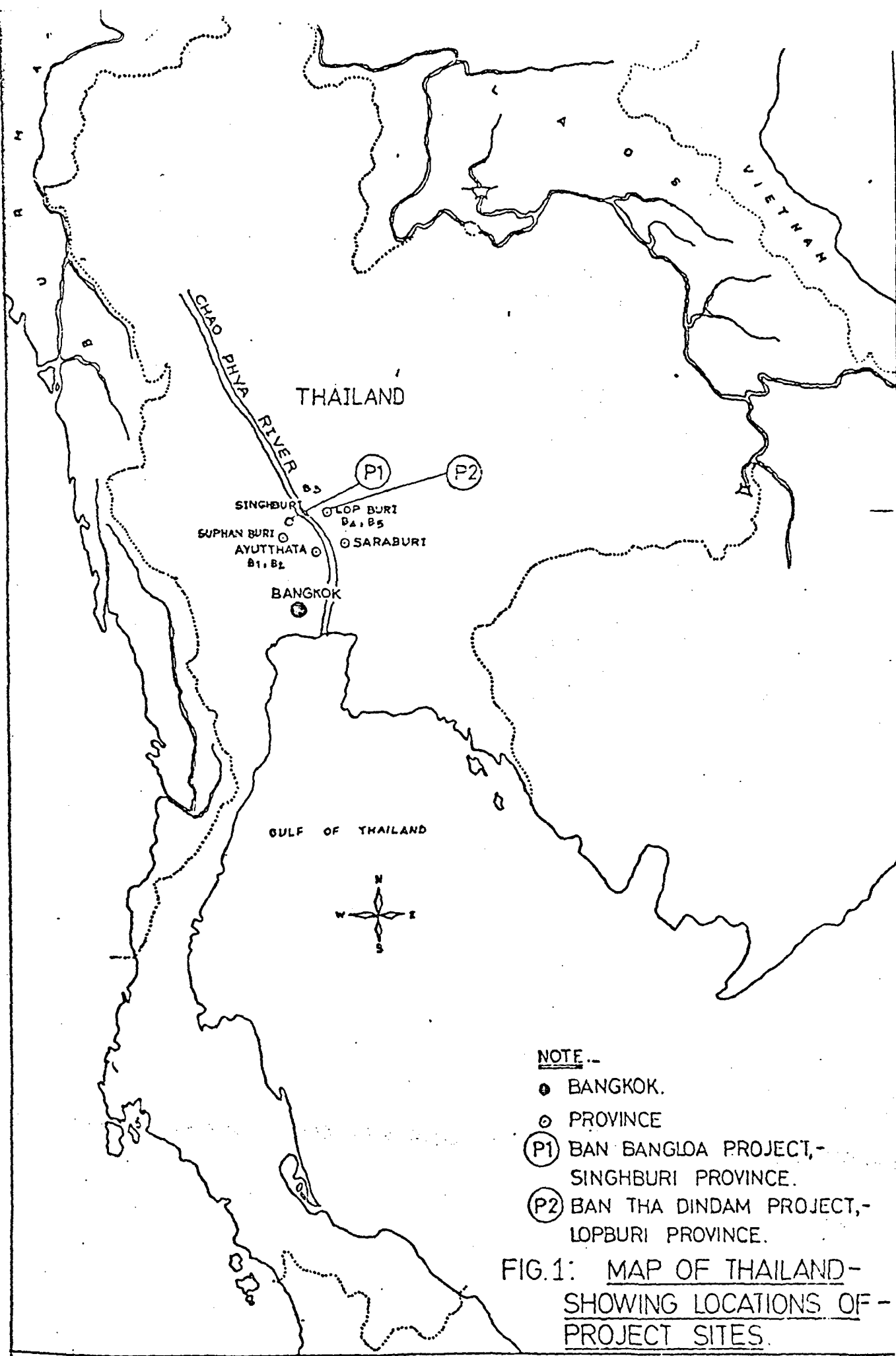
- a) the degree of the community participation and the need of the health education required to guarantee the success of the project, the essential criteria for the successful operation and maintenance are to be analyzed,
- b) the impact of the water supply system and its accessibility pattern, their general health status; the impacts of public or private water supply connections will also be compared,
- c) whether such system can be operated and maintained on the self sustained basis with minimum technical supervision and financial assistance from the outside sources

#### 4. PROGRESS REPORT OF THE COMMUNITIES SELECTED

Ban Bangloa  
Village,  
Singhบุรี  
Province

Background  
Information

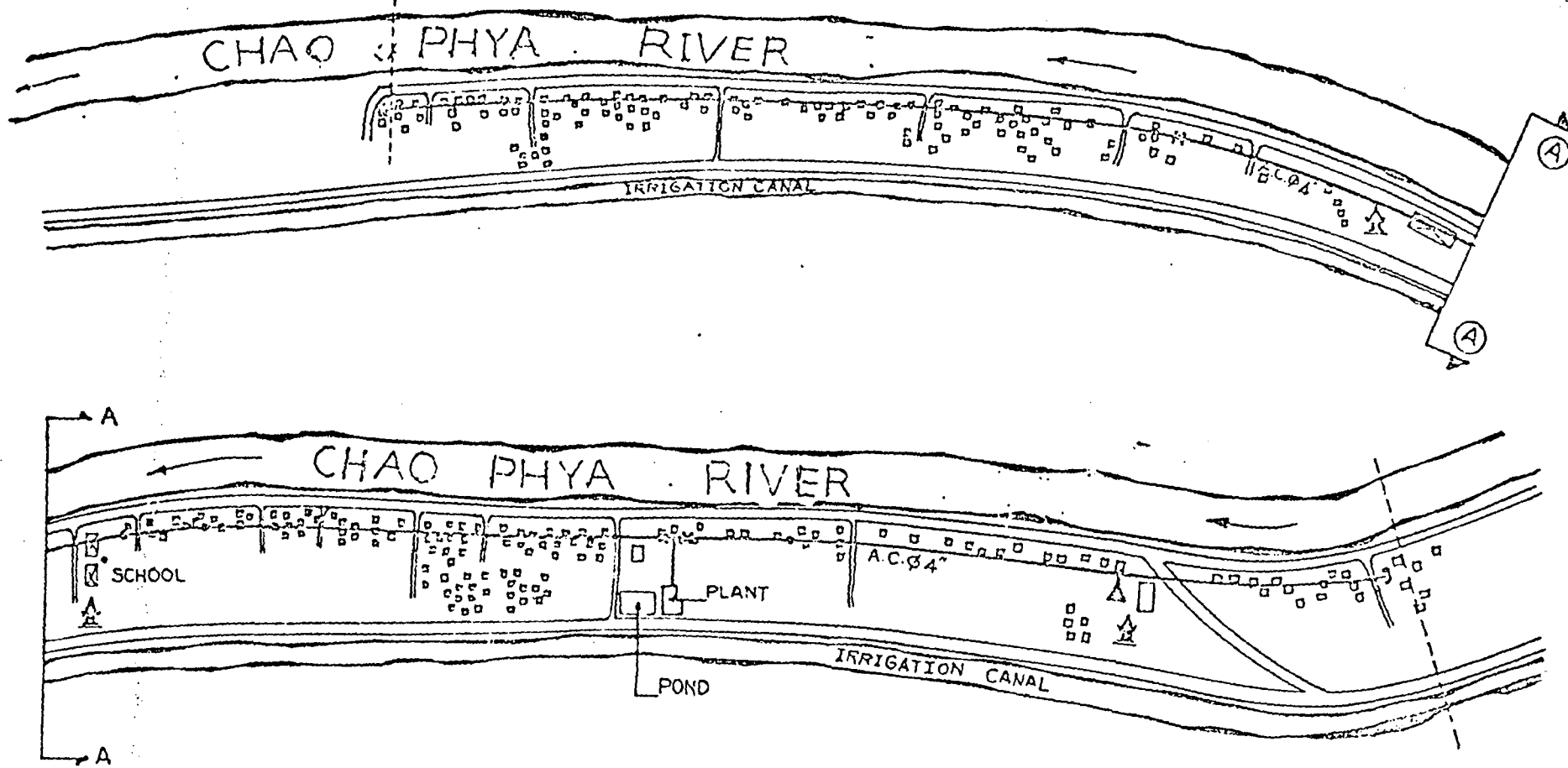
Ban Bangloa is located at latitude  $14^{\circ}45'$  N and longitude  $100^{\circ}15'$  E in Muang District, Singhบุรี Province, and is about 120 kms. north of Bangkok. It is situated on the eastern bank of Chao Phya River (Fig. 1). The village is located between the Chao Phya River and an irrigation canal and inhabited by approximately 400 families with an average of about 5 persons. The houses are lined along the river bank more than along the canal side (Fig. 2 & 3). The river provides a gentle sand slope along the river bank. And it has been found that the river water floods this area during the monsoon or rainy season period. During the dry season the land has been used for cultivation (Fig. 4). Difference of the water level in the river is about 6-7 m. between the two seasons. Heavy rain upstream always causes torrential in the river with high turbidity.



NOTE:-

- BANGKOK.
- PROVINCE
- ⊙ P1 BAN BANGLOA PROJECT, - SINGHBURI PROVINCE.
- ⊙ P2 BAN THA DINDAM PROJECT, - LOPBURI PROVINCE.

FIG.1: MAP OF THAILAND - SHOWING LOCATIONS OF - PROJECT SITES.



SYMBOLS

- A.C.  $\phi 4"$
- $\nabla$  — VALVE
- $\square$  — CAP

FIG 2: SHOWING THE LAY-OUT OF THE WATER-SUPPLY - DISTRIBUTION SYSTEM FOR BAN BANGLOA, SINGHBURI.

NUMBER OF HOUSES : 400

POPULATION : 2,000

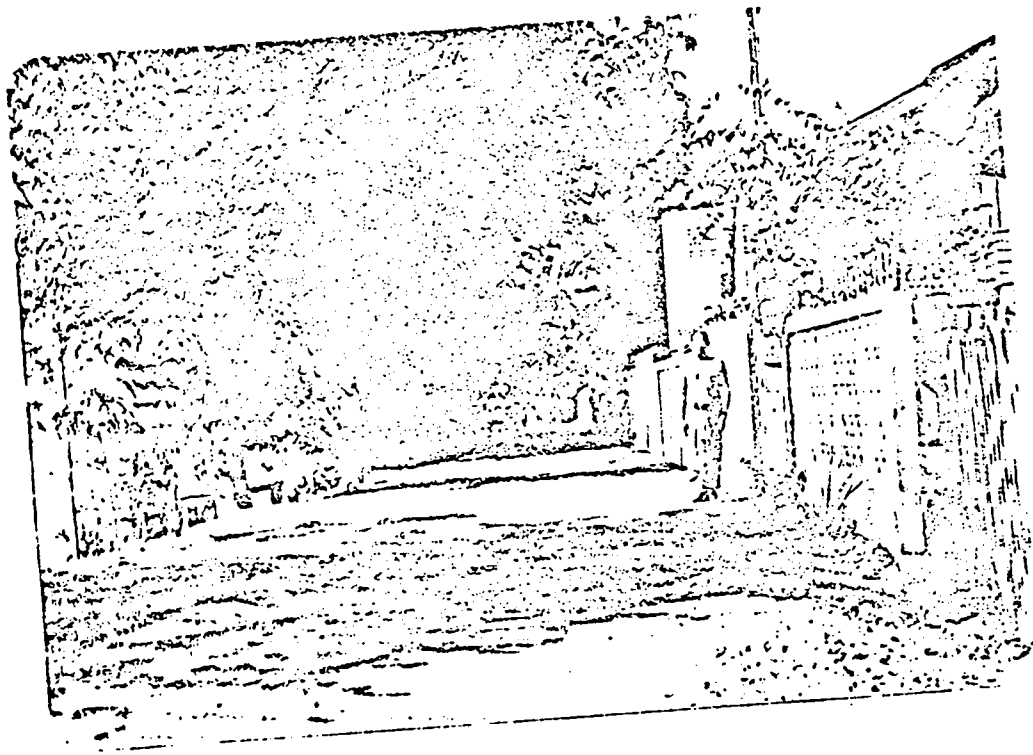


FIG : 3  
General view of Ban Bangloa, Singhburi Province, seeing  
road parallel to the Chao Phya River.

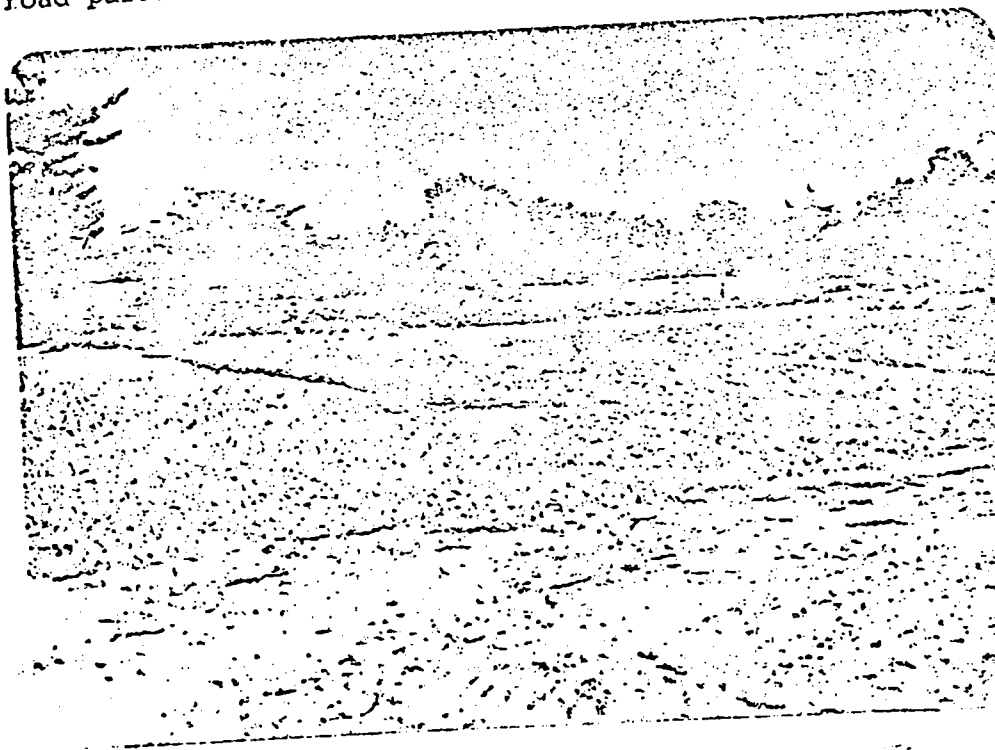


FIG : 4  
Showing the gentle slope of sandbeach along the Chao Phya  
River at Ban Bangloa, Singhburi Province during the dry  
season. The cultivation in small plots on the bank may  
be noticed.

Climate

In view of climatic conditions, Ban Bangloa is situated in the central part of the country which lies in tropical zone. The average temperature throughout the year ranges from 15°C- 38°C. The average annual rainfall is about 1,157 mm.

Occupation and  
Income

The principal occupation of the local people in this community is rice-farming, the remainings are labour, trading and government service. The average yearly income per family varies from ¥ 10,000-15,000 (US\$ 500-750) which is relatively high in comparison to the country's average (US\$ 200 per year according to the National Statistics Report of 1979).



FIG : 5

Showing shallow well dug in sand beach with a suction pipe connection at Ban Bangloa, Singhburi Province.

## Education

The village has a primary school of the level up to the compulsory grade (seventh grade). Any students who wish to further their study may go to Singhburi provincial centre which is only 5 kms. away. At the centre, there are both secondary school and vocational school available. More than 60 % of the villagers have already passed the former compulsory level at fourth grade, and most of them are literate.

## Water and Sanitation

At present the existing water used for the household is obtained mainly from river. The villagers who live along the river dig a shallow well in the sand beach and put the small casing into the opening in order to prevent the well collapse. The pipe is then connected to their individual houses for private use (Fig. 5); the hand pump — sometimes small diesel engine pump, is installed to facilitate the service to individual houses (Fig. 6).

As the river water is rather turbid during rainy season, the alum is commonly used for coagulation in order to remove turbidity in the individual house-containers. In some houses the water is allowed for self-settling for one to two days and then decanted the top clear water for use. The container used for keeping water is earthen jar of about 100 l. size which can be easily seen throughout the country. However, the rain water is quite commonly used for drinking purpose. Boiling water before use for drinking is also practiced in some houses.

In view of sanitation, the refuse disposal is mostly collected in open pit for burning. Live stock-raising which is very popular is also commonly kept in the house vicinity; small animals such as chicken, duck, pig and etc are raised under the house floors. The private soakage-pit latrine is employed in more than 90 % in the village household.



FIG : 6

Hand pump connecting to a dug well on the river bank is being used in a household at Ban Bangloa, Singhburi Province.

#### Participation

As for participation, the results of the survey have revealed that the villagers under the leadership of the village headman are willing to contribute free labour and materials for digging holding pond and laying pipelines. Their contribution are summerized in Table 2.

TABLE 1: Community contribution towards the water treatment system construction.

| DESCRIPTION                        | VALUE EQUIVALENT |       |
|------------------------------------|------------------|-------|
|                                    | BAHT             | US \$ |
| 1. Cash                            | 10,000           | 500   |
| 2. Sand gravel                     | 10,000           | 500   |
| 3. Labour for digging holding pond | 10,000           | 500   |
| 4. Land for treatment plant        | 60,000           | 3,000 |
| <hr/>                              |                  |       |
| Total contribution value           | 90,000           | 4,500 |

Percentage of contribution as compared to the total cost of construction = 4.4 %

In addition, the villagers are willing to pay for water meter connection for their own house and for the equity of water revenue to be charged on metering basis.

1.7 Description of the Treatment Plant

The raw water for Ban Bangloa Water Supply is taken from the irrigation canal, the plant design has consisted of the following processes :-

1. Holding pond for self settling
2. Pre-filter unit
3. Slow sand filter
4. Chlorination

The flow diagram of the treatment plant is shown in Fig.7.

1.8 Engineering Design Criteria

The construction of Ban Bangloa Water Supply Plant has started since October, 1978. It is designed to serve 2,000 people with the capacity of 10 m<sup>3</sup>/hr. It is expected that the rate of consumption for the whole village will be around 100-150 m<sup>3</sup>/day. The raw water source is pumped from the irrigation canal, which is about 20 m. from the treatment plant into the holding pond with capacity of approximately 4,800 m<sup>3</sup>, thus providing the theoretical



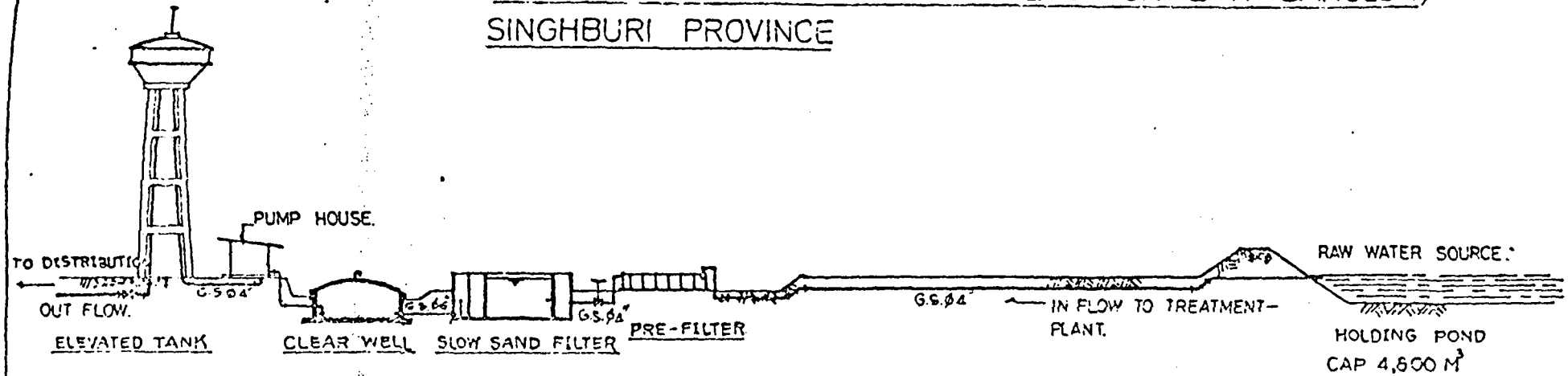
detention period of about 1½ months before flowing into the horizontal flow pre-filter by gravity. The flow of water is regulated by the adjustment of a gate valve.

The pre-filter unit is designed as a rectangular box of 6.5 m. wide x 8.8 m. long and 1 m. deep packed with crushed stones of various sizes. The box is divided into seven sections provided with wire mesh interception (Fig. 8). The effluent from the pre-filter is controlled by V-shape wier. The filter has been designed as rectangular box with the dimension of 5 m. wide x 6 m. long and 2.8 m. deep. The sand of graded size is filled in the filter bed about 1.25 m. high. The water to be filtered is to be lefted on top of sand about the same height as sand bed. The top of filter is open as free board about 0.30 m. (Fig. 9). The filtration rate is designed at  $0.15 \text{ m}^3/\text{m}^2/\text{hr}$ .

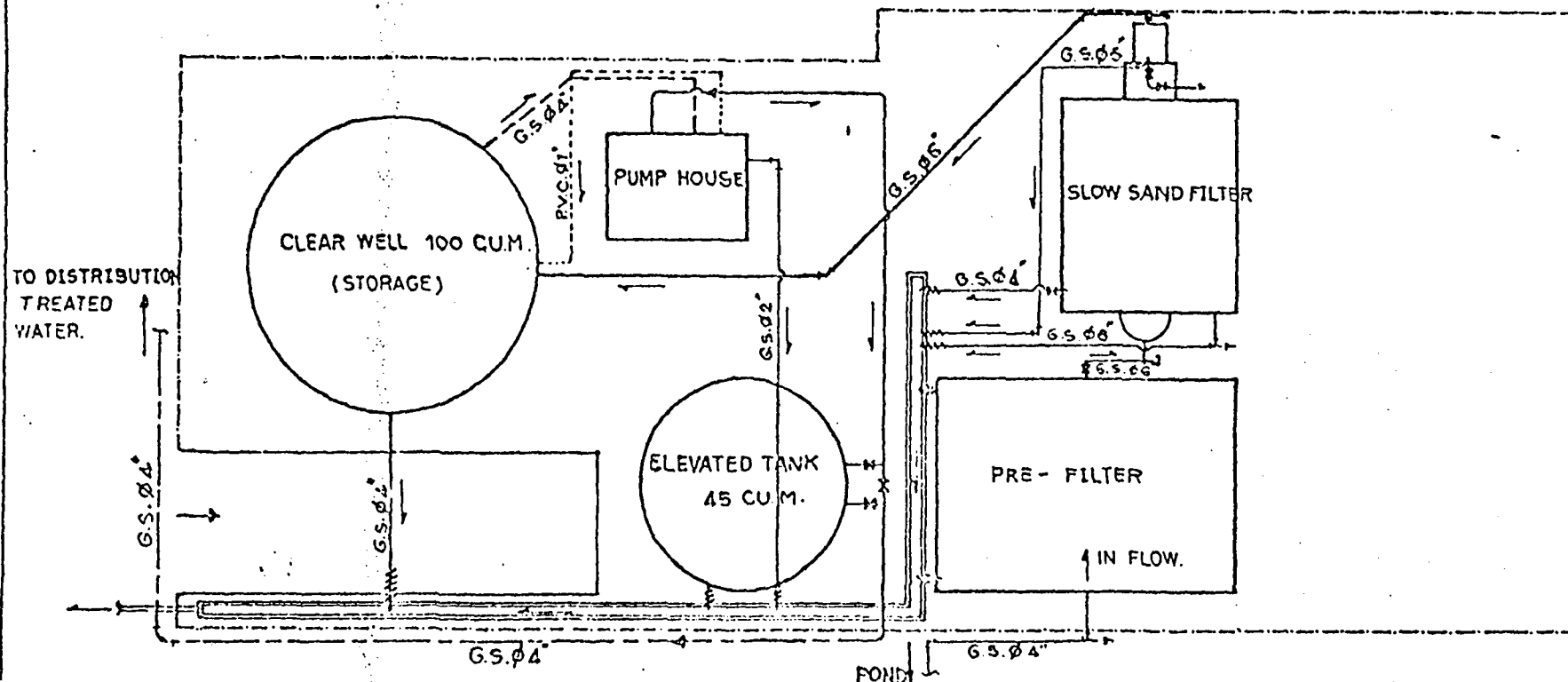
The finished water is subjected to chlorination and passed into the clear well of the capacity of  $100 \text{ m}^3$ . It is then pumped to the elevated tank of  $45 \text{ m}^3$  and finally supplied by gravity to consumers within the community.

The salient features and the engineering design criteria of Ban Bangloa Water Supply Plant are summarized in Table 2 and Table 3 respectively.

FIG 7 WATER SUPPLY TREATMENT PROCESS FOR BAN BANGLCA,  
SINGHBURI PROVINCE



TREATMENT PLANT PROFILE



TREATMENT PLANT LAY-OUT PLAN

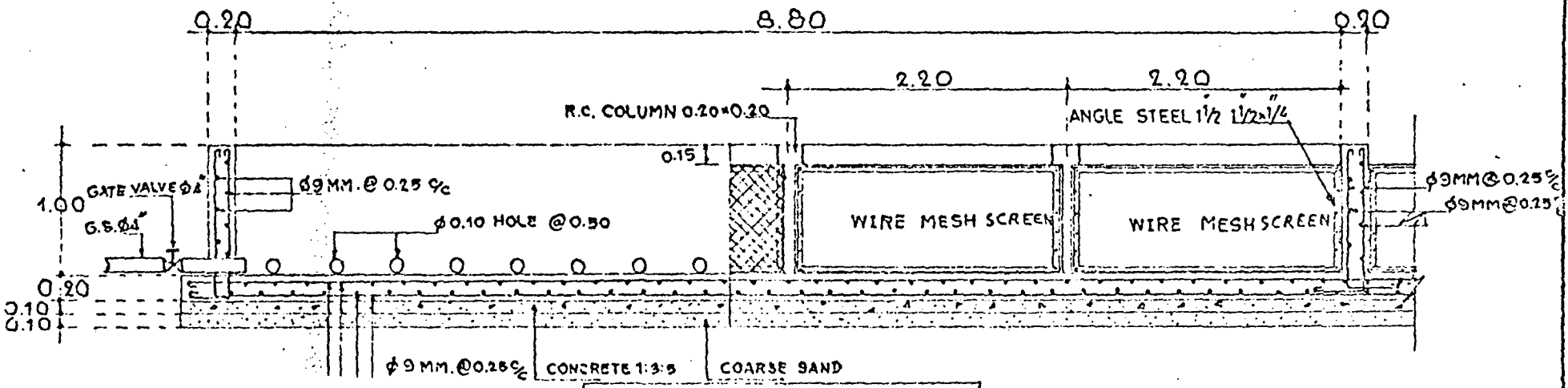
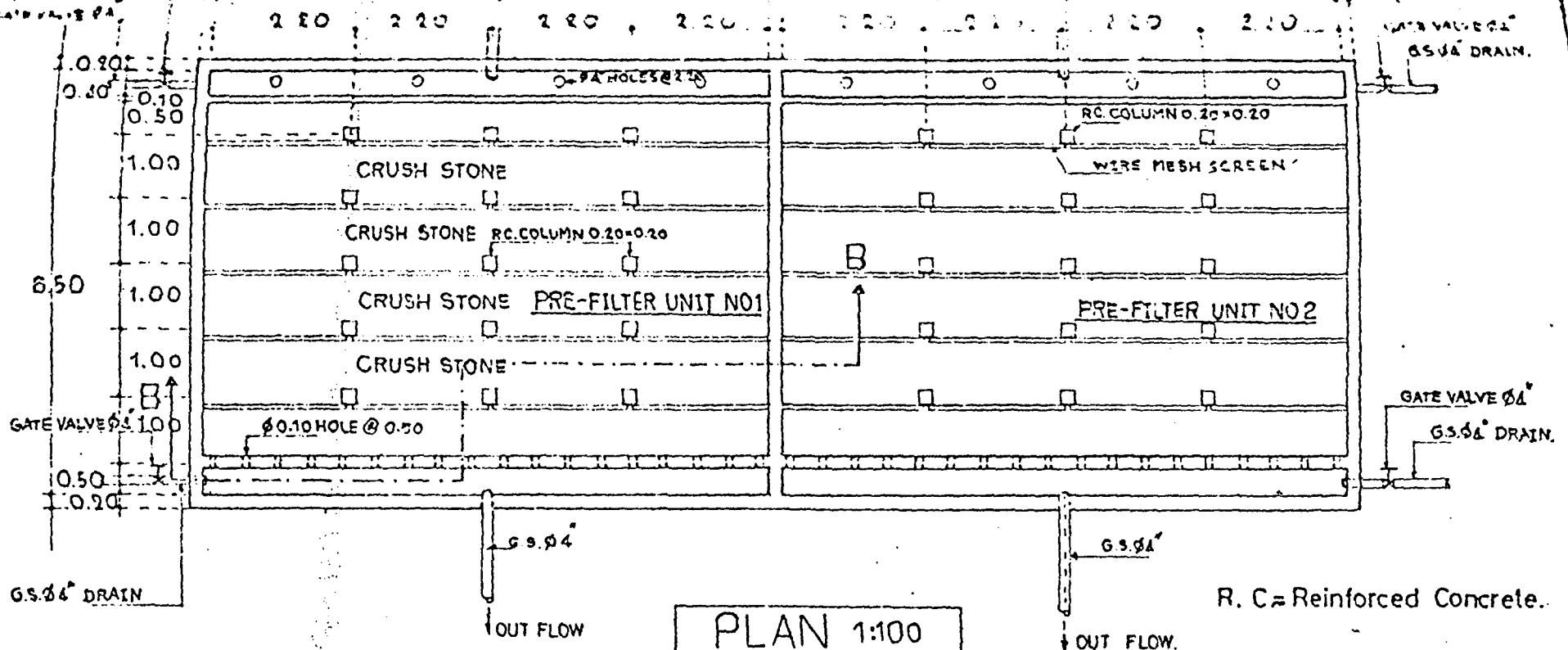


FIG. 8 DETAILS OF PRE-FILTER UNIT

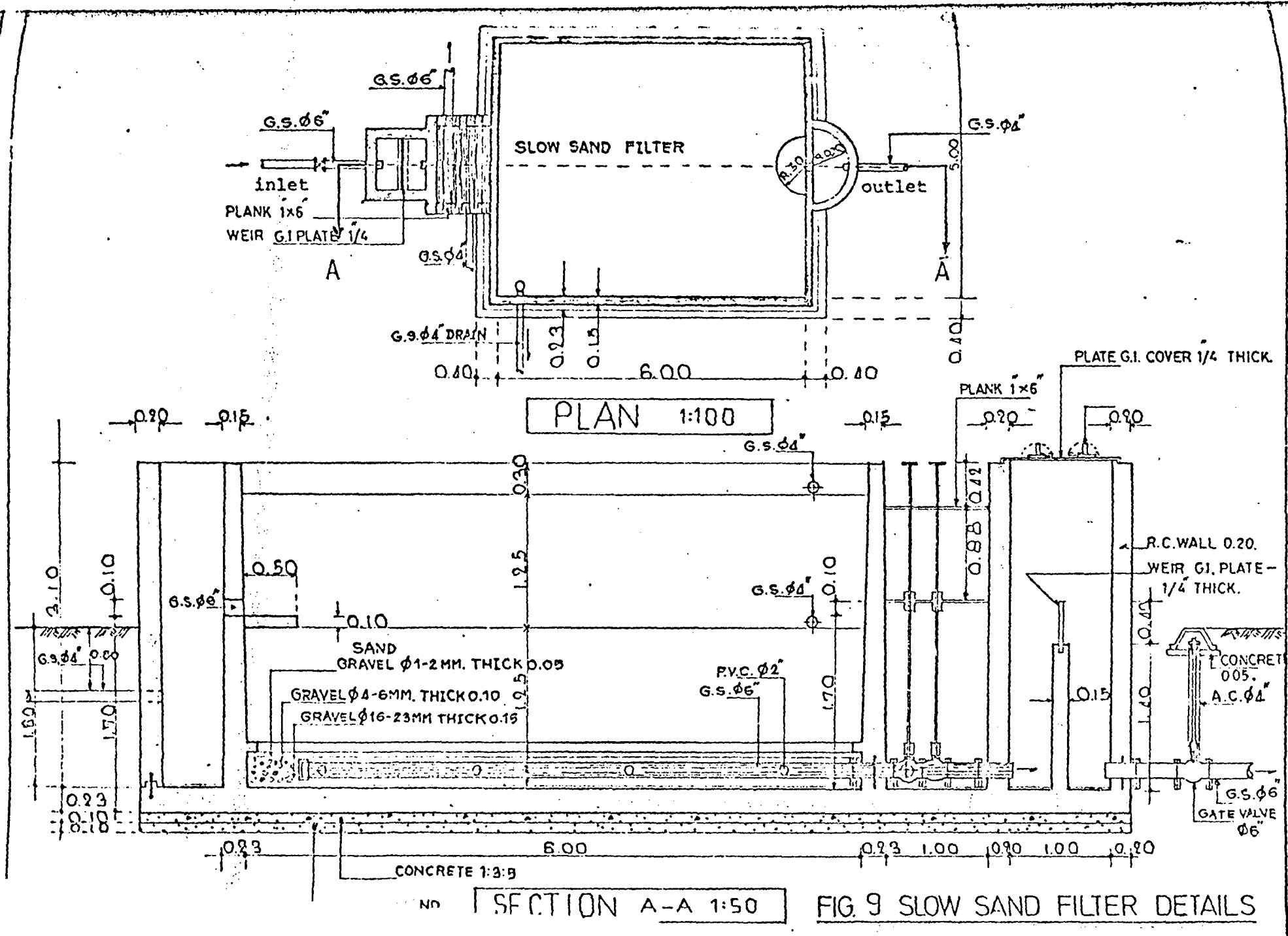


TABLE 2 : Salient features of Ban Bangloa Water Supply Plant

| DESCRIPTION                                                   | DATA                                                        |
|---------------------------------------------------------------|-------------------------------------------------------------|
| 1. Location                                                   | 120 kms. north of Bangkok                                   |
| 2. Population served                                          | 2,000                                                       |
| 3. Temperature range                                          | 15° C-38° C                                                 |
| 4. Raw water source                                           | Chao Phya River                                             |
| 5. River water level difference between dry and rainy seasons | 6-7 m.                                                      |
| 6. Holding pond                                               | 4,800 m. <sup>3</sup> (providing 1-½ months detention)      |
| 7. Number of engine pumps required                            | 2 (one for raw water and one for finished water)            |
| 8. Pre-filter                                                 | 1 unit (detention time 5 hrs.)                              |
| 9. Slow sand filter                                           | 1 unit) design rate 0.15m <sup>3</sup> /m <sup>2</sup> /hr) |
| 10. Chlorination                                              | Hypochlorite                                                |
| 11. Clear well capacity                                       | 100 m. <sup>3</sup>                                         |
| 12. Elevated tank capacity                                    | 45 m. <sup>3</sup>                                          |
| 13. Revenue collection                                        | metering system                                             |
| 14. Hour of filter run per day                                | 8                                                           |
| 15. Hour of service per day                                   | 24                                                          |

6.1.9 Progress Work to Date

The main construction of Ban Bangloa Water Supply Treatment Plant has been carried out by the selected contractor through open bidding. Some small part of the construction such as digging storage pond and laying pipe line has been carried out by the villagers. The progress of plant during the construction are shown in Fig. 10 and 11. It is expected that the system will be ready for operation within the next 3-4 months at most.

TABLE 3: Percentage of construction progress of Ban Bangloa Water Treatment System (up to June 1979).

| UNIT UNDER CONSTRUCTION      | % OF COMPLETION |
|------------------------------|-----------------|
| 1. Holding pond <sup>d</sup> | 90              |
| 2. Pre-filter                | 90              |
| 3. Slow sand filter          | 20              |
| 4. Clear well                | 20              |
| 5. Elevated tank             | 85              |
| 6. Distribution system       | 90              |

FIG : 10

Holding pond (capacity Of 4,800 m<sup>3</sup>) for the Water Treatment Plant at Ban Bangloa, Singhburi Prov. S.S.

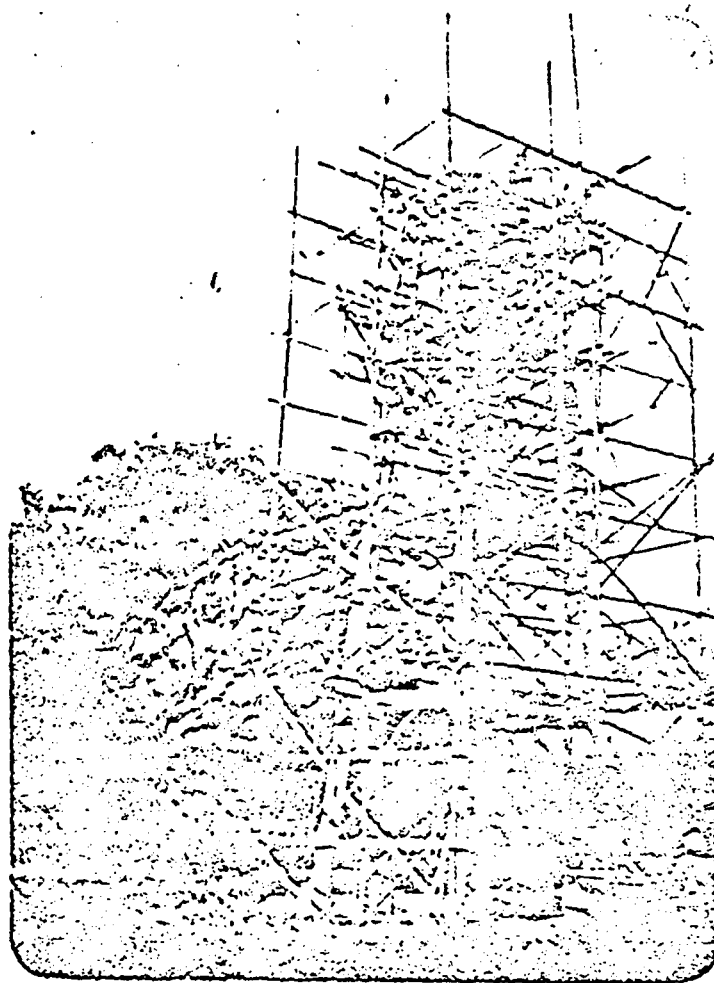


FIG : 11

Elevated tank under construction at Ban Bangloa,  
Singhburi Province.

6.1.10 Construction  
Cost  
Breakdown

Most construction has been carried out through the bidding process. Table 4 shows the construction cost breakdown of various units at Ban Bangloa. The percentage of each unit as compared to the total costs are also calculated. It should be noted that the construction cost of the pre-filter and slow sand filter units are 7.5 % and 13.0 % of the total costs respectively. The cost of the distribution system is 23 % of the total cost but this cost still has not included the cost of connection to individual houses.

TABLE 4: Results of cost breakdown of various units of the system at Ban Bangloa, Singhburi Province.

| DESCRIPTION                                                              | COST-BAHT<br>(US\$ 1 = ฿ 20) | % OF TOTAL<br>COST |
|--------------------------------------------------------------------------|------------------------------|--------------------|
| 1. Raw water pump house                                                  | 51,000                       | 3.4                |
| 2. Electric pump for<br>raw water                                        | 60,000                       | 4.0                |
| 3. Clear water pump<br>house                                             | 39,000                       | 2.6                |
| 4. Electric pump for<br>clear water                                      | 60,000                       | 4.0                |
| 5. Pipe connection within<br>raw water pump house                        | 14,000                       | 1.0                |
| 6. Pipe connection within<br>clear water pump house<br>& treatment plant | 61,000                       | 4.0                |
| 7. Pre-filter                                                            | 112,500                      | 7.5                |
| 8. Slow sand filter                                                      | 195,000                      | 13.0               |
| 9. Clear well                                                            | 162,500                      | 11.0               |
| 10. Elevated tank                                                        | 247,500                      | 16.7               |
| 11. Chlorination tank                                                    | 10,000                       | 0.6                |
| 12. Raw water distribution<br>& delivery system                          | 343,500                      | 23.0               |
| 13. Tools for repair of<br>engine and for pipe<br>connection             | 15,000                       | 1.0                |
| 14. Miscellaneous items,<br>fence, name plate & etc.                     | 123,000                      | 8.2                |
| <b>TOTAL COST</b>                                                        | <b>1,494,000</b>             | <b>100.0</b>       |



Ban Thadindam  
Village,  
Lopburi Province

4.2.1 Background

Information

Ban Thadindam is located at latitude 15° 15' N and longitude 101° 15' E in Chaibadal District, Lopburi Province. The village is located about 220 kms. in the northerly direction of Bangkok (Fig 1). It is inhabited by 220 families by 6 persons. It was awarded by the Government Committee as a demonstration village on development in 1978 (Fig. 12 & 13).

4.2.2 Climate

Ban Thadindam is also situated in the central part of the country in tropical zone. The average temperature is about the same as Ban Bangloa, falls between 15° C-38° C. The average annual rain fall is about 1,069 mm., while the average relative humidity is 71.45 %.

4.2.3 Occupation  
and Income

As the village is surrounded by the fertile black soil which can provide high yield of cultivation, the principal occupation has been rice-farming. Labour and home-industry such as mat-weaving, stock-raising are the next professions. The average yearly income per family lies between ¥ 10,000-20,000 (US\$ 500-1,000).

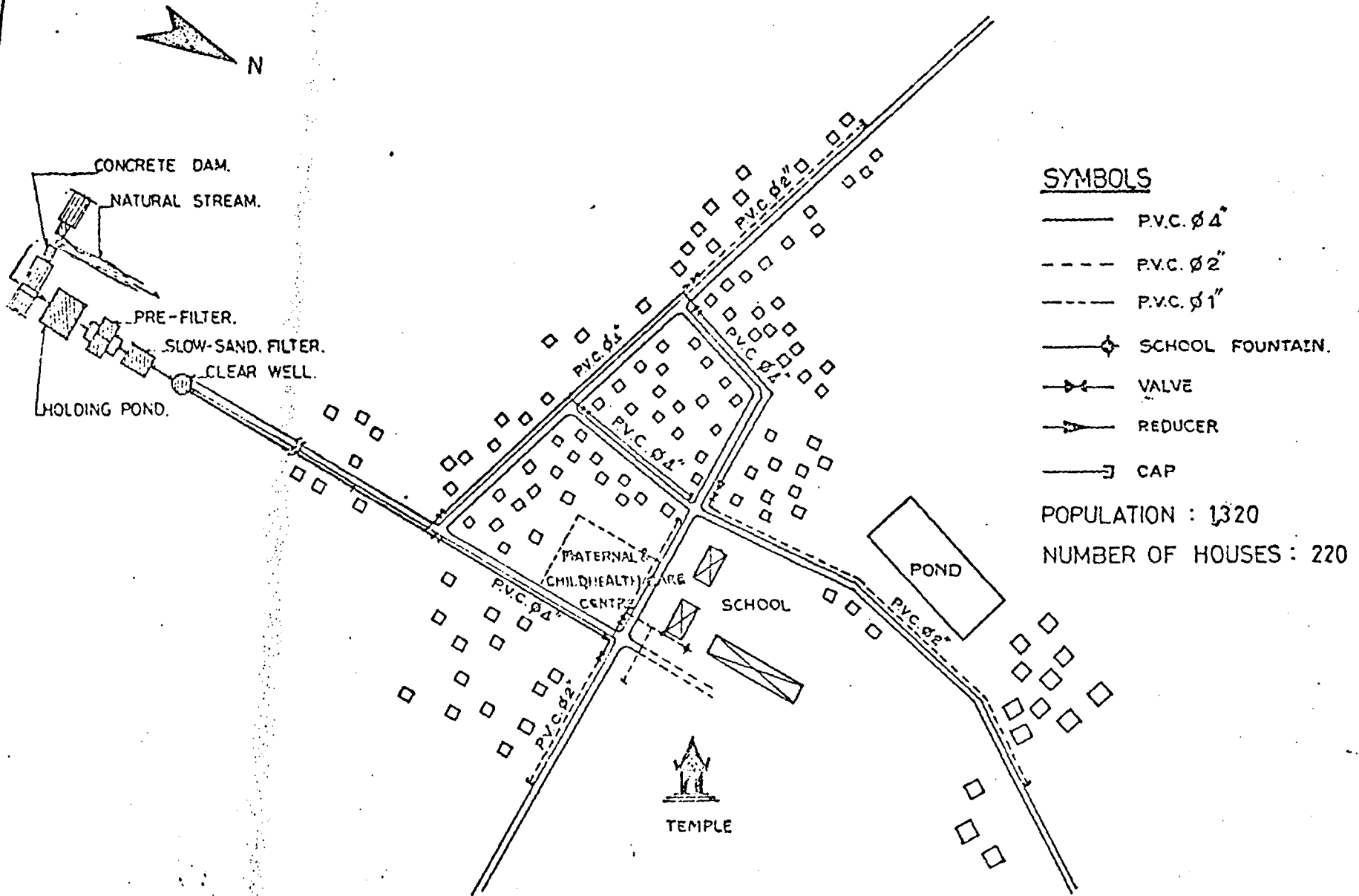
4.2.4 Education

A school of the compulsory level is provided within the village. Vocational school and college of education are available in Lopburi Province for one who would like to further the study. More than 86 % of the villagers are literate.

4.2.5 Water and  
Sanitation

The village lies at the bottom of a hilly area where natural springs can be found flowing through the village and finally to Pasak River. The villagers therefore, have depended on this natural stream for their livelihood since the old days. The private shallow wells are also found in this village. The water from spring is so clear that chemical coagulation is not needed. Rain water is also used and collected in earthen jars for drinking purpose. Each household, in general

BAN THADINDUM. AMPHUR CHAIBADAL. CHANGHAD LOBBURI.



SYMBOLS

- P.V.C.  $\phi 4$ "
- - - P.V.C.  $\phi 2$ "
- · - · P.V.C.  $\phi 1$ "
- ◆ — SCHOOL FOUNTAIN.
- | — VALVE
- > — REDUCER
- ] — CAP

POPULATION : 1320  
 NUMBER OF HOUSES : 220

FIG.12 MAP SHOWING DISTRIBUTION SYSTEM.

has its own latrine which is a good indication of sanitation programme. The refuse is mostly collected in an open pit and disposed of by burning. Poultry and livestock are also kept under the floor of the house and house surrounding areas.

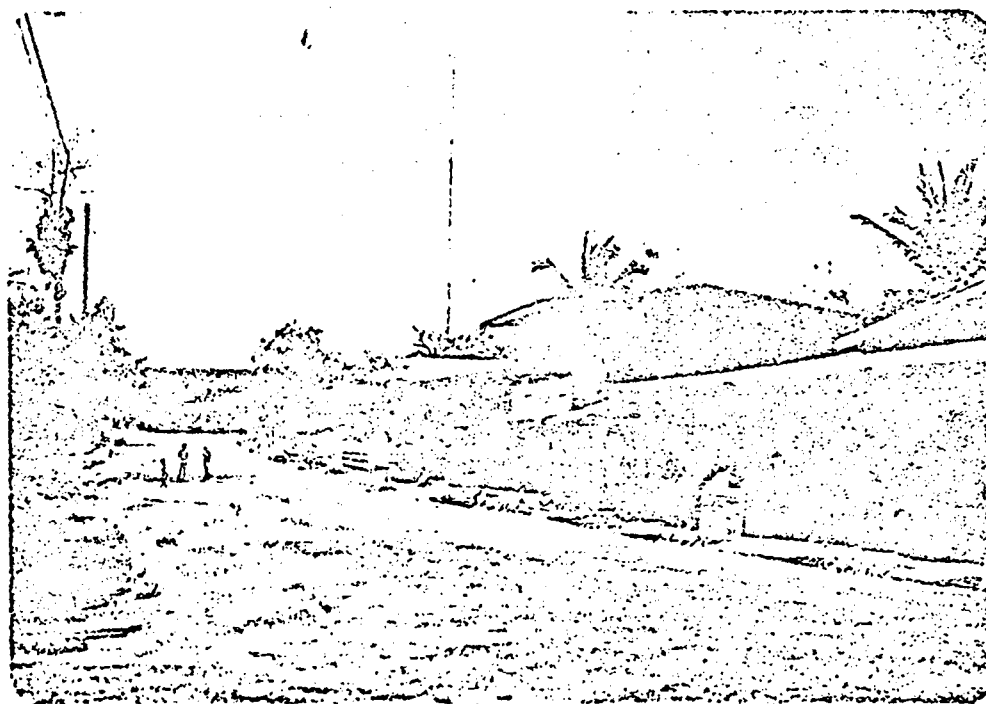


FIG : 13

Showing general view of Ban Thadindam, Lopburi Province

2.6 Participation Villagers are quite eager to participate in village meeting. When the rural water supply has been introduced into the village, they have been informed that they have to participate in the project to some extent. The preliminary survey has revealed that they agreed to provide free labour, materials and contribution towards water meter for their house connectic Table 5 shows the extent of community participation.

TABLE 5: Community participation.

| DESCRIPTION                               | VALUE EQUIVALENT |       |
|-------------------------------------------|------------------|-------|
|                                           | BAHT             | US \$ |
| 1. Labour for digging holding pond        | 10,000           | 500   |
| 2. Land for treatment plant               | 10,000           | 500   |
| 3. Distribution system within the village | 80,000           | 4,000 |
| Total contribution value                  | 100,000          | 5,000 |

Percentage of contribution as compared to the total cost of construction = 10.1%

2.7 Description of Treatment Plant at Ban Thadindam

Ban Thadindam Water Supply Plant is located on a hill which give rise an elevation of about 20 m. above the ground level. The raw water originates from a small spring of the hill side and flows in a small stream through the village. Its turbidity is thus comparatively low throughout the year and is very ideal for the water supply since very little or almost no treatment is needed.

The Water Supply Plant has been constructed at the site about 800 m. from the village boundary. The stream bed, with concrete wall of about 13 m. long, earthen compact dams are then extended on both sides of the concrete dam wings, thus giving the complete dam for controlling the water level is installed in the opening at the middle of the dam to regulate the water flow (Fig. 14 & 15).

An earth channel of about 3m. wide and 1m. deep and 200m long is constructed to divert the raw water from the dam into the holding pond (Fig. 16). The main features of

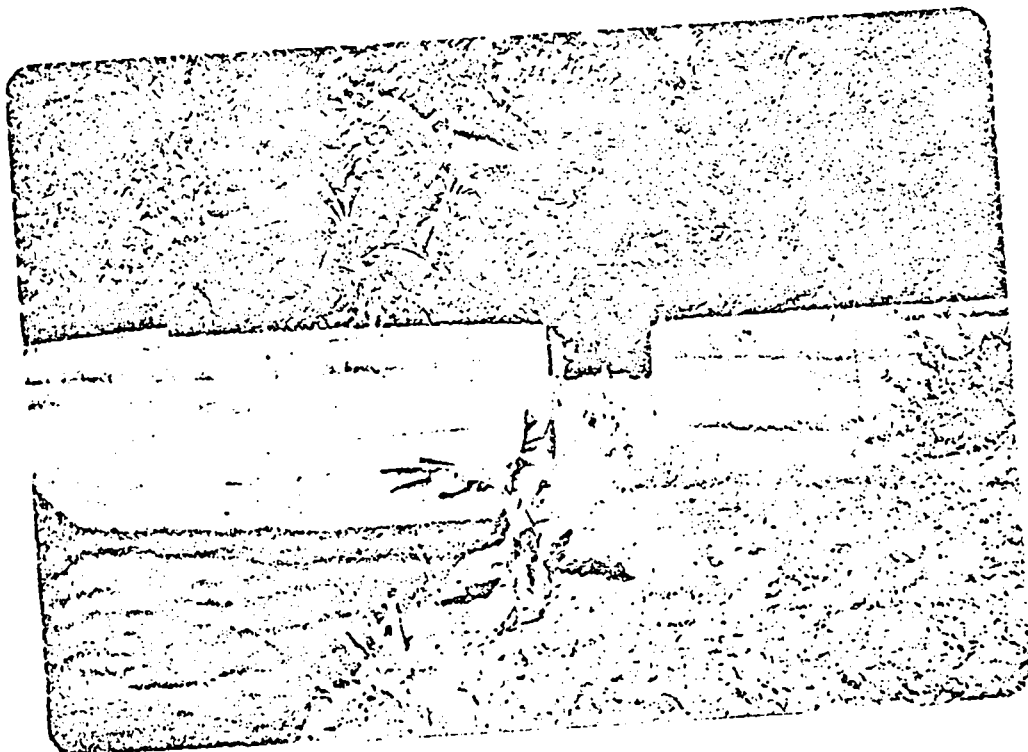


FIG : 14  
Photo showing the dam across the stream bed at Ban Thadindam, Lopburi Province.

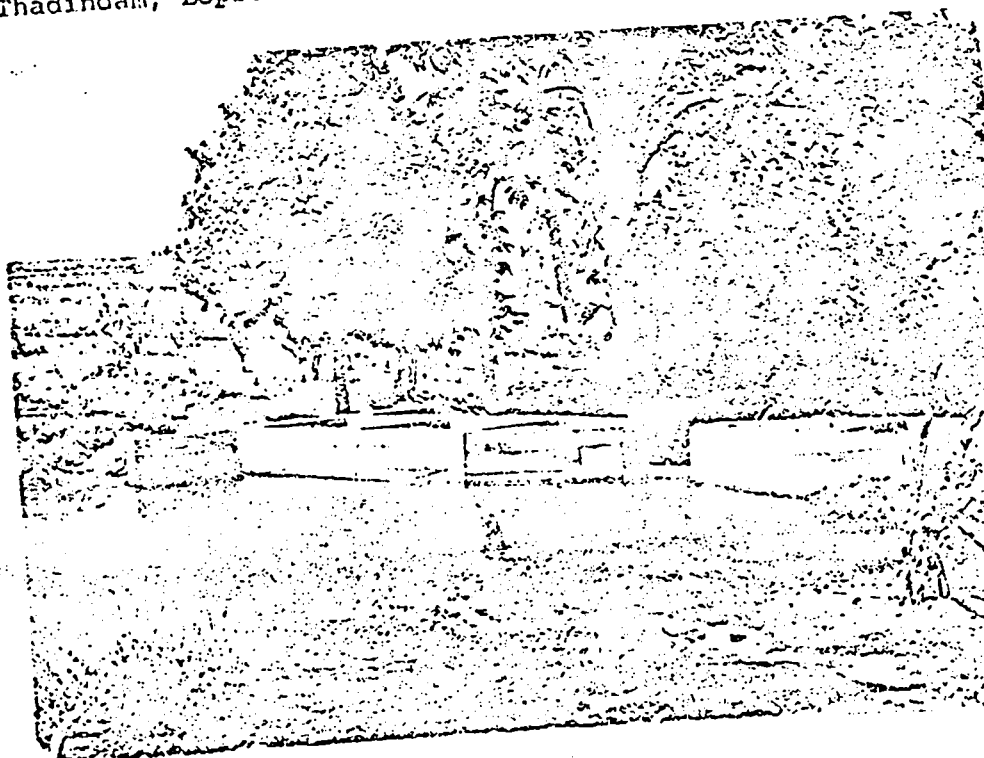


FIG : 15  
Photo showing the concrete dam at Ban Thadindam Lopburi Province.

the treatment process consist of a holding pond, pre-filtration and slow sand filtration. The small holding pond or reservoir of an area of approximately 1,600 m<sup>2</sup> and 3 m. deep is built to provide the detention period of approximately 6 weeks.



FIG : 16

Photo showing the earth channel conveying raw water to holding pond.

The water from the holding pond is then allowed to flow into the pre-filter which is a rectangular tank of 6.5m wide x 8.8 m. long and 1m. deep. The tank is divided into seven small compartments with wire mesh partition. The tank is packed with graded crushed stones of various

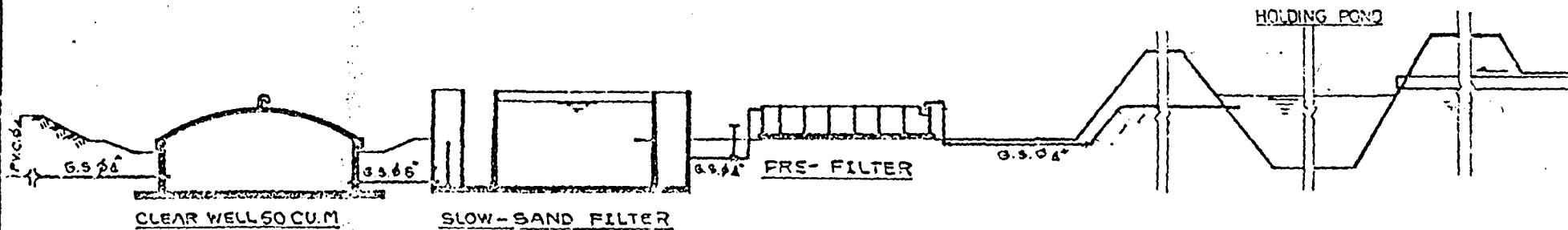
sizes. The flow of water into pre-filter is controlled by a gate valve; then into the slow sand filter by V-notch weir. The filter has been designed as rectangular tank with the dimension of 5 m. wide x 6 m. long and 2.8 m. deep. The graded sand is filled in the bed to about 1.5 m. high. The water height above sand bed is to be about 1.5 m. The free board provided is about 0.30 m. The conventional filtration rate of  $0.15 \text{ m}^3/\text{m}^2/\text{hr.}$  has been used in the design. The treated water is allowed to flow into a clear well of the capacity of  $60 \text{ m}^3$ , from which it is supplied to the villagers by gravity (Fig. 16).

The salient features of Ban Thadindam Water Supply Plant can be summarized as Table 6.

TABLE 6 : Salient features of Ban Thadindam Water Supply Plant.

| DESCRIPTION                         | DATA                             |
|-------------------------------------|----------------------------------|
| 1. Population served                | 1,320                            |
| 2. Raw water source                 | natural spring                   |
| 3. General physical characteristics | clear                            |
| 4. Dam                              | 30 m. long                       |
| 5. Holding pond capacity            | $4,800 \text{ m}^3$              |
| 6. Pre-filter                       | 1 unit (6.5m. x 8.8m. x 1 m.)    |
| 7. Slow sand filter                 | 1 unit (5m. x 6m. x 2.8 m. deep) |
| 8. Clear well capacity              | $60 \text{ m}^3$                 |

BAN THADINDUM. AMPHUR CHATBADAL. CHANGWAD LOFBURI.



TREATMENT PLANT PROFILE

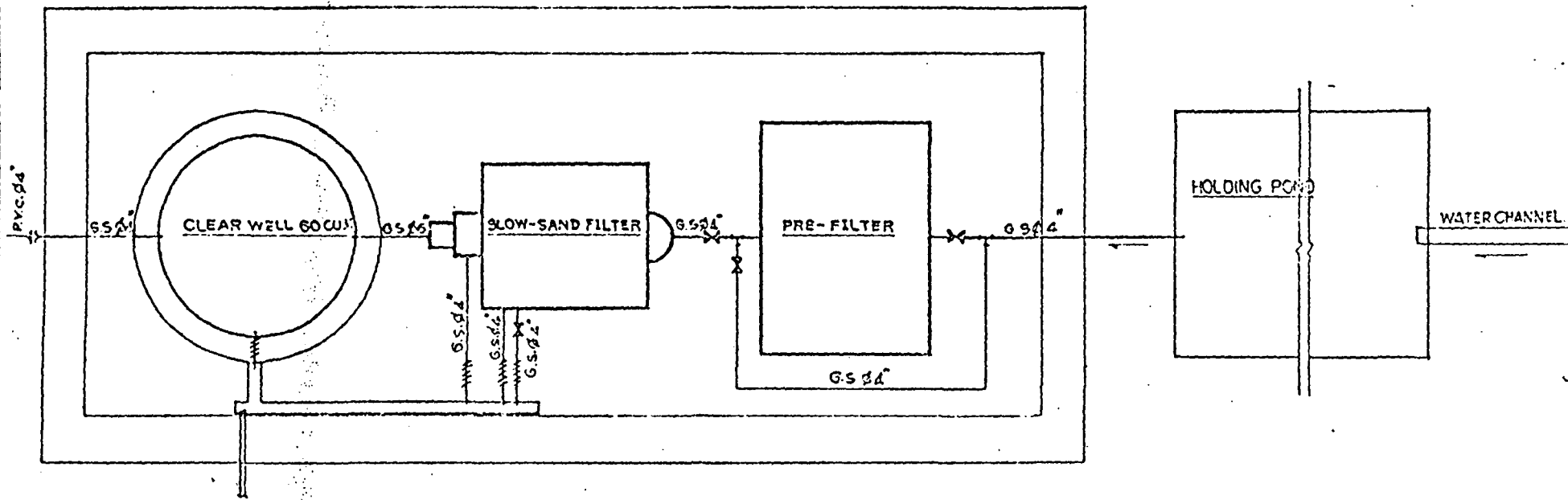


FIG 16 TREATMENT PLANT LAY-OUT PLAN



2.8 Progress Work  
to Date

The construction of Ban Thadindam Water Supply Plant has been initiated since the end of 1978 and it is expected to be finished before the end of 1979. The treatment plant has been carried out by the contractor, some part of the distribution system pipe laying and digging of holding pond have been responsible by the villagers. Fig. 17 & 18 are the progress of construction. Table 7 shows the percentage of construction progress upto June, 1979.

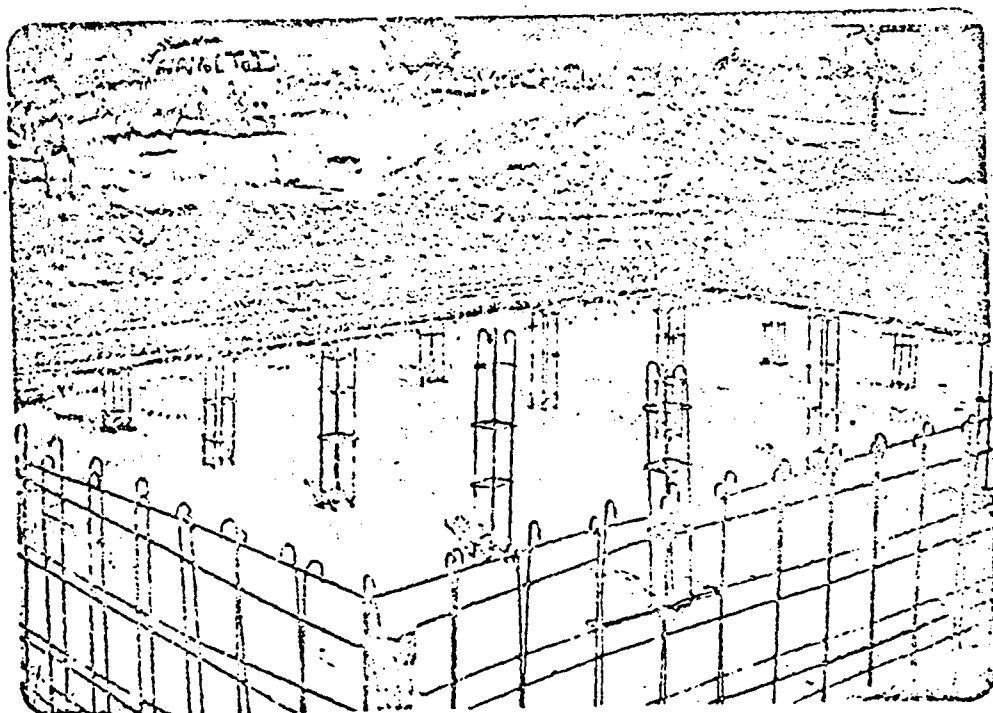


FIG : 17  
Pre-filter of Ban Thadindam, Lopyburi Province.



FIG : 18

Photo showing the site for slow sand filter at Ban Thadindam, Lopburi Province.

TABLE 7 : Progress of construction of Ban Thadindam Water Treatment Plant (as June, 1979).

| DESCRIPTION            | % OF COMPLETION |
|------------------------|-----------------|
| 1. Holding pond        | 95              |
| 2. Pre-filter          | 30              |
| 3. Slow sand filter    | 80              |
| 4. Clear well          | 25              |
| 5. Distribution system | 20              |

4.2.9 Costruction  
Cost  
Breakdown

The construction of the treatment plant has been carried out by the contractor. The cost of the construction is much lower than Ban Bangloa Water Supply Plant as the elevated reservoir and pumps are not required.

TABLE 8 : Result of bidding of Ban Thadindam Water Supply Plant, Lopburi Province.

| DESCRIPTION                                          | COST-BAHT<br>(US\$ 1 = ฿ 20) | % OF TOTAL   |
|------------------------------------------------------|------------------------------|--------------|
| 1. Pre-filter                                        | 108,200                      | 12.5         |
| 2. Slow sand filter                                  | 242,600                      | 28.1         |
| 3. Clear well                                        | 130,700                      | 15.2         |
| 4. Main distribution system                          | 327,000                      | 37.9         |
| 5. Miscellaneous items, fence,<br>name plate and etc | 54,500                       | 6.3          |
| <b>TOTAL COST</b>                                    | <b>863,000</b>               | <b>100.0</b> |

Annex 1 : Questionnaires on KAP Test

Knowledge 1.1 Do you know why are you sick from diarrhoea ?

Test at

Ban Bangloa,

Singhuri

Province

| KNOWLEDGE                | NO. OF FAMILIES | PERCENT |
|--------------------------|-----------------|---------|
| Wrong answer             | 15              | 9.2     |
| Food & water consumption | 122             | 74.3    |
| No answer                | 27              | 16.5    |
| TOTAL                    | 164             | 100     |

1.2 Do you know how to take care of a sick person's clothes which have been contaminated by excreta ?

| KNOWLEDGE                                                             | NO. OF FAMILIES | PERCENT |
|-----------------------------------------------------------------------|-----------------|---------|
| Wrong answer                                                          | 34              | 20.7    |
| Boil the contaminated clothes & dispose of the excreta into the privy | 112             | 68.3    |
| No answer                                                             | 18              | 11      |
| TOTAL                                                                 | 164             | 100     |

1.3 What would you do when you know that many villagers are becoming serious ill with diarrhoea ?

| KNOWLEDGE    | NO. OF FAMILIES | PERCENT |
|--------------|-----------------|---------|
| Wrong answer | 7               | 4.3     |
| Vaccination  | 137             | 83.5    |
| No answer    | 20              | 12.2    |
| TOTAL        | 164             | 100     |

Attitude  
Test at  
Ban Bangloa,  
Singhauri  
Province

2.1 They say " Diarrhoea can infect man at all age if man does not take care of his food and drinking water ".

| ATTITUDE  | NO. OF FAMILIES | PERCENT |
|-----------|-----------------|---------|
| Agree     | 153             | 93.3    |
| Disagree  | 7               | 4.3     |
| No answer | 4               | 2.4     |
| TOTAL     | 164             | 100     |

2.2 The contaminated clothes can be sterilized by washing with water and detergent.

| ATTITUDE  | NO. OF FAMILIES | PERCENT |
|-----------|-----------------|---------|
| Agree     | 42              | 25.6    |
| Disagree  | 33              | 20.1    |
| No answer | 89              | 54.3    |
| TOTAL     | 164             | 100     |

2.3 There is no need to be vaccinated when we know that there is diarrhoea in neighbour's house.

| ATTITUDE  | NO. OF FAMILIES | PERCENT |
|-----------|-----------------|---------|
| Agree     | 26              | 15.9    |
| Disagree  | 14              | 8.5     |
| No answer | 124             | 75.6    |
| TOTAL     | 164             | 100     |

1. Practice  
Test at  
Ban Bangloa,  
Singhburi  
Province

3.1 Do you avoid eating half-cooked food ?

| PRACTICE | NO. OF FAMILIES | PERCENT |
|----------|-----------------|---------|
| Yes      | 146             | 89      |
| No       | 18              | 11      |
| TOTAL    | 164             | 100     |

3.2 Have you ever washed contaminated clothes in a public stream, canal or other sources ?

| PRACTICE | NO. OF FAMILIES | PERCENT |
|----------|-----------------|---------|
| Yes      | 52              | 31.7    |
| No       | 112             | 68.3    |
| TOTAL    | 164             | 100     |

3.3 Have you ever been vaccinated for cholera prevention ?

| PRACTICE | NO. OF FAMILIES | PERCENT |
|----------|-----------------|---------|
| Yes      | 160             | 97.6    |
| No       | 4               | 2.4     |
| TOTAL    | 164             | 100     |

Knowledge 4.1 Do you know why are you sick from diarrhoea ?

Test at Ban

Thadindam

Lopburi

Province

| KNOWLEDGE                | NO. OF FAMILIES | PERCENT |
|--------------------------|-----------------|---------|
| Wrong answer             | 13              | 15.5    |
| Food & water consumption | 46              | 57.8    |
| No answer                | 25              | 29.7    |
| TOTAL                    | 84              | 100     |

4.2 Do you know how to take care of a sick person's clothes which have been contaminated by excreta ?

| KNOWLEDGE                                                         | NO. OF FAMILIES | PERCENT |
|-------------------------------------------------------------------|-----------------|---------|
| Wrong answer                                                      | 24              | 28.6    |
| Boil the contaminated clothes & dispose of the excreta into privy | 53              | 63.1    |
| No answer                                                         | 7               | 8.3     |

4.3 What would you do when you know that many villagers' are becoming seriously ill with diarrhoea ?

| KNOWLEDGE    | NO. OF FAMILIES | PERCENT |
|--------------|-----------------|---------|
| Wrong answer | 8               | 9.5     |
| Vaccination  | 56              | 66.7    |
| No answer    | 20              | 23.8    |
| TOTAL        | 84              | 100     |

5. Attitude  
Test at Ban  
Thadindam,  
Lopburi  
Province

5.1 They say " Diarrhoea can infect man at all age if man does not take care of his food and drinking water ".

| ATTITUDE     | NO. OF FAMILIES | PERCENT    |
|--------------|-----------------|------------|
| Agree        | 71              | 84.5       |
| Disagree     | 7               | 8.3        |
| No answer    | 6               | 7.2        |
| <b>TOTAL</b> | <b>84</b>       | <b>100</b> |

5.2 The contaminated clothes can be sterilized by washing with water and detergent.

| ATTITUDE     | NO. OF FAMILIES | PERCENT    |
|--------------|-----------------|------------|
| Agree        | 20              | 23.8       |
| Disagree     | 13              | 15.5       |
| No answer    | 51              | 60.7       |
| <b>TOTAL</b> | <b>84</b>       | <b>100</b> |

5.3 There is no need to be vaccinated when we know that there is diarrhoea in neighbour's house.

| ATTITUDE     | NO. OF FAMILIES | PERCENT    |
|--------------|-----------------|------------|
| Agree        | 6               | 7.1        |
| Disagree     | 12              | 14.3       |
| No answer    | 66              | 78.6       |
| <b>TOTAL</b> | <b>84</b>       | <b>100</b> |



6. Practice  
Test at Ban  
Thadindam,  
Lopburi  
Province

6.1 Do you avoid eating half-cooked food ?

| PRACTICE | NO. OF FAMILIES | PERCENT |
|----------|-----------------|---------|
| Yes      | 49              | 58.3    |
| No       | 35              | 41.7    |
| TOTAL    | 84              | 100     |

6.2 Have you ever washed contaminated clothes in a public stream, canal or other sources ?

| PRACTICE | NO. OF FAMILIES | PERCENT |
|----------|-----------------|---------|
| Yes      | 11              | 13.1    |
| No       | 73              | 86.9    |
| TOTAL    | 84              | 100     |

6.3 Have you ever been vaccinated for cholera prevention ?

| PRACTICE | NO. OF FAMILIES | PERCENT |
|----------|-----------------|---------|
| Yes      | 78              | 92.9    |
| No       | 6               | 7.1     |
| TOTAL    | 84              | 100     |

TABLE 1 (Annex 2 ); Results of the raw water analysis  
of Ban Bangloa, Singhburi Province.

| CHARACTERISTICS          | RAW WATER QUALITY |          |
|--------------------------|-------------------|----------|
|                          | MARCH, 79         | JUNE, 79 |
| 1. pH                    | 7.2               | 7.5      |
| 2. Colour                | 15                | -        |
| 3. Turbidity             | 65                | 40       |
| 4. Suspended solids      | 61                | -        |
| 5. Dissolved solids      | 99                | -        |
| 6. Alkalinity, pp        | 12                | -        |
| 7. Alkalinity, mo        | 72                | -        |
| 8. Hardness              | 88                | 98       |
| 9. Calcium               | 20                | -        |
| 10. Magnesium            | 9.2               | 1.9      |
| 11. Copper               | 0.06              | 0.57     |
| 12. Chromium, hexavalent | nil               | -        |
| 13. Sulphate             | 20                | -        |
| 14. Chloride             | 4                 | 6        |
| 15. Fluoride             | 0.13              | -        |
| 16. Nitrate              | 0.3               | -        |
| 17. Nitrite              | -                 | 0.189    |
| 18. BOD                  | 3.6               | -        |
| 19. Zinc                 | -                 | 0.124    |

TABLE 2 (Annex 2) : Results of raw water analysis of  
Ban Thadingam, Lopburi Province.

| CHARACTERISTICS   | RAW WATER QUALITY IN MARCH, 79 |              |
|-------------------|--------------------------------|--------------|
|                   | STREAM                         | HOLDING POND |
| 1. pH             | 6.9                            | 7.3          |
| 2. Colour         | 5                              | 5            |
| 3. Turbidity      | 1                              | 1            |
| 4. Total solids   | 575                            | 544          |
| 5. Alkalinity, pp | nil                            | nil          |
| 6. Alkalinity, mo | 246                            | 134          |
| 7. Hardness       | 294                            | 290          |
| 8. Calcium        | 97                             | 66           |
| 9. Magnesium      | 13                             | 31           |
| 10. Copper        | 0.05                           | 0.05         |
| 11. Chromium      | nil                            | nil          |
| 12. Sulphate      | 10                             | 10           |
| 13. Chloride      | 87                             | 93           |
| 14. Fluoride      | 0.21                           | 0.2          |
| 15. Nitrate       | 0.26                           | 0.26         |
| 16. Nitrite       | -                              | -            |
| 17. Zinc          | -                              | -            |
| 18. Iron          | nil                            | nil          |
| 19. Manganese     | 0.15                           | 0.22         |

TABLE 1 (Annex 3): Engineering design criteria employed by the Rural Water Supply Division, Department of Health, for the design of water treatment systems.

| DESCRIPTION                                  | DESIGN CRITERIA                           |
|----------------------------------------------|-------------------------------------------|
| 1. Population growth rate                    | 3 %                                       |
| 2. Design period                             | 10 years                                  |
| 3. Maximum day demand                        | 1.5 x average day demand                  |
| 4. Total storage                             | 70 % average day supply                   |
| 5. Elevated storage                          | 20 % average day supply                   |
| 6. Per capita consumption                    |                                           |
| - for sanitary district<br>& large community | 80 l. per capita per day                  |
| - for common village                         | 50 l. per capita per day                  |
| 7. Pipe material                             | Asbestos cement, PVC,<br>Galvanized steel |
| 8. Minimum pressure                          | 10 psi at curb                            |