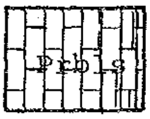
## 2. AQUIFERS IN WHICH FLOW IS DOMINANTLY THROUGH FISSURES OR GOLUTION OPENINGS

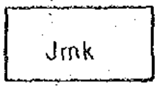
### a - MODERATELY PRODUCTIVE AQUIFERS


PHU KADUNG FORMATION (Jurassic) : Consisted of micaceous slabbly sandstone, siltstone, mudstone, shale and sandstone, locally basal conglomerate of reddish brown, purplish red and greenish gray colors. Thickness may be as much as 2,400 meters. Yield ranges from 5 - 35 $m^3$/hr with good water quality from fractured zones . Drilling in non-fractured horizon may result in dry hole or yield only 2 - 3 $m^3$/hr of water.



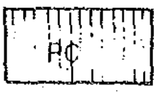

RAT BULI LIMESTONES (PERMIAN) : Consisted of massive to well bedded cavanous sand fossiliferous limestones, normally intercalated with shale or slatly shale with some chert beds, forming cliff and karstic terraces. Yield ranges from 5 - 10 $m^3$/hr from solution openings or fractured zones. Water is generally characterized by moderate to high concentration of bicarbonate.

b - LESS PRODUCTIVE AQUIFERS




PHRA WIHAN FORMATION (JURRISSIC) : Consisted of a sequence of hard and resistant orthoquartize, arkosic sandstone, pebbly sandstone and conglomerate. Generally yields small quantity of water due to high degree of cementation and generally lack of interconnected fissures. Water is good quality.


BASALT : The well know sapphire and rubies bearing basalt is characteristically of successive thin and thick flow shelt, scoracious, highly weathered, commonly jointed or fractured. The fissure zones generally yield 5 - 10 $m^3$/hr of good quality water.



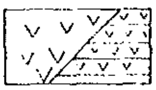
METASEDIMENTARY FORMATIONS (PERMIAN ? TO CARBONIFEROUS) : Consisted of clastic sedimentary rocks belonging to Rat Buri and Kaeng Krachan Groups of which quartzitic sandstone, feldspartic sandstones, phylitic to slaty shales, and graywacks are predominated interbedding tuffs and agglomerates occur in places. Wells drilled in fractured zone may yield up to 10 $m^3$/hr of slightly hard water, but wells of lower yields are common.

3. AQUIFERS OF LIMITED POTENTIAL, CONCEALED AQUIFERS, REGION WITHOUT SIGNFICANT GROUND WATER

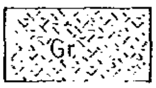
a - CONCEALED AQUIFER AND AQUIFER OF LIMITED POTENTIAL.


METAMORPHIC ROCKS (DEVONIAN TO CARBONIFEROUS) : Consisted of slate, phylite, schist, quartzite, argillaceous limestone with occasional talc, chert and quarts micaschist. Drilled wells may yield very few to about 40 $m^3$/hr of minerallized water. Saline water is expected in area where the aquifer forms bedrocks underlying the coastal plains accetable quality can be, however locally obtained.

b - IMPERMEABLE ROCKS GENERALLY WITHOUT GROUND WATER.


Rh & Rh-tuff

UNCLASSIFIED EXTRUSIVE ROCKS : Consisted of andesite, rhyolite, trachyte and volcanic tuff of varying thickness and age. Ground water occurs mainly in joints fractures, and weathering zone. Yield ranges from meager to 7 $m^3$/hr has been exceptionally obtained. Water quality is generally good except in area along the shore line.




GRANITIC ROCKS : Consisted of fine grained to porphyritic, locally concealed under unconsolidated sediments. Outcrops and concealed bodies in coastal plain region are intensely weathered as deep as 20 meters. Ground water of exceptional quantity has been developed from fractured zones, but meager quantity is generally obtainable from weathered zones which extend to the depth exceeding 10 meter. Water quality is of fair to good but in places high concentration of fluoride and iron are common.


PЄng - PЄsch

GNEISS AND SCHIST : Non-productive even in decomposed zones.

GEOLOGIC & HYDROGEOLOGIC SYMBOLS

| | |
|---|---|
| F ——— F | Fault |
| | Geological Boundary |
| ——— — — | Changwat Boundary |
| ——— — — | International Boundary |
| ◎ | Changwat Capital |
| o | Amphoe |
| ——— | Roads |
| ——— | Rail Roads |
| | Stream |
| MA 20/150<br>40/036 | Drilled Well(in feet)<br>Well Number/Depth of Well in Feet<br>Static Water Level/Spectic Capacity |

### 2-4-3 Results of Geoelectric Prospecting Survey

Boring is the most accurate of all soil exploration methods, but is difficult to perform because it is expensive and because it must be carried out at many sites. If approximate information on the geologic nature of the survey area can be obtained before boring, the amount of boring can be minimized in order to reduce survey time and costs.

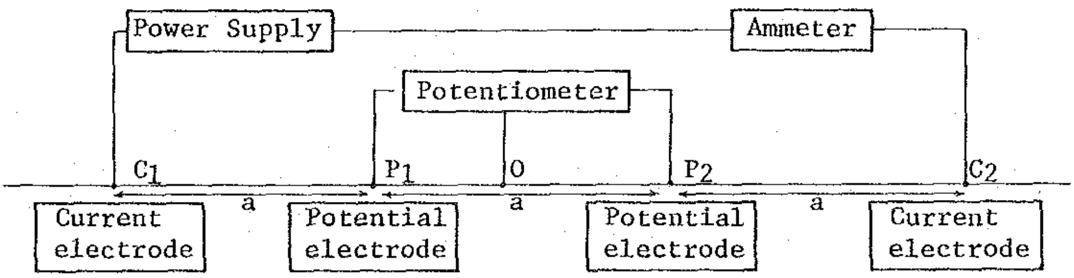
Geoelectric prospecting is one of the common geophysical tests. The resistivity method is the most widely used type of geoelectric prospecting because of the universal fact that resitivity differs from aquifer to aquiclude and because the soil to be explored is stratified in most instances. A clue to the geophysical nature of the soil is obtained by determining its resistivity.

The resistivity of soil is influenced by the following factors:

1. Mineral content
2. Compactness of soil constituents
3. Soil porosity
4. Water content

The electric logging performed was carried out by Wenner's four-electrode method as follows:

(Wenner's Method)




$$\text{Apparent resistivity } (\rho) = 2\pi \times \frac{\text{Potential difference (V)}}{\text{Total current (I)}} \times \begin{matrix}\text{Electrode}\\ \text{spacing } (\alpha)\end{matrix}$$

The electrode spacing was varied from 0.5 m to 100 m.

The record of formations passed through during geoelectric prospecting was analyzed by Sundberg's standard curve and direct vision method. The $\rho\alpha$-$\alpha$ curves are shown in Figs. 2-20 through 2-24.

Ban Sam Rong:

This is located in a basin area with an elevation of about 130 m; the Sai Khao River divides the area into model villages No. 8 and No. 2 and flows toward the eastern border with Khampuchea.

Geoelectric prospecting was performed at two points in the Ban Sam Rong area and the following data was obtained.

Survey No. 4

Surface soil in 0 ∿ 1.3 m thick, and clay predominates in the layer 1.3 ∿ 9.7 m. The layer 9.7 ∿ 15.7 m is assumed to consist of sand and gravel of 495 ohm-m resistivity and the soil below 15.7 m seems to consist of hard rock (corresponding to limestone).

It is presumed that ground water flows through the layer of sand and gravel at a depth of 9.7 ∿ 15.7 m.

Survey No. 5:

Surface soil is 0 ∿ 1.2 m, and resistivity is decreased in the layer 1.2 ∿ 2.2 m deep. This layer seems to be composed of humic gley soil. The layer 2.2 ∿ 10.6 m deep appears to consist of sand, and the layer 10.6 ∿ 21 m deep consists of sand and gravel. The material of this layer is moderately hard. At depths below 21 m, hard rock similar to that of survey No. 4 exists.

It is presumed that ground water flows through the stratum of gravel at a depth of 5 ∿ 15 m. When survy sites No. 4 and No. 5 are compared, the No. 4 site seems to provide a better supply source from the standpoint of avoiding contamination with domestic sewage. Be that as it may, the well siting should be determined in consideration of the presence of hard rock, distance from the Sai Khao River, distance from the existing sources of pollution, and the service of the well as a public facility.

Tagad Ngao:

This Model Area is located on a plateau with an elevation of about 8 m sandwiched between two creeks, with hilly land with an elevation of 78 m behind it. The model village is located at 2 to 3 km from the coast.

Geoelectric prospecting survey was performed at two points in this model area.

Survey No. 2:

Surface soil is 0 ∿ 1.8 m thick and dry. Its resistivity is high. At depths ranging from 1.8 ∿ 3.4 m the resistivity is 247 ohm-m; this value corresponds to gravel. Below 3.4 m, the resistivity is low and the presence of clay is suggested. At the depth of 8 m which is equal to the elevation of this district, the resistivity is near 0. This fact suggests that ground water of this district is affected by salt water.

Survey No. 3:
Surface soil is 0 ∿ 1.3 m followed by a stratum showing clay predominance and 52 ohm-m resistivity. At depths of 31.5 ∿ 50 m, the soil has resistivity of 145 ohm-m; this value suggests that the soil is sandstone. It is presumed that ground water occuring below 50 m is affected by salt water as at site No. 2.

Judging from these results of the geoelectric prospecting survey, it can safely be presumed according to Ghyben-Hergberz's law that an aquifer of fresh water exists under the hilly land with an elevation of 78 m. In this model area, wells should be excavated at points a little more towards the mountains from site No. 3; however, the distance from site No. 4 must also be taken into consideration. It is well to anticipate that the water table of this aquifer may sink during the low water season, especially in the drought period in part because of evaporation through the ground surface and drafts from the shallow wells. To avoid a sharp decline in well water production during the dry season, deep wells 30 ∿ 35 m deep should be excavated to tap unconfined water. When tapping this aquifer, care should be exercised so that the water table does not fall below the sea water level.

The prapokklao area:
This is located in the Chanthaburi river basin. The aquifer in this area is therefore easily recharged.

The southwest area of the urban area where the Prapokklao Hospital is located is situated in reclaimed marshy land with an elevation of about 6 m. Electric logging was performed in vacant land about 100 m apart from the existing well. According to the geoelectric prospecting survey results, the surface soil is dry to a depth of up to 0.8 m and clay of 55 ohm-m resistivity predominates in the layer of 0.8 ∿ 17 m. Below 17 m, the soil resistivity decreases, suggesting that salt water has intruded by the aquifer. There are signs, however, that below 50 m the soil resistivity decreases further.

Based on the results of hydrogeological and geological surveys and geoelectric logging, the following recommendations are made:

1. In the first stage, shallow wells 15 ∿ 20 m deep should be excavated. These wells will yield certain amounts of water from the alluvial aquifer.
2. In the second stage, deep wells about 70 m deep should be driven to tap unconfined water at a depth of 50 to 60 m below the ground surface.
3. From the hydrogeological point of view, it is desirable that the wells of this model area be dug in the lowland area north of the city of Chanthaburi at the junction of the Chanthaburi River and its tributary or in the balsaltic layer on the Tha Mai side, assuming that these points are not too far from the Prapokklao Hospital.

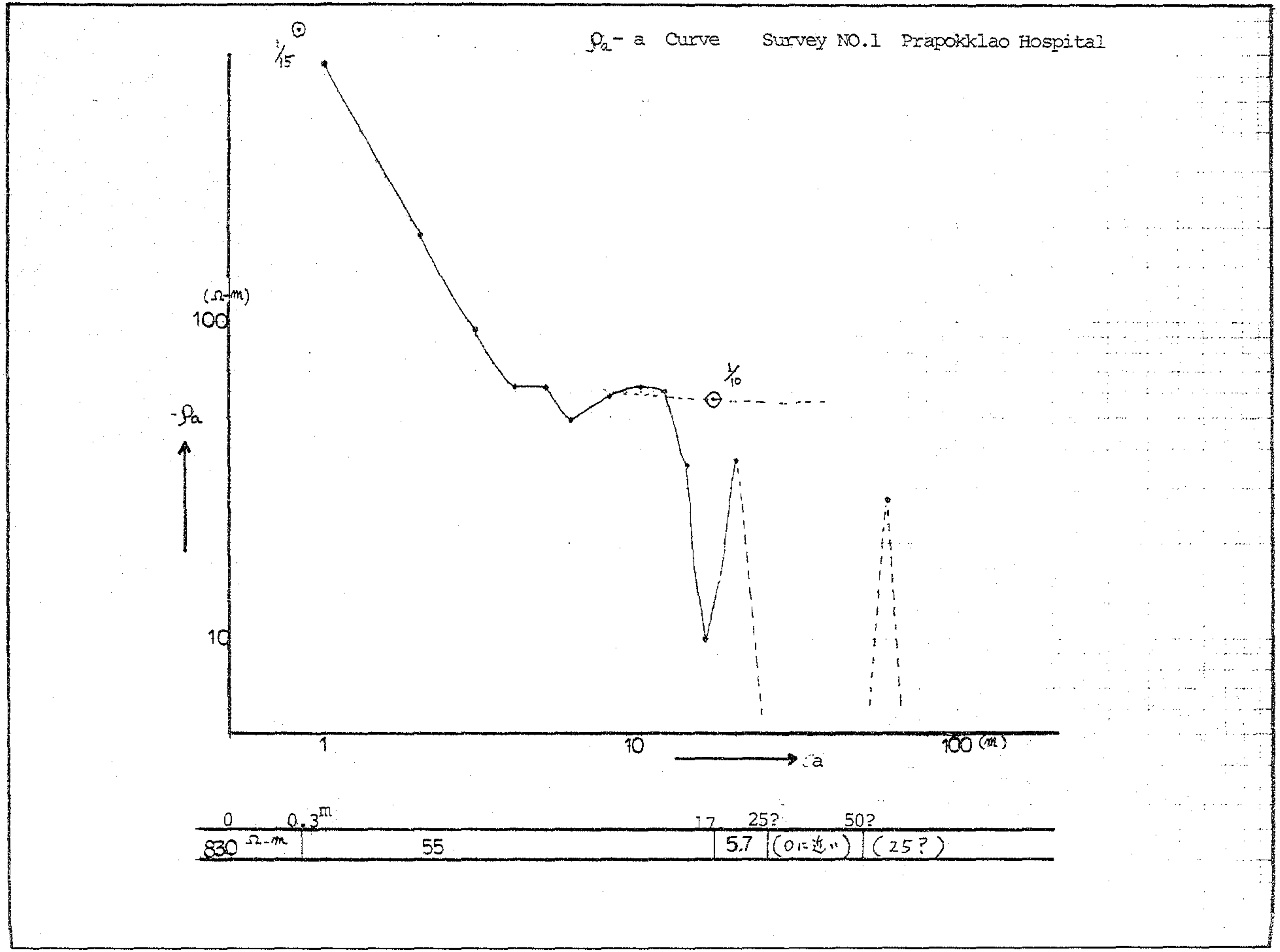



Fig.2-19 Data Sheet of Geoelectric Prospecting

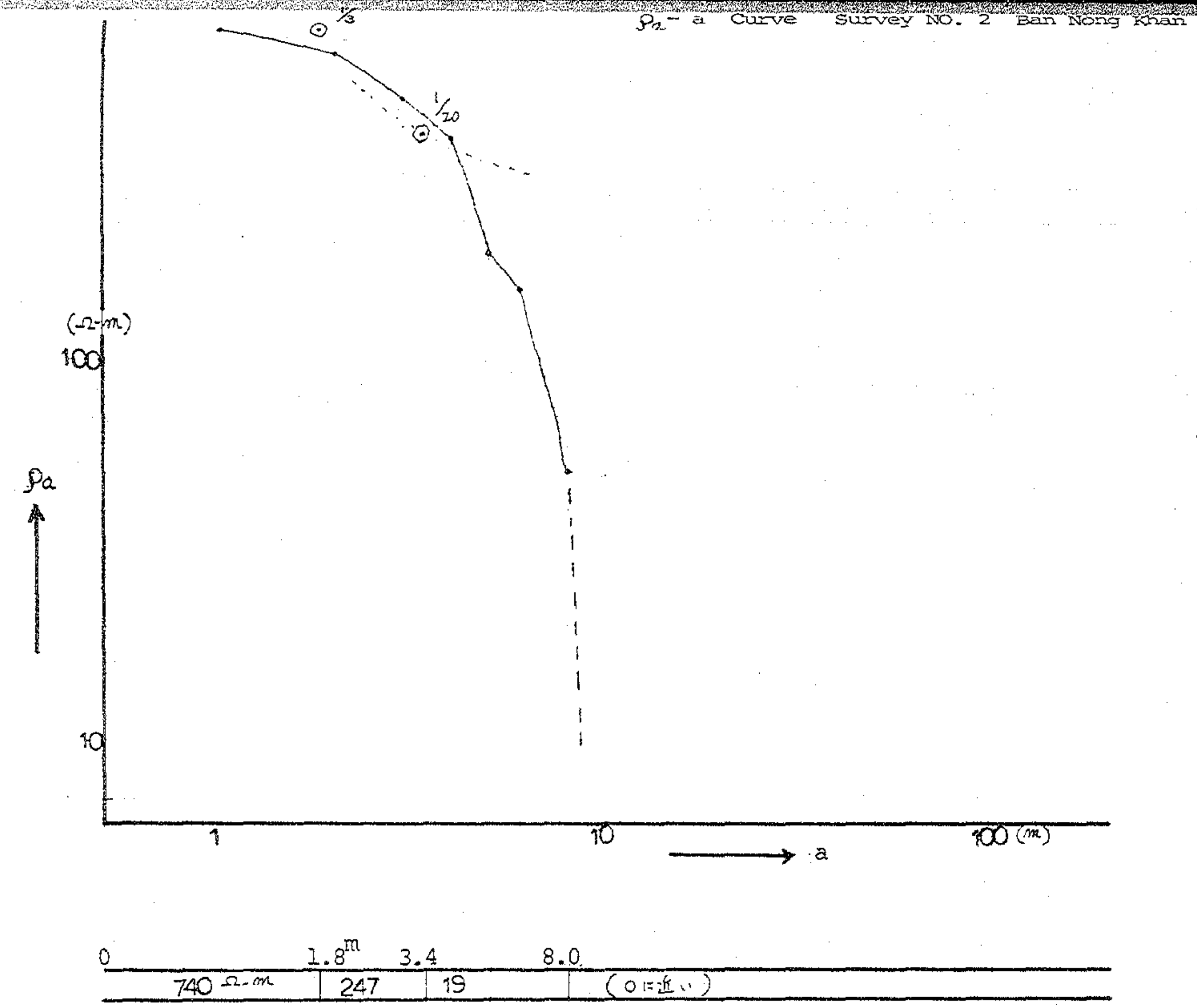



Fig.2-20 Data Sheet of Geoelectric Prospecting

$\rho_a$ - a Curve Survey NO.3 Ban Nong Khan

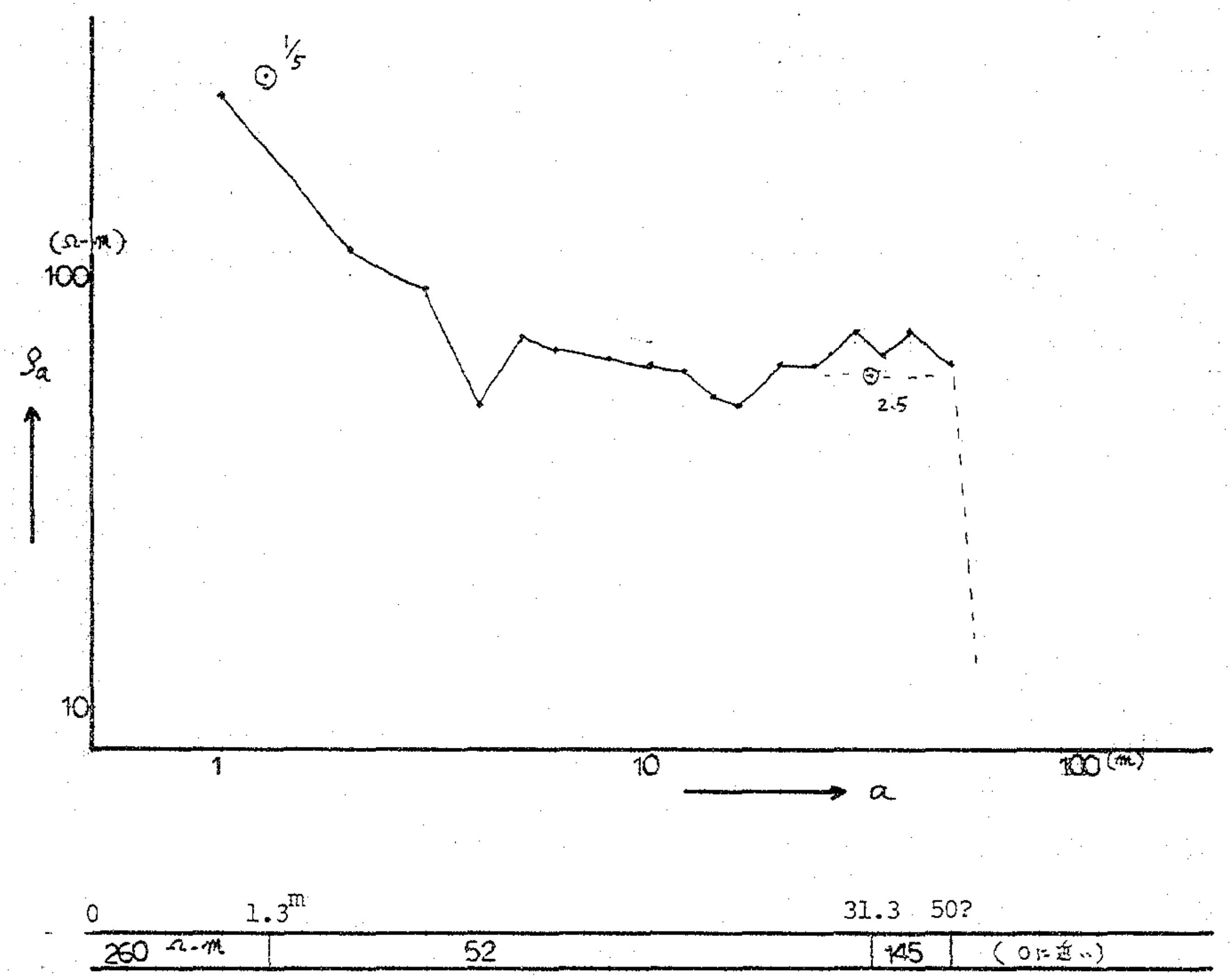



Fig.2-21 Data Sheet of Geoelectric Prospecting

$\rho_a$ - a Curve Survey NO.4 Ban Rong

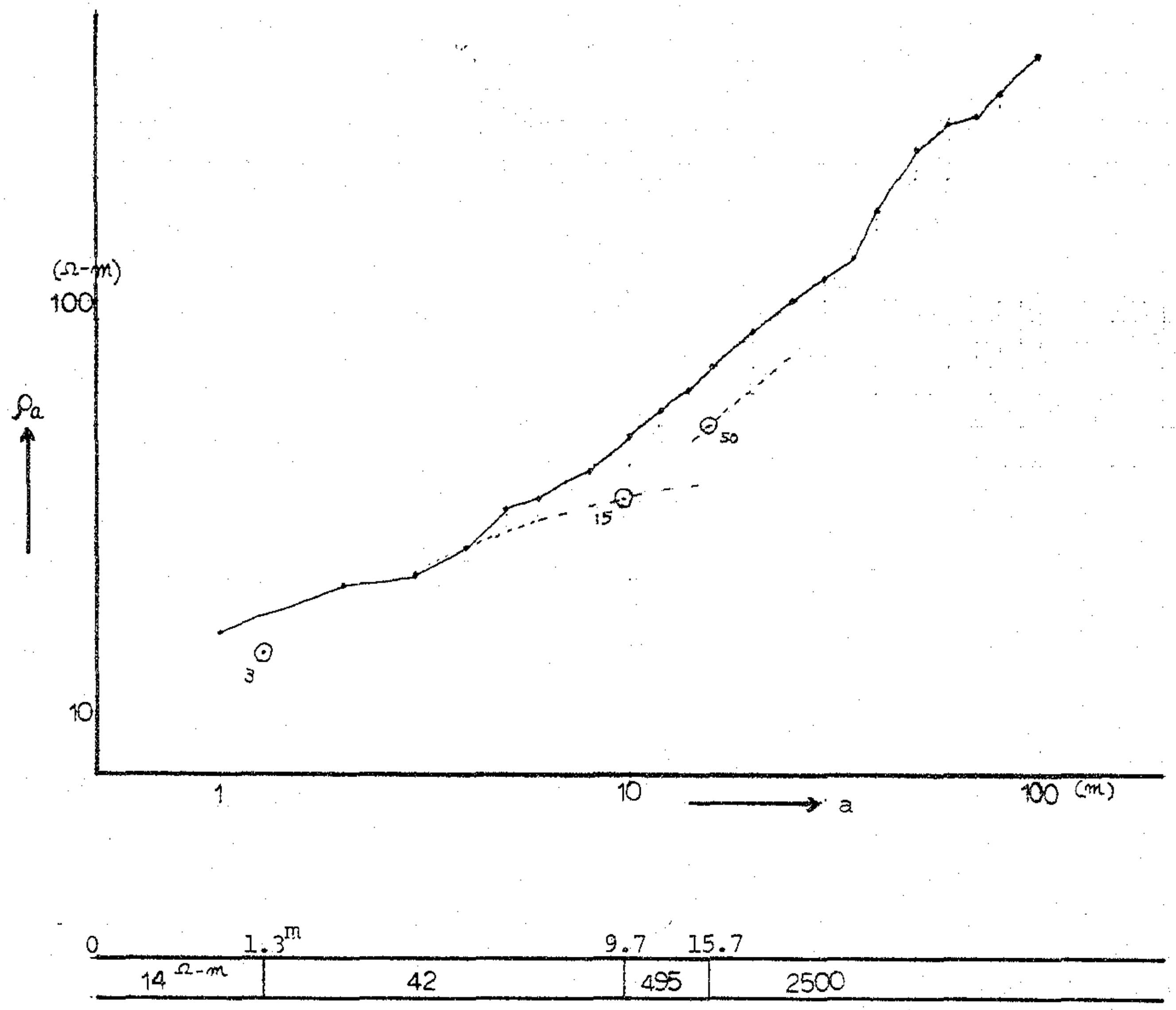



Fig.2-22 Data Sheet of Geoelectric Prospecting

$\rho_a$ - a Curve   Survey NO.5 Ban Rong

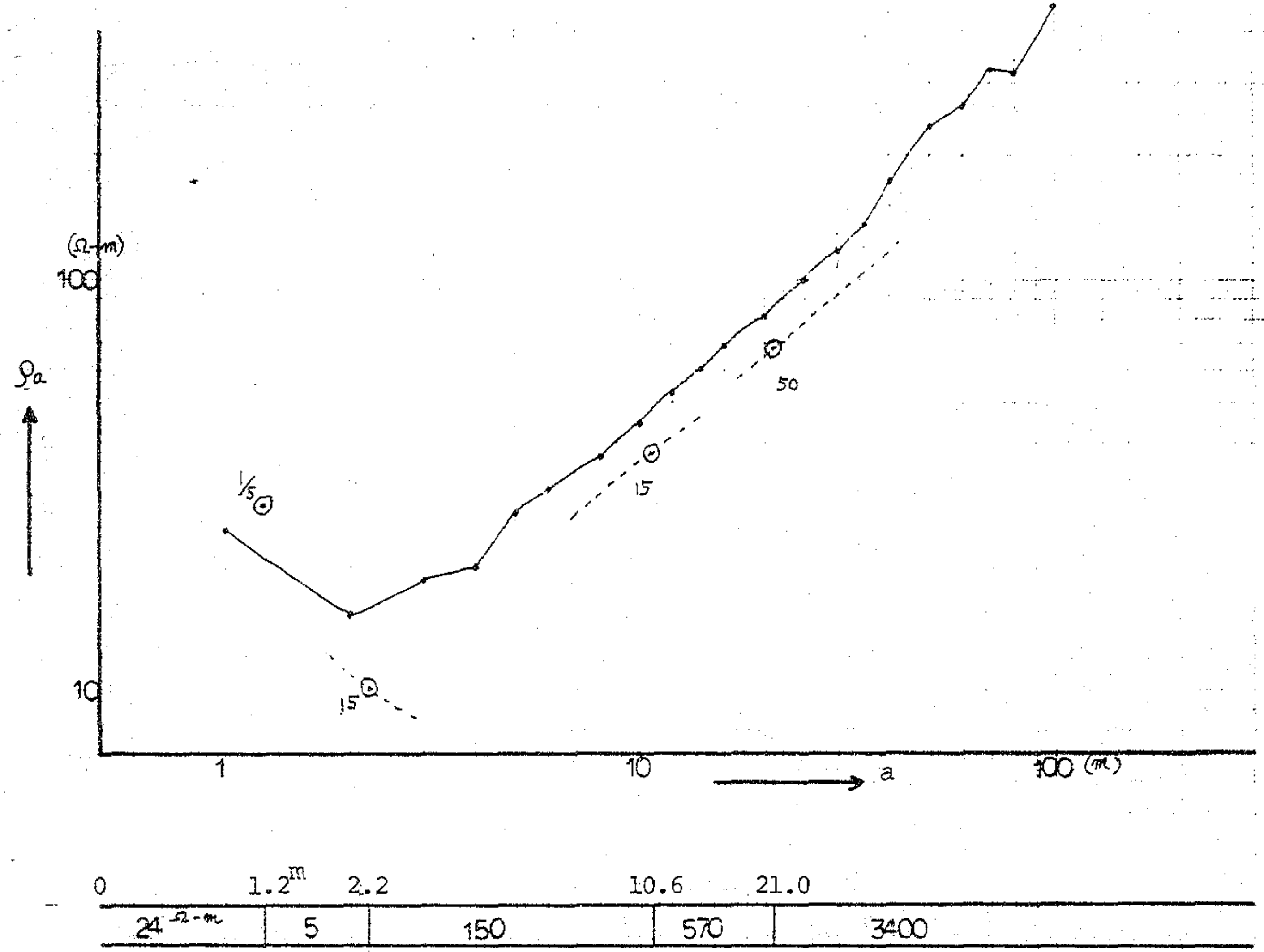
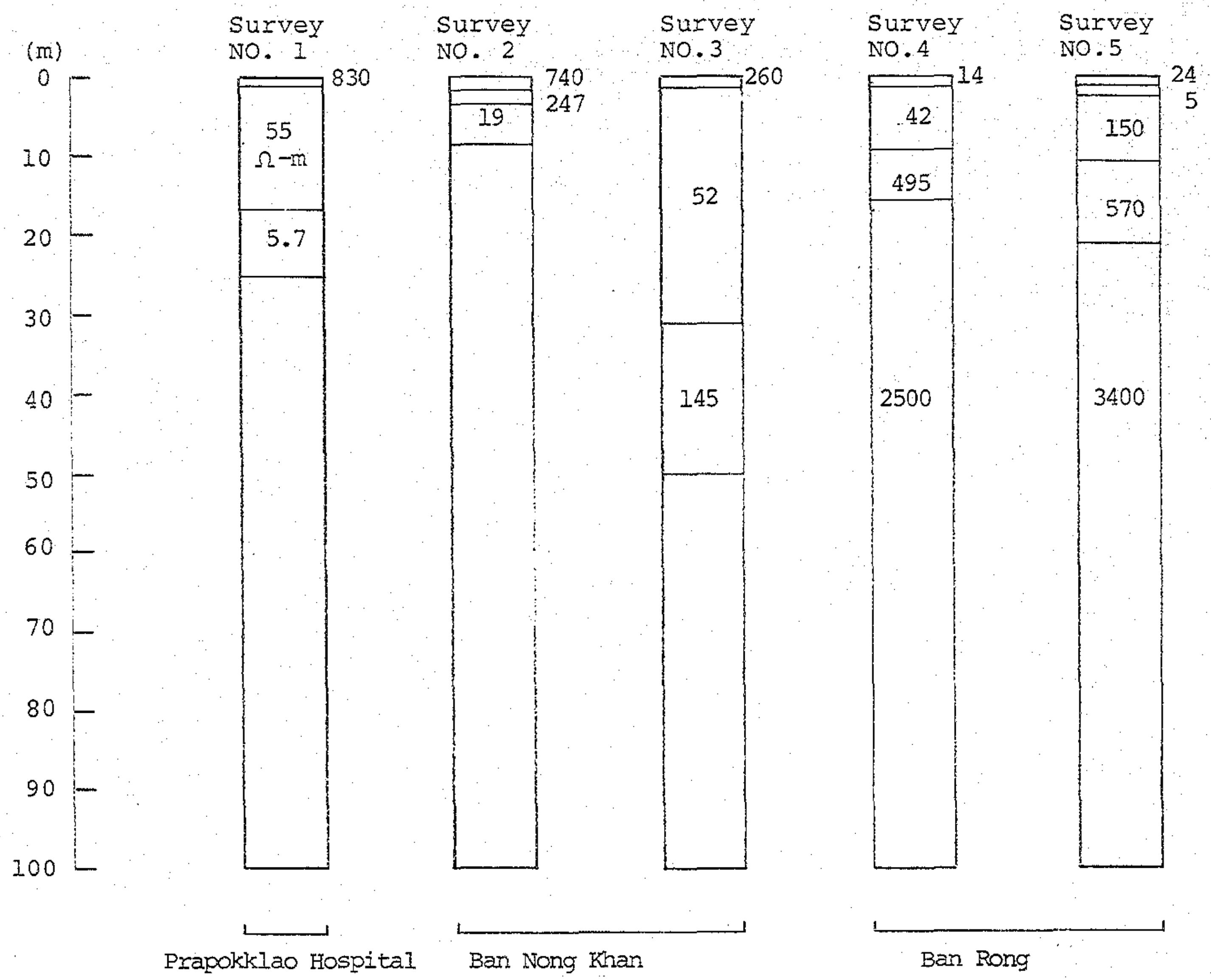



Fig.2-23 Data Sheet of Geoelectric Prospecting

Fig.2-24 Presumed Columns of Geological Log Based on Geoelectrical Resistivity Method



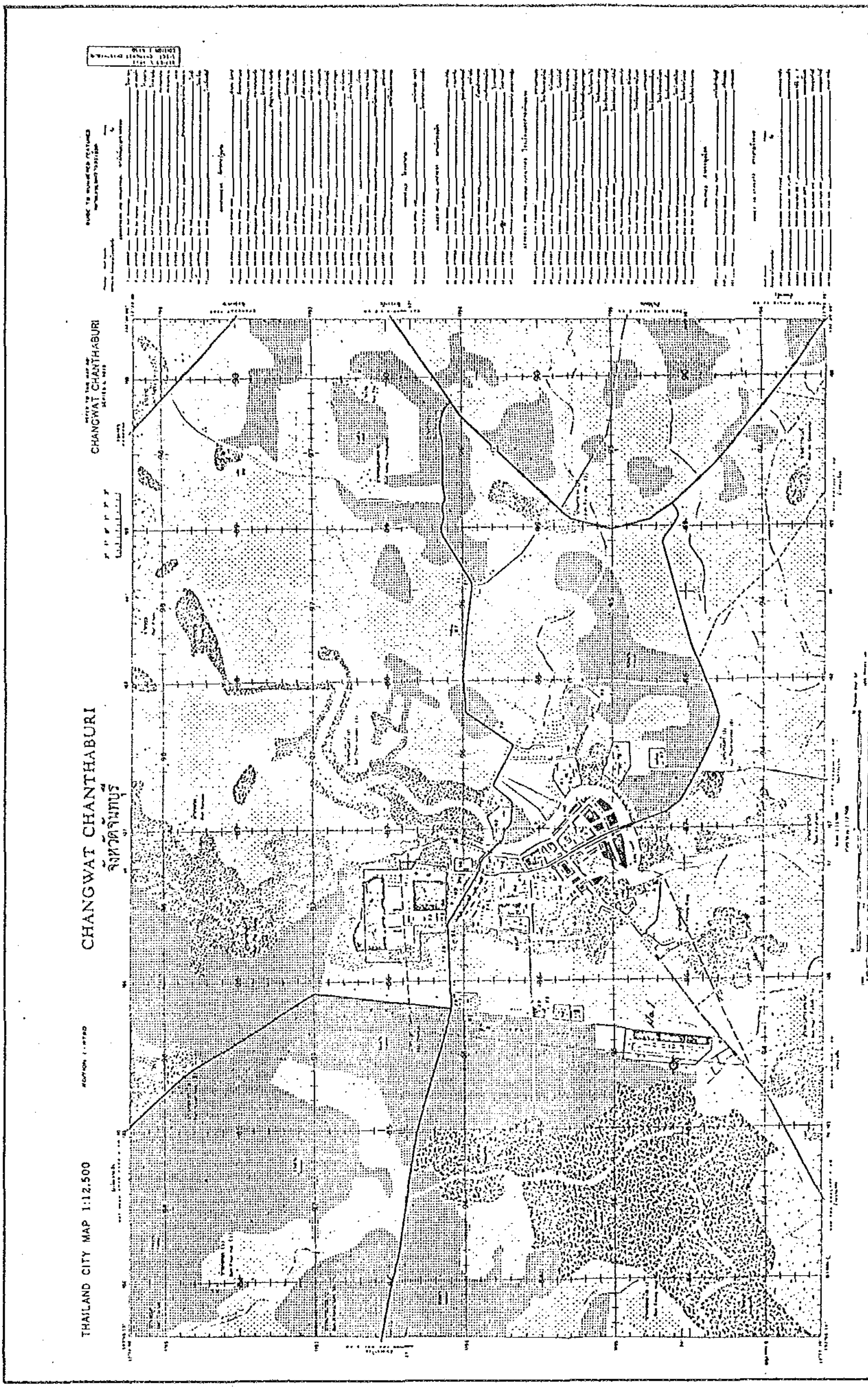



Fig.2-25 Map of Chanthabaori City Area

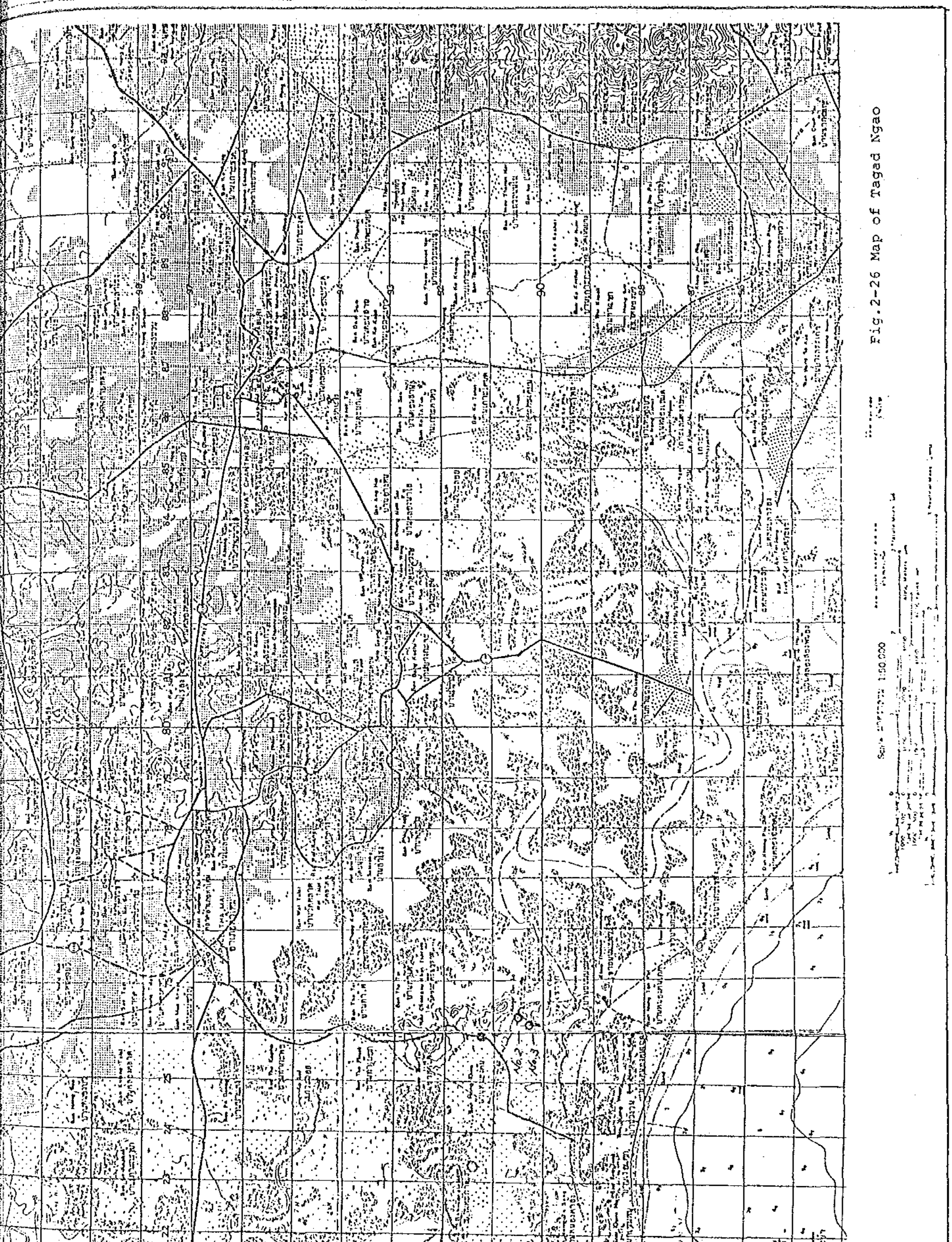


Fig.2-26 Map of Tagad Ngao

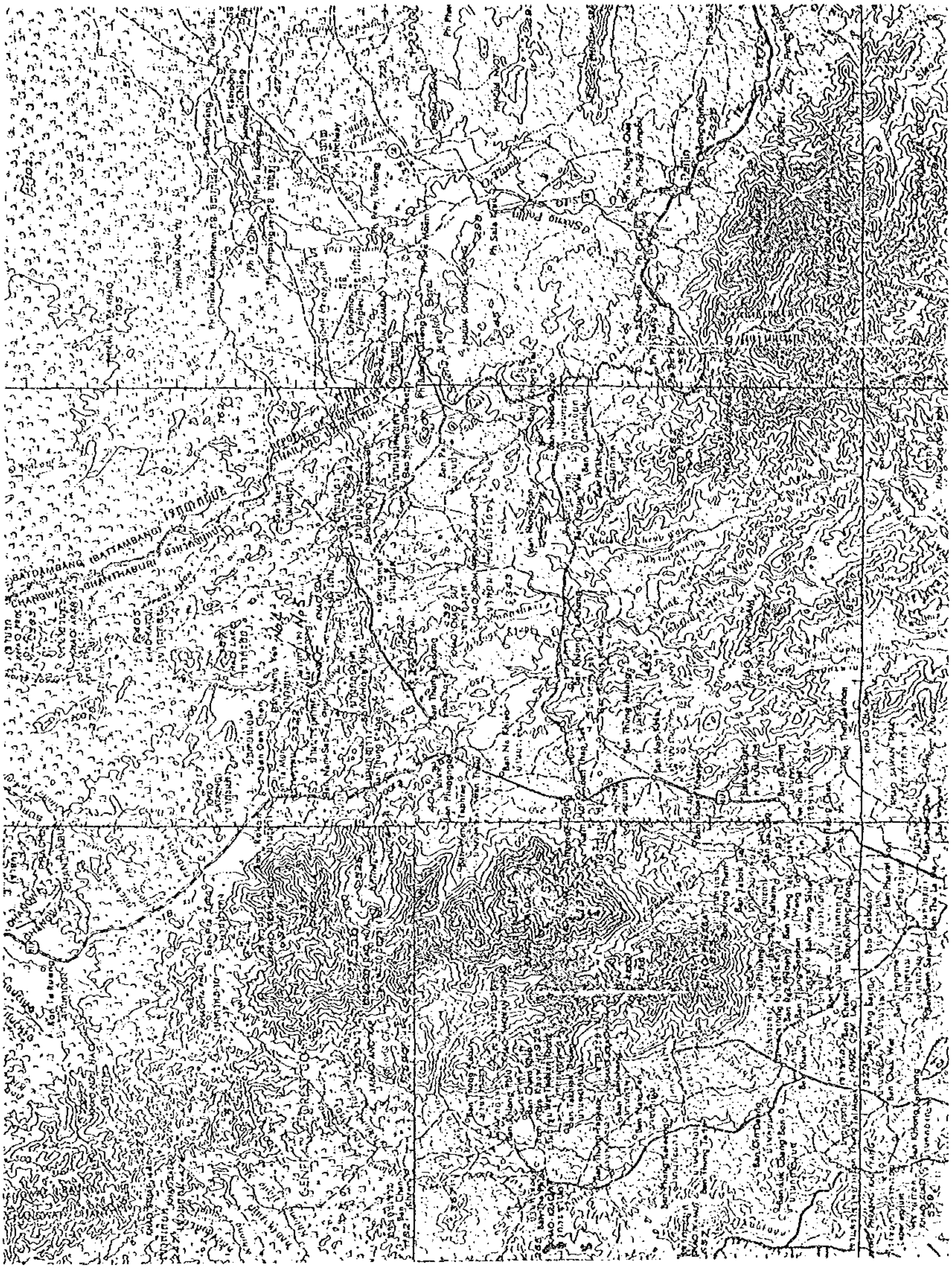


Fig.2-27 Map of Pong Nam Ron

### 2-4-4 Ground Water Hydraulics

When appraising the ground water resources and planning the well management system, it is necessary to obtain hydrogeologic constants of the aquifer at the site of interest in addition to hydrogeologic information. The hydrogeologic constants can generally be obtained by lifting tests.

The pumping test and the analysis of its results are carried out in several ways. In the present survey, the water level recovery test which is comparatively easy to perform was carried out and the transmission coefficient (T) and coefficient of transmissibility or coefficient of permeability (K) were determined by the straight line analytical Jacob method.

The pumping test can be performed in a deep well having a suitable aquifer. In the model areas, none of the existing wells qualified for the pumping test. Furthermore, as the survey happened to be conducted in the dry month of December, care had to be exercised so that water would not be wasted just for purposes of this survey. Accordingly, the pumping test was performed in the shallow well in the premises of the Ban Bo model area and in the privately owned shallow well near the Prapokklao Hospital; both the wells were equipped with a lifting pump and a storage facility of sufficient capacity to hold the water lifted for test purposes.

The pumping test was performed in a well in use; the pump was stopped in the middle of operation and the subsequent rise in water level was measured.

The data were analyzed by the straight line analytical Jacob method; t/t' was measured along the logarithmic scale of semi-logarithmic graph paper and S' was measured along the arithmetic scale to plot the S'-t/t' curve (Fig. 2-29). The difference in S, or $\Delta S$ in one cycle of logt/t' was determined, and the transmission coefficient "T" was calculated by the equation:

$$T = \frac{0.183Q}{\Delta S} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

where, T = transmission coefficient
Q = lifting volume
t = time lapsed after onset of lifting
t' = time lapsed after end of lifting
S' = difference between natural water level and recovered water table
ΔS = water level difference in one cycle of log t/t'

The transmission coefficient obtained in the two test wells are shown below.

(A) Prapokklao Hospital Vicinity

$Ta = 1.596 \times 10^{-4}\ m^3/sec/m$

(B) Ban Bo

$Tb = 2.611 \times 10^{-4}\ m^3/sec/m$

The coefficient of transmissibility "K" can be obtained by dividing "T" by the estimated aquifer thickness "M".

$$K = \frac{T}{M} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

$$Ka = \frac{Ta}{2.6\ m} = 6.14 \times 10^{-3}\ cm/sec$$

$$Kb = \frac{Tb}{2.6\ m} = 1.00 \times 10^{-3}\ cm/sec$$

Table 2-10 Pumping Test Results

| Items / Well | Transmission Coefficient | | Coefficient of Transmissibility |
|---|---|---|---|
| | $m^3/day/m$ | $m^3/sec/m$ | cm/sec |
| Well A | 13.789 | $1.596 \times 10^{-4}$ | $6.14 \times 10^{-3}$ |
| Well B | 22.559 | $2.611 \times 10^{-4}$ | $1.00 \times 10^{-3}$ |

The relationship between coefficient of transmissibility and soil formations can generally be expressed as shown in Table 2-11.

Table 2-11 Soil Characteristics and Ground Water Hydraulics

| Soil | Primary (Grain Size) | Secondary (Crushed) | Range of Coefficients of Transmissibility (cm/sec) $10^{2}$ $10^{0}$ $10^{-2}$ $10^{-4}$ $10^{-6}$ $10^{-8}$ | Well Yield High Medium Low | Type of Water-bearing Layer |
|---|---|---|---|---|---|
| Loose solid deposits | | | | | |
| Gravel | 30∿40 | | | | Aquifer |
| Coarse sand | 30∿40 | | | | Aquifer |
| Medium grain to fine sand | 30∿35 | | | | Aquifer |
| Silt | 40∿50 | Occasionally/rate (Mud cracks) | | | Aquiclude |
| Compact solid deposits | | | | | |
| Limestone, dolomite | 1∿50 | Solution, joint wall | | | Aquifer or impervious stratum |
| Coarse to medium grain sandstone | <20 | Joint wall, crushed | | | Aquifer or aquiclude |
| Fine sandstone, mudstone | <10 | Joint wall, crushed | | | Aquifer or impervious stratum |
| Shale, siltstone | - | Joint wall, crushed | | | Aquifer or aquiclude |
| Volcanic rock | | | | | |
| Basalt | - | Joint wall, crushed | | | Aquifer or impervious stratum |
| Acidic volcanic rock | - | | | | Impervious stratum aquifer |
| Crystalline rock | | | | | |
| Plutonic rock, metamorphic rock | | Joint wall, crushed | | | Impervious stratum aquifer |

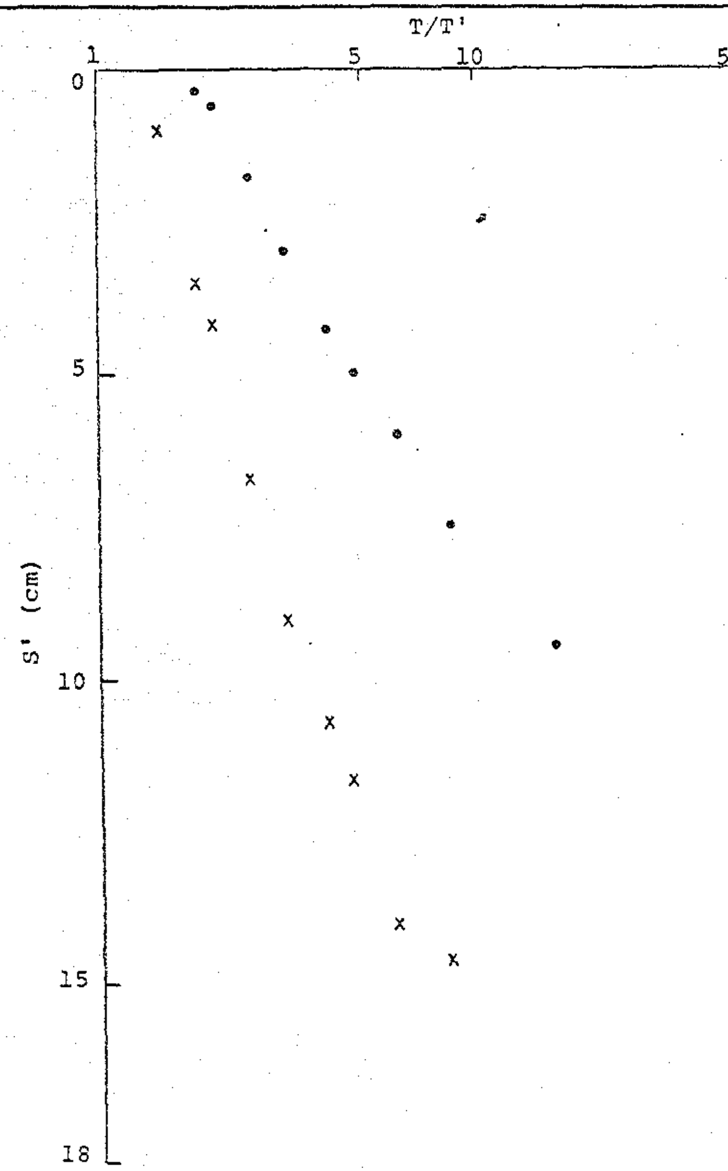



Fig.2-28

----- S' - T/T' Curve for Analysis of Pumping Test ---

... : The vicinity of Prapokklao Hospital

xxx : Ban Bo, Tambol Bo

T : Time past from start of pumping

T' : Time past from stoppage of pumping

S' : Difference of water level between static level and recovery level

# CHAPTER 3 WATER SUPPLY PLANNING

# CHAPTER 3 WATER SUPPLY PLANNING

## 3–1 Basic Plan

When planning the improvement of the water supply facilities the model areas, the following basic considerations should be taken into account.

1) It is of great concern in these model districts to determine how to secure a reliable supply source during the dry season. Uncertain water supply sources during the dry season are one of the barriers to the improvement of public health and saniation in these districts.

   The water supply facilities planned in these areas therefore must provide the communities with as much water of good quality as will be needed throughout the year.

2) The water supply facilities should be operated, maintained and managed mainly by the people of the community. Therefore, the water supply facilities should be designed for easy operation and low operating cost.

3) The water supply facilities should be universally applicable to many locales as model facilities of the project area. In this respect it is most desirable that the facilities be cheap to build and that it be built with materials and equipment which are available locally.

In the interest of public health and sanitation, the water supply facilities should ideally provide the communities with water not only for drinking purposes but also for other domestic purposes, such as washing and bathing. However, the results of soil exploration suggest, the water supply system may not permit deep well drafts at all times. A realisc approach to the solution of the water supply in these areas would be to implement the water works project in several stages: in the first stage a water supply system which has sufficient capacity to supply water only for drinking purposes will be built, and in the second stage the water supply system will be expanded to meet other domestic requirements.

When shallow well water and rainwater are to be used, a minimum of water treatment equipment should be considered.

## 3-2 Design Criteria

Water works are facilities for production and distribution of water for drinking and other household purposes. The production and distribution of potable water has two phases: one is associated with the quality of water and facilities required to obtain the desired quality of water, and the other concerns the water handling facilities and their capacity.

In the case of the proposed water supply facilities, it is planned to secure supply sources of potable water, and, as stated in Section 3-1 on "Basic Plan", no special water treatment facility will in principle be considered. However, if there will be no alternative but to depend on rainwater or shallow well water, a minimum of water treatment equipment will be considered.

The quality of water of the proposed water supply system will comply with WHO drinking water standards.

The second consideration has to do with the regional characteristics of the model districts as discussed below.

Water consumption : 20 liters/person/day

The water works design criteria of the P.W.W.A. which administers the local water works are given in Appendix A. According to the P.W.W.A., the level of water consumption is given as follows:

House connection : 80 liters/person/day

No house connection : 50 liters/person/day

In the proposed water supply system, however, it is assumed that water supply to the communities considered will serve no purposes other than drinking and cooking for the time being.

As opposed to the water demand of 50 liters/person/day estimated by the P.W.W.A., the water demand on the proposed water supply system has been estimated to be 20 liters/person/day (= 17 liters/person/day = 50 - 33) since the water demand for domestic purposes other than drinking and cooking, which are estimated as follows, are not considered.

| | | |
|---|---|---|
| Bathing | : | 20 liters/person/day |
| Washing | : | 10 liters/person/day |
| Cleaning, etc. | : | 3 liters/person/day |
| | Total | 33 liters/person/day |

# Table 3-1 Comparison of Water Quality Standards

| Item \ Nation | WHO | WHO European Standard | USA Marin Ideal Water | USA Standard | West Germany | France | Holland | Yugoslavia | Czechoslovakia | Sweden | Mexico | Indonesia | South Korea | Philippines | England |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Turbidity | | | 0.1° | 5° | | | 0.5° | 10° | 5° (3° on the average) | Very little | Pursuant to USA standard | Shall not exceed 1mg/lit. | Pursuant to Japanese standard. | Pursuant to WHO standard. | No particular standard is established. |
| Color | | | 3° | 15° | | | 20° | 30° | 20° | 20° - 40° | * | | | | |
| Odor | | | Unchanged if treated by carbon | 3° | | | There shall be no offensive odor. | None | None | Very little | * | Shall be transparent, tasteless and odorless. | | | |
| Taste | | | None | No abnormal taste | | | | None | None | | * | | | | |
| pH | 7.0 - 8.5 (6.5 - 9.2) | | | | | | | 6.5 - 9.0 | | | 9.6 | 6.5 - 9.0 | | | |
| Total alkalinity | | | Variation of the order of less than 1 in water cylinder | | | | | | | | 400 | | | | |
| Ammonia nitrogen | 0.5 | 0.5 | | | | | 0.2 | 0.1 | 0 | 0.5 | | Shall not be present | | | |
| Nitrite nitrogen | | | | | | | 0.1 | 0.005 | 0 | 0.02. | | Shall not be present (except the case of deep well). | | | |
| Nitrate nitrogen | 40 (80) | 5.0 | 5.0 | 45 | 50 | 10 | 100 | 15.0 | 35 (15 for babies two months or less old) | 30 | | 20 | | | |
| Chlorine ion | 200 (400) | 350 | | 250 | 20 | 250 | 250 | 250 | 50 | 300 | 250 | 250 | | | |
| Sulfate ion | 200 (400) | 250 | | 250 | | 250 | | 200 | (6.0 - 8.0) (200 for hard water) | | 250 | 25.0 | | | |
| Mn-COD | 10 | | | | 20 | | 20 | 12 | 12 | 20 - 40 | 10 | 10 | | | |
| Evaporation residue | | | | 500 (100) ppm | | | | 1000 | 500 - 1000 | | 500 (1000) | Soluble substances less than 1000 | | | |
| Total hardness | 100 - 500 | 100 - 500 | 80 | | 350 | | | | 8 - 12 dH (150-200) | 100 | 300 | 5 - 10 dH | Pursuant to Japanese standard. | Pursuant to WHO standard. | No particular standard is established. |
| Calcium | 75 (200) | | | | | | | | | | | | | | |
| Magnesium | 50 (150) | | | | | 125 | | | | | 125 | 125 | | | |
| Total iron | 0.3 (1.0) | 0.1 | 0.05 | 0.3 | 0.2 | 0.1 | 0.1 | 0.3 | 0.3 | 0.2 - 0.4 | | 0.2 | | | |
| Manganese | 0.1 (0.5) | 0.1 | 0.01 | 0.05 | 0.1 | 0.05 | 0.05 | 0.3 | 0.05 | 0.1 | 1.5 | 0.1 | | | |
| Copper | 1.0 | 0.05 | 0.2 | 1.0 | 3.0 | 0.05 | | 0.5 | 3.0 | | 3.0 | 3.0 | | | |
| Lead | 0.1 | 0.1 | 0.3 | 0.05 | 0.3 | 0.05 | 0.1 | 0.05 | 0.1 | | 0.1 | 0.05 | | | |
| Zinc | 50 (150) | 5.0 | 1.0 | 5.0 | | 5.0 | | 15.0 | 5.0 | | 15 | 5.0 | | | |
| Chromium | 0.05 | 0.05 | | | | | 0.05 | 0.05 | 0 | | 0.05 | | | | |
| Hexavalent chromium | | | 0.01 | 0.05 | | | | | | | | | | | |
| Mercury | | | | 0.05 | 0.05 | | | | 0 | | | | | | |
| Arsenic | 0.2 | 0.2 | 0.01 | 0.01(0.05) | | 0.05 | 0.2 | 0.05 | 0.05 | | 0.05 | 0.05 | | | |
| Fluorine | 1.0 (1.5) | 1.5 | Varied according to the temperature | 0.6 - 1.7 | 0.5 | 1.0 | | 1.5 | 1.0 | | 1.5 | 1 - 1.5 | | | |
| Silicic acid | | | | | | | | | | | | | | | |
| Cyanic ion | 0.01 | 0.01 | 0.01 | 0.01 (0.2) | | | | | | | | | | | |
| Cyanide | | | | | | 0 | 0.01 | | 0 | | | | | | |
| Phenols | 0.002 (0.002) | 0.001 | 0.005 | 0.001 | | 0.001 | | 0.001 | 0.003 | | 0.001 | | | | |
| Organic phosphorus | | | None | | | | | | | | | | | | |
| Anionic surfactant | | Be careful to the contents | 0.2 | 0.5 | | | | | | | | | | | |
| Residual chlorine | | | | 0.05 - 0.1 | When injection of chlorine up to 0.3 ppm is required, 0.6ppm | Less than 0.1 | | | Less than 0.2 | | 0.2 1.0 for combined residual chlorine | | | | |
| Cadmium | | 0.005 | 0.01 | 0.01 | | | | | | | | | | | |
| Radioactivity | α $10^{-9}$ μc/ml β $10^{-8}$ μc/ml | α 1 μμc/ℓ β 10 μμc/ℓ | β 100pc/ℓ Ra 2263 pc/ℓ Sr 905pc/ℓ | Ra 225.3 μμ/ℓ Sr 90.10 μμc/ℓ Gross β 100μμc/ℓ throughout a year | 100μμc/ℓ | | β 10μμc/ℓ or less a year | β $10^{-8}$ μc/ml α $10^{-9}$ μc/ml Ra 2264x10 μc/ml | Ra 226 $2.6 \times 10^{-2}$ c/ℓ | | | | | | |
| Bacteria | | | 1 in 1 ℓ | | | | | | | Less than 100 in 1cc | Pursuant to USA standard | Less than 100 in 1 ml | | | |
| Coliform group bacteria | Less than 10 MPN throughout a year | 15 in 100 100cc samples | | Less than 10% of total sample tubes showing positive a month | 0 in 100ml | Negative | Underground water; less than 1/ℓ Surface water; less than 2/ℓ | 0 in clean water 100 cc. Less than 10 in raw water 100cc | No pathogenic bacteria shall be observed. | Less than 2 in 100cc (Colliergenes) | * | Negative in 100ml | | | |

Table 3 - 2 JAPANESE WATER QUALITY STANDARD

| | | |
|---|---|---|
| Shall not contain organisms or substances which is tainted or suspended to be tainted by any pathogenic organ. | Ammonia nitrogen and nitrite nitrogen | Shall not be detected simultaneously. |
| | Nitrate nitrogen | Shall not exceed 10 ppm. |
| | Chlorine ion | Shall not exceed 200 ppm. |
| | Organic matters (Mn-COD) | Shall not exceed 10 ppm. |
| | Bacteria | Zoogloea formed in sample water of 1 ml shall not exceed 100 in number. |
| | Coliform group bacteria | Shall not be detected. |
| Shall not contain cyanogen, mercury or other harmful substances. | Cyanic iron | Shall not be detected. |
| | Mercury | Shall not be detected. |
| | Organic phosphorus | Shall not be detected. |
| Shall not contain copper, iron, fluorine, phenols and other substances in excess of their respective acceptable limit. | Copper | Shall not exceed 1.0 ppm. |
| | Iron | Shall not exceed 0.3 ppm. |
| | Manganese | Shall not exceed 0.3 ppm. |
| | Zinc | Shall not exceed 1.0 ppm. |
| | Lead | Shall not exceed 0.1 ppm. |
| | Hexavalent chromium | Shall not exceed 0.05 ppm. |
| | Arsenic | Shall not exceed 0.05 ppm. |
| | Fluorine | Shall not exceed 0.8 ppm. |
| | Calcium, magnesium or like (Hardness) | Shall not exceed 300 ppm. |
| | Evaporation residue | Shall not exceed 500 ppm. |
| | Phenols | Shall not exceed 0.005 ppm on a phenol basis. |
| | Anionic surfactant | Shall not exceed 0.5 ppm. |
| Shall not present any abnormal acidity or alkalinity. | Hydrogen ion concentration | pH shall be 5.8 to 8.6 both inclusive. |
| There shall be no abnormal taste nor odor except for those due to disinfectant. | Odor | Shall not be abnormal. |
| | Taste | Shall not be abnormal. |
| Shall be almost colorless and transparent in appearance. | Color | Shall be less than 5°. |
| | Turbidity | Shall be less than 3°. |

Remarks: In addition to these water quality standards, the Ministry of Health & Welfare takes such administrative measures as follows:

(1) As for manganese, there are some instances where increase in color and black suspended matters due to manganese were observed. Manganese removal equipment shall therefore be provided for water susceptible to the influence of manganese with a view to reducing the manganese content to about 0.05 ppm or less.

(2) Cadmium content shall not exceed 0.01 ppm as a provisional standard.

(3) Atomic absorption spectrophotometry shall be used for the inspection of mercury content. Mercury content shall not exceed 0.001 ppm on a total mercury basis.

Table 3 - 3 Environmental Standard Concerning the Protection of Human Health

| Item | Cadmium | Cyanogen | Organo-phosphoric compounds | Lead | Chromium (VI) | Arsenic | Total mercury | Alkyl mercury | PCB |
|---|---|---|---|---|---|---|---|---|---|
| Standard content | 0.001 ppm or less | Shall not be detected. | Shall not be detected. | 0.1 ppm or less | 0.05 ppm or less | 0.05 ppm or less | 0.0005 ppm or less | Shall not be detected. | Shall not be detected. |

Remarks:

1. The standard content shall be the maximum value. However, the standard content for total mercury shall be a mean value throughout a year.
2. The term "organo-phosphoric compounds" means parathion, methylparathion, methydimeton and EPN.
3. Only in the case where river water is apparently contaminated by mercury due to any natural cause, the standard content for total mercury shall be 0.001 ppm or less.
4. The expression "Shall not be detected" means that the content detected by the predetermined measuring method is below the threshold value of detection. (The threshold value of detection is 0.1 ppm for cyanogen, 0.1 ppm for organo-phosphoric compounds, 0.0005 ppm for alkyl mercury and 0.0005 ppm for PCB, respectively).

## 3–3 Water Supply Facilities Planning

1) Area and Population Served

The model areas consist of the following four communities which are distributed in the Province of Chanthaburi, as stated in Chapter 2 "General Information on the Model Areas".

a) Ban Sam Rong (Tambol Sai Kao, Amphur Pangnomroon)

b) Ban Nong Khan (Tambol Tagad Ngao, Amphur Thamai)

c) Ban Bo (Tambol Bo, Amphur Khlung)

d) Prapokklau Hospital Vicinity (Amphur Muang)

The areas and populations of these model districts are listed in Table 3-4.

Table 3-4 Areas and Population of Model Areas

| Plan | Model Area | Village | Tambol | Amphur | Population or Area |
|---|---|---|---|---|---|
| A | Ban Sam Rong | No. 2 | Sai Kao | Pangnamroon | 665 persons |
| | | No. 8 | | | 423 persons |
| B | Ban Nong Khan | No. 4 | Tagad Ngao | Thamai | 564 persons |
| C | Ban Bo | No. 3 | Bo | Khlung | 545 persons |
| D | Prapokklan Hospital Area | - | - | Muang | 700 $m^2$ |

2) Facility Planning

(1) Water Sources

The water resource information collected in the field surveys in the model areas is discussed at length in Section 2-3 on "Present Water Supply in the Model areas" and in Section 2-4 on "Topography and Hydrogeology of the Model areas". Based on the findings obtained in these surveys, the following recommendations are made regarding the water sources for the proposed water supply facilities.

a) Ban Sam Rong (Villages Nos. 2 and 8)

This model area is located in a river basin with an elevation of about 130 m surrounded by hills. Unlike in Ban Bo and Tagad Ngao, there is no need to worry about contamination of ground water with salt water, however the soil test results suggest the presence of very hard rock below 20 m depths. To avoid tapping ground water contaminated with domestic sewage and to cope with a decrease in ground water flow during the dry season, a deep well 70 ∿ 100 m deep should be sunk in this model area.

b) Tagad Ngao (Village No. 4)

This model area is located in the coastal lowland surrounded by creeks. It is not advisable at all to sink a deep well here since the deep ground water is assumed to be affected by salt water. As the results of the hydrogeological surveys suggest, ground water at a depth of 30 m or so seems to be of reasonably good quality. A medium-depth well should therefore be sunk to a depth of about 30 m to tap the layer bearing fresh water.

c) Ban Bo (Vilalge No. 3)

This model area is also located near the coast and its ground water is affected by salt water to a considerable extent. The model area is situated on a sand bar formed on a plateau protruding into the sea. As ground water in deep strata has not been explored yet, it is conservatively assumed that fresh water cannot be tapped in this area.

For the purposes of developing water supply facilities, it would not be appropriate to expand the Klung water works or sink a deep well at a nearby site. The most recommendable policy is to collect rainwater to supply drinking water.

d) Prapokklao Hospital Area

The Prapokklao Hospital is supplied by the water supply facilities of the city of Chanthaburi; however, this municipal water supply system still leaves much desired both qualitatively and quantitatively.

Based on hydrogeological data it is presumed that ground water beyond a certain depth is affected by salt water in this model area. However, if shallow wells alone are used for the supply of water, they would pose various problems such as contamination and supply shortage during the dry season.

In this model area, a deep well 60 ∿ 70 m deep should be sunk. However, it is not clear from either the existing data or from the geophysical tests to what extent ground water is affected by salt water at this depth. If much salt water should rise during excavation, the bore hole can be driven to such a depth that the effect of salt water is no longer appreciable.

(2) Water Treatment Facility

According to the design policy formulated based on the field survey results and discussions with the personnel from the central and local government agencies, the water treatment facility is planned as follows:

a) It is necessary to consider the possibility that the supply sources outside the wells are contaminated. Hence, a simple multi-layer sand filter will be installed in order to remove suspended matter from the water drawn.

b) If water collected is to be stored for extended periods, it will be disinfected to prevent occurrence of contageous diseases.

(3) Water Supply System

Four types of water supply systems can be considered for the model areas. They should be employed singly or in combination to fit the regional characteristics of each model area.

System No. 1
Shallow well or deep well equipped with a hand pump. If a shallow well is selected, a filter should be used to filter stored water before use since a shallow well water is easily contaminated.

System No. 2
Deep well from which water is lifted by a pump or a windmill into an elevated storage tank. No taps other than ones for distributing drinking water will be provided.

System No. 3
A deep well from which water is lifted by a pump into an elevated storage tank or a storage tank on top of the building. A common tap and a pipeline leading to the laboratory will be provided.

System No. 4
Rainwater storage. A filter will be provided as in the case of well No. 1 to filter stored water before use.

Fig. 3-1
LAYOUT PLAN OF SYSTEM NO. 1

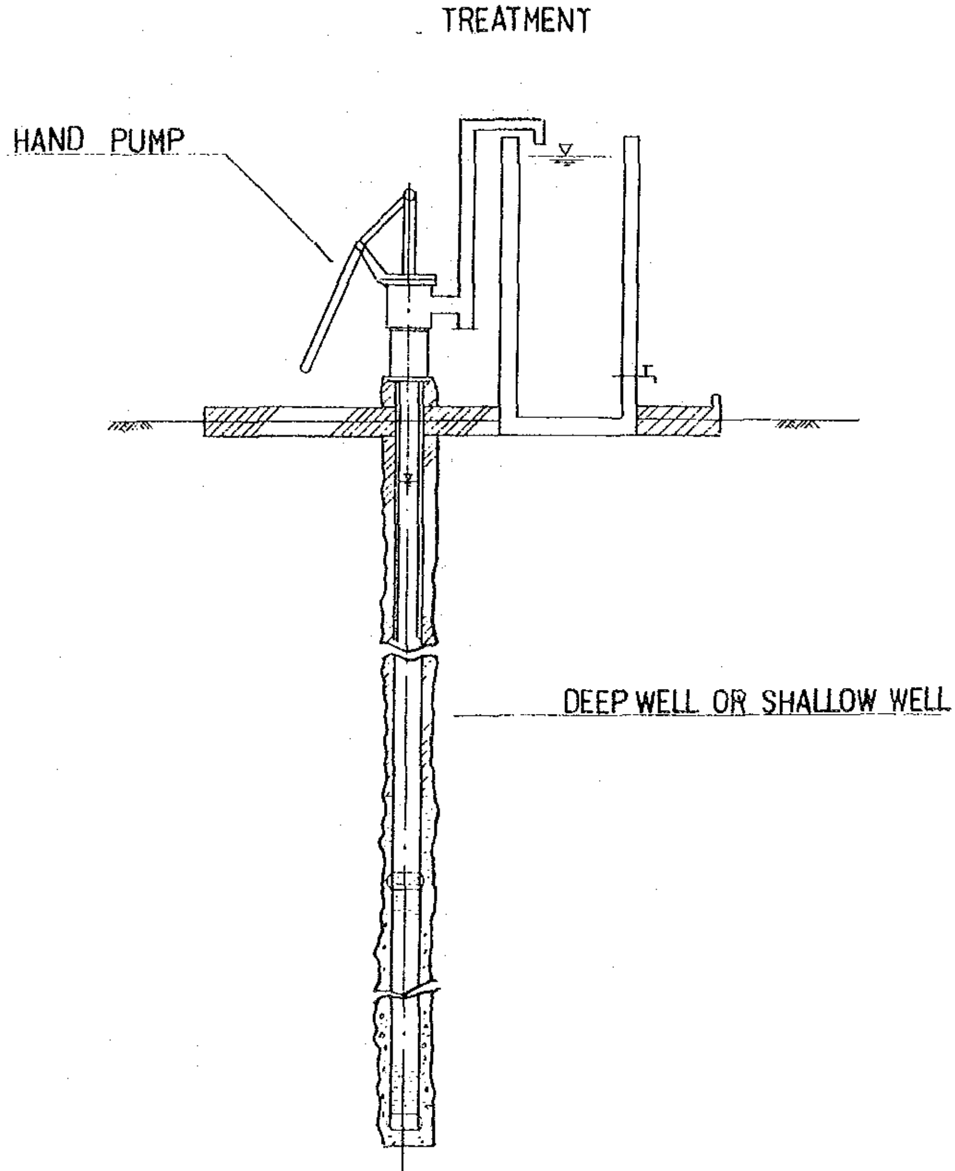


Fig. 3 - 2
LAYOUT PLAN OF SYSTEM NO. 2

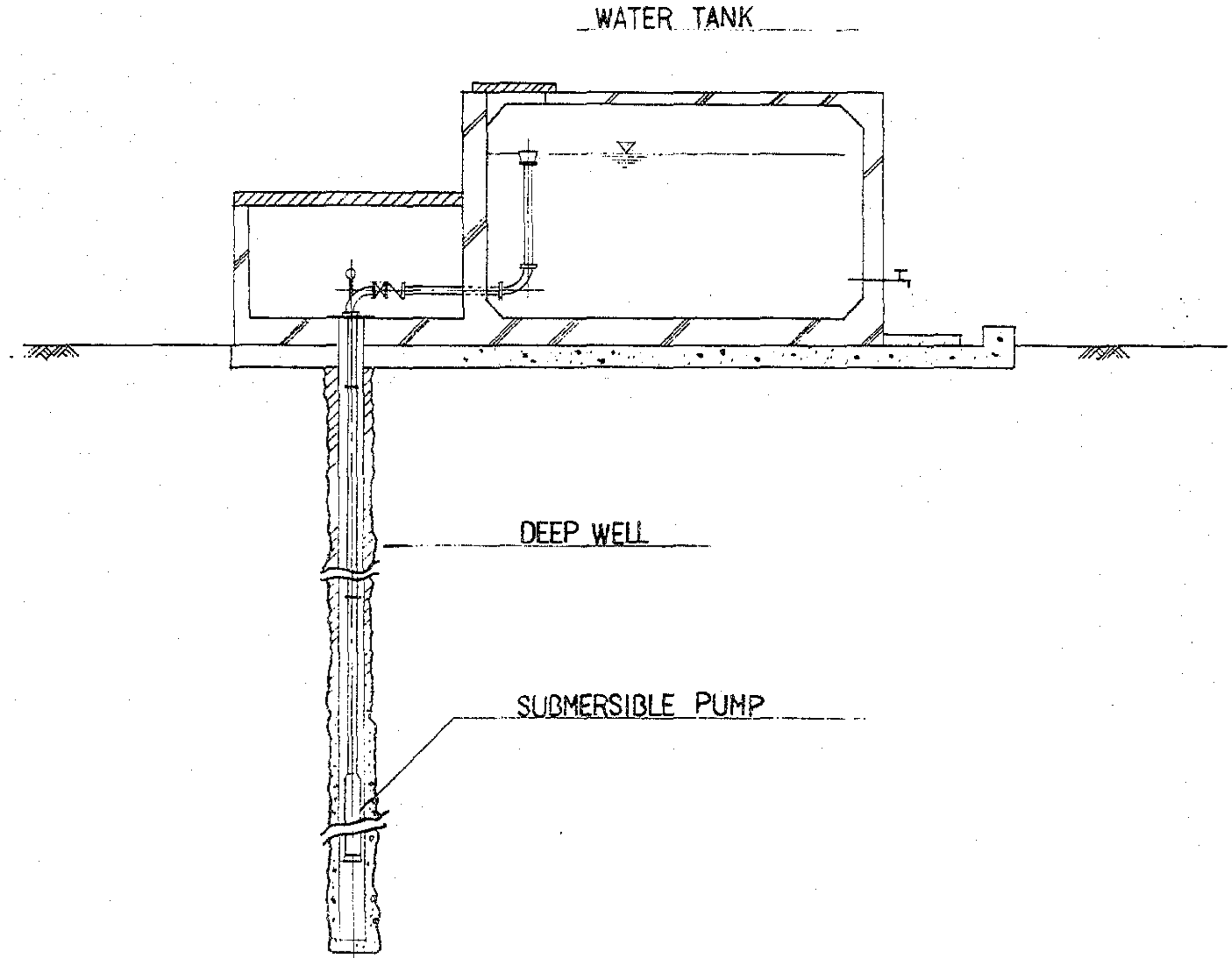


Fig. 3 - 3
LAYOUT PLAN OF SYSTEM NO. 3

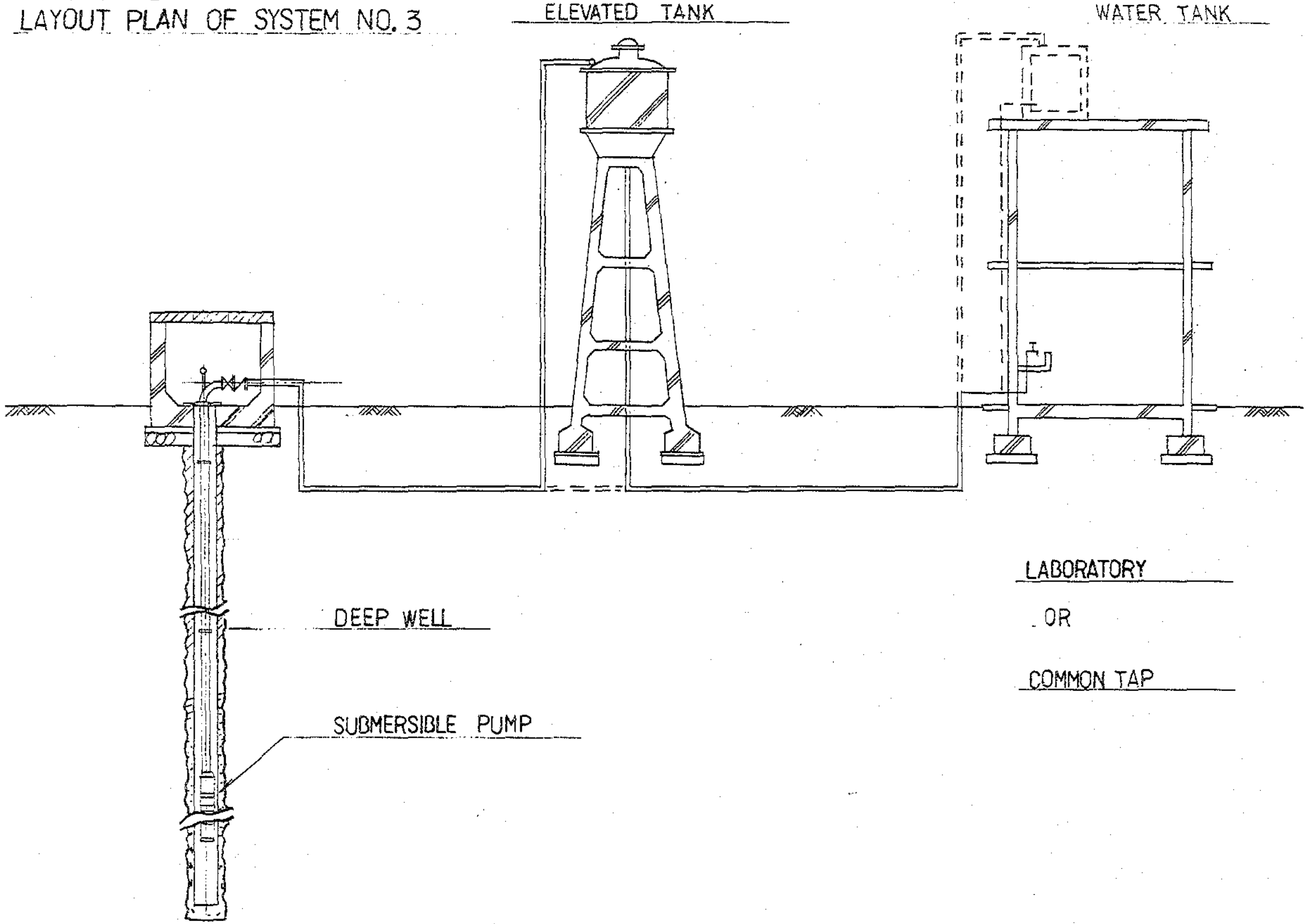
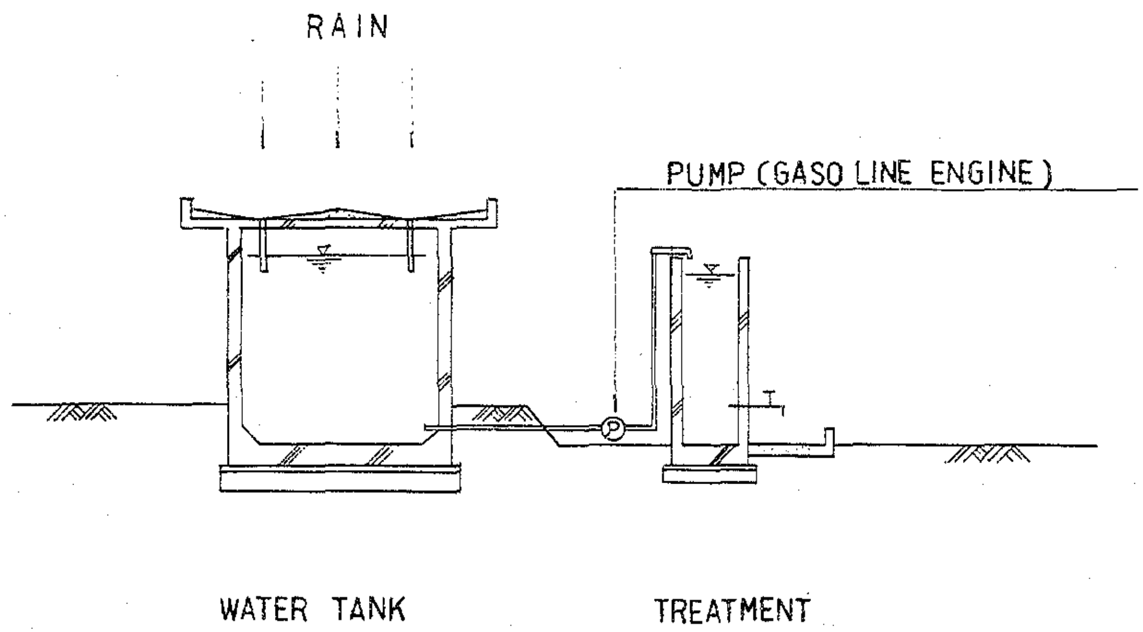


Fig. 3-4
LAYOUT PLAN OF SYSTEM NO. 4



# CHAPTER 4 MODEL STUDY

# CHAPTER 4 MODEL STUDY

## 4-1 Design of Water Supply Facilities

1) Scale of the Facilities

The scale of the proposed water supply facilities has been planned as follows:

- Model Plan A (Ban Sam Rong)

  Water demand = 1,088(persons) x 20(liter/person/day)
  = 21.76 $m^3$/day ≑ 30 $m^3$/day

- Model Plan B (Ban Nong Khan)

  Water demand = 564(persons) x 20(liters/person/day)
  = 11.28 $m^3$/day ≑ 15 $m^3$/day

- Model Plan C (Ban Bo)

  Water demand = 545(persons) x 20(liters/person/day)
  = 10.90 $m^3$/day ≑ 11 $m^3$/day

- Model Plan D (The Vicinity of the Prapokklao Hospital)

  Water demand = 700 $m^2$ x 25.5(liters/$m^2$/day)
  = 17.85 $m^3$/day ≑ 20 $m^3$/day

2) Design of the Facilities

(1) Supply Facilities

Ground water will be utilized in all but the Ban Bo model areas. In these ground water areas wells will be sunk and ground water will be lifted by pumping. The well facilities are listed according to the model area in Table 4-5.

In the Ban Bo model area rainwater will be utilized. In this area it is necessary to store as much rainwater during the rainy season as will be required to fill the demand throughout the dry season, calculated as follows:

Storage capacity = 11.0 $m^3$/day x 30 days/month x 5 months ≑ 1,650 $m^3$

The area of the rain collecting facility which is required to collect 1,650 $m^3$ of rainwater is 917 $m^2$ [= 1,650 $m^3$÷ (2,400 mm x 0.75)].

If four units are installed for the rain storage facility, the capacity of each unit can be calculated as follows:

Capacity per unit = 1,650 $m^3$ ÷ 4 units = 412.5 $m^3$/unit
≒ 420 $m^3$/unit

Assuming its depth is 3.0 m, its width and length will be 10.0 and 14.0 m respectively. If the area of each rain collecting unit is 230 $m^2$, and its width and length will be 13.0 and 18.0 m respectively.

- Rainwater storage tank 10.0 m in width, 14.0 m in length and 3.0 m in depth x 4 units
- Rainwater collecting facility 13.0 m in width x 18 m in length x 4 units

(2) Water Treatment Facility

a) Sand Filter

A sand filter with a filtration rate of 4 ~ 5 m/day and a depth of 2.5 m will be provided. The specifications of the water treatment facility are listed according by model area in Table 4-3.

b) Disinfecting Equipment

The water will be disinfected by regularly addition of calcium hypochlorite to the storage tank. The rate of addition will be 2 ppm (mg/L) on the average. If water demand is 30 $m^3$/day, 0.06 kg of calcium hypochlorite will be required as calculated below.

30 $m^3$/day x 2 mg/L = 0.06 kg/day

If the rate of utilization of calcium hypochlorite is 30%, then the actual requirement will be 0.2 kg/day, as calculated below.

0.06 kg/day ÷ 0.30 = 0.2 kg/day

Accordingly, the monthly requirement of calcium hypochlorite will be 6 kg.

0.2 kg x 30 days/month = 6 kg/month

Table 4-1 Facilities Well

| Model District | | Model Plan A | Model Plan B | Model Plan D |
|---|---|---|---|---|
| Water Demand ($m^3$/day) | | 30 | 15 | 20 |
| Well | Type of Well | Deep well | Semi-deep well | Deep well |
| | Depth (m) | 80 | 25 to 35 | 70 |
| | Type of Pump | Hand pump | Hand pump | Submersible pump |
| | Estimated Production ($m^3$/day) | 100 | 50 | 50 |
| | Bore Hole Diameter (mm) | 200 | 300 | 250 |
| | Casing Pipe Diameter (mm) | 100 | 200 | 150 |
| | Screen Diameter (mm) | 100 | 200 | 150 |
| | Screen Length (m) | 30 | 10 | 30 |

Table 4-2 Treatment Facilities

| Model District | Model Plan A | Model Plan B | Model Plan C | Model Plan D |
|---|---|---|---|---|
| Water Demand ($m^3$/day) | 30 | 15 | 11 | 20 |
| Water Reservoir ($m^3$) | - | 1.5 | 420 | 8 |
| Filter Diameter (mm) | - | 2,000 | 1,500 | - |
| Calcium hypochlorite Dosage (kg/day) | 0.2 | 0.1 | 0.08 | 0.14 |
| Number of Water Taps | 1 | 1 | 1 set | - |

## 4–2 Construction Cost Estimates

The construction costs of the proposed water supply system have been estimated in the present study on the basis of fixed unit prices of the main cost elements. All the unit prices and calculations used in this study are based on the material and labor costs surveyed in the Province of Chanthaburi as of December 1980.

The civil engineering work and foundation work required for a water supply system of this scale are well within the capabilities of local contractors operating in the province of Chanthaburi, and all necessary materials seem to be available there. Accordingly, the present construction cost estimate has been based on the general prices surveyed in the province of Chanthaburi, with reference to the prices of the models of water tanks referred to by the Sanitation Division of the Ministry of Public Health.

On the other hand, the sinking of the well appears to be beyond the capabilities of local contractors operating in the Province of Chanthaburi. Accordingly, the well sinking costs have been estimated with reference to the prices quoted by contractors in Bangkok based on the physical characteristics of each model area.

The price and calculation data which were collected during the field survey are listed in the Appendix.

As in many other parts of the world prices have been escalating in Bangkok in the past one or two years, due to the increasing of import prices, especially crude oil. For the second straight year prices have been rising an annual rate of 25 ∿ 30 percent and this price surge is expected to continue into 1981. However, the construction estimate in the present study does not include contingencies and hence is net of inflation contingency.

The approximate construction cost estimate based on the model study is shown in Table 4-3, and its particulars are given in Table 4-4 and 4-5.

Table 4-3 Construction Costs

| Item / Model Plan | Construction Cost (in baht) | Construction Period (Days) | Population Served (Persons) | Area Served ($m^2$) | Construction Cost (in baht) | | |
|---|---|---|---|---|---|---|---|
| | | | | | Per person | Per household* | Per $m^2$ |
| A | 1,090,000 (27) | 120 | 1,088 | 30 | 1,022 | 4,088 | 36,334 |
| B | 800,000 (19) | 90 | 564 | 15 | 1,419 | 5,676 | 53,334 |
| C | 700,000 (37) | 90 | 545 | 11 | 1,285 | 5,140 | 63,637 |
| D | 1,479,000 (100) | 120 | - | 20 | - | - | 63,950 |
| Total | 4,069,000 (100) | 420 | 2,197 | 76 | 3,706 | 14,824 | 227,255 |
| Average | 1,017,250 | 105 | 733 | 19 | 1,236 | 4,944 | 56,814 |

*Each household is assumed to consist of 4 members.

## Table 4 - 4 COST ESTIMATES FOR MODEL PLAN

| MODEL AREA | MODEL PLAN | CONSTRUCTION COST (Baht) | CONSTRUCTION PERIOD (day) |
|---|---|---|---|
| Sai Kao (Ban Sam Rong) | Model Plan A | 1,090,000 | 120 |
| Tagad Ngao (Ban Nong Khan) | Model Plan B | 800,000 | 90 |
| Bo (Ban BO) | Model Plan C | 700,000 | 90 |
| Prapokklao Hospital | Model Plan D | 1,479,000 | 120 |
| Total | | 4,069,000 | 420 |

## 4 - 5 (a) CONSTRUCTION COST OF FACILITIES

MODEL PLAN - A

| ITEM NO. | WORK DESCRIPTION | Q'TY | UNIT | UNIT PRICE (฿) | AMOUNT (฿) |
|---|---|---|---|---|---|
| 1. 0 | Well Construction | | | | |
| 1 | Transportation and preparation | 1 | L.S. | | 35,000 |
| 2 | Drilling of well (Ø200 mm) | 80 | M | 5,500 | 440,000 |
| 3 | Furnish and install of well casing (Ø 100 mm) | 80 | M | 1,100 | 88,000 |
| 4 | Furnish and install of submersible pump complete with electric motor and accessories | 1 | L.S. | | - |
| 5 | Furnish and install of hand pump complete with necessary accessories | 1 | L.S. | | 20,000 |
| 6 | Furnish and install of well screen (Ø 100 mm) | 30 | M | 3,000 | 90,000 |
| 7 | Gravel packing and cement seal | 1 | L.S. | | 15,000 |
| 8 | Soil and water sampling | 1 | L.S. | | 10,000 |
| 9 | Well chamber construction | 1 | L.S. | | 5,000 |
| 10 | Pumping test and other miscellaneous works | 1 | L.S. | | 155,000 |
| | Sub-Total | | | | 858,000 |
| 2. 0 | Construction of well platform | | | | |
| 1 | Earth work and leveling works | 1 | L.S. | | 5,000 |
| 2 | Concrete work including reinforcement and plastering | 1 | L.S. | | 10,000 |
| | Sub-Total | | | | 15,000 |
| 3. 0 | Construction of pumping station | | | | |
| 1 | Earth work and leveling works | 1 | L.S. | | - |
| 2 | Brick masonry including cement motor works | | M2 | | - |

| ITEM NO. | WORK DESCRIPTION | Q'TY | UNIT | UNIT PRICE (฿) | AMOUNT (฿) |
|---|---|---|---|---|---|
| 3 | Concrete works | | M3 | | - |
| 4 | Reinforcement bar works | | kg | | - |
| 5 | Forming works | | M2 | | - |
| 6 | Plastering works | | M2 | | - |
| 7 | Plumbing works | 1 | L.S. | | - |
| 8 | Electrical works | 1 | L.S. | | - |
| | Sub-Total | | | | - |
| 4. 0 | Construction of sand filter | | | | |
| 1 | Earth work and leveling works | 1 | L.S. | | - |
| 2 | Concrete works | | M3 | | - |
| 3 | Reinforcement bar works | | kg | | - |
| 4 | Forming works | | M2 | | - |
| 5 | Plastering works | | M2 | | - |
| 6 | Plumbing works | 1 | L.S. | | - |
| 7 | Furnish and install of gravel and sand | 1 | L.S. | | - |
| 8 | Miscellaneous works | 1 | L.S. | | - |
| | Sub-Total | | | | - |
| 5. 0 | Construction of elevated water tank | | | | |
| 1 | Basis work and leveling works | 1 | L.S. | | - |
| 2 | Furnish/install of water storage tank complete with necessary coating | 1 | L.S. | | - |
| 3 | Plumbing works | 1 | L.S. | | - |
| 4 | Miscellaneous works | 1 | L.S. | | - |
| | Sub-Total | | | | - |
| 6. 0 | Installation of water supply(transmission) pipes | | | | |
| 1 | Civil works for piping | 1 | L.S. | | - |
| 2 | Plumbing works | | M | | - |
| | Sub-Total | | | | - |

| ITEM NO. | WORK DESCRIPTION | Q'TY | UNIT | UNIT PRICE (Ø) | AMOUNT (Ø) |
|---|---|---|---|---|---|
| 7. 0 | Spare parts for two years operation | 1 | L.S. | | 10,000 |
| 8. 0 | Tools and Test kits | 1 | L.S. | | 7,000 |
| 9. 0 | Engineering supervision<br>Supervision shall be scheduled twice: when starting of construction and inspection and during Turn-over. | 1 | L.S. | | 200,000 |
| | Grand Total ------------------------------------------------ | | | | 1,090,000 |

## 4 - 5 (b) CONSTRUCTION COST OF FACILITIES

MODEL PLAN - B

| ITEM NO. | WORK DESCRIPTION | Q'TY | UNIT | UNIT PRICE (Ø) | AMOUNT (Ø) |
|---|---|---|---|---|---|
| 1. 0 | Well Construction | | | | |
| 1 | Transportation and preparation | 1 | L.S. | | 25,000 |
| 2 | Drilling of well(Ø 300 mm) | 35 | M | 4,000 | 140,000 |
| 3 | Furnish and install of well casing(Ø 200 mm) | 35 | M | 1,600 | 56,000 |
| 4 | Furnish and install of submersible pump complete with electric motor and accessories | 1 | L.S. | | - |
| 5 | Furnish and install of hand pump complete with necessary accessories | 1 | L.S. | | 15,000 |
| 6 | Furnish and install of well screen(Ø 200 mm) | 15 | M | 6,000 | 90,000 |
| 7 | Gravel packing and cement seal | 1 | L.S. | | 15,000 |
| 8 | Soil and water sampling | 1 | L.S. | | 10,000 |
| 9 | Well chamber construction | 1 | L.S. | | 5,000 |
| 10 | Pumping test and other miscellaneous works | 1 | L.S. | | 155,000 |
| | Sub-Total | | | | 511,000 |
| 2. 0 | Construction of well platform | | | | |
| 1 | Earth work and leveling works | 1 | L.S. | | 5,000 |
| 2 | Concrete work including reinforcement and plastering | 1 | L.S. | | 10,000 |
| | Sub-Total | | | | 15,000 |
| 3. 0 | Construction of pumping station | | | | |
| 1 | Earth work and leveling works | 1 | L.S. | | - |
| 2 | Brick masonry including cement motor works | | M2 | | - |

| ITEM NO. | WORK DESCRIPTION | Q'TY | UNIT | UNIT PRICE (฿) | AMOUNT (฿) |
|---|---|---|---|---|---|
| 3 | Concrete works | | M3 | | - |
| 4 | Reinforcement bar works | | kg | | - |
| 5 | Forming works | | M2 | | - |
| 6 | Plastering works | | M2 | | - |
| 7 | Plumbing works | 1 | L.S. | | - |
| 8 | Electrical works | 1 | L.S. | | - |
| | Sub-Total | | | | - |
| 4. 0 | Construction of sand filter | | | | |
| 1 | Earth work and leveling works | 1 | L.S. | | 15,000 |
| 2 | Concrete works | 5.8 | M3 | 1,500 | 8,700 |
| 3 | Reinforcement bar works | 185 | kg | 20 | 3,700 |
| 4 | Forming works | 35 | M2 | 250 | 8,750 |
| 5 | Plastering works | 45 | M2 | 150 | 6,750 |
| 6 | Plumbing works | 1 | L.S. | | 1,500 |
| 7 | Furnish and install of gravel and sand | 1 | L.S. | | 12,000 |
| 8 | Miscellaneous works | 1 | L.S. | | 1,600 |
| | Sub-Total | | | | 58,000 |
| 5. 0 | Construction of elevated water tank | | | | |
| 1 | Basis work and leveling works | 1 | L.S. | | - |
| 2 | Furnish/install of water storage tank complete with necessary coating | 1 | L.S. | | - |
| 3 | Plumbing works | 1 | L.S. | | - |
| 4 | Miscellaneous works | 1 | L.S. | | - |
| | Sub-Total | | | | - |
| 6. 0 | Installation of water supply(transmission) pipes | | | | |
| 1 | Civil works for piping | 1 | L.S. | | - |
| 2 | Plumbing works | | M | | - |
| | Sub-Total | | | | - |

| ITEM NO. | WORK DESCRIPTION | Q'TY | UNIT | UNIT PRICE (฿) | AMOUNT (฿) |
|---|---|---|---|---|---|
| 3. 0 | Spare parts for two years operation | 1 | L.S. | | 10,000 |
| 4. 0 | Tools and Test kits | 1 | L.S. | | 6,000 |
| 5. 0 | Engineering supervison Supervision shall be scheduled twice: when starting of construction and inspection and during Turn-over. | 1 | L.S. | | 200,000 |
| | Grand Total ------------------------------------------------ | | | | 800,000 |

4 - 5 (c) Construction costs of facilities

MODEL PLAN - C

| ITEM NO. | WORK DESCRIPTION | Q'TY | UNIT | UNIT PRICE (฿) | AMOUNT (฿) |
|---|---|---|---|---|---|
| 1. 0 | Rainfall water storage tank | | | | |
| 1 | Earth work and leveling works | 1 | L.S. | | 15,000 |
| 2 | Concrete works | 96 | M3 | 1,400 | 134,400 |
| 3 | Reinforcement bar works | 5680 | kg | 15 | 85,200 |
| 4 | Forming works | 735 | M2 | 210 | 154,350 |
| 5 | Plastering works | 420 | M2 | 120 | 50,400 |
| 6 | Plumbing works | 1 | L.S. | | 5,000 |
| 7 | Furnish and install of water collecting | 1 | L.S. | | 11,000 |
| 8 | Miscellaneous works | 1 | L.S. | | 2,650 |
| | Sub-Total | | | | 458,000 |
| 2. 0 | Construction of sand filter | | | | |
| 1 | Earth work and leveling works | 1 | L.S. | | 3,000 |
| 2 | Concrete works | 4.3 | M3 | 1,400 | 6,020 |
| 3 | Reinforcement works | 125 | kg | 15 | 1,875 |
| 4 | Forming works | 27 | M2 | 210 | 5,670 |
| 5 | Plastering works | 20 | M2 | 120 | 2,400 |
| 6 | Plumbing works | 1 | L.S. | | 5,000 |
| 7 | Furnish and install of gravel and sand | 1 | L.S. | | 7,000 |
| 8 | Miscellaneous works | 1 | L.S. | | 1,035 |
| | Sub-Total | | | | 32,000 |

| ITEM NO. | WORK DESCRIPTION | Q'TY | UNIT | UNIT PRICE (฿) | AMOUNT (฿) |
|---|---|---|---|---|---|
| 3. 0 | Spare parts for two years operation | 1 | L.S. | | 5,000 |
| 4. 0 | Tools and Test kits | 1 | L.S. | | 5,000 |
| 5. 0 | Engineering supervison Supervision shall be scheduled twice: wnen starting of construction and inspection and during Turn-over. | 1 | L.S. | | 200,000 |
| | Grand Total ------------------------------------ | | | | 700,000 |

## 4 - 5 (d) CONSTRUCTION COST OF FACILITIES

MODEL PLAN - D

| ITEM NO. | WORK DESCRIPTION | Q'TY | UNIT | UNIT PRICE (฿) | AMOUNT (฿) |
|---|---|---|---|---|---|
| 1. 0 | Well Construction | | | | |
| 1 | Transportation and preparation | 1 | L.S. | | 25,000 |
| 2 | Drilling of well (Ø 250 mm) | 70 | M | 4,000 | 280,000 |
| 3 | Furnish and install of well casing (Ø 150 mm) | 70 | M | 1,500 | 105,000 |
| 4 | Furnish and install of submersible pump complete with electric motor and accessories | 1 | L.S. | | 47,000 |
| 5 | Furnish and install of hand pump complete with necessary accessories | 1 | L.S. | | 110,000 |
| 6 | Furnish and install of well screen (Ø 150 mm) | 30 | M | 5,000 | 150,000 |
| 7 | Gravel packing and cement seal | 1 | L.S. | | 15,000 |
| 8 | Soil and water sampling | 1 | L.S. | | 10,000 |
| 9 | Well chamber construction | 1 | L.S. | | 5,000 |
| 10 | Pumping test and other miscellaneous works | 1 | L.S. | | 155,000 |
| | Sub-Total | | | | 902,000 |
| 2. 0 | Construction of well platform | | | | |
| 1 | Earth work and leveling works | 1 | L.S. | | 5,000 |
| 2 | Concrete work including reinforcement and plastering | 1 | L.S. | | 10,000 |
| | Sub-Total | | | | 15,000 |
| 3. 0 | Construction of pumping station | | | | |
| 1 | Earth work and leveling works | 1 | L.S. | | 20,000 |
| 2 | Brick masonry including cement motor works | 27 | M2 | 300 | 8,100 |

| ITEM NO. | WORK DESCRIPTION | Q'TY | UNIT | UNIT PRICE (฿) | AMOUNT (฿) |
|---|---|---|---|---|---|
| 3 | Concrete works | 5.8 | M3 | 1,500 | 8,700 |
| 4 | Reinforcement bar works | 265 | kg | 20 | 5,300 |
| 5 | Forming works | 38 | M2 | 250 | 9,500 |
| 6 | Plastering works | 42 | M2 | 150 | 6,300 |
| 7 | Plumbing works | 1 | L.S. | | 17,100 |
| 8 | Electrical works | 1 | L.S. | | 15,000 |
| | Sub-Total | | | | 90,000 |
| 4. 0 | Construction of sand filter | | | | |
| 1 | Earth work and leveling works | 1 | L.S. | | - |
| 2 | Concrete works | | M3 | | - |
| 3 | Reinforcement bar works | | kg | | - |
| 4 | Forming works | | M2 | | - |
| 5 | Plastering works | | M2 | | - |
| 6 | Plumbing works | 1 | L.S. | | - |
| 7 | Furnish and install of gravel and sand | 1 | L.S. | | - |
| 8 | Miscellaneous works | 1 | L.S. | | - |
| | Sub-Total | | | | - |
| 5. 0 | Construction of elevated water tank | | | | |
| 1 | Basis work and leveling works | 1 | L.S. | | 4,500 |
| 2 | Furnish/install of water storage tank complete with necessary coating | 1 | L.S. | | 115,000 |
| 3 | Plumbing works | 1 | L.S. | | 10,000 |
| 4 | Miscellaneous works | 1 | L.S. | | 1,500 |
| | Sub-Total | | | | 131,000 |
| 6. 0 | Installation of water supply(transmission) pipes | | | | |
| 1 | Civil works for piping | 1 | L.S. | | 42,000 |
| 2 | Plumbing works | 900 | M | 80 | 72,000 |
| | Sub-Total | | | | 114,000 |

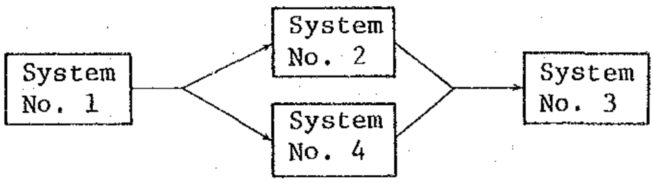
| ITEM NO. | WORK DESCRIPTION | Q'TY | UNIT | UNIT PRICE (฿) | AMOUNT (฿) |
|---|---|---|---|---|---|
| 7. 0 | Spare parts for two years operation | 1 | L.S. | | 20,000 |
| 8. 0 | Tools and Test kits | 1 | L.S. | | 7,000 |
| 9. 0 | Engineering supervision<br>Supervision shall be scheduled twice: when starting of construction and inspection and during Turn-over. | 1 | L.S. | | 200,000 |
| | Grand Total ---------------------------------------- | | | | 1,479,000 |

## 4-3 Construction Schedule

As stated earlier, the improvement of the water supply in the Province of Chanthaburi was planned as part of the project to promote provincial health services in Thailand. Accordingly, this study takes into consideration the close relationship of the proposed water supply system with national projects and the characteristics of the model districts. In the light of the nature of the proposed water supply system, the objective of this study is to indicate general guidelines for filling the urgent need for water supply sources. The program contained in this study should therefore be revised, changed or expanded as necessary to meet the changing needs of the areas under discussion.

The construction periods of the four model plans are shown in Table 4-6. To insure the satisfactory implementation of the programs, the following conditions should be taken into consideration:

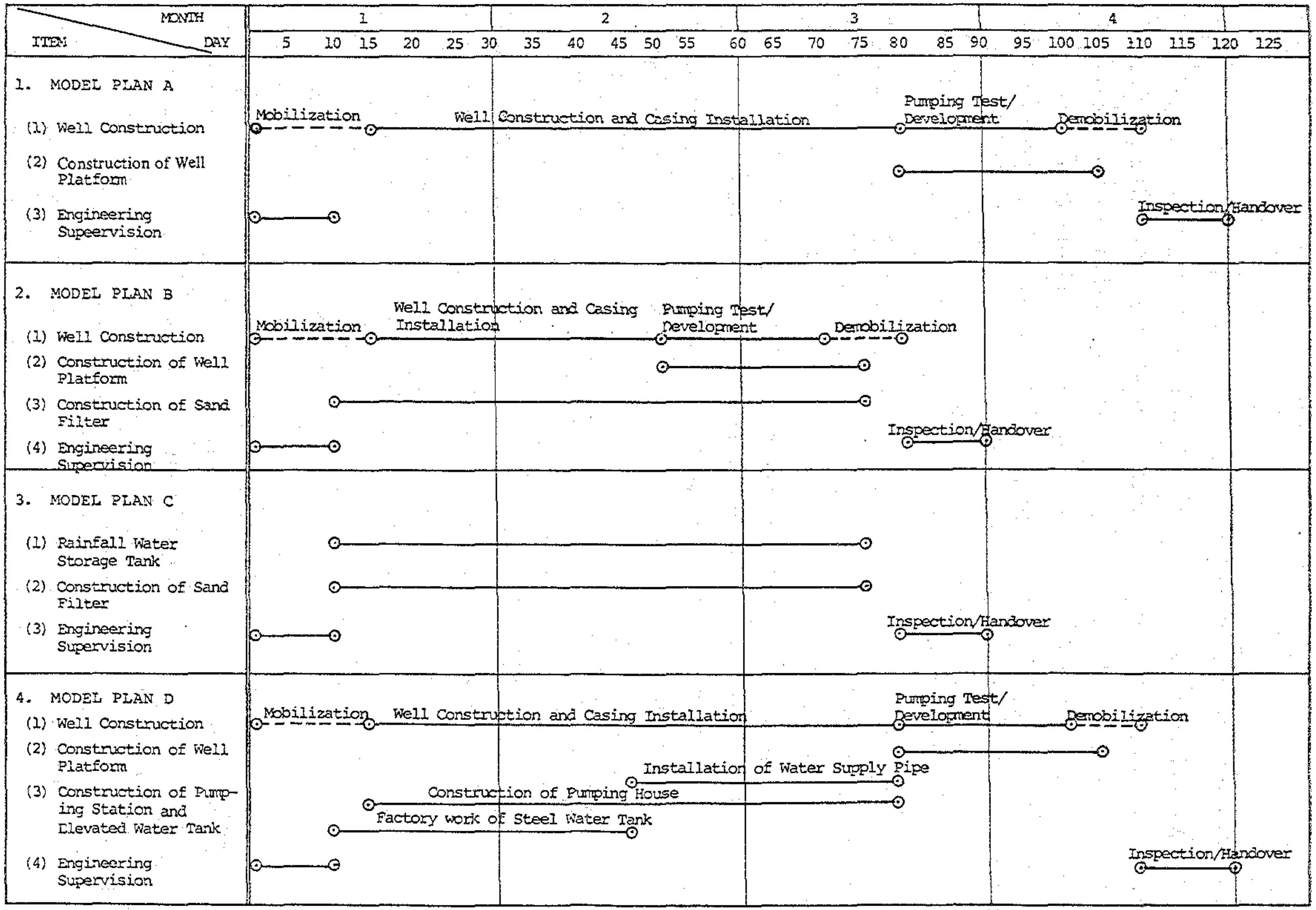
(1) In general, water supply systems should be selected in the priority indicated below.




In the selection of optimum systems, it is important to consider the condition of water resources costs, cost-benefit relationship, future supply of electric power, future increase in water demand and other factors which will affect the water supply system.

(2) The model plans are based on the assumption that a supervisor (project engineer) will be sent to the construction sites at the time of ordering equipment and on completion of construction work in order to make necessary arrangements with the contractor, confirm the location of the construction sites, give fundamental instructions to the contractor and inspect the completed work.

Table 4-6 ESTIMATED EXECUTION SCHEDUL OF FACILITIES



## 4-4 Maintenance and Management

As already stated in Section 3-1 "Basic Plan", the proposed water supply system should be managed by the people of the community who will benefit from the project; it should be operated, maintained and managed on their own responsibility. Furthermore, it is strongly recommended that the communities will participate in the proposed water supply system project from the start of planning.

1) Maintenance and Management

A water supply system management committee which represents the village or area corresponding to a village should be set up as the first step. A committee of this nature at the regional level is of particular importance because it takes the responsibility for the operation, maintenance and management of the regional water supply system on behalf of the community and because the committee members who take leading positions in the village can teach the villagers in the usage of the water supply system and motivate them toward improved consciousness of the water supply project.

The committee will appoint several selected villagers and train them in the maintenance of the water supply system, especially in the operation and maintenance of the hand pumps. In the course of time, those villagers will be virtually responsible for the maintenance of the water supply system. The villagers who will take care of the water supply system should be compensated according to their merits. The villagers so appointed will in turn take the responsibility of maintenance and management of the water supply facilities and keep on hand simple repair parts. Should the water supply facilities fail, the villagers in charge will go to the regional health center for necessary parts or refer the repair to a plumbing contractor.

The committee should keep close contact with the volunteer communicators and health volunteers already on duty and seek their assistance.

To promote the development of the model water supply system as part of the national project to promote provincial health services, the central government should provide assistance for the maintenance and management of the model water supply system. It is also very desirable that the Department of Medical Sciences which launched this model water supply facilities project set up a management committee to assist in implementing, operating, maintaining and managing the model water supply facilities. These model water supply facilities have much in common with the shallow well improvement project promoted by the Sanitation Division with regard to the scale of the system, consumable replacements, standardization, and so forth. In this respect, it will be necessary to take advantage this shallow well improvement project to facilitate the realization of the proposed model water supply facilities in the Province of Chanthaburi.

2) Regular Maintenance

a) Ordinary Problems

Of all the components of the water supply facilities planned in the study, the hand pump is the easiest component to fail. Therefore, mention will be made here of the maintenance of this item. Its common problems and information for trouble-shooting are summarized in Table 4-7 and 4-8.

b) Manufacturer's Instructions

The information set forth in the manufacturer's manual concerning assembling, installation, lubrication and maintenance should be scrupulously observed. The hand pump should be completely inspected and adjusted prior to installation.

c) Training

In the training program, the installation, operation and maintenance of the hand pump should be given particular prominence. When training villagers on the installation, operation and maintenance of the hand pump with the aid of the manufacturer's instruction manual or manual prepared by a public organization, on-the-job training should be provided. The effect of the on-the-job training can be increased if use is be made of an actually installed hand pump together with training materials and worn or damaged parts.

3) Operating and Overhead Costs and Benefits

The water supply facilities includes the four model plans described in Section 3-3 "Water Supply Planning". From the standpoint of operating and overhead costs the water supply facilities are divisible into several basic units, as shown below. The estimated useful life of these basic units is also shown below.

| Basic Units | Estimated Useful Life |
|---|---|
| (1) Well | 15 years |
| (2) Hand pump | 10 years |
| (3) Submersible pump | 10 years |
| (4) Concrete tank | 30 years |
| (5) Steel tank | 20 years |
| (6) Distribution pump | 20 years |
| (7) Taps and valves | 20 years |
| (8) Pump house | 30 years |

The useful like of mechanical equipment was placed at 10 years, and that of pipes, tanks and other ancillary equipment of comparatively simple construction was estimated at 20 years. The useful life of the concrete structure was placed at 30 years in consideration of the climatic conditions in the model areas. The estimation of the useful like of the components of the water supply facilities is based on the assumption that it is operated and maintained properly.

The operating and overhead costs of the water supply system are broadly divisible into the following elements:

(1) Energy costs

(2) Consumable and replacement costs

(3) Operating and administrative costs

Of the four model areas Prapokklau Hospital vicinity is the only area that is served by electric power lines. Nonetheless, the wear and replacement periods of parts will vary with the capacity of the water supply facilities of each district.

The maintenance and administration system will also differ from model plan D which will be placed under direct control of the Prapokklao Hospital to other model plans. Further, it is possible and advisable to establish an administration system which considers the physical characteristics of each model area. The operating and overhead costs of the water supply system are generally considered to represent the following percentages of the total installed cost.

| | |
|---|---|
| Mechanical equipment | 4 to 6% |
| Pipes and tanks | 0.5 to 2% |
| Structures | 0.5 to 1% |

The approximate annual operating and overhead costs of the water supply facilities are given in Table 4-8. Those costs were estimated with reference to the prices of parts commercially available in the Province of Chanthaburi and to the records of operation and mainteannce of the existing systems (mainly ones built in Japan), e.g., replacement periods and records of wear.

The energy cost represents the charges for electricity required to operate the submersible pump. Judging by the capacity of the pump and water demand, the average daily operation time was placed at 8 hours in order to calculate the total annual wattage required. The results of calculation are given in Table 4-7. This estimate is based on the local level of electricity charges.

The administrative costs are divisible into the following cost elements:

Personnel : 5,760 baht/year

> Two people attend to the installation twice a week.
>
> 2 (persons) x 2 (times/week) x 4 (times/month) x 12 (months/year) = 192 persons/year
>
> Each person will be paid 30 baht/day for each inspection visit.
>
> 192 (persons/year) x 30 (baht/person) = 5,760 baht/year

| | | |
|---|---|---|
| Transportation and fuel | : | 1,540 baht/year |
| Office expenses | : | 700 baht/year |
| Reserves for major repairs | | 1,000 baht/year |
| Total | | 9,000 baht/year |

When evaluating the benefits of the proposed water supply facilities, it is necessary to consider it separately from general water works.

The water works is usually a public enterprise and its benefits are evaluated on the basis of its profitability. Water facilities to which this principle does not apply need to be evaluated in terms of the following benefits:

(1) Benefit to consumers

(2) Benefit to the health of the community

(3) Benefit to the public good and industry

(4) Other benefits worth special mention

Of those benefits, (1) and (2) can be expected from the proposed water supply facilities. The facilities will certainly be effective in the protection of public health, especially in the prevention of communicable water-borne diseases. A water supply which is reliable throughout the year will contribute a great deal to the improvement of the standard of living of the community.

At present, the people who are served by the Provincial Water Works Authority pay 2 baht/$m^3$ water, about half the production cost. (The actual water production cost is 4.5 baht/$m^3$ of which 2.5 baht is borne by the government). Apart from the scale and capacity of the water supply facilities, the production cost of the system can be considered to represent the sum of operating, overhead and administrative costs. Take for example the proposed water supply system of Tagad Ngao which is expected to involve comparatively larger costs.

Production cost : 14,000 baht/year

Water demand

15 $m^3$/day x 30 days/month x 12 months/year = 5,400 $m^3$/year

Production cost per $m^3$ of water

$$\frac{\text{Annual production cost}}{\text{Annual water demand}} = \frac{14{,}000 \text{ baht}}{5{,}400 \text{ m}^3} = 2.6 \text{ baht/m}^3$$

Similarly, the water production costs in other model areas is calculated as follows:

- Ban Sam Rong

$$\frac{14{,}000 \text{ baht}}{10{,}800 \text{ m}^3} = 1.3 \text{ baht/m}^3$$

- Ban Bo

$$\frac{11{,}500 \text{ baht}}{3{,}960 \text{ m}^3} = 2.9 \text{ baht/m}^3$$

- Prapokklao Hospital

$$\frac{32{,}500 \text{ baht}}{7{,}200 \text{ m}^3} = 4.5 \text{ baht/m}^3$$

The population served, annual water demand and production cost in the four model areas are summarized in bellow.

Table 4-7 Water Production Costs

| Model Area | Population Served | Annual Total Water Demand | Annual Production Cost of Drinking Water (Baht/year) | Production Cost of Drinking Water per $m^3$ (Baht/$m^3$) |
|---|---|---|---|---|
| Ban Sam Rong | 1,088 | 10,800 | 14,000 | 1.3 |
| Tagad Ngao | 564 | 5,400 | 14,000 | 2.6 |
| Ban Bo | 545 | 3,960 | 11,500 | 2.9 |
| Prapokklao Hospital | 700 ($m^2$) | 7,200 | 32,500 | 4.5 |
| Total | 2,197 | 27,360 | 72,000 | 11.3 |
| Average | 733 | 6,840 | 1,800 | 2.9 |

If the production costs are to be met by charging the users a percentage of the operation and maintenance cost of the water supply facilities, the water rate will not differ much from that charged by the Provincial Water Works Authority except for the Prapokklao Hospital water supply system. Especially in the Ban Sam Rong area with a relatively large population to be served, the production cost per $m^3$ of drinking water will be as low as 1.3 baht. The charge based on this production cost will not be a very heavy expense for the individual households to shoulder. The average production cost per $m^3$ of drinking water for the three model areas excluding Prapokklao Hospital is 2.3 baht.

However, the water supply facilities are, so to speak, an emergency countermeasure which will help to prevent frequent occurrence of communicable water-borne diseases and meet the needs for drinking water in the provincial communities during the dry season. Therefore, based on the objectives and nature of the water supply facilities, it is desirable that the water cost be reduced to a minimum.

Table 4-8 Annual Operating and Overhead Costs of Water Supply Facilities

(in baht)

| Cost Element / Model Plan | Model District | Energy | Consumables | Administrative | Total | Annual Expense Charged to the Community | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Per Person | Per Household* | Per $m^3$** |
| A | Sai Kao (Ban Rong) | - | 5,000 | 9,000 | 14,000 | 14 | 56 | 467 |
| B | Tagad Ngao (Ban Nong Khan) | - | 5,000 | 9,000 | 14,000 | 25 | 100 | 934 |
| C | Bo (Ban Bo) | - | 2,500 | 9,000 | 11,500 | 22 | 88 | 1,046 |
| D | Prapokklao Hospital | 12,500 | 10,000 | 10,000 | 32,500 | - | - | 1,625 |
| Total | | 12,500 | 22,500 | 37,000 | 72,000 | 61 | 244 | 4,072 |
| Average | | 12,500 | 5,625 | 9,250 | 18,000 | 21 | 82 | 1,018 |

* Each household was assumed to consist of 4 members.

** Based on planned water demand.

Table 4 - 9 COMMON HAND PUMP TROUBLES AND REMEDIES

| TROUBLE | LIKELY CAUSE | REMEDY |
|---|---|---|
| 1. Pump handle works easily but no water delivered. | A. No Water at the source. Well dry. | Rehabilitate well, or develop a new source or sources of water. |
| | or | |
| | B. Level of water has dropped below suction distance of pump. | Can be checked with vacuum gauge or with weighted string. Reduce pumping rate or lower pump cylinder. |
| | or | |
| | C. Pump has lost its priming. | Prime the pump. If the pump repeatedly loses its priming it may be periodically pumping the well dry, the suction line may be leaking, or the suction valve or discharge check valve may be leaking. Repair line or valve. |
| | or | |
| | D. The cylinder cup seals ("leathers") may be worn out | Renew the cylinder cup seals ("leathers"). |
| | or | |
| | E. The valves or valve seats may be worn or corroded. | Renew valves and repair or renew seates. |
| | or | |
| | F. With a deep-well plunger pump the plunger rod may be broken. | This trouble would be indicated by the pump running freer and and probably quieter. Turn the pump over by hand and note if there is resistance on the upstroke. Broken rods must be renewed and this usually means pulling the drop pipe and cylinder out of the well. |
| | or | |
| | G. Shutoff valve may be closed (force pump). | Open valve |
| | or | |



Continued

| TROUBLE | LIKELY CAUSE | REMEDY |
|---|---|---|
| 1. Pump handle works easily but no water delivered (continued) | H. Hole in suction pipe. | Renew suction pipe. Cylinder may be lowered below water level in well. |
| | or | |
| | I. The suction pipe may be plugged with scale or iron bacterial growth or sediment. | Can be checked with vacuum gauge. Remove suction pipe and clean or renew. |
| | or | |
| | J. The pump cylinder may be cracked. | Renew the cylinder. |
| | or | |
| | K. Leak at base of cylinder. | Renew cylinder gasket. |
| | or | |
| | L. One or more check valves held open by trash or scale. | Remove valves and inspect for trouble. With deep-well plunger pumps this may mean pulling the pump cylinder or plunger and valves out of the well. |
| 2. Pump runs but delivers only | A. Plunger leathers badly worn (plunger and piston pumps). | Renew leathers. |
| | or | |
| | B. Well not yielding enough water. | Decrease demands or establish new sources of water. |
| | or | |
| | C. Cracked cylinder (plunger or piston pump). | Renew cylinder. |
| | or | |
| | D. Check valve(s) liaking. | Repair valve(s). |
| | or | |

Continued

| TROUBLE | LIKELY CAUSE | REMEDY |
|---|---|---|
| 2. Pump runs but delivers only a small amount of water. (continued) | E. Screen or suction valve may be obstructed. | Removed and clean |
| | or | |
| | F. Suction pipes are too small. | Can be checked with vacuum Gauge. Install pipe with larger diameter, or for deep well pump, lower pump cylinder below water level in well. |
| | or | |
| | G. Suction valve(s) may be out of order. | Repair valve(s). |
| | or | |
| | H. Cracked drop pipe or coupling. | Renew drop pipe or coupling. |
| 3. Pump needs too many strokes to start | A. Pump has lost its priming. | Prime the pump. If the pump repeatedly loses its priming, it may be periodically pumping the well dry, or the suction line or the suction valve may be leaking. Repair or renew line or valve. |
| | or | |
| | B. The cylinder cup seals ("leathers") may be worn out. | Renew the cylinder cup seals. |
| 4. Handle springs up after down stroke. | A. Suction pipe plugged up below pump cylinder. | Remove pump and clean out suction pipe. If well has filled with dirt up to suction pipe, the well should be cleaned out or the pipe cut off. |
| | or | |
| | B. Plunger check valve fails to open or to close. | Repair check valve. |
| | or | |

Continued

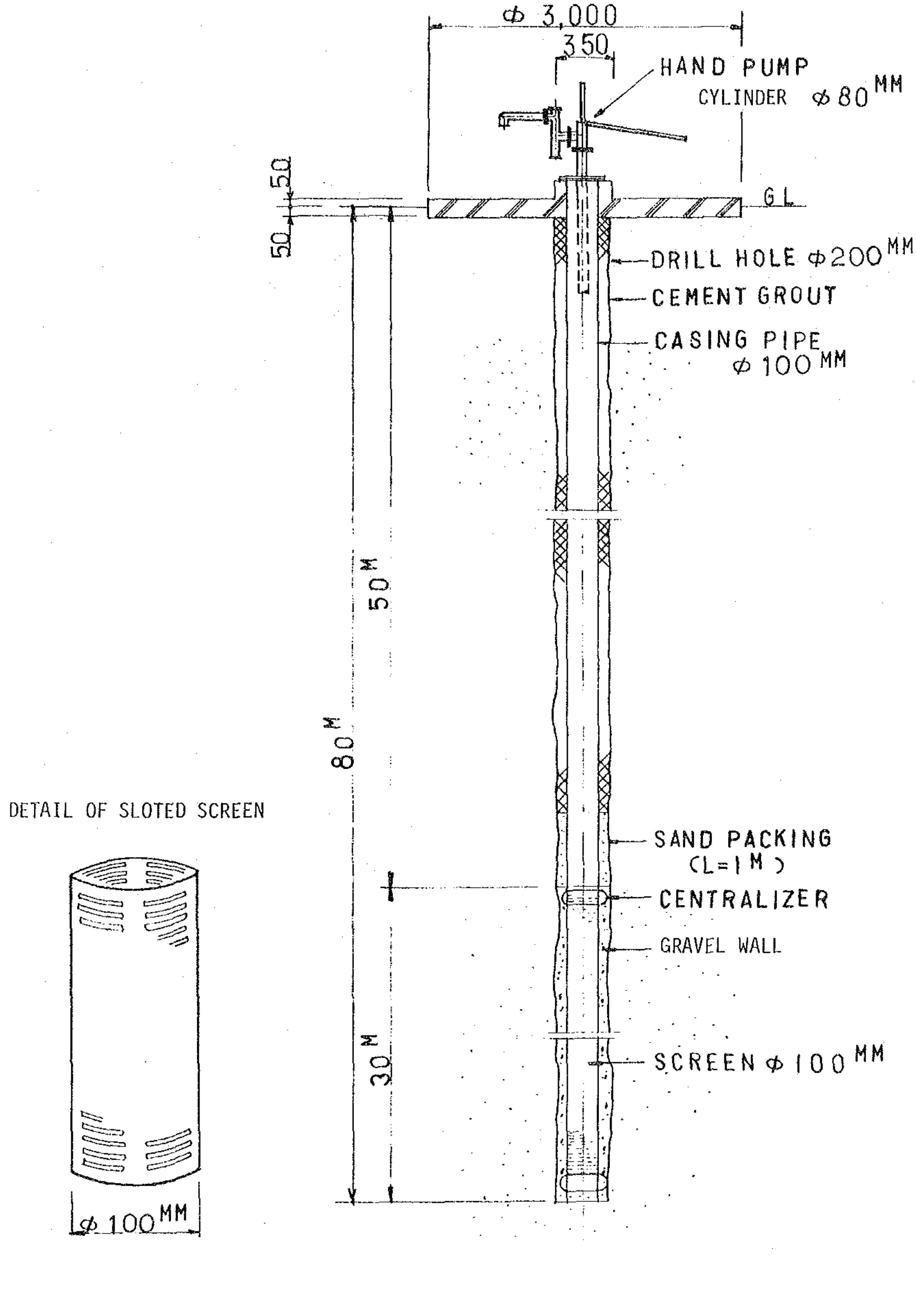
| TROUBLE | LIKELY CAUSE | REMEDY |
|---|---|---|
| 4. Handle springs up after down stroke (continued) | C. Suction pipe too small. | Replace with larger suction pipe. |
| | or | |
| | D. Water too far below pump (suction pipe too long) | Place cylinder nearer water. |
| 5. Leaks at suffing box | A. Packing worn out or loose. | Renew or tighten packing. Leave packing nut loose enough to allow a slow drip of water. The water serves as a lubricant. |
| | or | |
| | B. Plunger rod badly scored. | Renew plunger rod. |
| 6. Pump is noisy | A. Bearings or other working parts of the pump are loose. | Tighten or renew parts. |
| | or | |
| | B. Pump is loose on mountings. | Righten mountings.. |
| | or | |
| | C. With deep-well plunger pumps having a steel plunger rod the rod may be slapping against the drop line. | Use a wooden rod or install guides for rod or straigten drop pipe if crooked. |

Table 4 - 10 SCHEDULE FOR MAINTENANCE OF HAND PUMP

| | | |
|---|---|---|
| daily | 1. | Clean the well-head and space for water-drawing. |
| Weekly | 1. | thorough clean-up of pump, well-head and surroundings. |
| | 2. | oil or grease all thing pins, bearings, and sliding parts, after checking that no rust has developed on them. |
| | 3. | inspect and take care of the drain ditch and the infiltration trench. |
| | 4. | record any comments from users about irregularities in working (tightness of parts, leaks from stuffing box, fall-off in water raised). Correct these when possible. |
| monthly | 1. | if necessary, adjust the stuffing box or gland. Usually this is done by tightening the packing nut. This should not be too tight-there should be a slight leak when the adjustment is correct. |
| | 2. | check that all nuts and bolts are tight, and check that there is no evidence of loose connections on the pump rods. |
| | 3. | check for symptoms of wear at the leathers, noting any comments from users about any falling off in the water raised. If the pump fails to raise water when worked slowly (e.g., at 10 strokes per minute), replace the leathers. |
| | 4. | carry out all weekly maintenance tasks. |
| annualy | 1, | paint all exposed parts to prevent development of rust. |
| | 2, | repair any cracked concrete in the well-head and surrounds. |
| | 3, | check wear at handle bearings and replace parts as necessary. On the Craelius pump, worn bushes can be replaced by short sections of pipe of suitable diameter. |
| | 4. | check plunger valve and foot valve; replace if found leaking. |
| | 5. | check the pump rod and replace any defective lengths or connectors. |
| | 6. | replace packing at the stuffing box or gland. |
| | 7. | carry out all monthly maintenance tasks. |

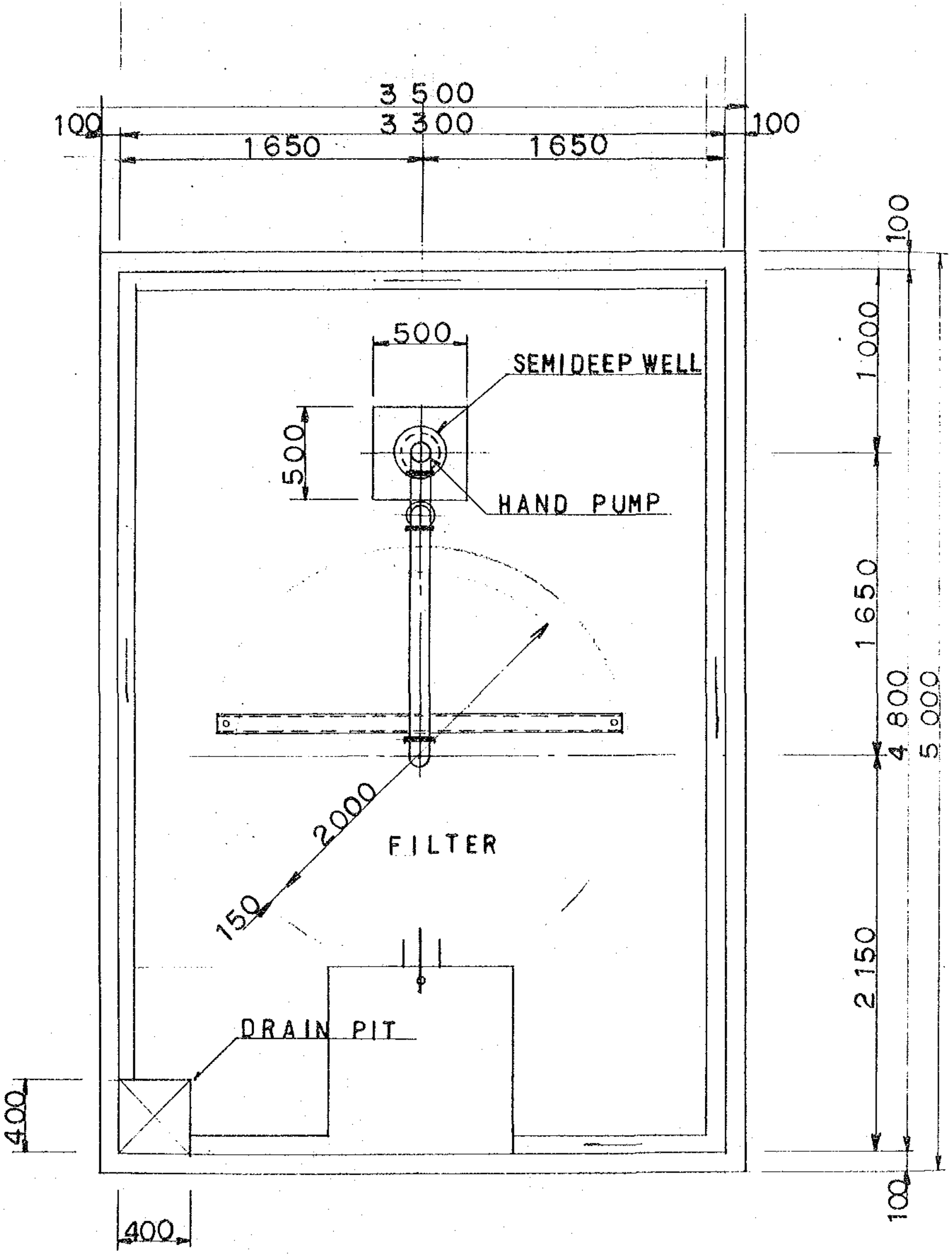
Fig. 4-1

# MODEL PLAN A




STRUCTURE OF WELL

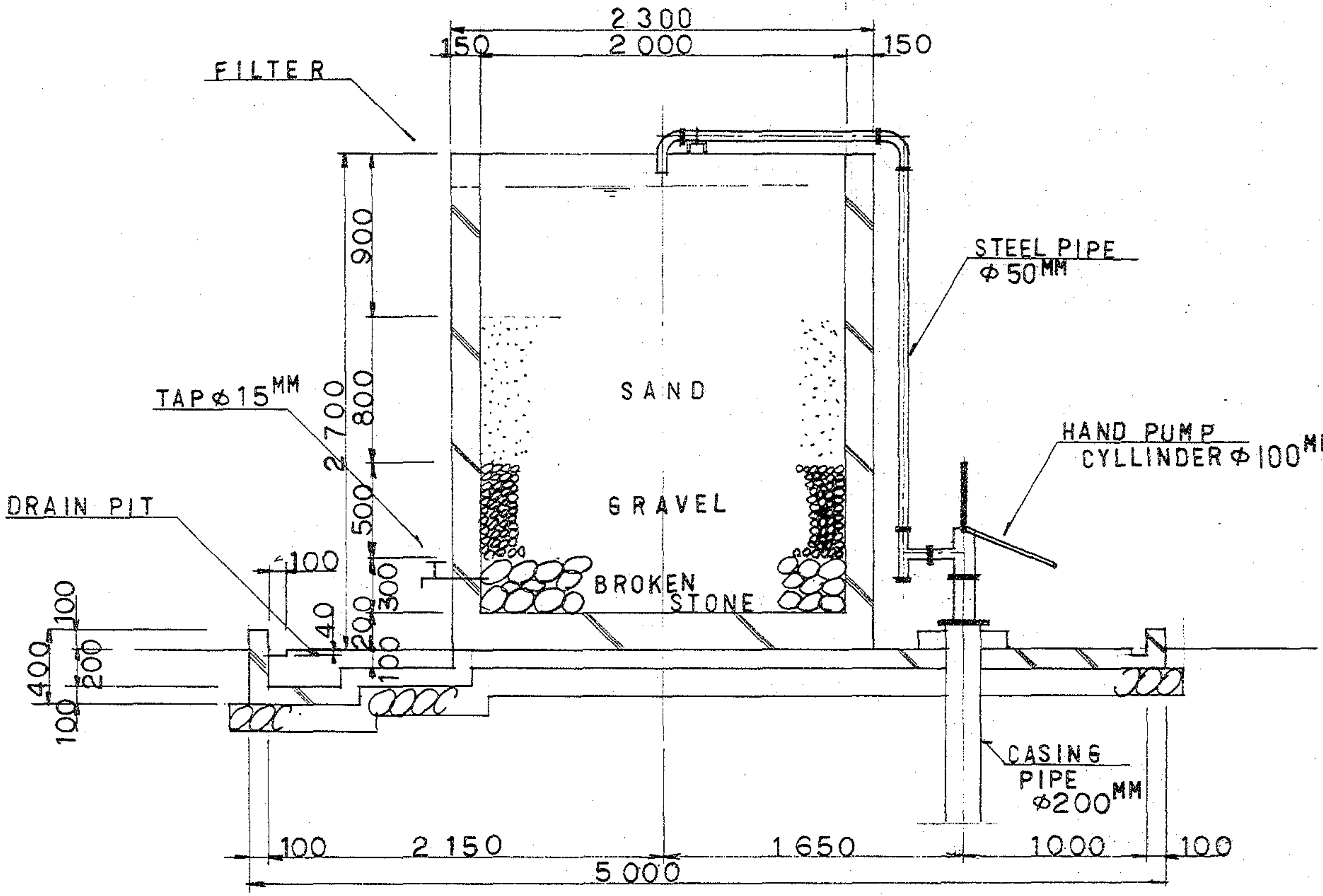
Fig. 4-2
# MODEL PLAN B

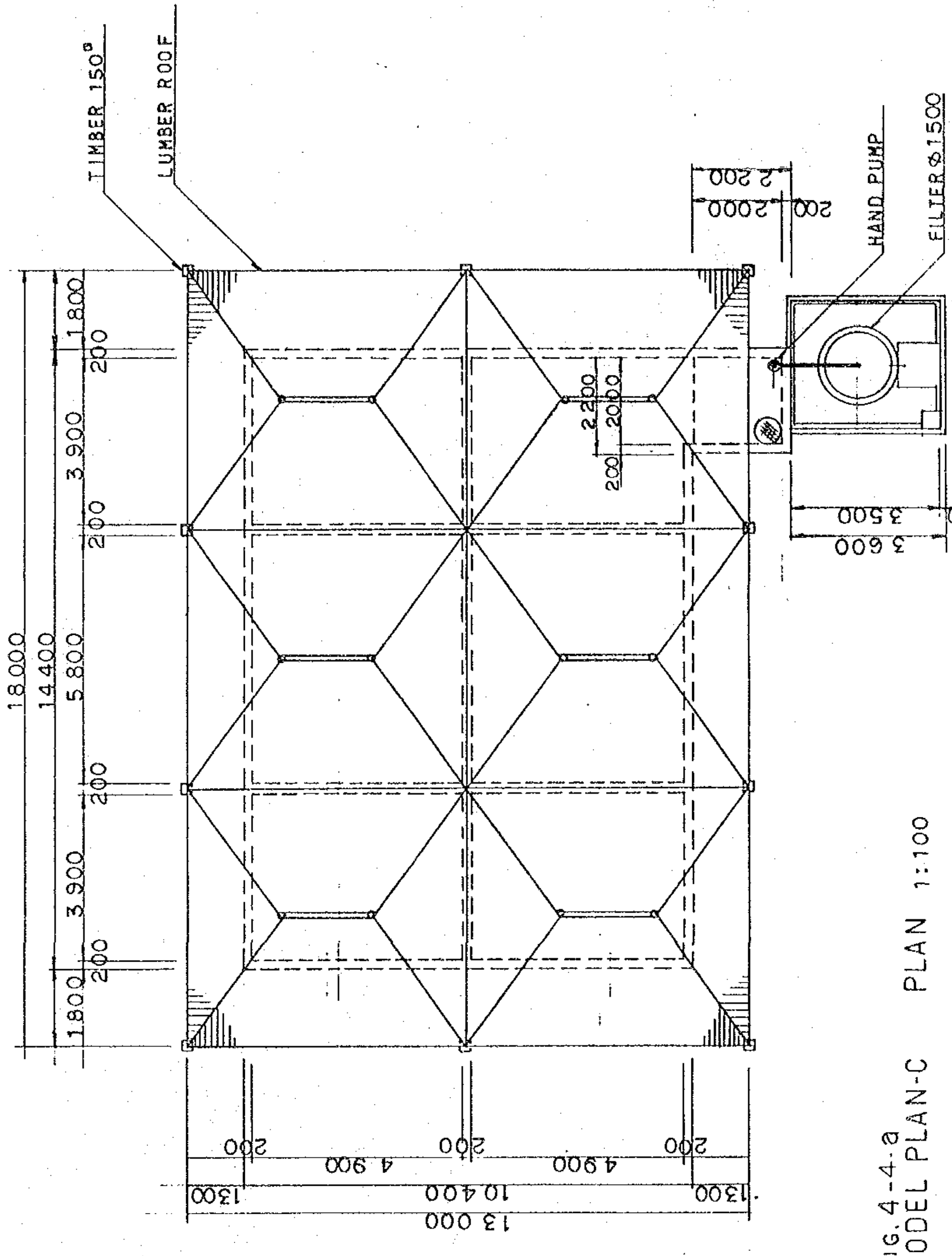



PLAN 1 : 40

Fig. 4-3

# SECTION






PLAN 1:100

FIG. 4-4-a
MODEL PLAN-C

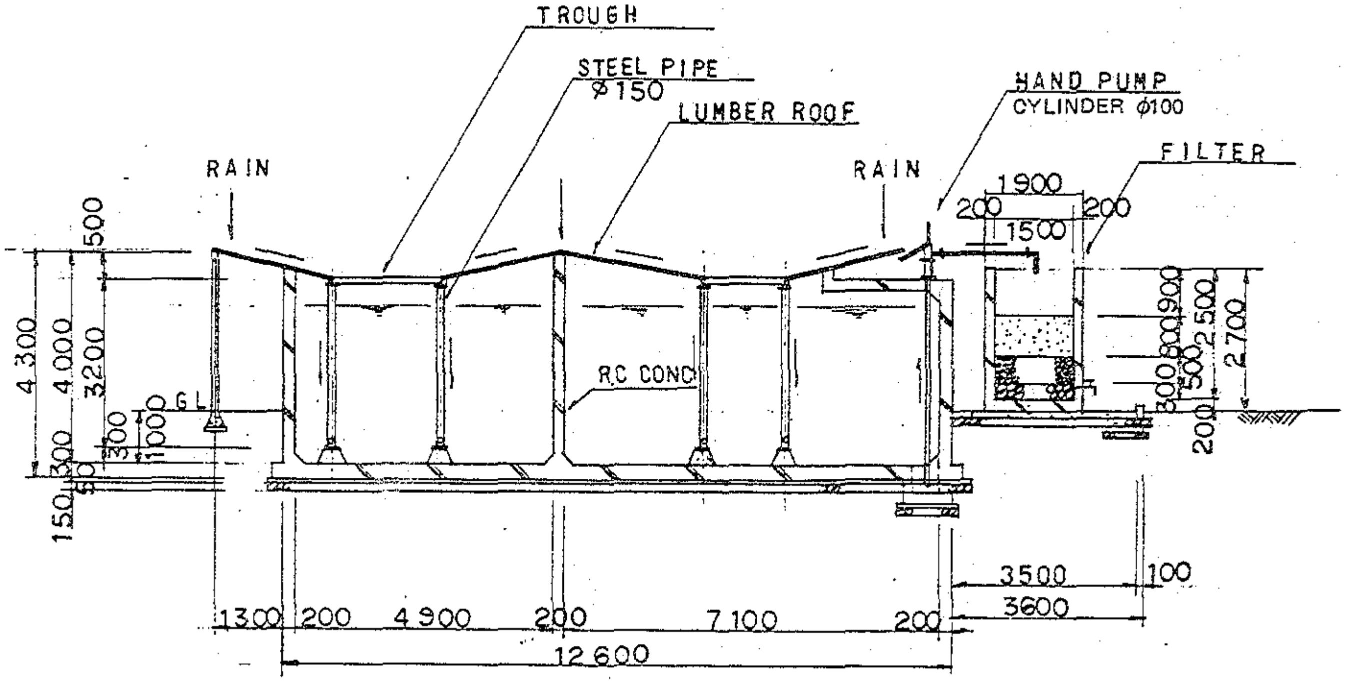
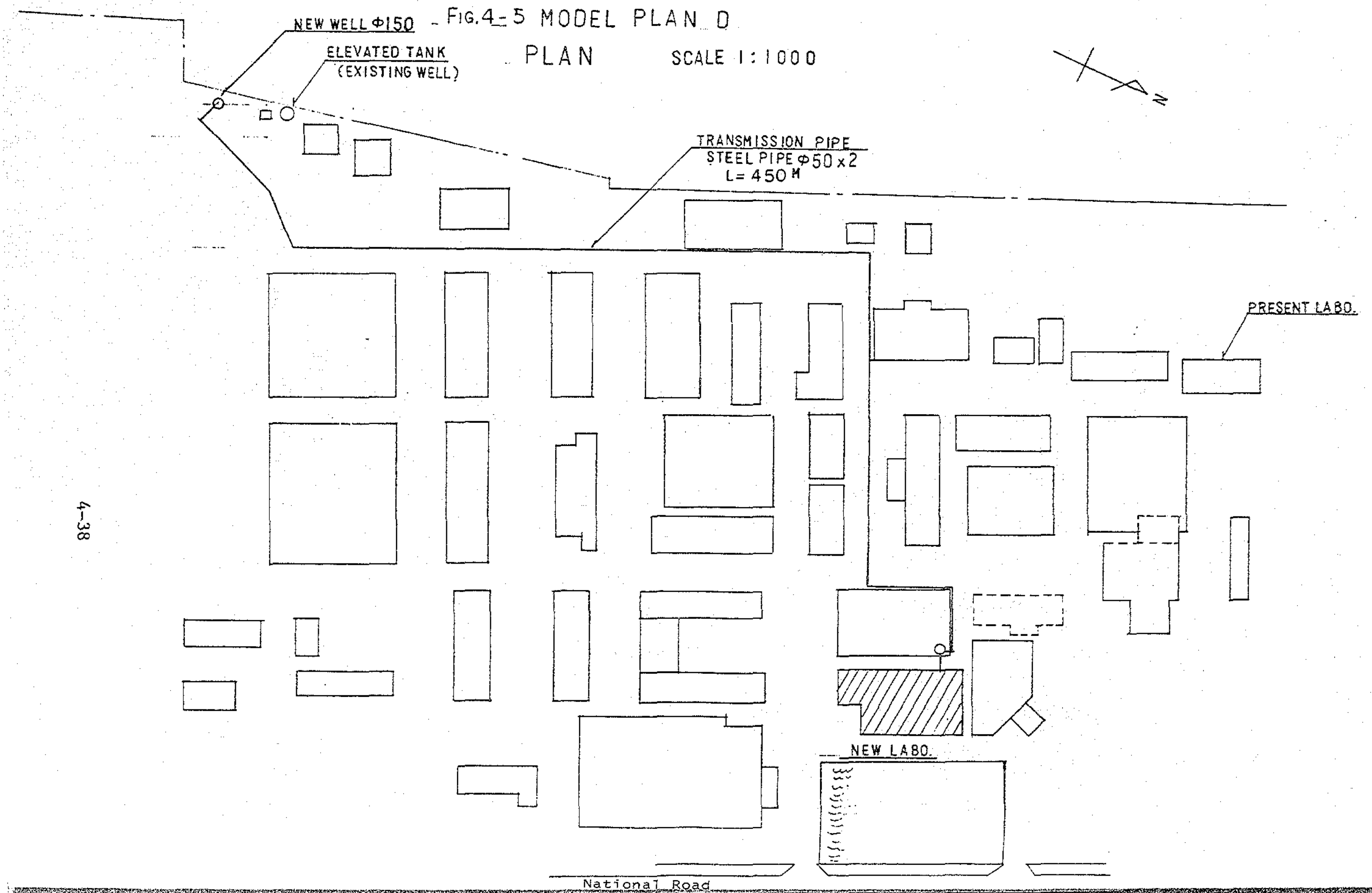



Fig. 4-4-b
SECTION

## FIG.4-5 MODEL PLAN D

PLAN SCALE 1:1000



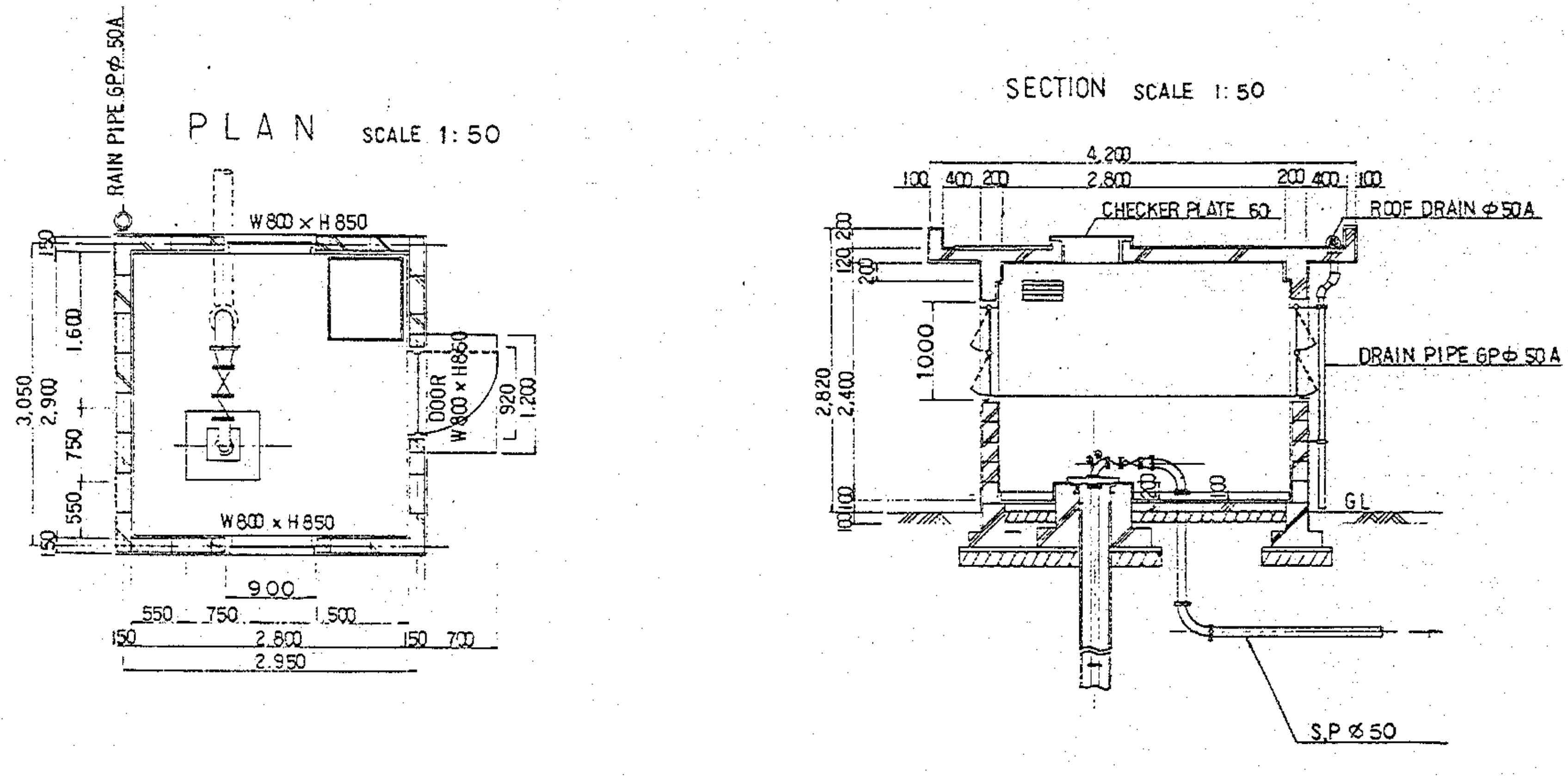
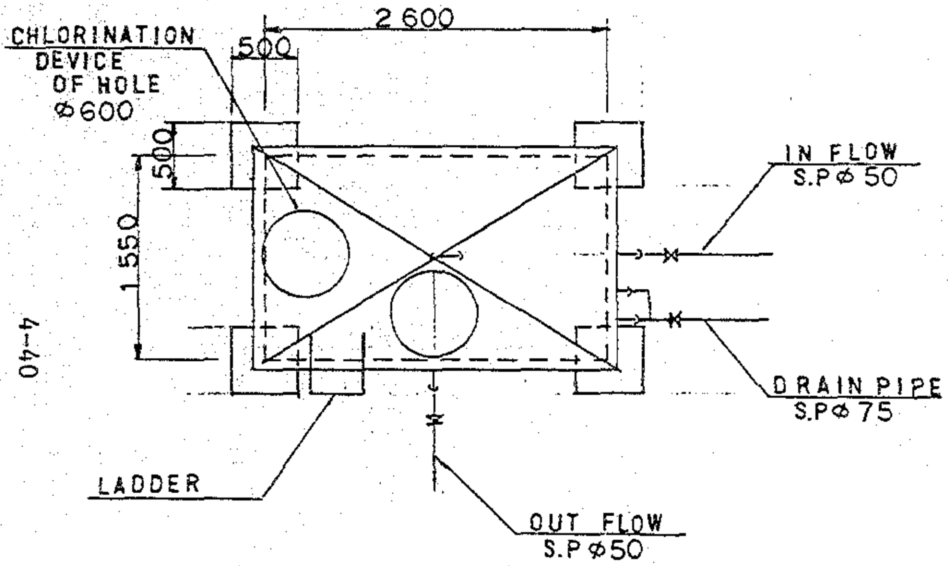
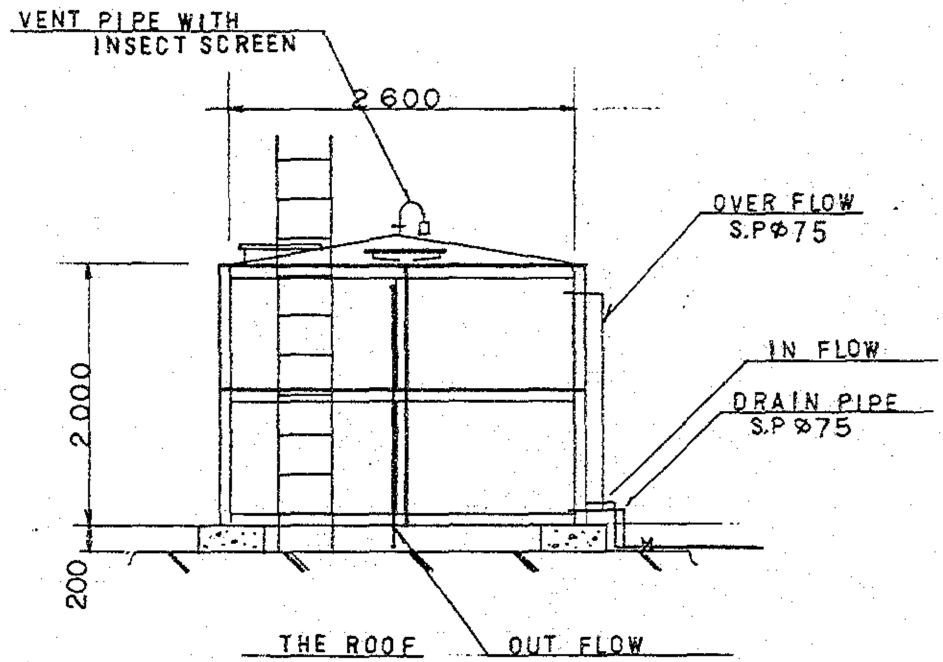



Fig.4 -6
DEEP WELL AND
PUMPING ROOM




PLAN 1:40




SECTION

FIG. 4-7
ELEVATED TANK

# APPENDIX

A: Design Criteria of P.W.W.A.

B: Technical Specification (Example)
- Submersible Pump -

C: Shop Drawings

D: Collected Data and Information

E: Collected Data for Cost Estimates

F: Photograph

## APPENDIX A: DESIGN CRITERIA OF P.W.W.A.

### ESTABLISHMENT OF PROJECT CRITERIA OF P.W.W.A.

#### Eligibility and Priority Criteria

Since the Community Potable Water Project was planned as a pilot project for the comprehensive National Potable Water Program, it was evident that program criteria had to be developed so that they could also be used for that program. Since the Royal Thai Government Department of Public Works, Ministry of Interior had already planned and partially implemented a program for communities with populations of over ten thousand, this number was established as the upper limit for communities to be considered for inclusion in the project. The lower limit was governed primarily by economic factors. Since per capita costs would have to be kept low to enable the broadest possible coverage with the limited funds available, the lower limit was set at a minimum population of 500 for any one system. (Communities with less than this number can normally be helped most economically by the Department of Community Development of the RTG Ministry of Interior.) In certain instances a group of small neighboring communities with less than 500 population each, but with an aggregate population exceeding 500 which can be served by a single system has been included in the project.

In order to qualify for inclusion in the project, communities are required to make formal requests in writing through the Changwad governor. The limited funds which have been made available for the project have necessitated a very careful review of community requests. Although during the early phases of the project the urgency of getting the program started affected the quality of review, this condition has long since been corrected and all requests now undergo an exhaustive review before approval is recommended.

Since the demand is much greater than the project can currently support, the size of the local community contribution becomes an important factor in determining project priorities. Every effort is made to obtain contributions of 50 percent or more of the cost where the system involves a sanitary district which has borrowing capability and up to 25 percent where the community does not have this capability. Non-economic factors do, of course, sometimes generate overriding priorities. In general, plant construction costs vary from 100 bahts ($5.00)/capita to 200 bahts/capita depending on the size of the population and the complexity of the installation.

During the early phases of the project, the scope of the program was limited primarily by the lack of qualified technical personnel. This condition has been substantially corrected and program limitations are now almost exclusively of a budgetary nature.

Technical Criteria

The development of appropriate technical criteria for the project was a matter of considerable concern to SED, USOM, and TAMS. The limited amount of funds dictated the lowest practicable criteria but good engineering practice dictated that the criteria be consistent with the requirements of the community. The situation was further complicated by the lack of reliable statistical data on the water habits of the residents to be served.

Studies were made of water usage in typical rural areas and the results compared with data from similar areas in other countries. SED, USOM and TAMS decided that consumption criteria should be developed for two different categories of communities, both of which were assumed to be constructed initially with 100 percent public taps. The designation of a community as category "A" or category "B" is dependent upon such factors as location, wealth, capacity of water source, village interest and extent of local contribution as well as the anticipated water habits of the community. It was assumed that at the end of ten years, category "A" communities would be 80 percent served by private house connections with an average overall per capita consumption of 80 liters per day, while category "B" communities would be only 40 percent served by private house connections with an average overall per capita consumption of 50 liters per day.

A plant life of ten years was utilized for design purposes, with a population growth figure of 3 percent annually, although plant structures with adequate maintenance should be usable well beyond this period. Some items of equipment such as pumps and engines may require replacement before the end of this period.

The maximum day demand was established as one-and-one-half times the average day demand and the peak hour demand was set at one-sixth of the average day demand. Since most of the communities do not have electricity and their budgets can only support one regular operator, the average pumping day was fixed at 10 hours to ensure that all normal pumping could be accomplished by one operator during daylight hours. To cover emergency situations, the maximum pumping day was set at 15 hours.

Total ground and elevated water storage was established at approximately 70 percent of the average day supply with the elevated portion a minimum of 20 percent of the average day supply. No provisions for the protection were incorporated in design criteria, although systems have in some instances been modified at the request of local authorities to include fire hydrants.

The design life for distribution systems was set at fifteen years. Asbestos cement and galvanized steel pipe were specified for plant piping and primary distribution mains, and PVC pipe for secondary distribution lines. A minimum pressure of 10 pounds per square inch at the curb was established for all distribution mains.

In general, the standard design criteria used as guidelines throughout the project were those of the American Water Works Association, with minor modifications as necessary to fit local conditions. To minimize the use of foreign exchange, locally manufactured products are utilized wherever practicable. Special attention has also been given to ensuring that proper emphasis is placed upon low initial cost and low oepration and maintenance costs in specifying various types of material and equipment.

Development of Standard Designs of P.W.W.A.

To get the project underway with a minimum of delay, existing SED plant designs were utilized for the first group of 17 plants. Modifications to these designs were made as necessary to fit local conditions during the spring and summer of 1966, and the plants were placed under contract for construction in September 1966.

The arrival of TAMS engineers prompted the decision to develop a group of new standard designs for the project based on the criteria outlined in Section V.* The basic principle employed in design development was to provide facilities which would yield a product meeting minimum U.S. Public Health Service standards and still the simple and economical to construct and easy to operate and maintain. The remote locations of most of the planned facilities, the inexperience of prospective operators and the absence of electrical power dictated simplicity, while budgetary limitations and the magnitude of the potable water problem made economical design particularly important.

The urgency of the project and the limited number of qualified TAMS and SED design personnel available made it necessary to restrict the various types of standard designs to a minimum. A series of standard treatment plants was designed with capacities of 10 cubic meters/hour, 20 cm/hr, 30 cm/hr and 50 cm/hr.** With these four capacities, it became possible to provide effective and economical systems for the entire population range (500 - 10,000) covered by the project.

* Standard design details are contained.

** Photographs of each size plant, as well as the Khon Kaen office and Warehouse Complex.

## Sources and Treatment

In addition to variations in system sizes, designs had to be developed to suit the various types and qualities of raw water. Ground water sources normally provide a good quality of water and treatment can often be limited to chlorination. In certain areas, however, an iron content of up to 10 ppm has necessitated more comprehensive treatment. Initial designs for ground water of this type provided for aeration, sedimentation, slow sand filtration and chlorination. Although a filtration rate about double the normally accepted rate has been used, the treatment has been completely satisfactory and has produced a very high quality water. Slow sand filters are not normally used for iron removal because they plug frequently, but this has not been a problem in Thailand because of the small size of the filters and the ready availability of labor for cleaning them.

Surface water is provided from a variety of sources including major rivers, such as the Mekong, the Mun, and the Chi, natural ponds and lakes, canals and irrigation reservoirs. In some areas, mountain streams or spring have supplied a good quality of water which requires only chlorination. In other instances, streams or rivers with sandy bottoms and low turbidity have allowed the use of infiltration galleries, supplemented by chlorination. In most instances, however, complete treatment of surface water, including coagulation, sedimentation, filtration and chlorination has been required.

Since it was originally assumed that it would be too difficult to train operators in the smaller communities to use rapid sand filters, initial designs for 10 cm/hr plants incorporated slow sand filters exclusively. However, the use of rapid sand filters proved not to be a problem and a corresponding design for this size plant has since been developed which allows substantial savings in construction costs.

## Facility Sizes and Design

Original designs provided for a 30 cm elevated steel tank with wood tower for the 10 cm/hr plant, a 45 cm elevated concrete tank with concrete columns for the 20 cm/hr plant, and a 60 cm elevated concrete tank with concrete columns for the 30 cm/hr plant. The elevated water storage was supplemented by ground water storage contained in concrete clear wells of 60 cm, 100 cm and 160 cm respectively for the 10 cm/hr, 20 cm/hr and 30 cm/hr plants. A separate concrete structure was provided for the treatment plant where required. Other plant facilities included raw and treated water pump houses, oil storage house, and a fenced enclosure for the plant area.

Initial construction costs have been a matter of considerable concern since the start of teh project and continuing attention has been given to providing more economical designs. The first step in this direction involved placing the treated water pump and the oil storage area under the flocculation unit. Steel tanks and structures have been designed for use with the 10 cm/hr, 20 cm/hr and 30 cm/hr plants. A concrete standpipe was designed for the 30 cm/hr plant to replace the elevated tank and the clear well. Since the standpipe provided useful storage under pressure equivalent to the elevated tank and clear well storage at a substantially lower cost, a similar design was prepared for the 50 cm/hr plant which has proven equally satisfactory.

Pilot plant studies indicated that a spiral flow type flocculator could be substituted for the baffle type included in the original designs without appreciable loss of efficiency, and that considerable savings would result. Consequently, designs have been completed for 10 and 30 cm/hr compact plants with the new type flocculator and many other improvements for use in the FY 1969 construction program.

Power

Original designs did not usually contemplate the availability of electricity, and both centrifugal and deepwell turbine pumps were designed and procured with diesel power units. An administrative decision within USOM resulted in the delivery of nearly all of the deepwell turbine pumps with gasoline power units, creating a most unsatisfactory situation at a number of plants since different types of fuel are required for each unit. Steps are being taken to correct this condition by the procurement of replacement diesel drive units.

Early designs for plants along the Mekong River and in other areas where there are major seasonal variations in source water levels incorporated the use of floating pumphouses with diesel-driven pumping units. Since electric power is becoming increasingly available in all rural areas, electrically operated pumps are being planned for use in a growing number of installations. Electrically operated submersible pumps have proven particularly advantageous over floating pumphouses.

During the initial phases of design development all design was accomplished by TAMS and SED engineers working in the Khon Kaen office. As the field engineers gained more experience, those portions of the design which are peculiar to the individual installation, such as plant layouts, distribution systems, infiltration galleries and raw water intakes, have been assigned to the field offices. All designs are still reviewed in the Khon Kaen office, which also retains responsibility for development of new design concepts and modifications and improvements to existing standards.

## APPENDIX B: TECHNICAL SPECIFICATION (EXAMPLE)

### - Submersible Pump -

General

The Supplier shall furnish and deliver to submersible vertical turbine type pumping unit(s) to the city of Chanthabri. Each pumping unit shall be close coupled to an electric motor designed for sustained and continuous operation under water.

Performance and Dimensional Requirements

The pumping units shall meet the operating and dimensional requirements as shown in the following table.

| Description | Spec. |
|---|---|
| Number of Unit | 1 |
| Power (min nameplate ratings) | 3.7 |
| Min cap at design head (litter/min) | 70 |
| Design head -- TDH (meters) | 100 |
| Well casing diameter (mm) | 150 |
| Discharge diameter (mm) | 32 |

Pump Construction

(a) General - Submersible pumping units shall conform to the requirements of JIS B8324 - Submersible Motor - Pump for Deep Well or "American Standards for Submersible Vertical Turbine Pumps" (AWWA Designation E101, Part B) and the following:

(b) Pump Bowl Assembly - The pump bowl assembly shall be equipped with cast-iron bowls and bronze impellers. The impellers shall be of cast bronze, smoothly finished and dynamically balanced. All bronze components shall conform to the requirements of ASTM Specification B62 or B145 or JIS H5111, BC-2 or BC-6. The bowls shall be of close grained cast-iron having a minimum tensile strength of 2,100 $kg/cm^2$, shall be free of blow holes, sand holes, and all other faults, and shall be accurately machined and fitted to close dimensions. The pump bowls shall be lined with porcelain enamel or epoxy. A pump bowl strainer of bronze shall be provided.

(c) Vertical Discharge Column - The column pipe shall conform to the "Specifications for Wrought-Steel and Wrought-Iron Pipe" (ASA Designation B36.10) schedule 30 steel pipe or JIS G3454, STPG38, schedule 40 pipe, with threaded sleeve couplings. The column pipe shall be sandblasted and coated internally and externally with coaltar epoxy or a 250 micron vinyl system.

(d) Submersible Cable - The electric cable shall be sized in accordance with AWWA E1-1. The cable shall be supported from the discharge column by non-magnetic stainless steel bands a minimum of every five (5) meters. A steel cable guard shall protect the cables where they pass the bowl assembly.

(e) Discharge Heads - The discharge head shall be of the surface plate type with flanged elbow, of cast iron and dimensions. The heads shall be designed to support the entire weight of the suspended parts. After fabrication the discharge heads shall be sandblasted and primed with one coat of red lead primer. The interior waterways shall be coated with epoxy or a 250-micron vinyl system. Anchor bolts shall also be furnished by the Supplier.

(f) Pump-Motor Coupling - The pump-motor coupling shall be of stainless steel and designed to transmit the total torque and thrust of the unit in either direction.

Motors

The motors shall be of the squirrel cage induction type, suitable for across-the-line starting and shall be capable of reduced-voltage starting. The motor shall be suitable for 220-volt, single-phase 50-hertz A.C. and capable of continuous operation under water. The motor temperature shall conform to the latest NEMA, JIS, JEC or JEM standards for submersible motors.

## APPENDIX C: SHOP DRAWINGS

Working or shop drawings prepared by the Contractor for any item shall consist of such detailed plans as may be required for the prosecution of the works. They shall include but not limited to shop details, installation methods, erection plans, exact layout diagrams and diagrams showing location, size, details and connections for all equipment and materials and must be approved by the Engineer before any work involving these shop drawings is performed. Shop drawings shall incorporate complete lists of spare parts, special tools, and other materials stocks to be furnished for proper maintenance and operation fo the equipment, as required by the Contract Documents. If no spare parts, special tools, or other items are to be furnished, the shop drawings shall specifically so state.

It is expressly understood that approval of the shop drawings by the Engineer shall not be construed as a complete check but will indicate only that the general method of construction and detailing is satisfactory. Approval shall not be construed as permitting departure from the Contract requirements. Approval of such shop drawings will not relieve the Contractor of the responsibility for only error which may exist, as the Contractor shall be responsible for the dimensions and detailing of adequate connections details of mutual agreement of dimensions and details and satisfactory construction of all works. It is mutually agreed that the Contractor shall be responsible for agreement and conformity of his working drawings with the Contract drawings and specifications.

The Contractor shall submit to the Engineer three (3) complete sets of all working and shop drawings. These working and shop drawings shall be completed and shall contain all required detailed information. If approved by the Engineer each copy of the working and shop drawings will be identified by the Engineer as having received such approval by being so stamped and dated. The Contractor shall make any corrections required by the Engineer and resubmit six corrected copies for approval.

A title block shall be located in the lower right hand corner of each drawing. The title block shall display the following:

a. Number and title of drawing

b. Date of drawing or revision

c. Name of project structure of facility

d. Name of Contractor submitting drawing

e. Clear identify of contents and location of the works, specification, title and number

The size of working and shop drawings shall be the same size or half size of the Contract drawings. The size of small drawings and schedules may be either letter size (21.5 cm by 28 cm)or legal size (21.5 m by 33 cm).

Drawings and schedules shall be checked and coordinated with the work of all descriptions involved before they are submitted for the approval to the Engineer and shall bear the Contractor's stamp of approval as evidence of such checking and coordination. Drawings submitted without this stamp of approval may be returned to the Contractor for resubmission.

The Contractor shall submit all drawings sufficiently in advance of construction requirements to permit no less than thirty (3) working days for checking and appropriate action. Additional time may be necessary for checking certain submittions and if necessary this is noted in the Supplemental Specifications. If the shop drawings are not approved then new submissions shall be prepared by the Contractor. The stated number of days for checking and action is required for each submission until approval is given.

If drawings show variations from the Contract requirements because of standard shop practice or for other reasons the Contractor shall describe such variations in his letter of transmittal. If acceptable the Engineer may approve any or all such variations subject to proper adjustment in the Contract requirements. If the Contractor fails to describe such variations he shall not be relieved of the responsibility for execution of the work in accordance with the Contract, even though such drawings have been approved.

If the drawings or schedules as submitted show a departure from the Contract requirements which the Engineer finds to be in the interest of the Authority and to be so minor as not to involve change in the Contract Price or time for completion the Engineer may approve the drawings.

One set of approved working and shop drawings will be returned to the Contractor. If the Contractor desires more than one set the requirements of quantity submitted shall be increased accordingly.

Upon approval of shop drawings, the Contractor shall furnish three (3) prints of each drawing and one (1) reverse reading, reproducible tracing of each drawing to the Engineer for his use.

The Contract Price shall include the cost of furnishing all working, shop and As-Built drawings and the Contractor will be allowed no extra compensation for such drawings.

Before final payment is made the Contractor shall furnish to the Engineer on original set of As-Built working and shop drawings clearly revised, completed and brought up-to-date showing the permanent construction as actually made.