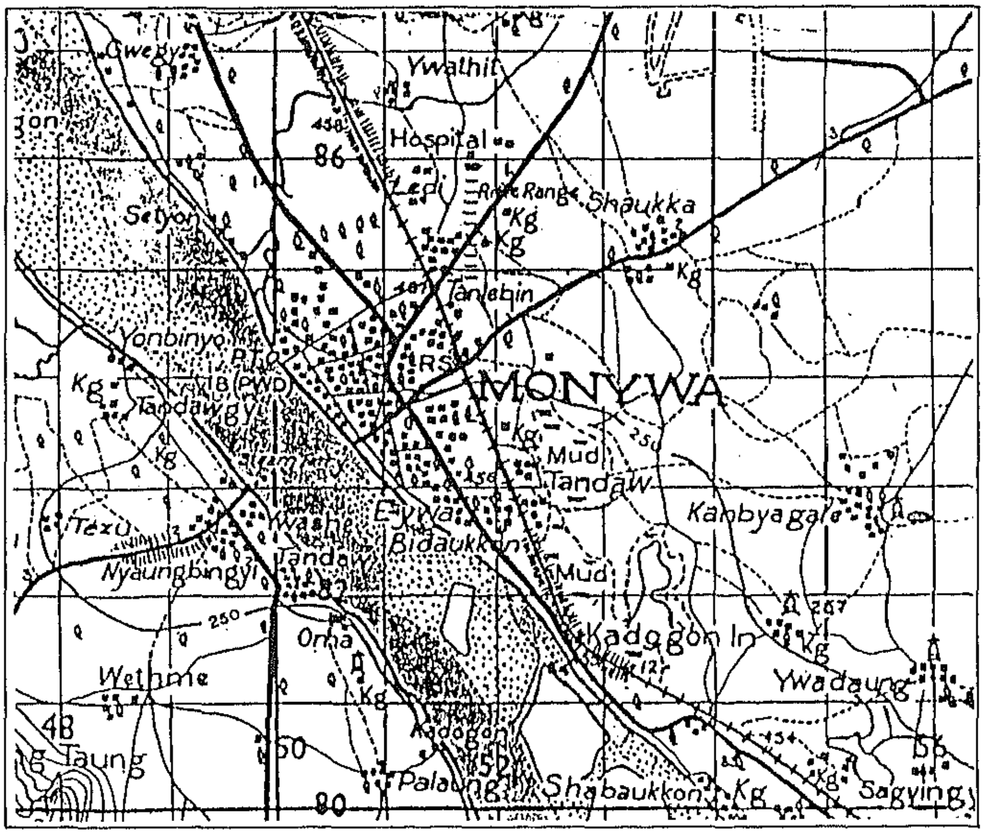
4.6 Monywa


Ywathit
Hospital
Shaukka
Tanebin
MONYWA
Mud
Tandaw
Kanbyagale
Kadogon In
Ywadaung
Sagying
Shabaukkon
Kadogon
Palaung
Orha
Wethme
Taung
Nyaungbingyi
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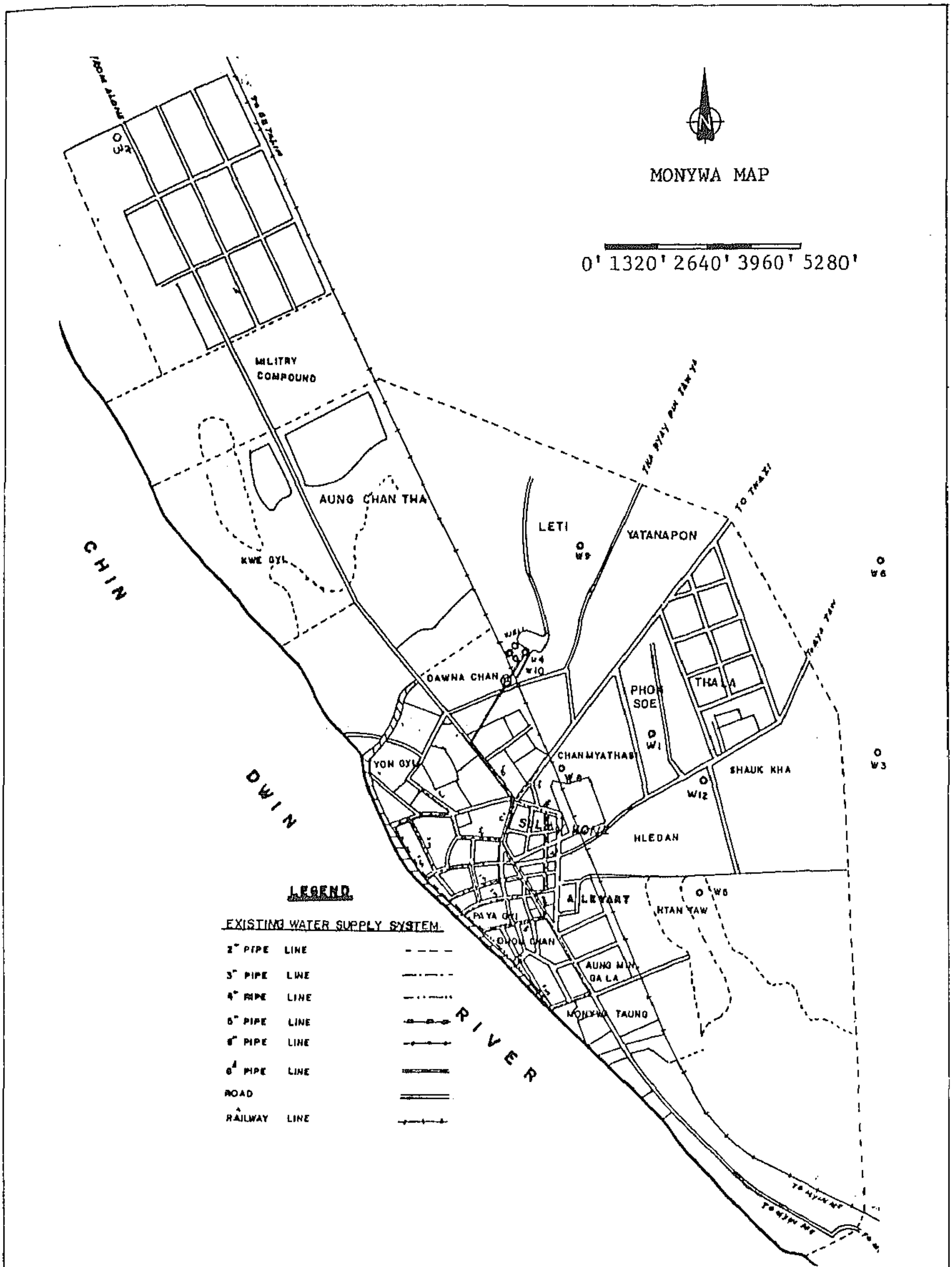
250
267
86
80
48



MONYWA MAP
0' 1320' 2640' 3960' 5280'
CHIN DWIN RIVER
MILITRY COMPOUND
AUNG CHAN THA
KWE GYI
LETI
YATANAPON
DAWNA CHAN
PHON SOE
THAZA
CHANMYATHAZI
SHAUK KHA
YON GYI
HLEDAN
A LEYART
HTAN TAW
PAYA GYI
AUNG MIN GALA
MONYWA TAUNG
LEGEND
EXISTING WATER SUPPLY SYSTEM
2" PIPE LINE
3" PIPE LINE
4" PIPE LINE
5" PIPE LINE
6" PIPE LINE
8" PIPE LINE
ROAD
RAILWAY LINE

4.6.1 Outline of The Area

Monywa is situated on the east coast of the Chindwin river at about 160 km to the northwest of Mandalay. The town area is 22 km^2 and the population as of 1983 is 105,096. The annual average population growth rate is as high as 2.5%.

Monywa is located on the railway line runing from Mandalay to Ye U at about 100 km to the north of Monywa. Moreover, it is adjacent to the Chindwin river and enjoys riverin transport facilities.

Many people come to this town and also, various products are collected and distributed from this town. It has, therefore, become the most important commercial town in the northern part of Burma.

The altitude of the town gradually increases toward the east up to or above 200m.

The maximum and minimum air temperatures in summer are 42.4°C and 21°C, respectively, and 29.4°C and 12.2°C in winter (December, January), respectively. The average precipitation for the past 10 years in 747 mm (315 to 1070 mm).

Monywa has many educational institutions, from primary to collage level. Agricultural products such as rice, wheat, sesame, corn, bean, peanut, cotton, etc. are cultivated. Factories and cottage industries are scattered in various parts of the town.

The existing water supply system was started in 1898. However, its capacity is only 1,800 m^3/d and supplies water for 8 hours per day in only 6 of 18 wards.

The water supply population by the existing facilities is only about 20% of the total, the remaining 80% taking drinking water from private or public wells inadequately. According to the survey, the water quality in the existing supply system is such that EC is 1400 to 1600 or below 2000 in the eastern part, but above 3000 (maximum 4800 to 6000) with private-dug wells in some areas. The river water has EC 100 which is very low but not hygienic. However, water from the wells near the river has very high value of EC 4800.

Fig. 4.6.1.1 shows the population and area by wards. Fig. 4.6.1.2 shows the ratio of areas by land use purposes.

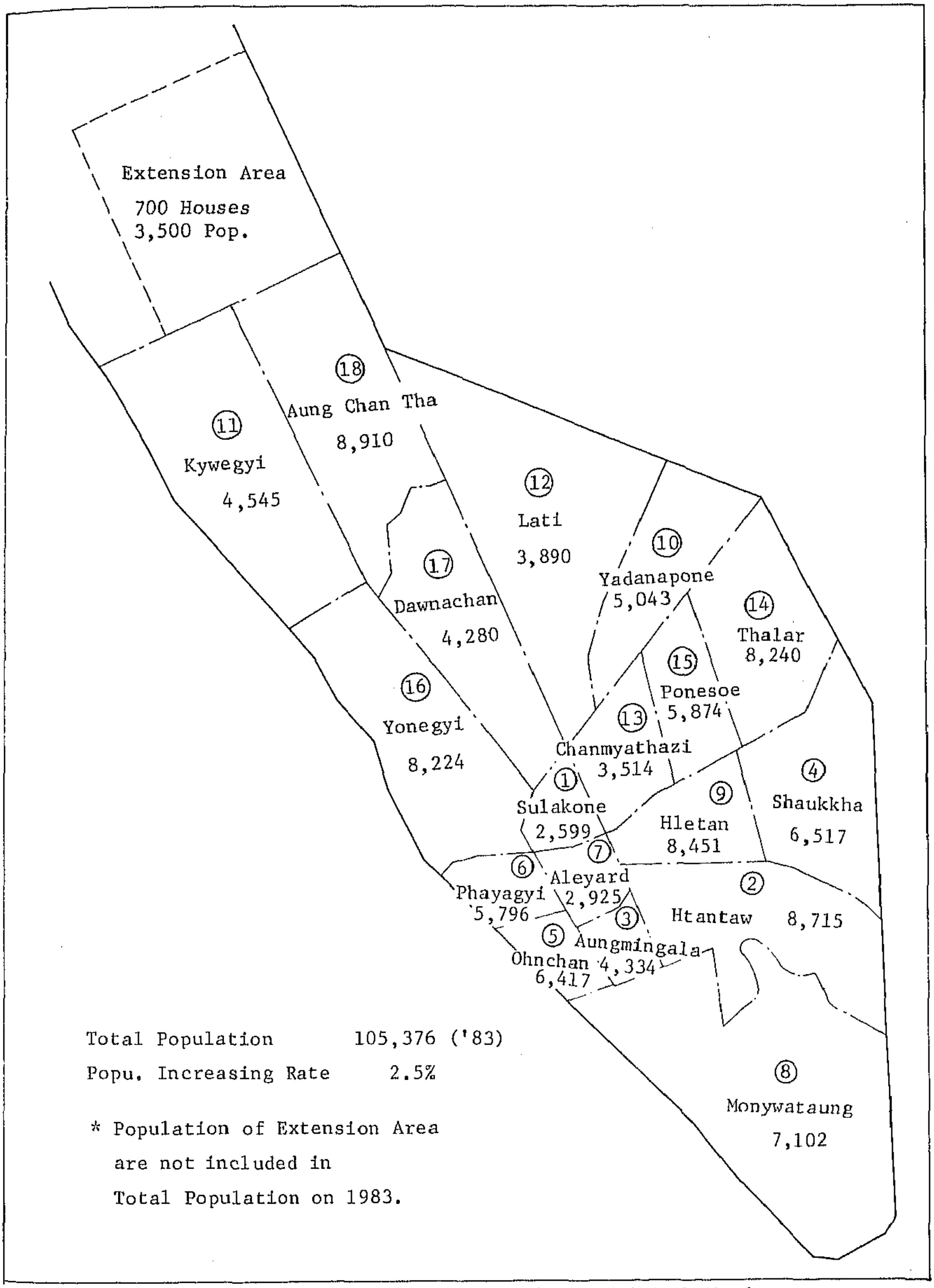
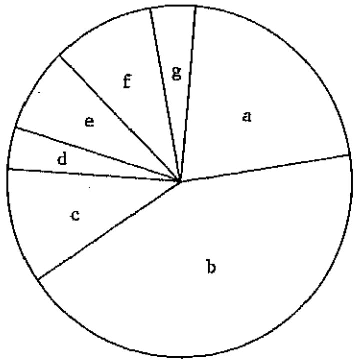


Fig. 4.6.1.1 Present Population of Each Ward



a)	Agricultural Field, etc.	21.28 %
b)	Residential Area	42.99 %
c)	Cemetery, Garden and Park	10.60 %
d)	Religious Center	3.92 %
e)	Commercial Places	7.74 %
f)	Industrial Areas	9.24 %
g)	Government Buildings (Offices, School, Hospital and Government Buildings)	4.23 %

Fig. 4.6.1.2 Ratio of Areas by Land Use Purposes of Monywa

4.6.2 Existing Water Supply Facilities

The water supply facilities of Monywa were constructed in 1898 and at present, it supplies water only to 6 of 18 wards. Water from 6 collection wells is pumped up into elevated tanks from which it is supplied through 2" to 8" ductile cast iron pipes. A deep well was dug to make up for deficient intake water in the dry season.

The water supply capacity is about 1800 m^3/day supplying wter to 25,000, 20% of the entire population. However, due to the deteroration of old distribution pipeline, the actual water supply amount is only about 1,300 m^3/day.

Fig. 4.7.2.1 shows outlines of the existing facilities.

Table 4.6.2.1 Outline of Existing Facilities

Facility	Item	Construction	Q'ty
Water intake facility	Infiltration type wells	R.C construction	6
	Deep well	6"φ D = 80m	1
Conveyance facility	Transmission pump	50 H.P. Motor 50 H.P. Diesel	1 1
	Transmission pipeline	Ductile cast iron pipe 6"	300m
Water distribution facility	Elevated tank	Panel construction $V = 90m^3$ H = 14m	1
		R.C construction $V = 108m^3$ H = 14m	1
	Distribution pipeline	Ductile cast iron pipe 8"	1,720m
		" 6"	1,700m
		" 5"	890m
		" 4"	2,090m
		" 3"	5,880m
		" 2"	1,340m
	Public hydrants		125
	House connections		425
	Fire fighting tanks	R.C. construction $V = 23m^3$	38

4.6.3 Water Resources Development Plan

1) Hydrogeology

(1) Topography and Geology

Neighboring the Monywa town, there are mountain areas consisting of the Pegu formations of the oligocene and middle and lower miocene of the tertiary period at about 10 km on the east side, surrounded by hills of the Irrawaddy formations of the upper miocene and pliocene of the tertiary period. At about 50 km on the west side, mountain areas consisting of the Pegu formations and other unnamed formations of the eocene, and mountain areas consisting of the cretaceous strata of the western fold belt are distributed. Between Monywa and the mountains, hills consisting of the Irrawaddy formations, and isolated hills consisting of volcanic rocks are scattered. (Refer to Fig. 4.6.3.1 and Fig. 4.6.3.2.)

The town of Monywa is situated on the east bank of the Chindwin river which flows to wards the south, joining the Irrawaddy river.

Inside the basin, the Irrawaddy formations are covered by the diluvium and alluvium formations in the surface layers. These formations are distributed to form flat lands. At the boundary of the flat lands and the hills and mountains, there are faults showing the topographical division clearly. The flat source slopes slowly toward the Chindwin river, and small rivers are distributed. The flat source is narrowed by the existence of isolated hills on both sides of the river.

(2) Hydrogeology

The alluvium plain contained between the series of hills on the east side and the Chindwin river flowing from the north-west side, is sloping slowly from east to west. This plain is covered with the alluvium formations of the quaternary period. From the existing wells, it has been confirmed that the diluvium formations are hidden.

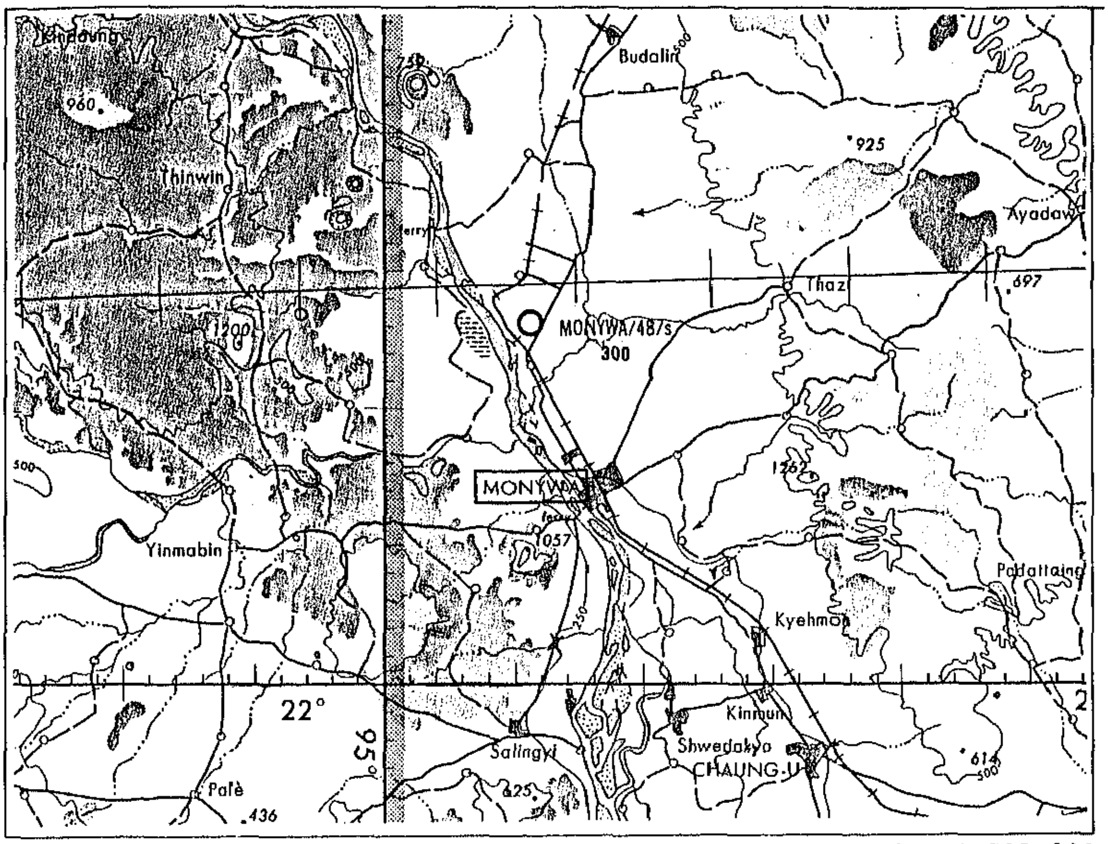


Fig. 4.6.3.1 Topographical Map of Monywa Scale 1:500,000

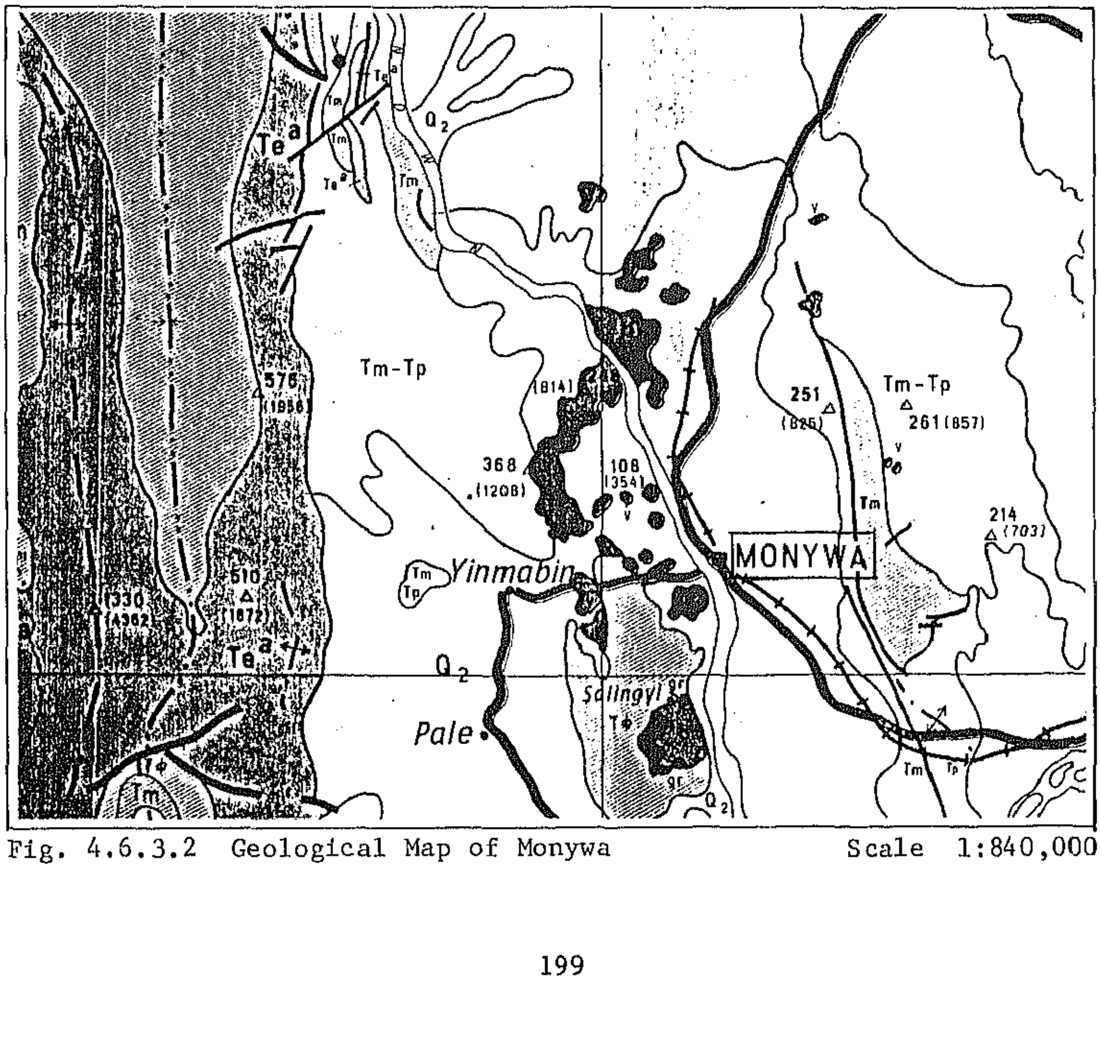


Fig. 4.6.3.2 Geological Map of Monywa Scale 1:840,000

2) Aquifer

It is said that the aquifers in the Monywa area include aquifers in the formations of the quaternary period and those of middle sand layers in the Irrawaddy formations.

① Aquifers in the formations of the quaternary period:

The aquifers of this kind are distributed in most parts of the Monywa area. Their thickness varies widely with location. These aquifers include diluvium and alluvium formations, both consisting of sand, clay and gravel alternates. These formations show makred lateral changes. However, in the diluvium formations, thick, continuous and potential aquifers are distributed. These aquifers consist of horizontal sand and gravel layers, and are distributed at 6 to 61m under the ground surface.

Hand-dug wells used with the aquifers in the alluvium formations have a water level of approximately 3 to 12m which varies with location. However, in the rainy season, the water level approaches the ground surface, while in the dry season, the water level goes below until these wells become dry in many cases.

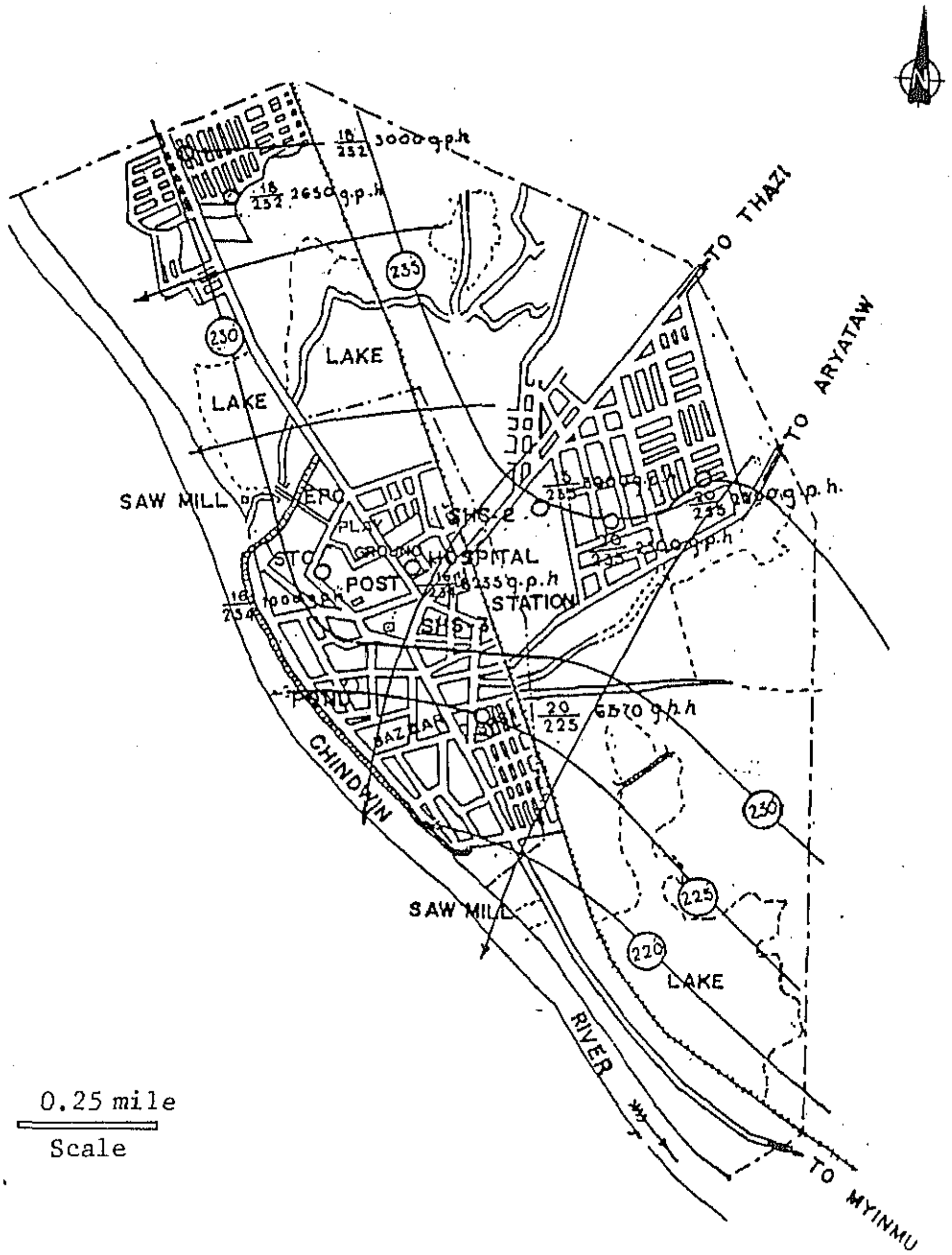
It is said that the aquifers in the diluvium formations are distributed at 15 to 183m. The lower aquifers seem to correspond to the Irrawaddy formations. The ground water to be stored in the quaternary formations flows from east to west. It has good water quality in general, but in the Monywa area, dissolved salts are very high.

② Aquifers in the Irrawaddy formations:

The Irrawaddy formations are exposed in hills in the eastern part of Monywa. These formations are divided into upper silt layers, middle sand layers and lower shale layers, and the aquifers are formed by the middle sand layers. The middle sand layers. The middle sand layers have large porosity and form good ground water storage layers.

Fig. 4.6.3.3 shows ground water contours and flowing directions in accordance with the existing data. This figure shows that the ground water flows toward the Chindwin river. It flow from east to west on the north side and from northeast to south-west on the south side.

The existing tube wells have well diameters of 2 inch in the main and 4 to 6 inch in some cases, and have depths of 20 to 25m in the main and about 35m in some cases. These wells are used with the aquifers which correspond to the alluvium. The tube wells which are used with the aquifers of the diluvium have depths of about 60 and much water is taken from them.



—O— Water Table Contour

——→ Flow Direction of Ground Water

O $\frac{18}{232}$ 3000 Existing Tube Well, Static Water Level

Fig. 4.6.3.3 Contour Map of Ground Water Table in Monywa

According to hydrogeologist at the site says, in the neighborhood of about 1.8 to 3.6 km northeast of Monywa, good aquifers are distributed down to 50m under the ground surface, and pump diameters 200mm, screen lengths 20m and pumping capacities Q are 100 m^3/h. IN the neighborhood of 3.6 to 7.0 km northeast, good aquifers are distributed down to 60m under the ground surface, and well diameters 200mm , screen lengths are 20m, and pumping capacities Q are 180 m^3/h. Fig. 4.6.3.4 shows typical well logs for the neighborhood of Monywa.

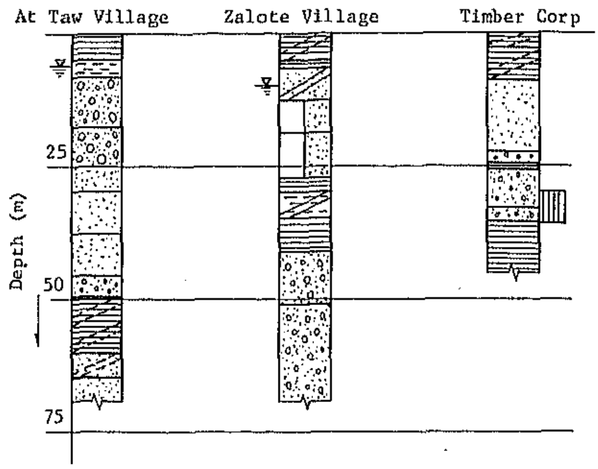


Fig. 4.6.3.4 Well-logs in Monywa

The ground structure in the neighborhood is nearly equal except At Taw village. The alluvium consists of sand and clay, and has thickness of about 10m. The portion below this is considered to correspond to the diluvium and consists of sand, clay and gravel distributed, respectively, in the upper middle and lower parts. Most of the existing wells are used with the sand and gravel in the upper part. The present plan is to use the gravel layer in the lower part. As seen in Fig. 4.6.3.4, it may be considered that the distribution varies with location.

The alluvium and diluvium distributed in this area are sand, gravel and clay alternates. The permeability of the alluvium and diluvium is not known. Table 4.6.3.1 shows the coefficient of permeability at some points where well logs are available (pumping quantity, static water level, running water level, etc. are known).

Table 4.6.3.1 Permeability Coefficient in Monywa

Well No.	Aquifer m (cm)	Draw down h_2-h_1(cm)	Discharge Q(cm^3/sec)	Diameter r (cm)	Permeability k (cm/sec)	Remarks
Timer corp.	610	1.77×10^6	12,500	10.16	2.07×10^{-2}	Al-Dl 36.6
Cotton Factory	305	3.17×10^6	3,750	7.62	7.03×10^{-3}	Al-Dl 21.5
-	610	1.61×10^6	3,750	7.62	7.03×10^{-3}	Al-Dl 21.6
-	458	2.78×10^6	3,125	7.62	3.39×10^{-3}	Al-Dl 22.8
-	488	7.59×10^5	3,750	7.62	1.49×10^{-3}	Al-Dl 22.5
-	305	6.07×10^6	10,300	7.62	5.12×10^{-3}	Al-Dl 28.3

Al: Aluvium
Dl: Diluvium

The coefficient of permeability was calculated in accordance with Thiem's formula (for free ground water) on assumption of the influence radius (R) of 500m.

The average value of the coefficient of permeability of the alluvium and diluvium in the Monywa area is 4.1×10^{-3} cm/sec for the well up to 30m and 2.1×10^{-2} cm/sec for the wells above 30m.

3) Ground Water Storage and Water Quality

(1) Ground Sater Storage

The annual precipitation P and potential evapotranspiration E are as follows.

$$
\begin{aligned}
\text{Precipitation} \quad P &= 728.5 \text{ mm} \\
\text{Evapotranspiration} \quad E &= Ep \times 0.7 \\
&= 2,009.4 \times 0.7 \\
&= 4,406.3 \text{ mm}
\end{aligned}
$$

Considering throughout the year, the ground water recharge G becomes as follows.

$$
\begin{aligned}
G &= P - E \\
&= 728.5 - 1,406.3 \\
&= 678 \text{ mm}
\end{aligned}
$$

This means that the evapotranspiration exceeds the precipitation and therefore, no ground water recharge takes place. Considering the rainy season only, the same may be said.

Here, the precipitation in the rainy season in the Monywa area is 650 mm. If it is assumed that 60% of this value flows into alluvium low lands, and the collection area is 30 km^2, then the influent water Q is given as follows.

$$
\begin{aligned}
Q &= P \times S \\
&= 650 \times 0.6 \times 30 \text{ km}^2 \\
&= 1.17 \times 10^7 \text{ m}^3
\end{aligned}
$$

If the infiltration ratio is assumed as 40%, then the ground water recharge G becomes as follows.

$$
\begin{aligned}
G &= 1.17 \times 10^7 \times 0.4 \\
&\fallingdotseq 4.68 \times 10^6 \text{ m}^3
\end{aligned}
$$

Thus, the annual water charge is 4.7×10^6 m^3.

For the range affected by the planned well points, the ground water storage can be obtaned from the volume and porosity of aquifers as follows.

$$V = A \times S \times E$$

where A: subject area 8 km^2

S: aquifer thickness 22m

E: porosity 15%

$$V = 2.64 \times 10^7 \ m^3$$

This value ignores the ground water make-up and flowout and shows the quantity stored in the present aquifer.

(2) Water Quality

As shown in Fig. 4.6.3.5, EC is not less than 3,000 μS/cm in the town area. In the highest case, its shows 6,000 μS/cm, indicating higher dissolved salts. The altitude of the area where EC is highest is lower than that of the surrounding areas, and ground subsidene due to pumping is conceivable. As distance from this area increases, EC tends to gradually decrease. At 0.5 to 2.25 km from the central part, EC is 2,000 to 3,000 μS/cm, at 2.25 to 3.5 km, EDC is 1,500 to 2,000, and at 3.5 km and larger, EC is below 1,500 μS/cm. In order take the drinking water as a source, it is therefore necessary far at least 2.25 km from the central part.

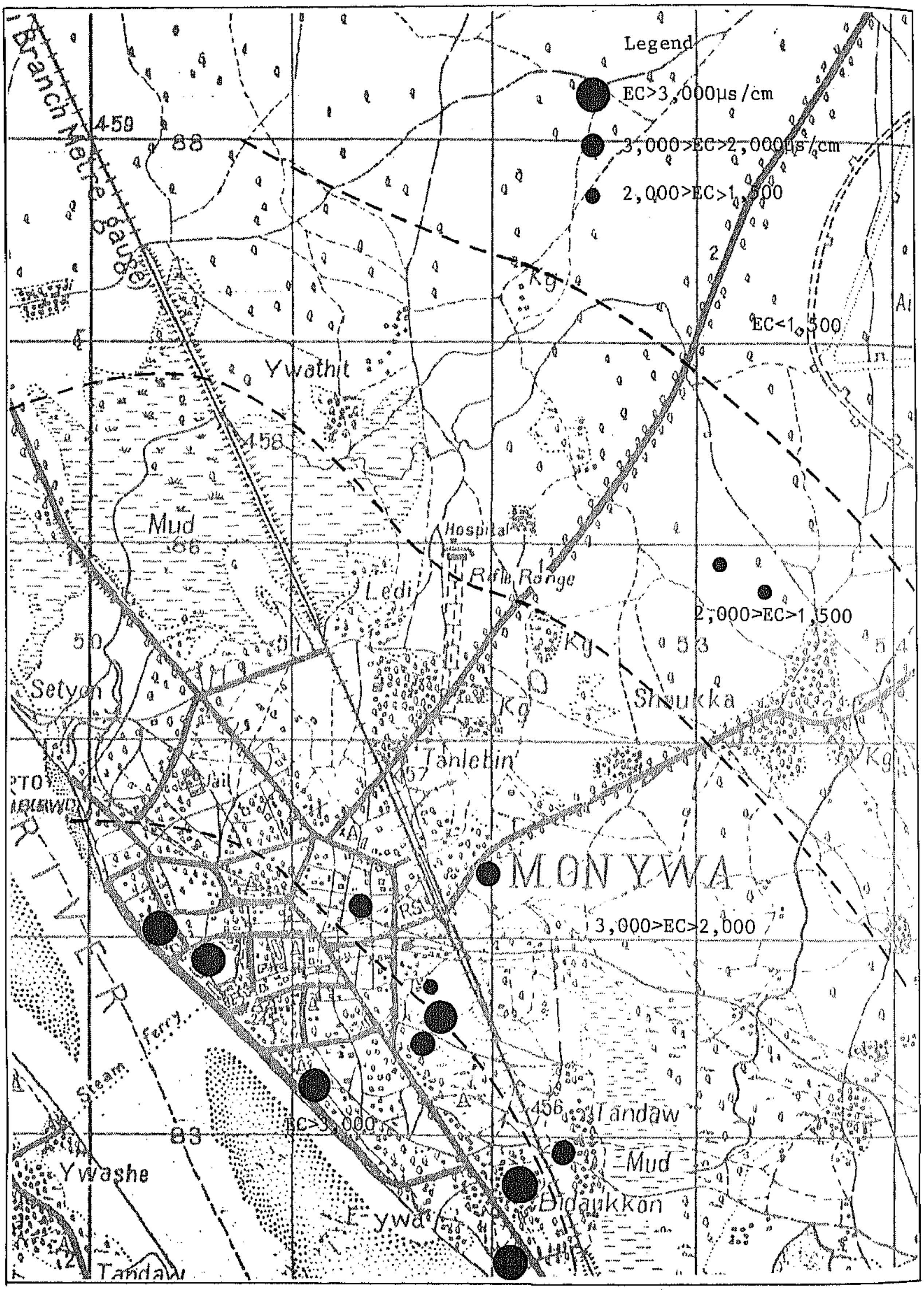


Fig. 4.6.3.5 Condition of Water Qarity

4) Discharge rate per Well, Spacing between Wells, and Well Depth

(1) Discharge rate per Well

The discharge rate per well must be grasped by conducting a pumping test. At this point, however, in accordance with Thiem's formula, the discharge rate per well will be estimated. The lowering of water level S is found as 7.10m by the following calculations for the spacing between wells 600m (influence basin 300m).

$$S = R/3000\sqrt{k}$$

where R is 300m and k is 2×10^{-8} m/sec.

The aquifer at the position where the screen is installed contains artesian water, and therefore, the discharge rate Q is given by

$$Q = \frac{2\pi Dk\ (H - h)}{2.3 \log R/r}$$

$$= \frac{2\pi \times 22 \times 2 \times 10^{-4} \times 7.1}{2.3 \log 300/0.125}$$

$$= 0.0251 \ m^3/sec \times 1,626 \ m^3/18 \ hr$$

Therefore, it is considered that in this area 1,400 m^3/18 hr can be expected.

(2) Spacing between Wells

The spacing bewteen wells shall be such that it does not cause decrease of the discharge rate due to neighboring wells causing drawdown of the water level, and does not cause interference between wells.

For this area, considering the ground formations, conditions of aquifers, the discharge rate per well, and the drawdown of the water level, the minimum spacing between wells will be taken as 600m.

(3) Well Depth

Regarding the well depth, considering the depth of storage of the aquifer of about 50m, as the lower limit the average depth of production wells will be taken as 56m (6m for sand pit).

4.6.4 Planning The Water Supply System

1) Project Area

The town area of Monywa is rectangular-shaped about 8.5 km along the Chindwin river and about 3.0 km toward the inland. The dwelling area is cut by lakes and military lands into three independent parts, northern, central and southern. About 80% of the present population are concentrated into the southern part. The northern part is the new extension area and has a population of about 3,500. The central pat is a relatively newly extended area with a plpulation of about 14,000 persons. All these three parts are covered in the project area with priority on the southern part, central part and northern part in this order.

2) Planned Water Supply Population

The present population is 108,876 in total. The annual average population growth rate for the 10 years is 2.5%.

In determining the planned water supply population, 6,800 dwellers in teh southern low lands are omitted. That is,

$(108,876 - 6,800) \times (1 + 0.025)^8$

$= 124,369$

Thus, the planned water supply population is taken as 124400 persons.

3) Allocation of Planned Water Supply Population

With the rapid increase in population of Monywa, the population density in the southern part exceeds 180 persons per ha. TDC is constructing a new town in the northern part. The allocation of the planned water supply population is based on such a conception that any ward with a population density in excess of 150 persons per ha can no more be allocated and any ward with a population density below 120 persons per ha may be allocated until reaching this value. Fig. 4.6.4.1 shows the results of such population allocation.

4) Planned Water Supply Amount

Planned water supply amount

= planned water supply population

x planned daily maximum supply per capita

$= 124,400 \times 105\ \ell$ pcd

$= 13,062,000\ \ell/\text{day}$

$= 13,000\ m^3/\text{day}$

5) Division into Water Supply Blocks

As described above, the planned water supply area is divided into three parts, northern, central and southern. Especially the southern part has a large population to be served. As shown in Fig. 4.6.4.2, the southern part is further divided into four water supply blocks. The planning specifications for each block are as shown in Table 4.6.4.1.

Table 4.6.4.1 Planning Specifications for Each Block

	Planned water supply population (number)	Water supply area (ha)	Population density (person/ha)	Planned water supply amount (m^3/d)
A	39,200	211	185.8	4,120
B	15,600	140	111.4	1,640
C	14,100	126	111.9	1,480
D	23,100	140	165	2,430
Sub-total	92,000	617	Ave. 149.1	9,670
E	16,400	140	117.1	1,720
F	16,000	245	65.3	1,680
Total	124,000	1,002	134,8	13,070

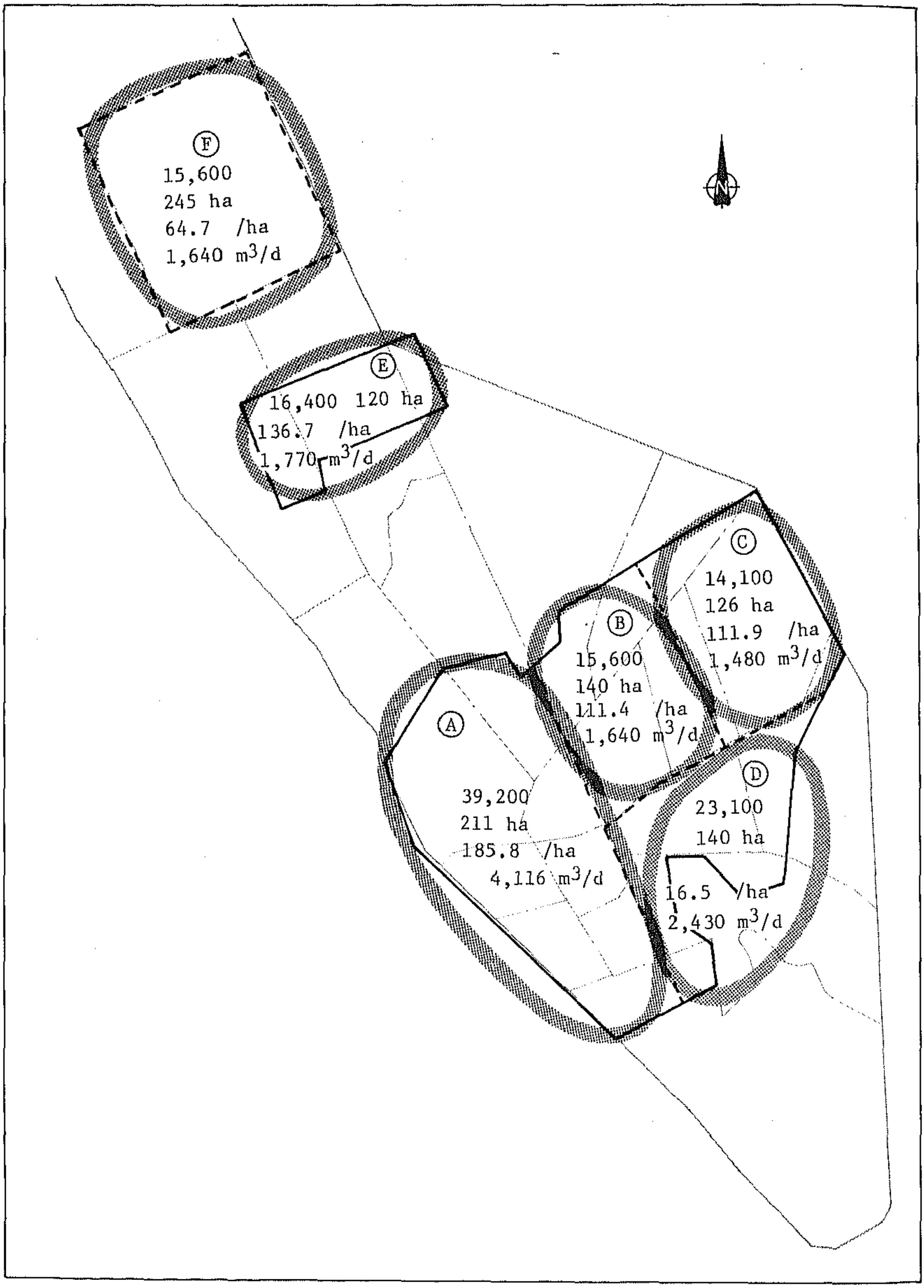


Fig. 4.6.4.1 Distribution of Design Population

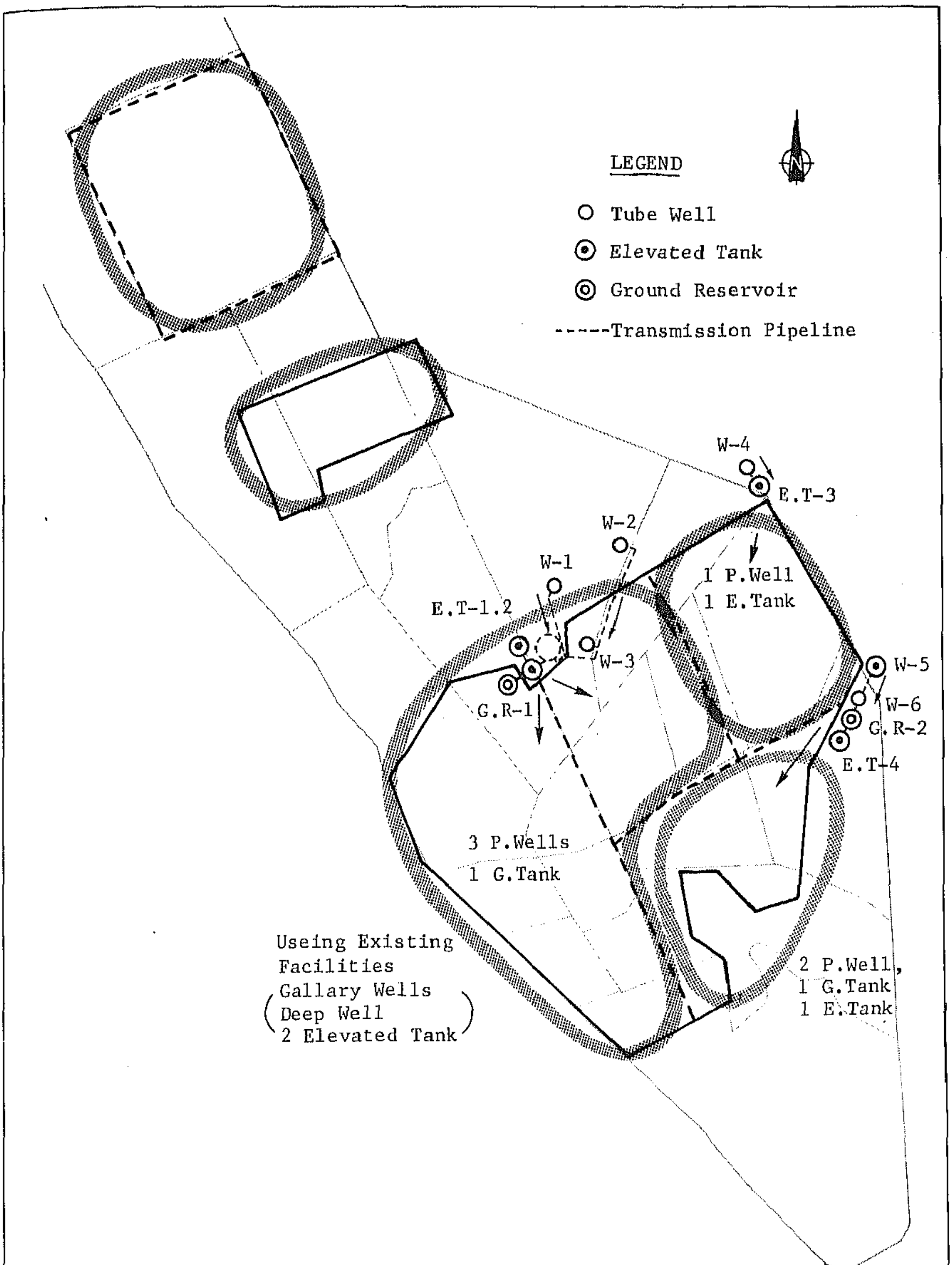


Fig. 4.6.4.2 Layout Plan of Proposed Facilities

6) Facility Planning

The planning water supply area is divided into southern, central and northern parts, which are located away from each other and each of which is given an independent water supply system.

(1) Southern part

The southern part has existing water supply facilities. In planning, it is supposed that the existing facilities should be utilized as far as possible.

The existing elevated tanks can cover the total range of block A and block B. For blocks C and D, new facilities are to be constructed.

For each block, the basic system is applied.

Since the planned discharge rate per well is 1400 m^3/day, the number of wells required for each block is as follows.

Block A, B	5760 ÷ 1400 = 4.1 → 4
Block C	1480 ÷ 1400 = 1.1 → 1
Block D	2430 ÷ 1499 = 1.7 → 2

However, the available discharge rate of the existing facilities is about 1400 m^3 and this corresponds to one planned well. Therefore, the number of planned wells for blocks A and B is taken as 3.

(2) Central and southern part

The planned water supply amount for the central and northern parts is 1720 m^3/day and 1680 m^3/day, respectively. Since the available discharge rate per well is 1400 m^3/day, two wells to 900 m^3/day each are to be installed.

In the central part, basic system 2 is applied, and in the northern part, basic system 1 is applied. (Refer to Fig. 3.4.2.1).

Fig. 4.6.4.4 shows the layout of facilities for each block.

7) Outline of Facilities

Table 4.6.4.2 shows specification and quantities for facilities.

Fig. 4.6.4.5 and Fig. 4.6.4.6 show water transmission pipings and distribution piping networks, respectively. For the planned wells and elevated tanks, refer to the drawings given at the end of this chapter.

Table 4.6.4.2 List of Proposed Facilities

Facility	Item	Classification	No.	Remarks
Water intake facility	Production wells	Planned intake rate 1400 to 1500m3/d φ250mm x H56m	9	Casing H = 34m Screen H = 22m
	Exploration wells	φ150mm x H65m	5	Casing H = 43m Screen H = 22m
	Observation wells	φ100mm x H56m	8	Casing H = 46m Screen H = 10m
	Intake pumps	φ125mmx1.361m^3/minx22kW	4	W-1 to W-4
		φ125mmx1.296m^3/minx18.5kW	5	W-5 to W-6 W-7 to W-9
		φ80mmx0.455m^3/minx3.75kW		Repairing for existing tube well
	Pump rooms	Brick construction 4m x 4m Building area 16m^2	9 buildings	
Water transmission facility	Water transmission pipes	φ200mm to φ300m T type ductile cast iron pipe class 3	5,720m	
		Various reducers	1 set	
	Sluice valves	φ200 to φ300mm	8	
	Air valves	φ20mm to φ25mm	8	
Water distribution facility	Junction wells	Capacity 480m^3 Underground RC construction	1	JW-1
		Capacity 210m^3 Underground RC construction	1	JW-2
		Capacity 150m^3 Underground RC construction	1	JW-3 (Ex-S)
		Capacity 140m^3 Underground RC construction	1	JW-4 (Ex-N)
	Elevated tanks	Capacity 50.5m^3 FRP panel Height 15m Steel base stand	1	ET-2
		Capacity 30.8m^3 FRP panel Height 15.0m Steel base stand	1	ET-1
		Capacity 34.1m3 35.9m^3 FRP panel Height 15.0m Steel base stand	2	ET3, ET4
	Relay pumps	φ250 x 5.448m^3/min x 30kW	1	JW-1
		φ150 x 2.592m^3/min x 15kW	3	JW-2 to JW-4
	Distribution pipes	φ75mm to φ350mm T-type ductile cast iron pipe class 3	45,320m	
		Various reducers	1 set	
	Sluice values	φ75 to φ350	127	
	Air valves	φ20mm to φ25mm		
Electric facility	Substation equipment	3φ4W 100kVA x 1, 50kVA x 2	3 sets	
	Transmission line	OW 30 to 50 CV 14 x 4c to 72 x 4c	28.4km	
		Accessories	1 set	

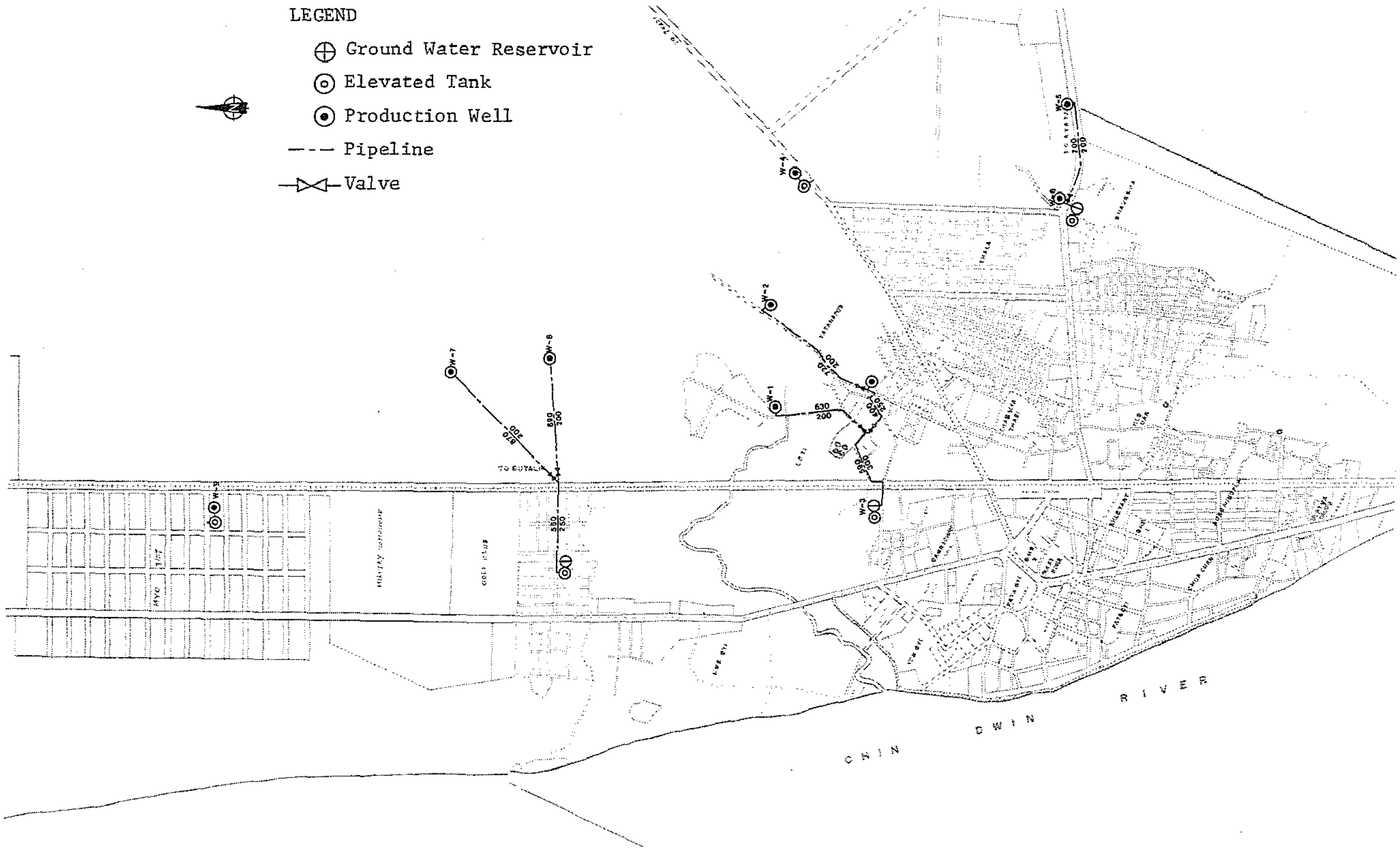


Fig. 4.6.4.3 Layout of Transmission Pipeline

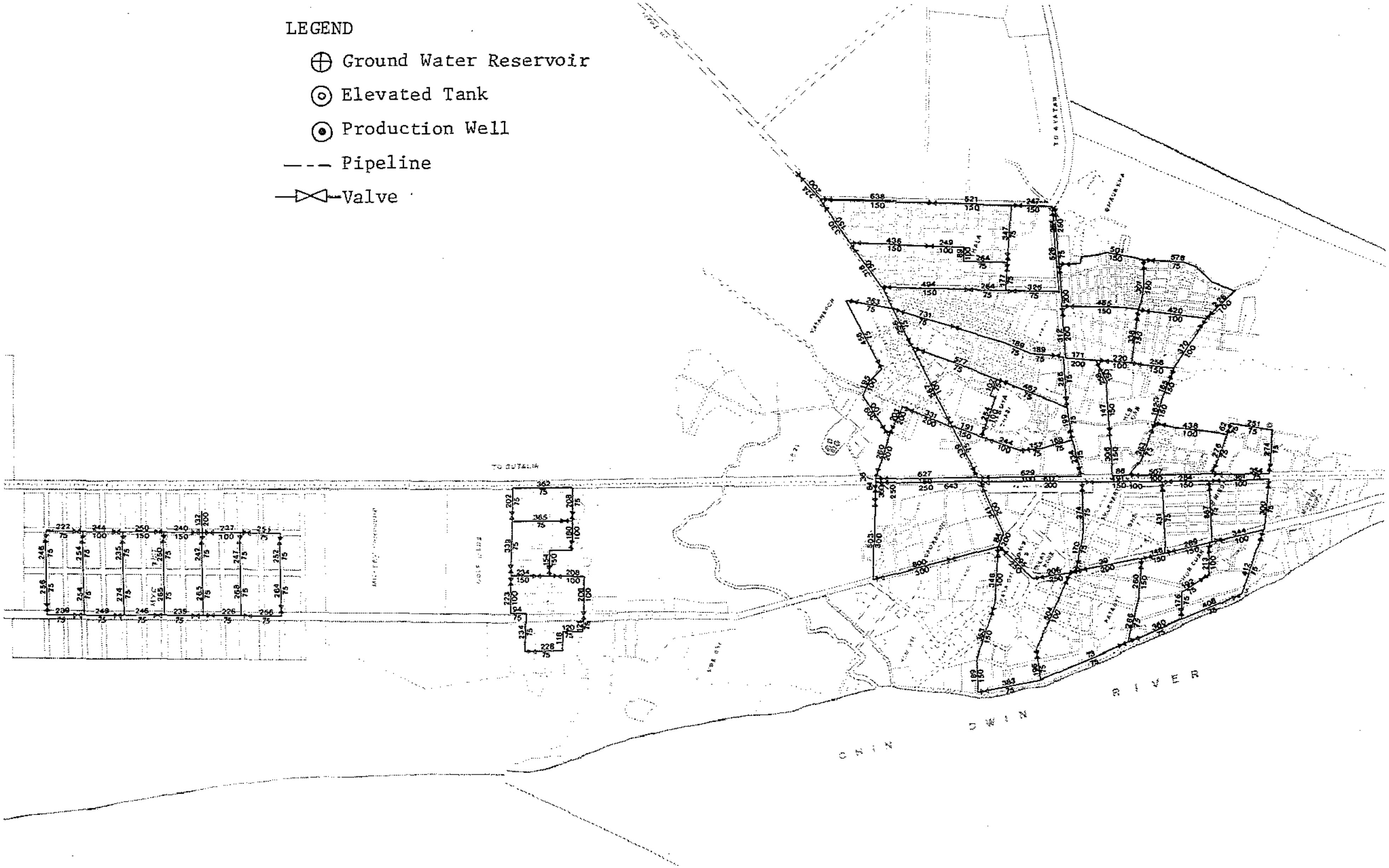


Fig. 4.6.4.4 Network of Distribution

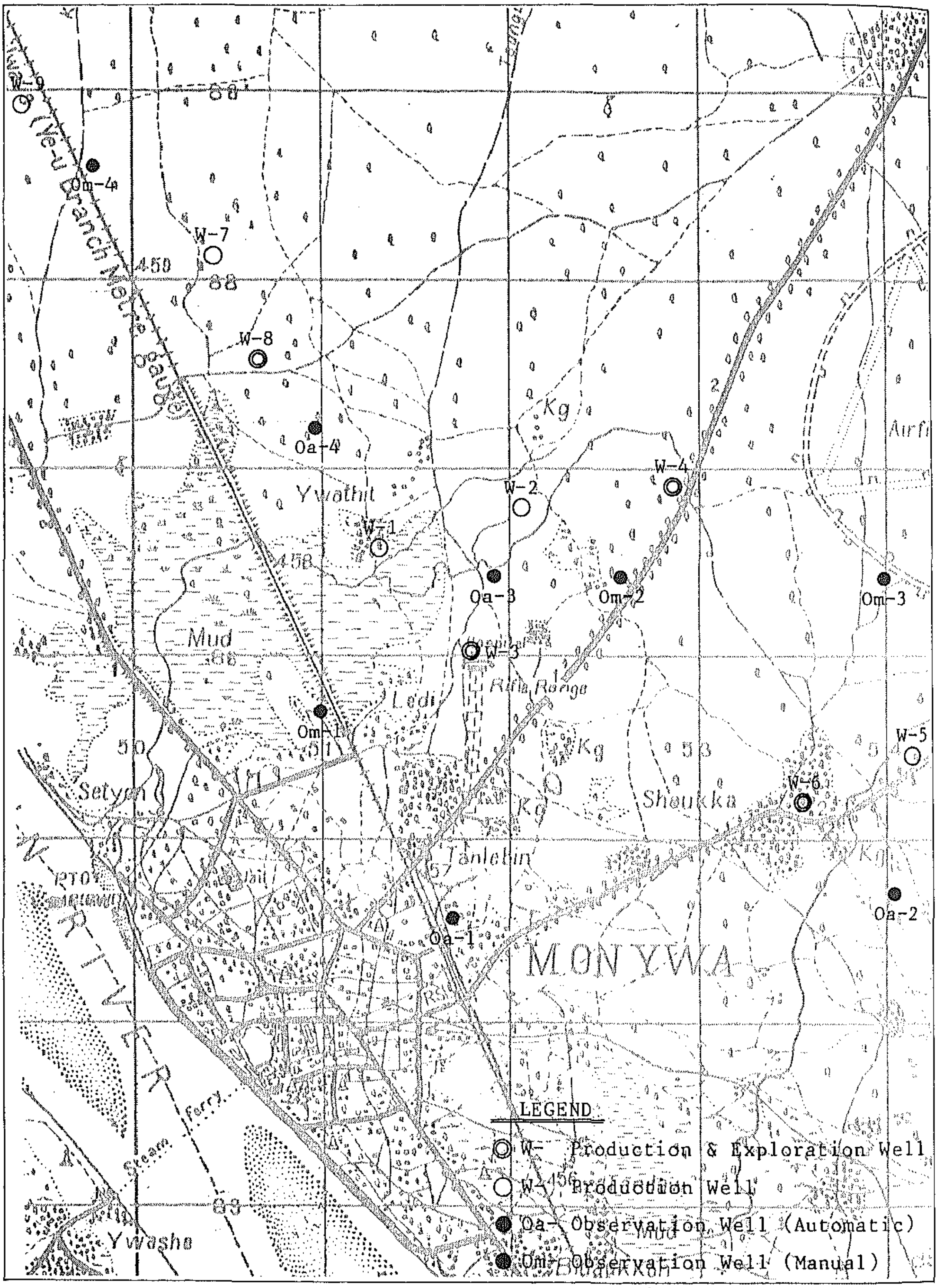
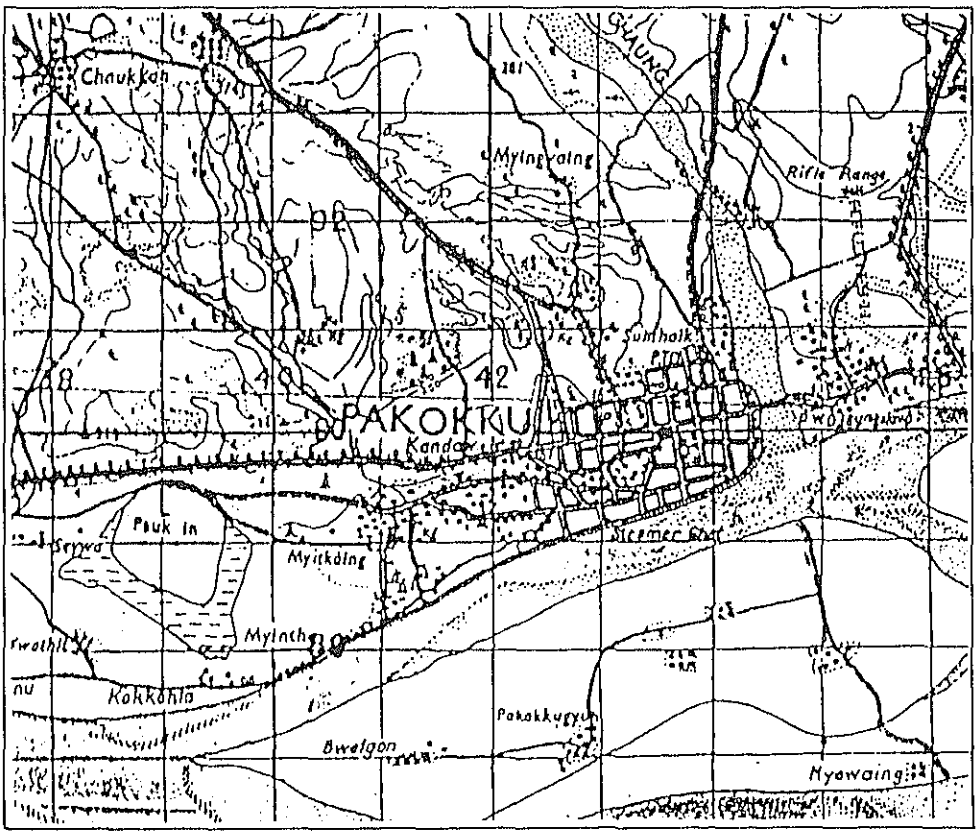
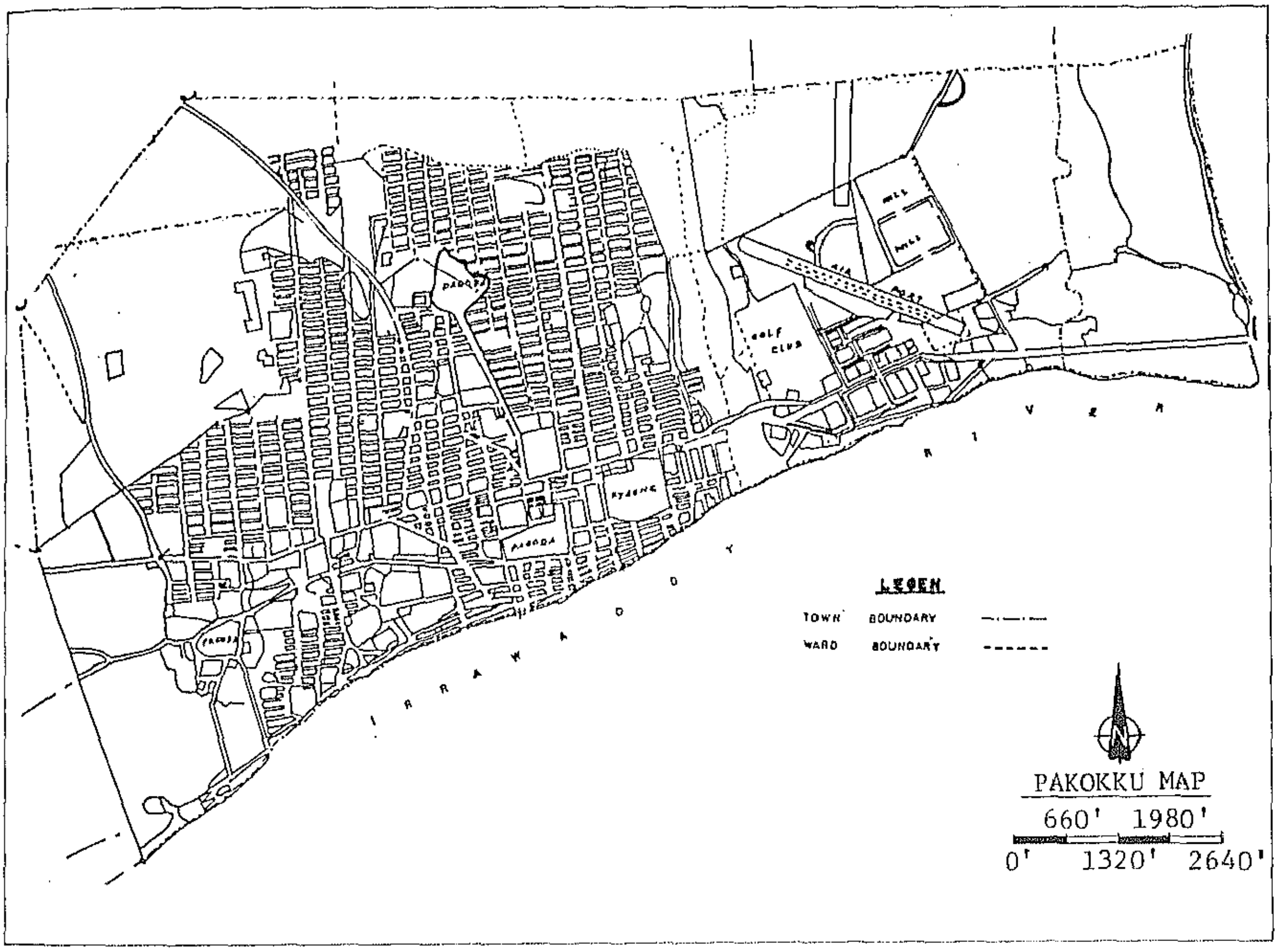


Fig. 4.6.4.5 Layout of Proposed Wells

4.7 Pakokku


Chaukkan
Myingyaing
Rifle Range
Sunhalk
42
PAKOKKU
Kandaw
Pauk In
Seywa
Myitkding
Mylnch
Kokkohla
Steamer
Pakokkugyun
Bwelgon
Nyowaing


LEGEN
TOWN BOUNDARY
WARD BOUNDARY
I R R A W A D D Y R I V E R
PAKOKKU MAP
660' 1980'
0' 1320' 2640'

4.7.1 Outline of the Area

Pakokku is situated at about 500 km to the north of Rangoon, on the east side of the Irrawaddy river. The town is divided into 15 wards, and has an area of about 9.7 km^2 and a population of 77,100 as of 1983. The populatin growth rate is 2.2%.

It is located in the arid area of Burma. The maximum air temperature is 43°C in May, and the minimum temperature is 10°C in December. The annual average precipitation is about 760 mm.

Because of heavy migration into this town, the population density is very high, and TDC is constructing a new town in the northern part of the town.

Electric power for the town is supplied from Kyunghaung power station, and transmission lines and transformers are being constructed for extension into the new areas.

At the preent, the town has no water supply system, and the dwellers secure water from deep wells and hand-dug wells insufficiently.

Fig. 4.7.1.1 shows the population and area by wards. Fig. 4.7.1.2 shows the ratio of areas by land use purposes.

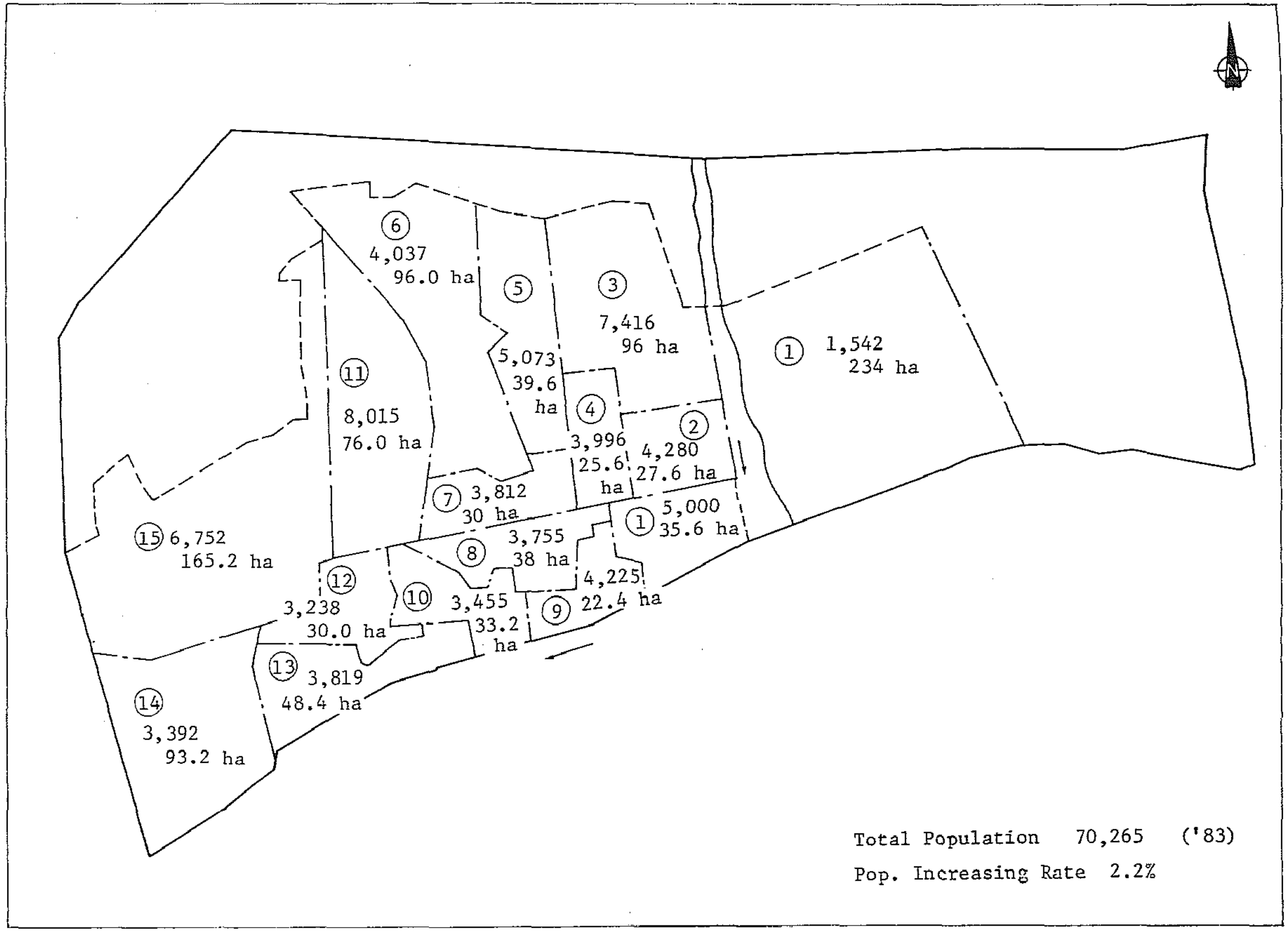
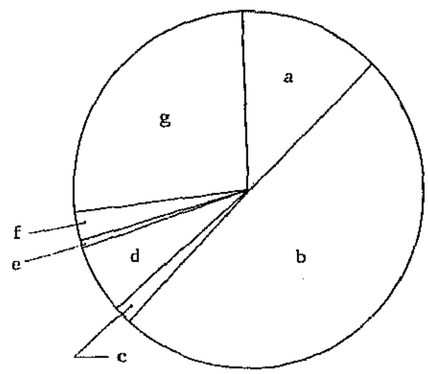


Fig. 4.7.1.1 Present Population and Area of Each Ward



a)	Agricultural Field, etc.	12.94 %
b)	Residential Area	49.66 %
c)	Cemetery, Garden and Park	1.70 %
d)	Religious Center	6.34 %
e)	Commercial Places	0.54 %
f)	Industrial Areas	2.61 %
g)	Government Buildings (Offices, School, Hospital and Government Buildings)	26.21 %

Fig. 4.7.1.2 Ratio of Areas by Land Use Purposes of Pakokku

4.7.2 Water Resource Development Plan

1) Hydrogeology

(1) Topography and geology

On the east and south side, the Pakokku area is adjacent to the Irrawaddy river, and on the north and west side, this area consists of hills of the Irrawaddy formations, mountains of the Pegu formations, the western fold belts of eocene layers and cretaceous strata. Pakoku is situated between these mountains and belongs to the Minku basin. (Refer to Fig. 4.7.2.1 and Fig. 4.7.2.2.)

Various strata including the Irrawaddy formations around Pakokku are in a condition disturbed by faults and folds, and the Irrawaddy formations and alluvial strata cover the Pegu formations unconformably.

The alluvial strata consist of yellowish brown loam, clay, slit and fine and medium sand, with river bed sediments contained. In the lower position, generally the Irrawaddy formations and Pegu formations are distributed. The Irrawaddy formations cover the Pegu formations unconformably, and their outcrops are seen in the gravel and clay and contain silicified wood and modules.

On the northern side of the Pakokku, hills of the Irrawsaddy formations spread, and slowly slope toward the Irrawaddy river.

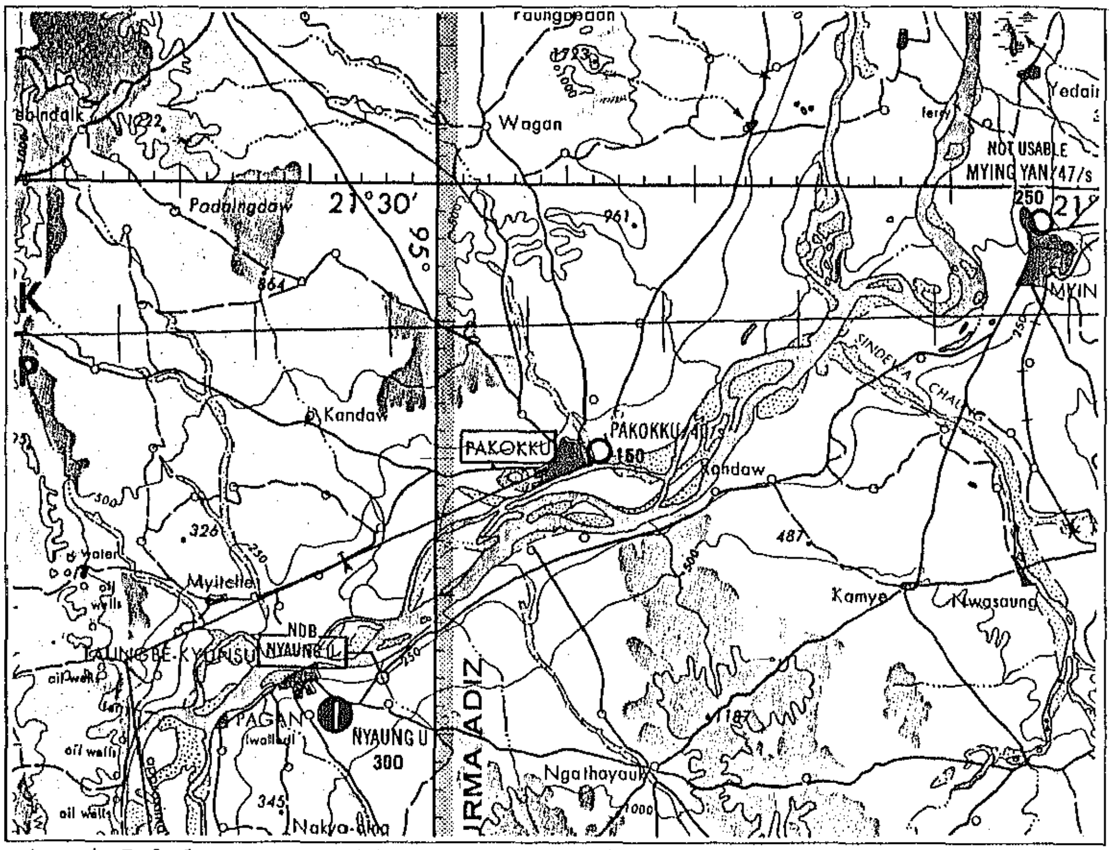


Fig. 4.7.2.1 Topographic Map of Pakokku Scale 1:500,000

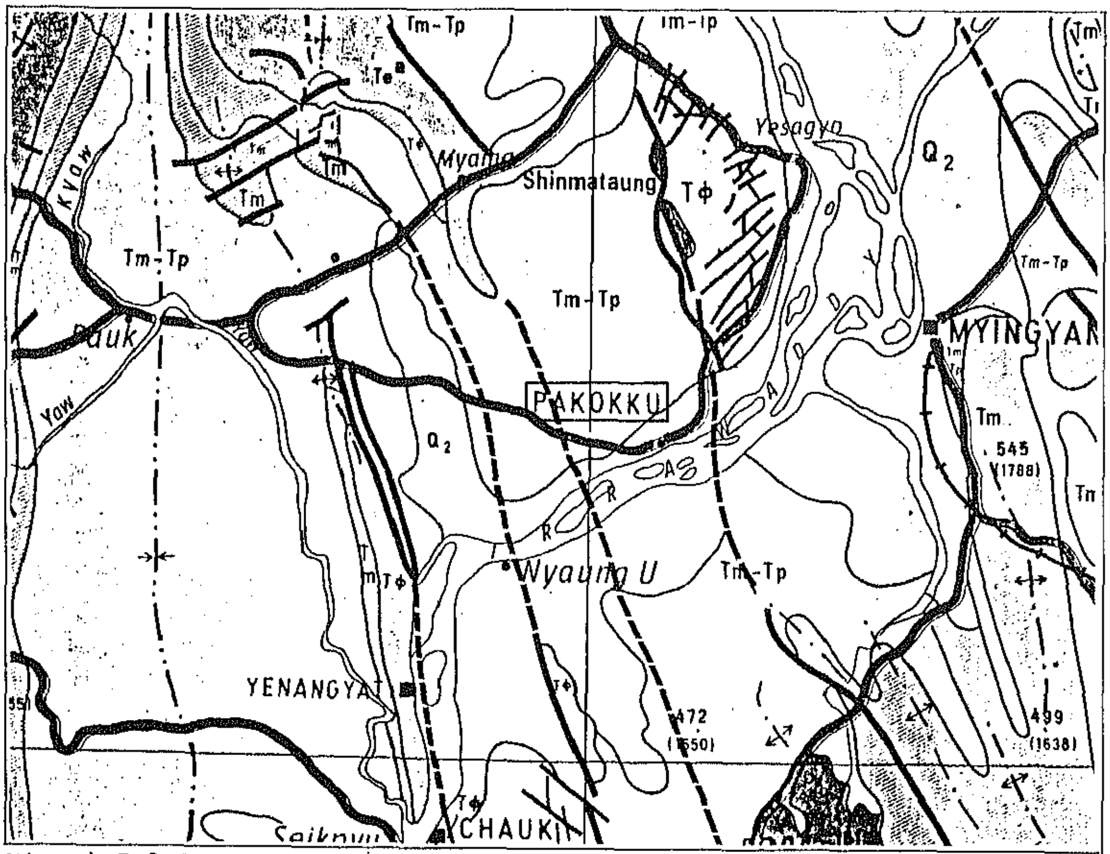


Fig. 4.7.2.1 Geological Map of Pakokku Scale 1:870,000

(2) Hydrogeology

The ground water in the Pakokku area is stored in the alluvial layers, the Irrawaddy formations and the Pegu formations.

The aquifers in the alluvial layers lie at 5 to 30m from the ground surface. The thickness is 2 to 6m or more. The shallow layer ground water is taken by hand-dug wells, but in the dry season, the wells dry up. The deep layer ground water is taken by tube wells. At these wells, the dissolved salt concentration of 210 to 640 mg/ℓ is recorded.

The aquifers of the Irrawaddy formations are divided into two layers, upper and lower. The upper layer lies at 30 to 45m and has thickness about 18m. The specific capacity of the Irrawaddy formations around Pakokku is 75 to 150 m^3/day/ and the groundwater storage is larger than in the other aquifers. The dissolved salt concentration is low, suitable for drinking.

The Pegu formations are in the consolidated or subconsolidated condition and are aquicludes. Where groundwater is stored, the dissolved salt concentration is as high as 4,480 mg/ℓ and the water, if pumped up, is not suitable for drinking.

Fig. 4.7.2.3 shows well logs typical of the Pakokku area. As a whole, sand layers are predominant and clay layers are thin.

Fig. 4.7.2.4 shows the groundwater profiles in the Pakokku area. Fig. 4.7.2.5 shows N-S and E-W sections. In the upper portion, the alluvial strata are thin, and under them, the upper Irrawaddy formations consist of sand layers and gravel layers, and the lower Irrawaddy formations consist of clay and sand alternates. Under EL-0m, the Pegu formations are distributed.

The static water level in dug wells is distributed nearly along the topographical surface, but the static water level in tube wells are distributed nearly horizontally and forms the average water level of the Irrawaddy river.

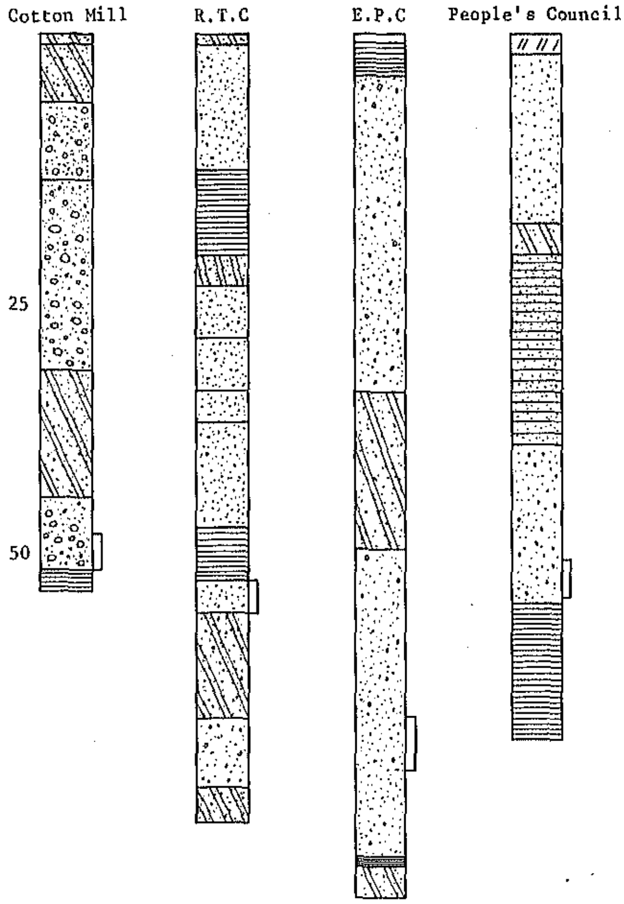


Fig. 4.7.2.3 Well Logs in Pakokku

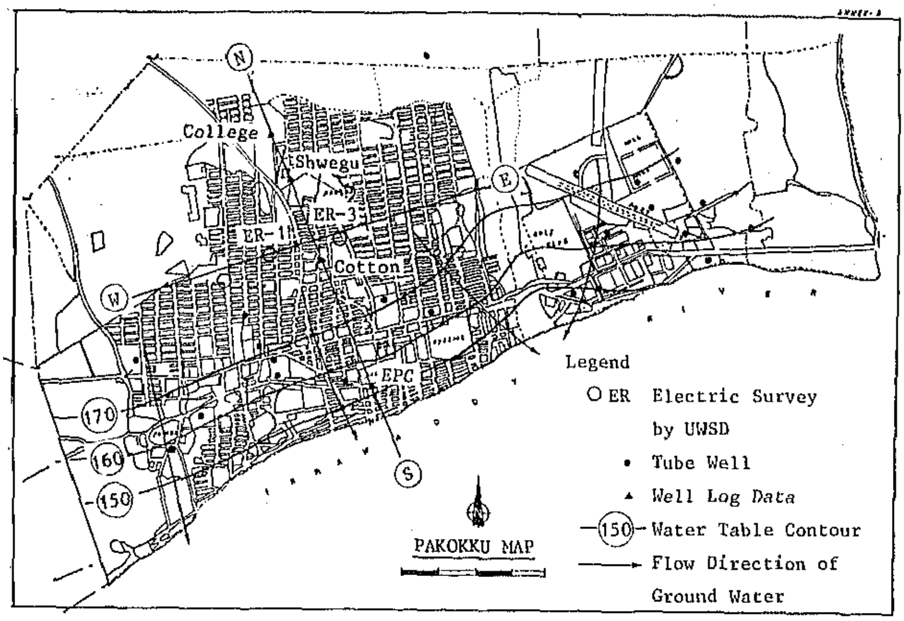


Fig. 4.7.2.4 Location of Tube-Well Points, Electric Survey Points and Section Points, and Ground Water Level Contour Map.

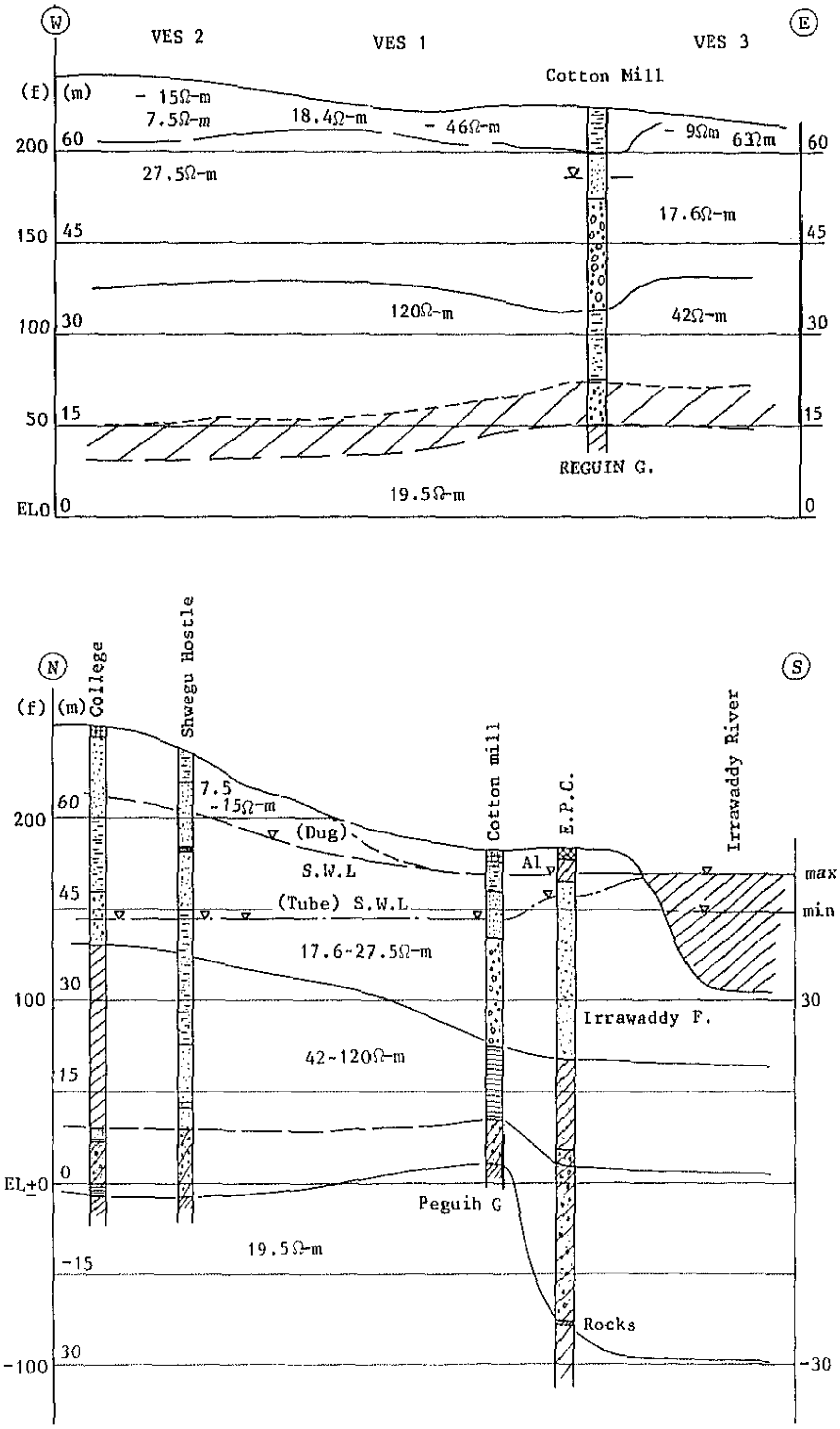


Fig. 4.7.2.5 Hydrogeological Section in Pakoku

2) Aquifer

The aquifers in the Pakokku area consist mainly of sand and gravel layers of the Irrawaddy formations. The thickness is generally about 20m, but as shown in the sectional view of Fig. 4.7.2.5, the properties and thickness vary with location. The depth is 24 to 30m or about 50m, and the discharge is small in the former and large in the latter.

Table 4.7.2.1 shows the coefficient of permeability obtained from the existing well logs.

Table 4.7.2.1 Coefficient of Permeability in Pakokku

Well No.	Aquifer m (cm)	Draw down H-h (cm)	Discharge Q (cm^3/sec)	Diameter r (cm)	Permeability k (cm/sec)	Old well No.
E.P.C	976	1,098	22,190	10.16	3.03×10^{-2}	
-	2,135	763	50,000	30.48	3.95×10^{-2}	

For the calculation, influence radius R = 500m was assumed. The average coefficient of permeability in Pakokku is as large as $k = 3.5 \times 10^{-2}$ cm/sec.

3) Ground Water Storage and Water Quality

(1) Ground Water Storage

The annual precipitation P and potential evapotranspiration E are as follows.

Precipitation P = 558.5 mm

Evapotranspiration E = Ep x 0.7

= 2,009.1 x 0.7

= 1,406.4 mm

(The value of evapotranspiration in Monywa is used.)

Considering throughout the year, the ground water recharge G becomes asa follows:-

$$G = P - E = 558.5 - 1,406.4 = -847.9 \text{ mm}$$

This means that the evapotranspiration exceeds the precipitation, and no ground water recharge takes place. The same may be said of the rainy season.

However, the groundwater in this area is recharged from the hills of the Irrawaddy formations on the back and from the Irrawaddy river. At this point, let us consider the recharge from the hills only.

The precipitation in the rainy season in Pakokku is about 465.7 mm. Assuming that 75% flows out to the surface and 25% infiltrates into the ground, and the recharge area is 200 km^2, then, the groundwater recharge is

$$Q = 0.12m \times 200$$
$$= 2.4 \times 10^7\ m^3$$

In addition, there is a recharge from the Irrawaddy river, and therefore, it is considered that the ground water make-up is aeequate.

The ground water storage will be calculated from the volume and porosity of the aquifers as follows.

$$V = A \times S \times E$$

where A: subject area 6 km^2

S: aquifer thickness 30m

E: porosity 15%

$$V = 6.5\ km^2 \times 20m \times 0.15$$
$$= 1.94 \times 10^7\ m^3$$

This value ignores the ground water make-up and flow out and shows the quantity stored in the present aquifer.

(2) Water Quality

In the east of the town, the Government Area, the well waters of TPC Office, and the Construction Corporation show comparataively higher EC, 1,000 and 2,000, respectively.

In the central area, the wells in General Hospital and Cotton Mill, both water samples show about 800 of EC, and in more northern area, the water from College Well shows EC 600, and the water at High School shows EC 540. The water quality of these wells seem fairly well.

In the west, EPC Deepwell water and well water in New Bazar show EC 750 and 900, respectively. A shallow well water of EPC has EC 220, quite high. Also at a dug well in Ward 15, the water shows EC 1,600.

Generally, it is supposed that the more northern part of the town and the deeper the wells are, the better the quality of water has show according to the field test results of water quality (EC).

Table 4.7.2.2 shows the water quality tested in Laboratory for the well water of EPC Deepwell, nearly in central south part of the town.

Table 4.7.2.2 Result of Laboratory Water Test for EPC Deepwell

Appearance	Clear
pH	8
Total Solids	480 mg/ℓ
Total Hardness	280 mg/ℓ
Permanent Hardness	17 mg/ℓ
Calcium Hardness	180 mg/ℓ
Total iron	0.15 mg/ℓ
Chloride	16 mg/ℓ
EC	750 μS/cm

4) Discharge rate per Well, Spacing between Wells, and Well Depth

The discharge rate per well must be grasped by conducting a pumping test. At this point, however, in accordance with Thiem's formula, the discharge rate per well will be estimated. The drawdown of water level S is found as 5.43m by the following calculations for the spacing between wells 600m (influence radius 300m).

$$S = R/3000\sqrt{k} = 300/3000 \times \sqrt{3.5 \times 10^{-4}}$$
$$= 5.34\text{m}$$

where R is 300m and k is 3.5×10^{-4} m/sec.

The discharge rate is

$$Q = \frac{2\pi Dk\ (H - h)}{2.3\ \log R/r}$$
$$= \frac{2\pi \times 20 \times 3.5 \times 10^{-4} \times 5.34}{2.3\ \log 300/0.127}$$
$$= 0.0303\ \text{m}^3/\text{sec} \fallingdotseq 1960\ \text{m}^3/18\ \text{hr}$$

Therefore, it is considered that the discharge rate per well 1,200 m^3/18 hr can be secured in this area.

The spacing between wells shall be such that it does not cause decrease of the discharge rate due neighboring wells causing drawdown the water level, and does not cause interference between wells.

For this area, considering the ground formations, conditions of aquifers and the discharge rate per well according to the existing data, the minimum spacing between wells will be taken as 600m.

Regarding the well depth, considering the lower limit depth of storage of the aquifer of about 100m, the average depth of production wells will be taken as 106m (6m for sand pit).

4.7.3 Planning The Water Supply System

1) Project Area

The town area of Pakokku develops towards the east-west direction along the Irrawaddy river, and is divided into two parts, eastern and western, by the Shwe Kyaung river.

The eastern part is composed of an air field, golf course, land for government use and for factories which have their own water supply facilities.

Most of the inhabitants live in the western part and the twon area is well arranged. This part has no water supply system and the dwellers depend on public or private well only.

In planning the water supply system, the eastern part is omitted from the project area. (Refer to Fig. 4.7.3.1.)

2) Planned Water Supply Population

The total population of the town as of 1983 is 71,807, of which 1,542 persons live in the eastern part. Therefore, the planned water supply population is 71,807 minus 1,542, that is, 70,265. The past average population growth rate is 2.2%, and therefore, the planned water supply population is 83,600.

3) Planned Water Supply Amount

Planned water supply amount

= 83,600 persons x 105 ℓ/person/day

= 8,778,000 ℓ/day

= 8,800 m^3/day

4) Division into Water Supply Blocks

The basic policy in the planned water supply area is to depend on gravity flow making use of the hills in the northern part. As shown in Fig. 4.7.3.2, the planned water supply area is divided into two blocks, each of which is given an independent water distribution network.

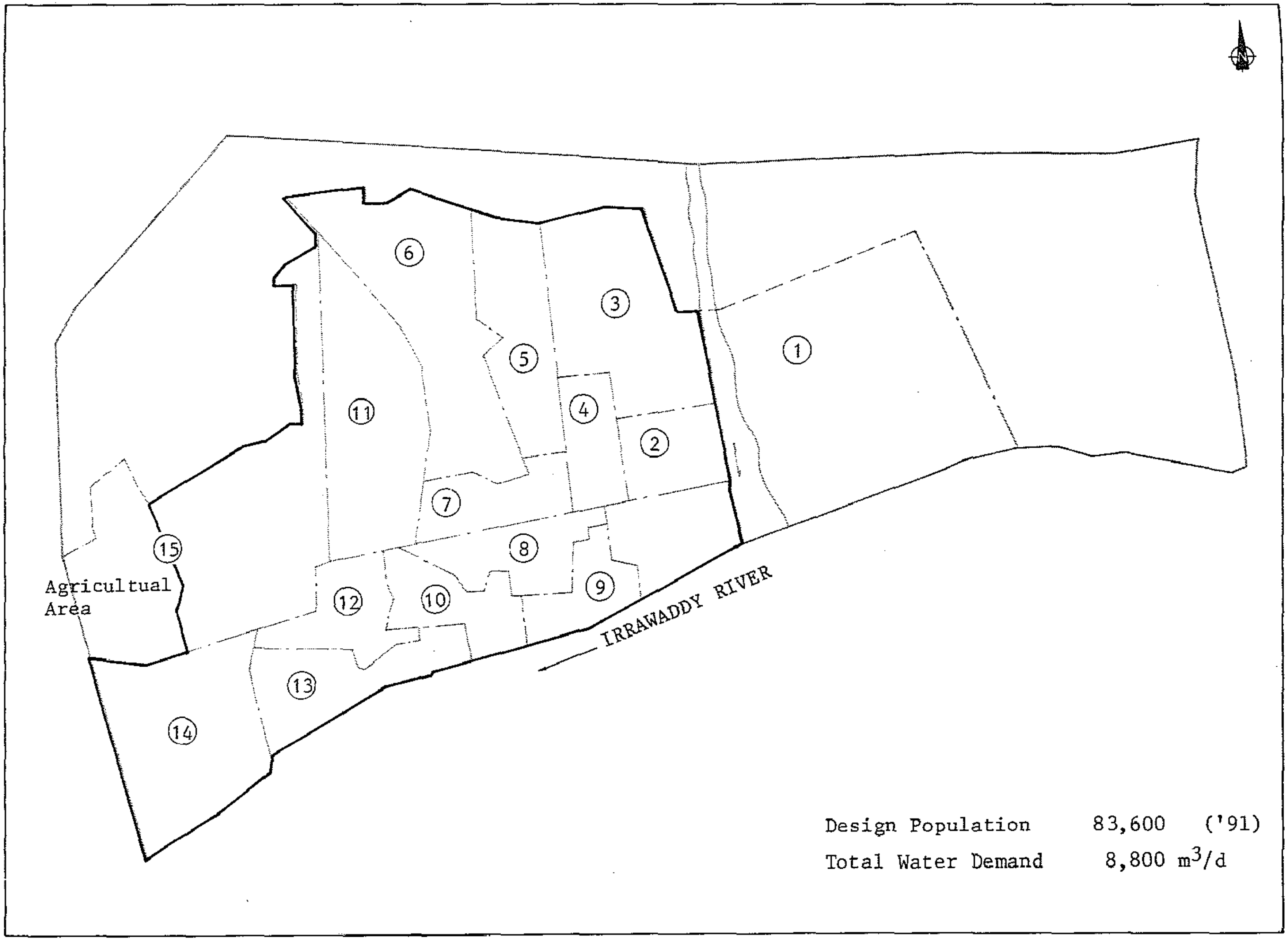


Fig. 4.7.3.1 Proposed Service Area

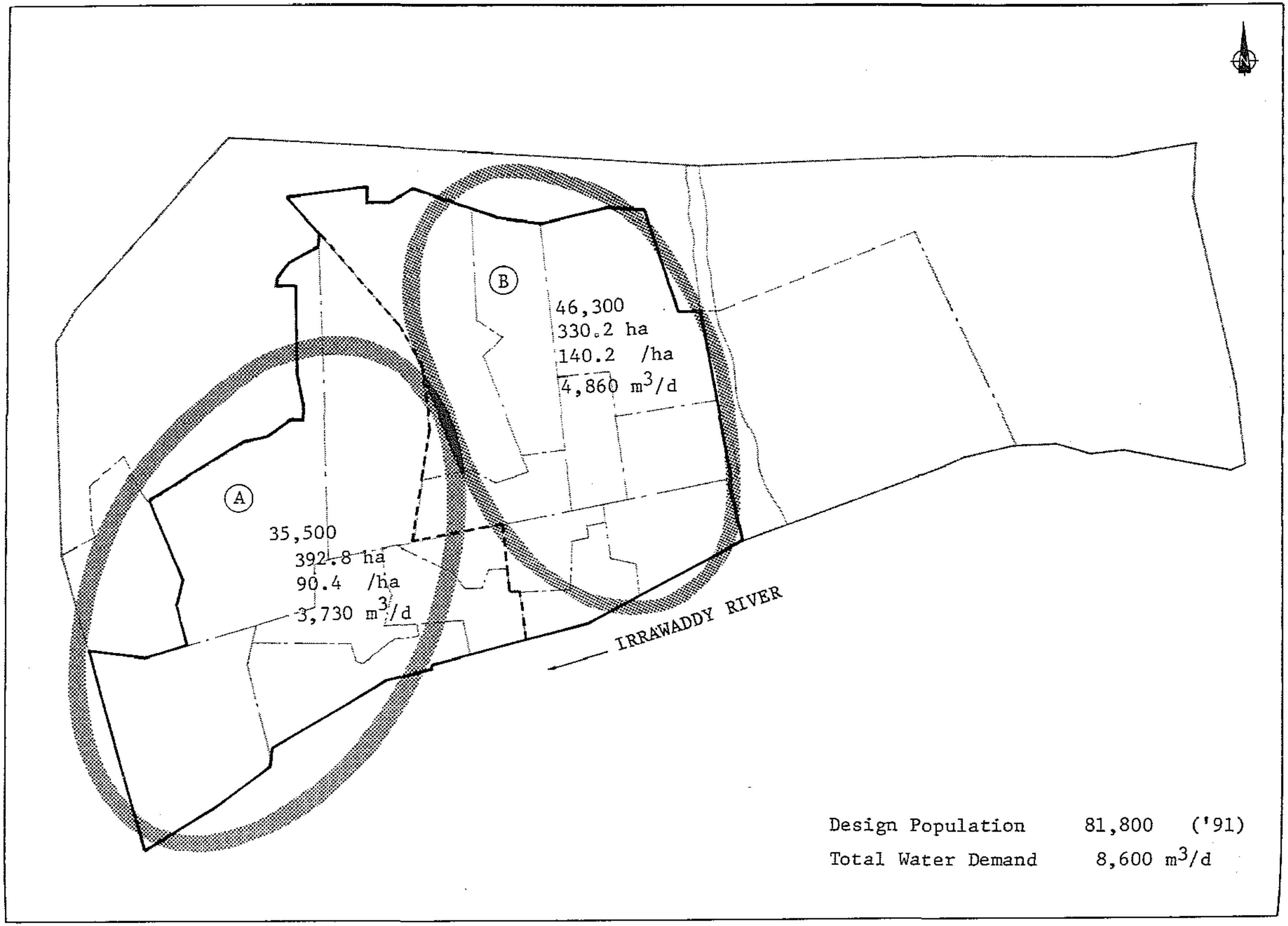


Fig. 4.7.3.2 Distribution of Design Population

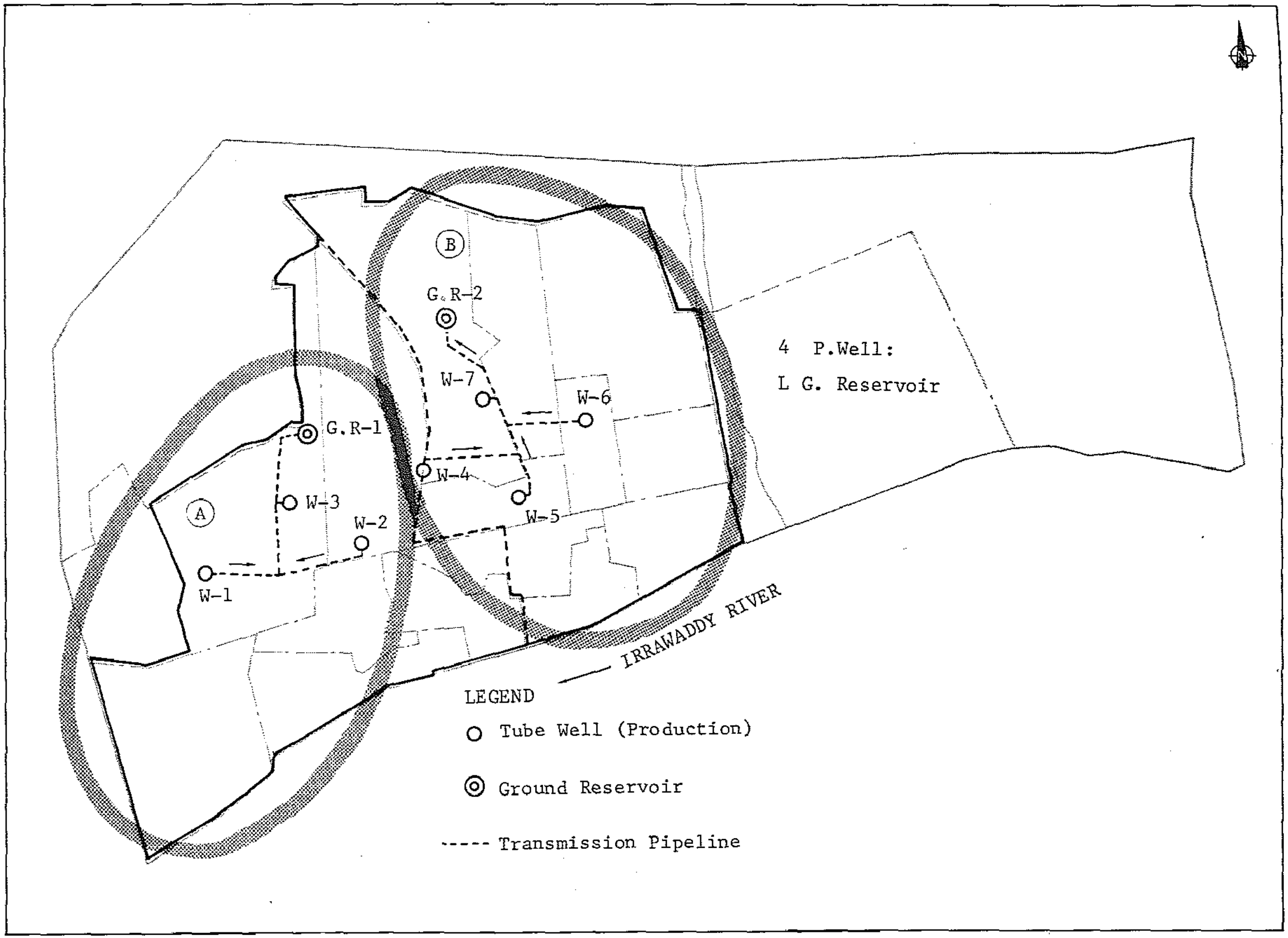


Fig. 4.7.3.3 Layout Plan of Proposed Facilities

The planning specifications for each block are as follows.

Table 4.7.3.1 Planning Specifications for each Block

	Planned water supply population (number)	Water supply area (ha)	Population density (person/ha)	Planned water supply amount (m^3/day)
A	37,100	385.4	96.3	3,900
B	46,500	381.7	121.8	4,880
Total	83,600	767.1	Ave.109.0	8,780

5) Facility Planning

For both blocks A and B, basic system 3 is applied. Fig. 4.7.3.3 shows the layout of facilities.

The planned discharge rate per well in this area is 1200 m^3/day as described above. The planned water supply amount is 3900 m^3/day and 4,880 m^3/day for block A and block B, respectively. Therefore, the number of wells required is determined as follows.

Block A: 3,900 ÷ 1,200 = 3.25 → 3

Block B: 4,800 ÷ 1,200 = 4.07 → 4

6) Outline of Facilities

Table 4.7.3.2 shows specifications and quantities for facilities.

Fig. 4.7.3.4 and Fig. 4.7.3.5 show water transmission pipeline and distribution pipeline networks, respectively. For the planned wells and elevated tanks, refer to the drawings given at the end of this chapter.

Table 4.7.3.2 List of Proposed Facilities

Facility	Item	Classification	No.	Remarks
Water intake facility	Production wells	Planned intake rate 1200 to 1250m^3/d φ250 to φ200 H = 106m	7	Casing φ250 H = 40m φ200 H = 42m Screen φ200 H = 24m
	Exploration wells	φ150mm x H123m	4	Casing H = 106m Screen H = 24m
	Observation wells	φ100mm x H106m	6	Casing H = 96m Screen H = 10m
	Intake pumps	φ100mmx1.11m^3/minx30kW	7	W-1 to W-7
	Pump rooms	Brick construction 4m x 4m Building area 16m^2	7 buildings	
Water transmission facility	Water transmission pipes	φ200mm to φ350mm T-type ductile cast iron pipe class 3	3,980m	
		Various reducers	1 set	
	Sluice valves	φ200mm to φ350mm	8	
	Air valves	φ20mm to φ25	6	
Water distribution facility	Storage tanks	Capacity 315m3 Underground RC construction	1	GR-1
		Capacity 410m^3 Underground RC construction	1	GR-2
	Distribution pipes	φ75mm to φ250mm T-type ductile cast iron pipe class 3	27,440m	
		Various reducers	1 set	
	Sluice values	φ75mm to φ250mm	71	
	Air valves	φ20mm	57	
Electric facility	Substation equipments	3φ4W 100 kVA	1 set	
	Transmission line	OW 22□ to 60□ CV 22□ x 4c	17.1km	
		Accessories	1 set	

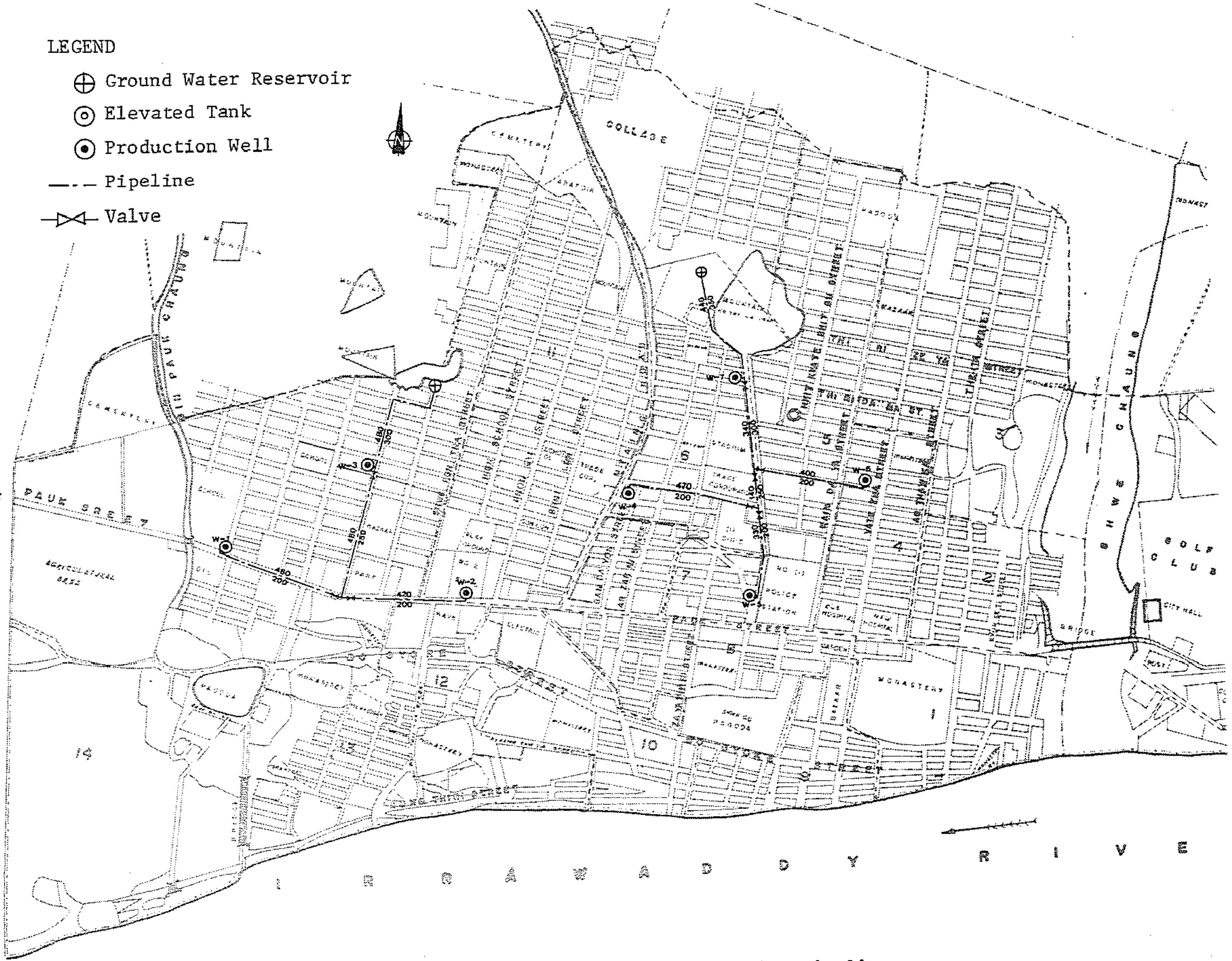


Fig. 4.7.3.4 Layout of Transmission Pipeline

Fig. 4.7.3.5 Network of Distribution Pipeline

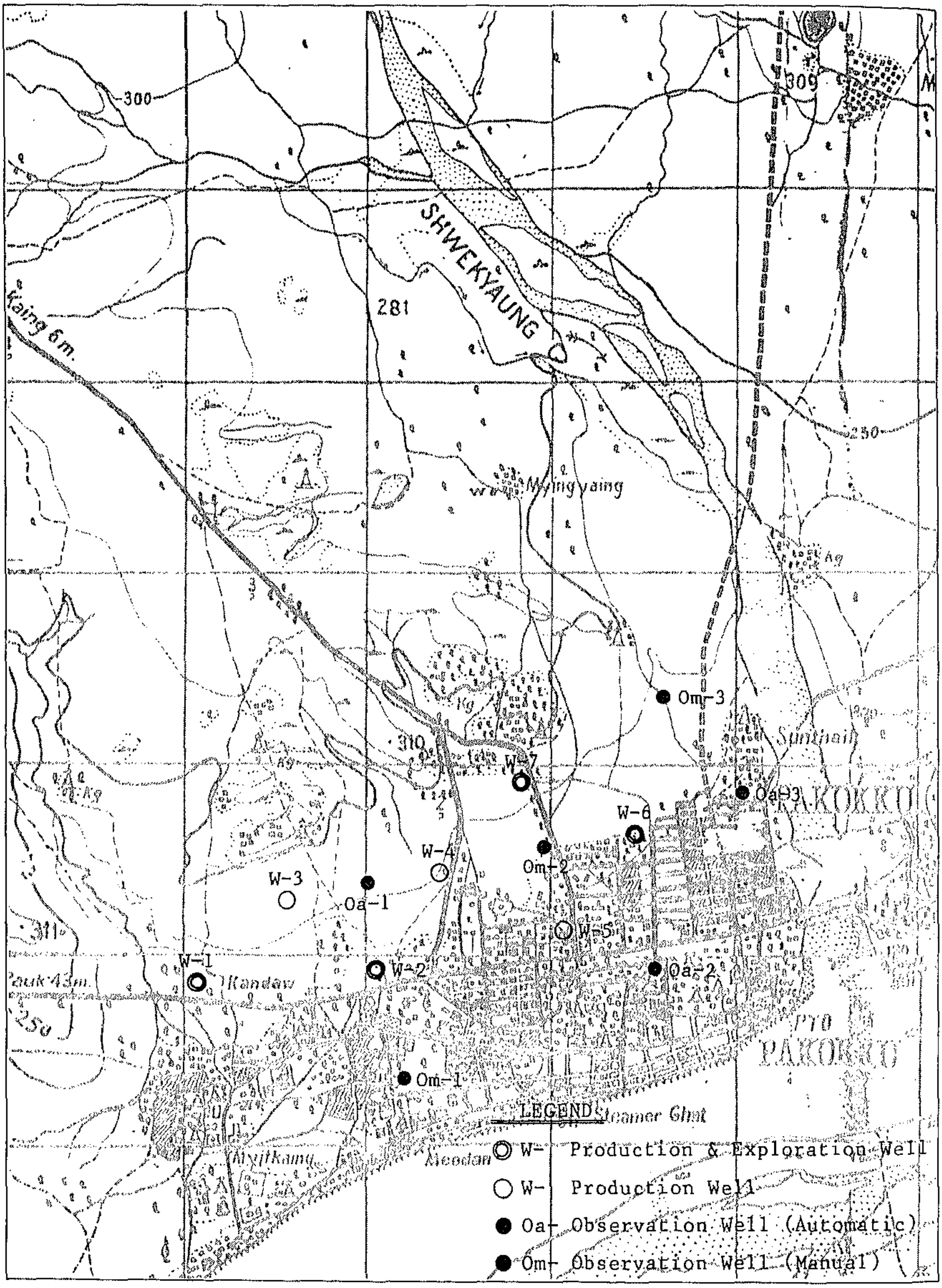
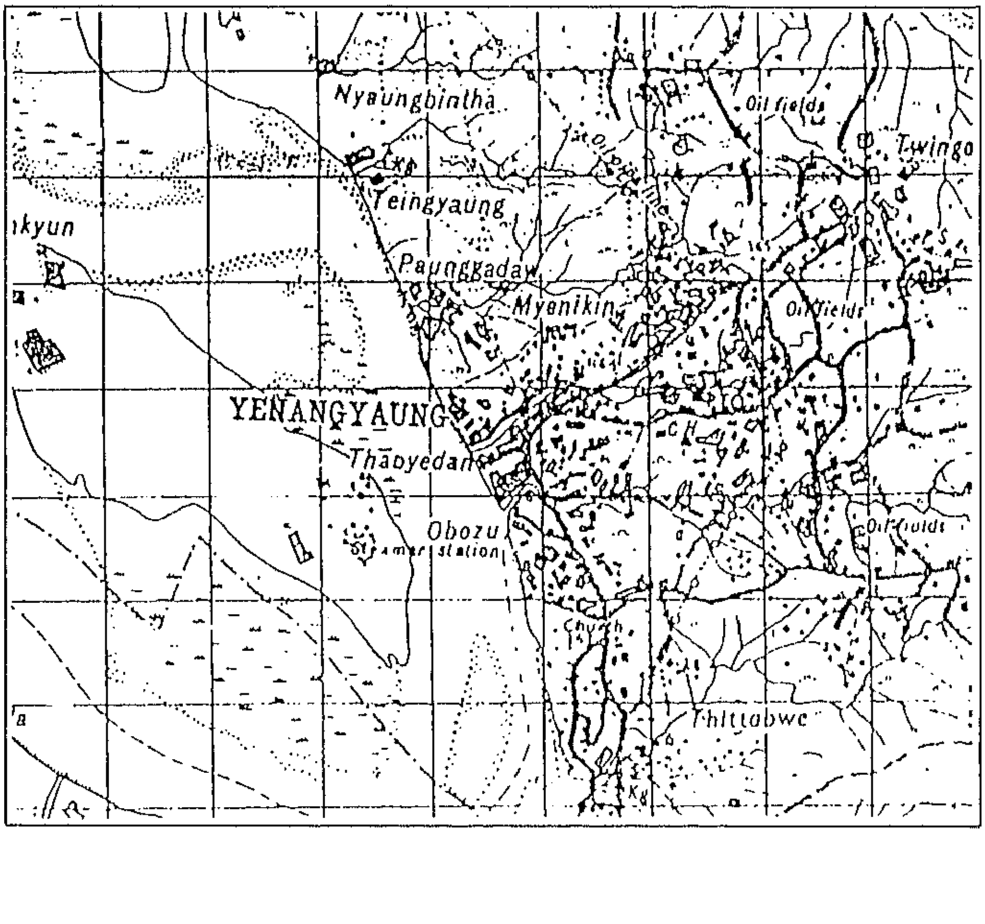


Fig. 4.7.3.6 Layout of Proposed Wells

4.8 Yenangyaung



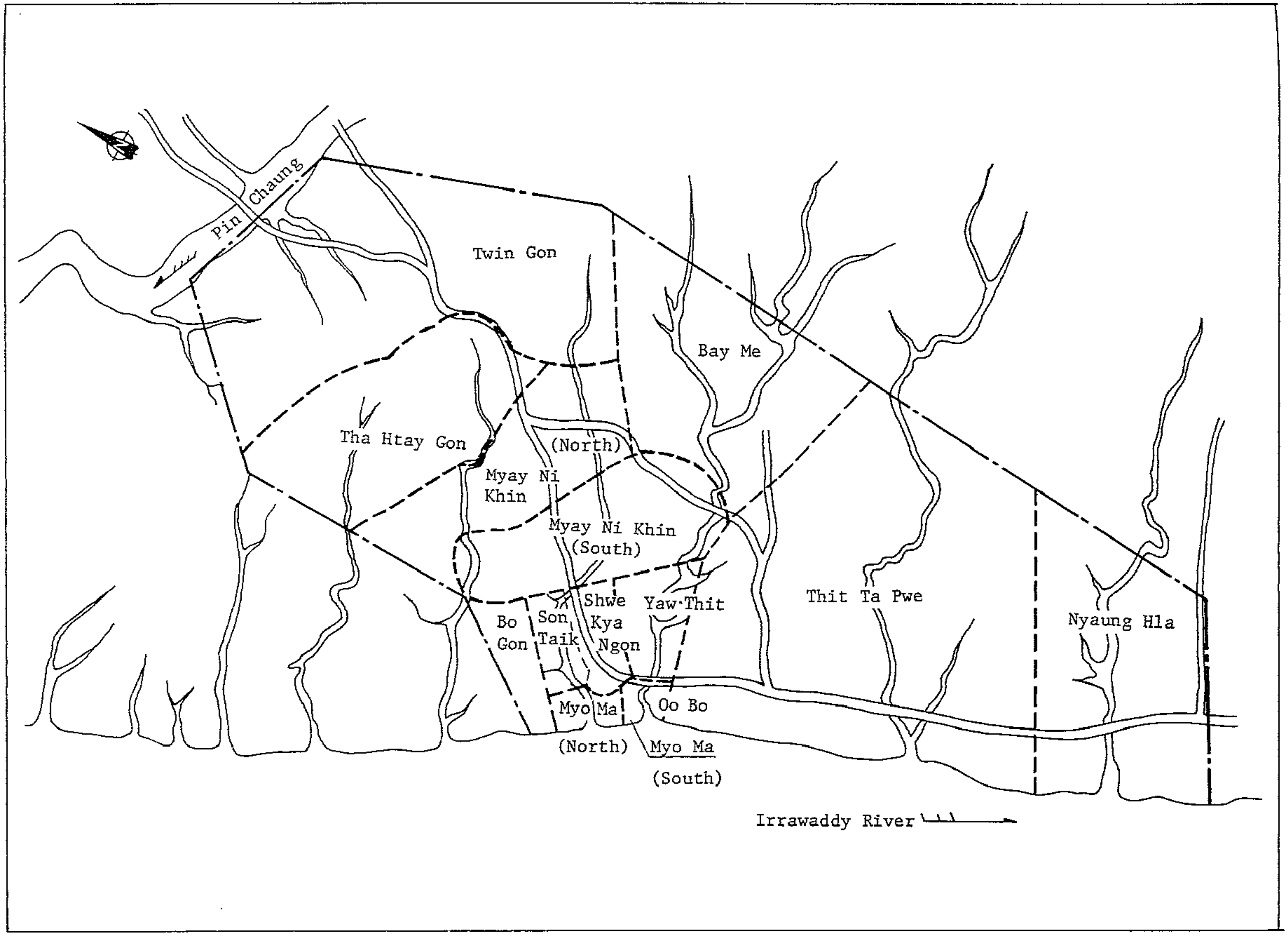


Fig. 4.8.1.1 Location of Each Ward

4.8.1 Outline of the Area

Yenangyaung is situated at about 40 km to the north of Magwe. It has a population of 71,475 as of 1983. The average population growth rate for the past 10 years is 1.6%. The maximum temperature is 33.9°C in winter (December to January) and reaches 43.9°C in April. The annual precipitation is about 500 mm.

The town has water supply facilities constructed after World WAr II, and the intake facilities and water transmission pumps are owned by MOC (myanma Oil Corp.). Since the water supply rate is limited, the inhibitants are troubled by water shortage at all times. To cope with this, several wells were dug at the center of the town, but the water is turbid, has high salt concentrations and is not suited for drinking.

4.8.2 Existing Water Supply Facilities

The water supply facilities in Yenangyaung comprise those constructed by TDC and those by MOC. The intake sources for both facilities are the infiltration type wells provided along the Pin Chaung river. The facilities by TDC have deteriorated, and only the water transmission main pipes, steel tanks and distribution pipes are usable at present. For water supply to the dwellers, therefore, it is necessary to obtain water from the water transmission pumps of MOC.

However, the available water quantity from MOC is limited to 400,000 gal per day, and water supply to the consumers is only for two hours per day, and/or only one day in three day cycle in some area.

Table 4.8.2.1 shows the outline of the existing water supply facilities of TDC. Fig. 4.8.2.1 shows their layout.

Table 4.8.2.1 Outline of Existing Water Supply Systems

Item	Type and shape	Q'ty	Capacity	Owner
Water intake facility	Infiltration type well φ12' x 20' depth	6	250 gal/min/W	M.O.C.
Transmission facility	Transmission pumps	4	3.15m/minx214mH x200kW	M.O.C.
	Transmission pipe φ14"			T.D.C.
Water distribution facility	Storage tank Steel tank (A)	1	4,500 m^3	"
	" (B)	1	230 m^3	"
	Distribution pipe φ10"			"
	φ8"			"
	φ6"			"
	φ4"			"
	φ3"			"
	φ2"			"

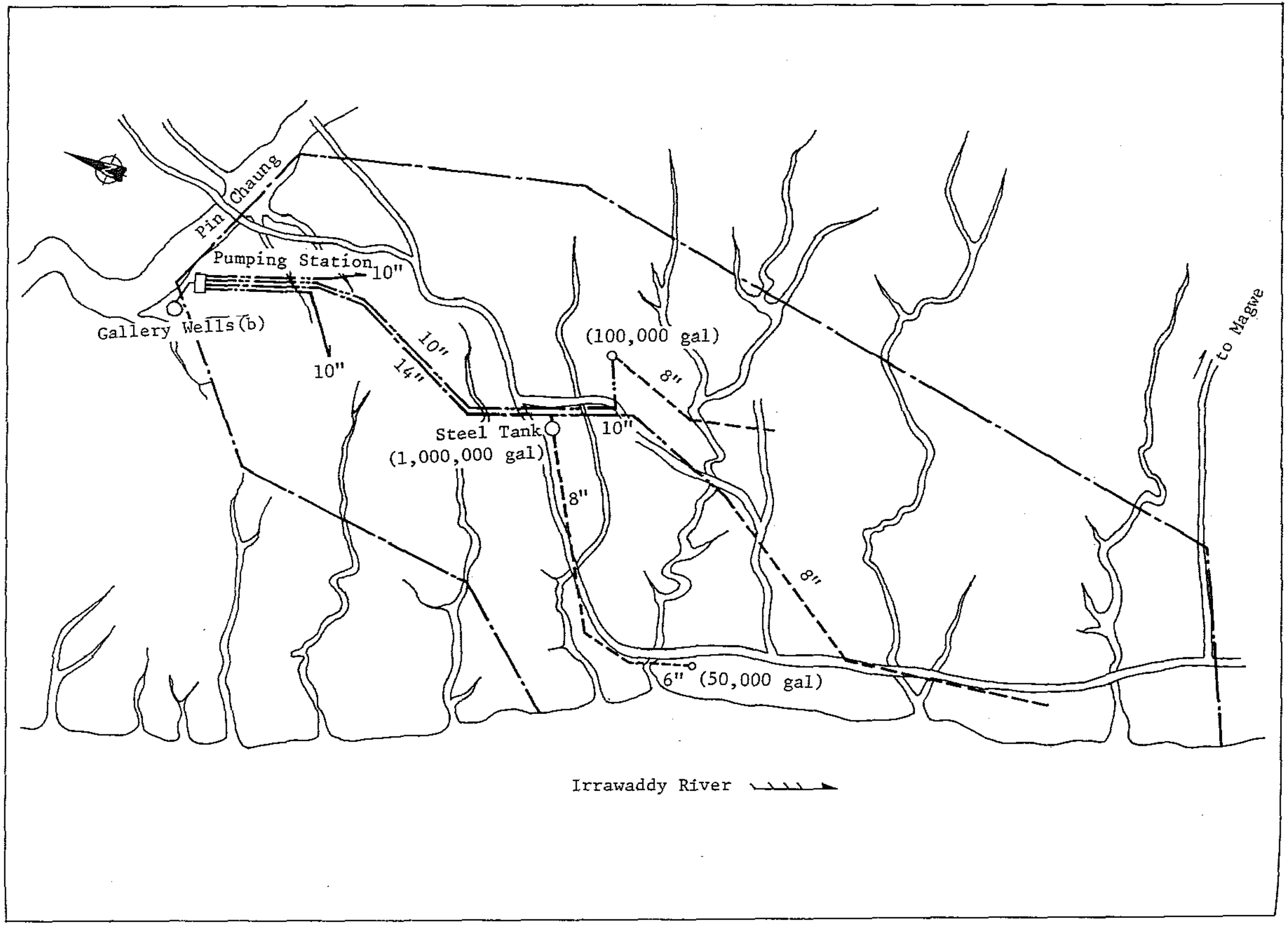


Fig. 4.8.2.1 Layout of Existing Facilities

4.8.3 Planning the Water Supply System

As described above, the water supply facilties of this town comprise the intake facility and water transmission pumps, owned by MOC, and the water transmission facility including water transmission pipes and water distribution facility owned by TDC. Further, the capacities of water transmission pipes and storage tanks are sufficient for the planned capacities in this project.

When constructing the water supply system owned by TDC, the system can be functioned if the infiltration type wells and water transmission pumps are installed.

Therefore, in this facility planning, several wells similar to MOC's infiltration wells are to be constructed as the intake along the Pin Chaung river and water transmission facility having the capacity meeting the requirements are to be installed.

Connection pipes are to be installed to the existing transmission pipes.

Table 4.8.3.1 Planning Specifications and Planned Water Supply Amount

Item	Specification	Remarks
① Population (1983)	71,475	
② Annual average population growth rate	1.6%	
③ Planned population (1991)	81,200	
④ Average water supply per person per day	70 ℓ	15 gal
⑤ Planned daily maximum supply per capita	105 ℓ	④ x 1.5
⑥ Planned water supply amount per day	8,500 m^3/day	

4.8.4 Facility Planning

1) Investigation of Infiltration Wells

Infiltration wells of Yenangyaung are six in number (RC, diameter 12'-0" x depth 2-'-0") constructed along the Pin Chaung river by MOC.

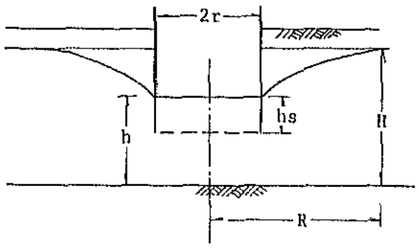
In the present plan, similar infiltration wells are to be constructed.

(1) Permeability of Pin Chaung river bed

The permeability of the Pin Chaung river bed is estimated from the condition of the present infiltration well. If it is assumed that the collector panel is incomplete, the aquifer is not so thick, and the side wall and bottom leak, then the coefficient of permeability is given by

$$k = \frac{Q \log \frac{R}{r} \sqrt{\frac{h}{h_s + 0.5r}} \sqrt[4]{\frac{h}{2h + h_s}}}{1.36\ (H^2 - h^2)}$$

(Forchheimer's equation)



where R = 50m

r = 1.8m

Q = 1.87 x $10^{-2} m^3/sec$

(present discharge rate by MOC)

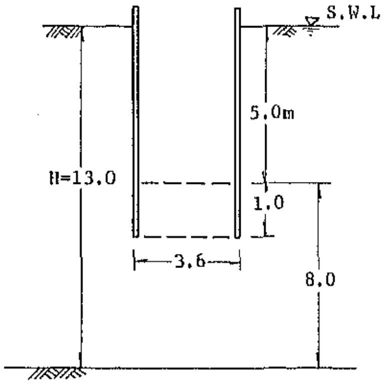
H = 13.0m

h = 10.0m (assumption)

k ≒ 5.0 x 10^{-2} cm/sec

(2) Well discharge rate

The size of the infiltration well is determined as follows and the discharge rate is estimated.



Conditions:

$k = 5.0 \times 10^{-}$ m/sec

$H = 13.0$ m

$h = 8.0$m

$h_S = 1.0$m

$r_0 = 1.8$m

$R = 335$m

$(R = 3000S\sqrt{k})$

The discharge rate is calculated in accordance with the same Forchheimer's equations as used for the coefficient of permeability. Then

$Q = 0.0184$ m^3/sec

$\fallingdotseq$ 1590 m^3/day

In order to meet the maximum planned water supply per day 7500 m^3/day,

$7500 \div 1590 = 4.7$

Five wells are required.

2) Outline of the Facilities

Fig. 4.8.4.1 shows the layout of the water intake and water transmission facilities in this project. Table 4.8.4.1 shows the necessary specifications and quantities for the facilities.

Table 4.8.4.1 List of Proposed Facilities

Facility	Item	Classification	No.	Remarks
Water intake facility	Production wells	Manshu well $Q = \phi 3.6$m x H6.0m	5	
	Intake pumps	ϕ150mmx2.315m^3/minx55kW	3	Including existing conveyance piles and connection pipes
	Pump room	Brick construction 7.0m x 4.5m Building area 167.7m^2	1 buildings	

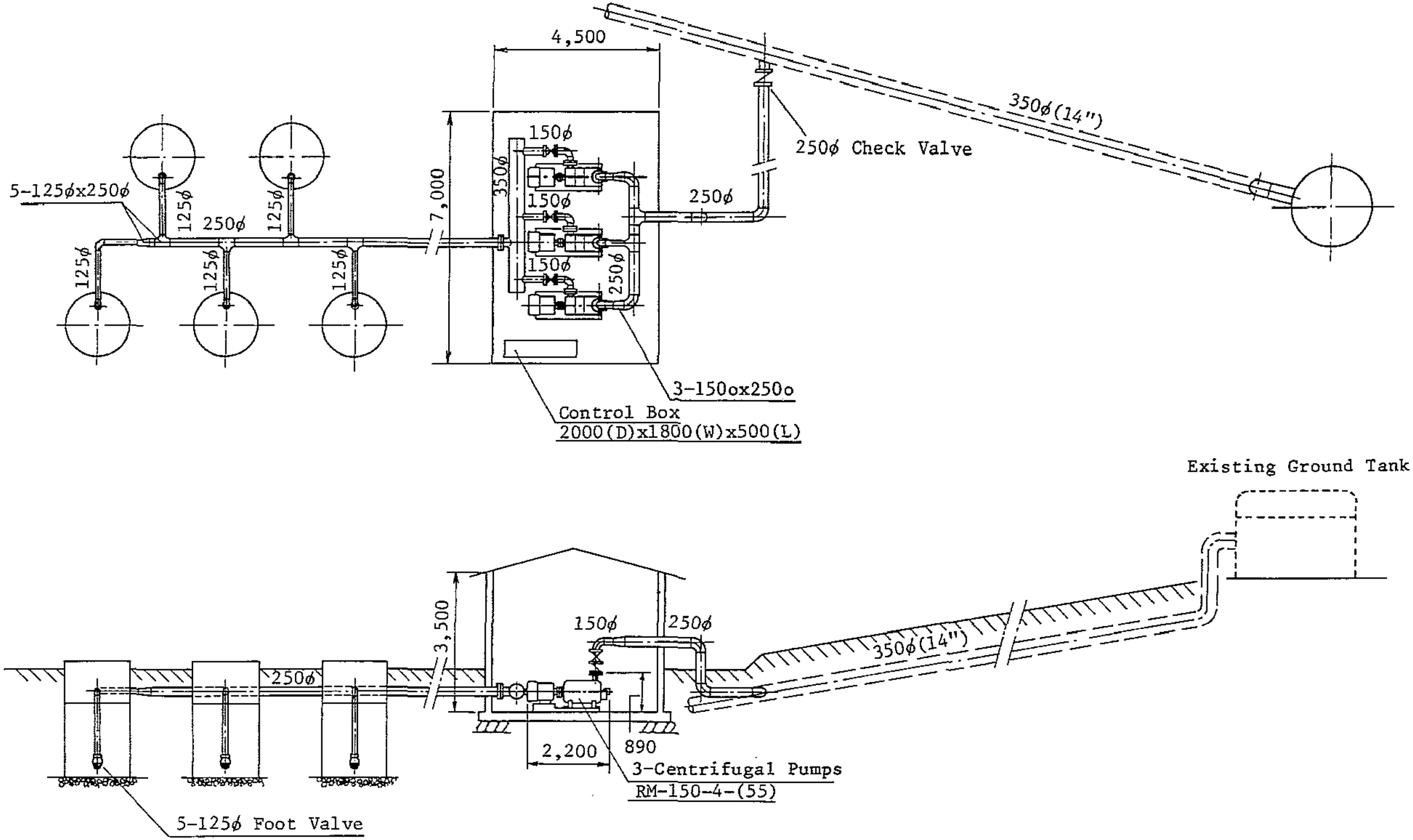
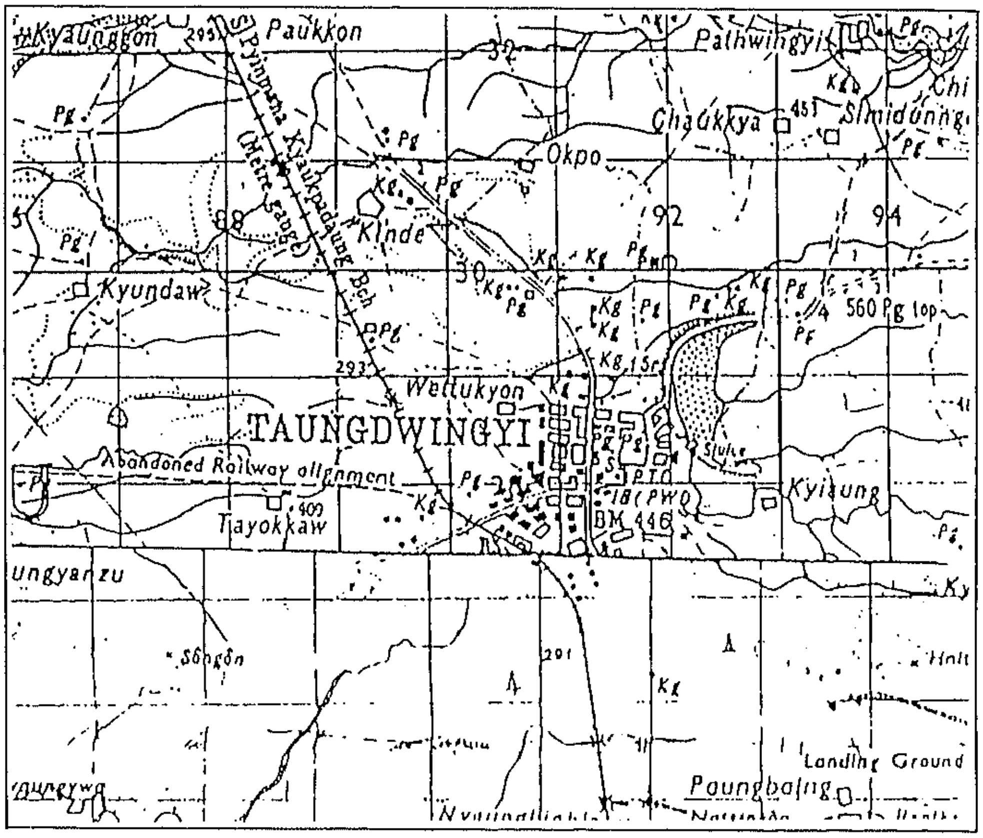


Fig. 4.8.4.1 Plan of Proposed Facilities

4.9 Taundwingyi



4.9.1 Outline of the Area

Taungwingyi is situated at 448 km to the north of Rangoon and about 48 km to the south east of Magwe. The population as of 1983 is about 38,500, and the annual average population growth rate is 1.6%.

The town land is nearly flat, slowly sloping from the north east.

The air temperature is 30° to 33°C in winter and 37° to 43.7°C in summer. The annual precipitation is 959 mm (458 to 1390 mm) on the average of 10 yeas.

Agricultural products such as rice, corn, sesame, peanut, bean, etc. are cultivated.

This town has a water supply system, but its supply capacity is not sufficient for the dwellers.

In addition to the pump stations, there are 14 tube wells at the center of the town. The depth is 24.4m to 73.8m. EC is 1000 to 1500 in all wells.

In the eastern part of the town, there is the Kandawgyi lake of about 1 km^2 (capacity 158.6 x 10^4 ton). This is a source of living water for the dwellers.

Fig. 4.9.1.1 shows the population and area by wards. Fig. 4.9.1.2 shows the ratio of areas by land use purposes.

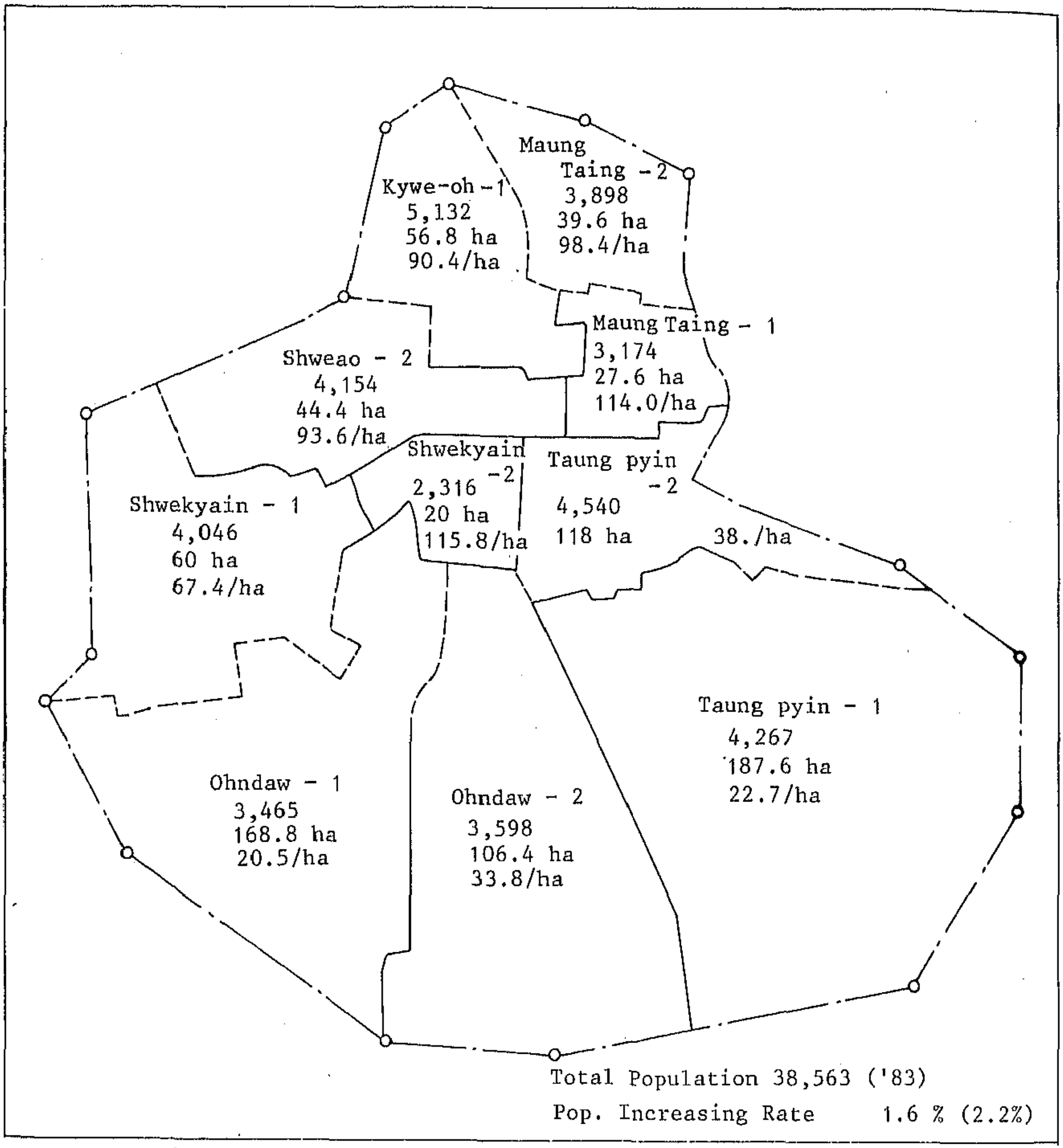
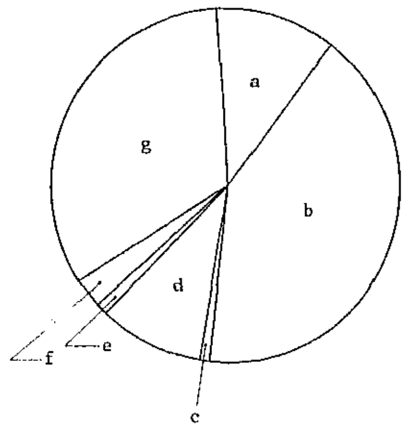


Fig. 4.9.1.1 Present Population and Area of Each Ward



a)	Agricultural Field, etc.	11.11 %
b)	Residential Area	41.67 %
c)	Cemetery, Garden and Park	0.74 %
d)	Religious Center	9.57 %
e)	Commercial Places	0.74 %
f)	Industrial Areas	2.76 %
g)	Government Buildings	33.41 %

(Offices, School, Hospital and Government Buildings)

Fig. 4.9.1.1 Ratio of Areas by Land Use Purposes of Taungdwingyi

4.9.2 Existing Water Supply Facilities

The water supply facilities of Taungdwingyi were constructed in 1952 for 5,000 persons. The water source consisted of three tube wells. The drinking water supply capacity of these facilities, however, is only about 120,000 gal (about 550 m^3) per day at the present, for water supply to the dwellers only for one and a half hours from 7 o'clock.

The groundwater from 3 tube wells is collected in the 200,000 gal. concrete ground tank. It is pumped up into the elevated tank from which the water flows down through ductile cast iron pipes by gravity to the dwellers.

Fig. 4.9.2.1 shows the layout of the existing facilities.

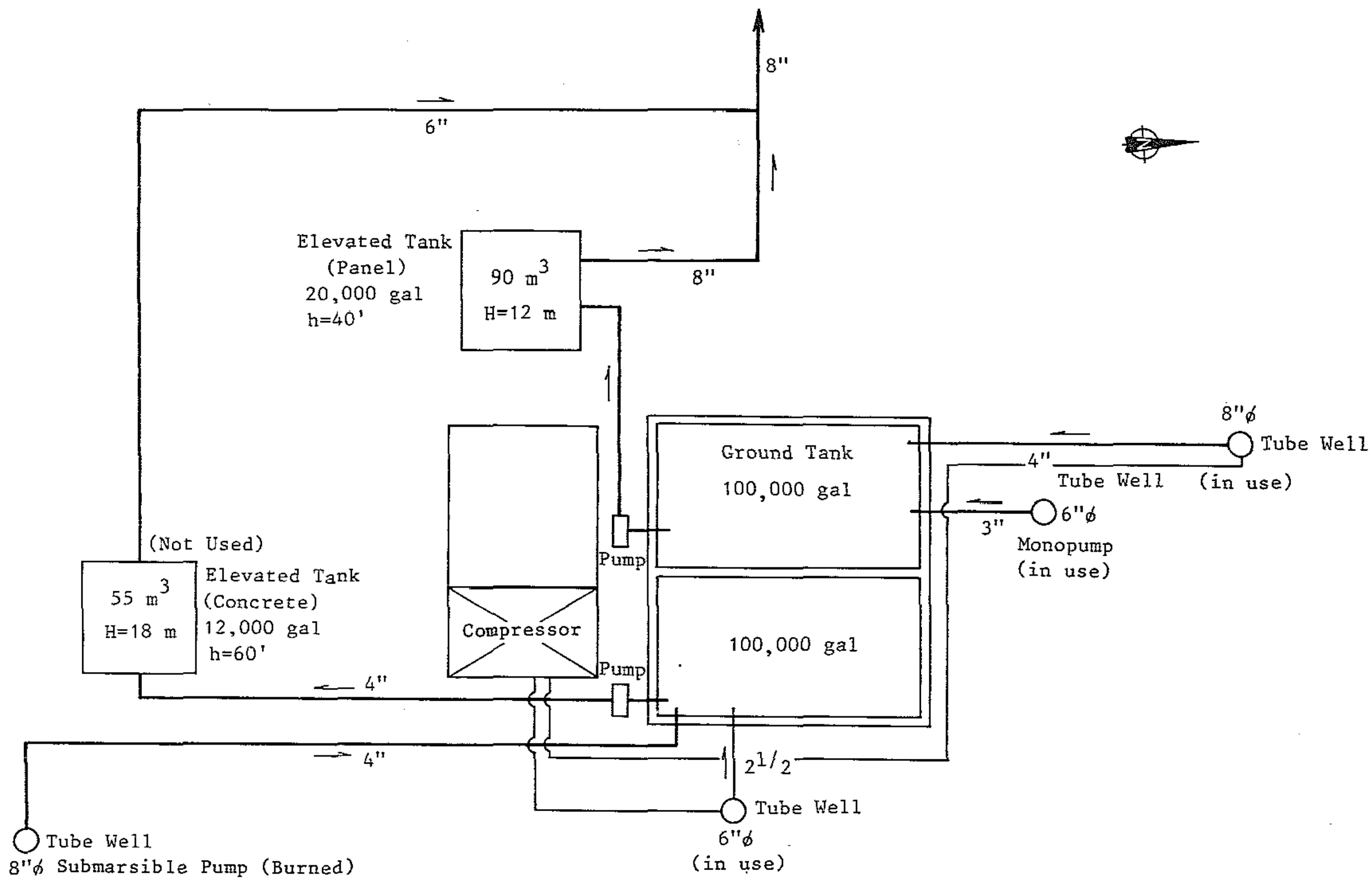


Fig. 4.9.2.1 Layout of Existing Pumping Station

4.9.3 Water Resource Development Plan

1) Hydrogeology

(1) Topography and geology

The Taungdwingyi area is located on the southeast side of the Taungdwingyi basin. At about 10 km on the east side, the Pegu Yoma uplifts and at about 20 km on the west side hills of the Irrawaddy formations and mountains of the Pegu formations, are distributed. In the neighborhood of the boundary between the hills and the mountains, the Irrawaddy river flows to the south. (Refer to Fig. 4.9.3.1 and Fig. 4.9.3.2.)

The Taungdwingyi basin is surrounded by these mountains and hills (300 to 600m above the sea level) and is 90 to 150m high. The surrounding mountains consist of the Pegu formations of the oligocene and middle and lower miocene of the tertiary period, and the hills consist of the Irrawaddy formations of the upper miocene and pliocene of the tertiary period. Around the Taungdwingyi basin, these formations are folded in the complicated condition. Inside the basin, the alluvial layers are distributed but as a whole, they are thin, and the Irrawaddy formations appear at shallow places.

On the alluvial low lands, the Yin Chaung flows through nearly the center of the basin to the west, and at about 40 km from the narrow part of the hills, combines with the Irrawaddy river. The basin is flat, but very slowly slopes toward the Yin Chaung. The Yin Chaung and its branch streams form the meander zone and flood only in the rainy season.

Fig. 4.9.3.3 shows geological diagrams of the Taungdwingyi basin. Around the basin, the diluvial layers and the Irrawaddy formations are distributed. On the east side of Taungdwingyi, Irrawaddy formations are distributed, sloping slowly, and developing erosion valleys prominently.

The geological layer order in the neighborhood of Taungdwingyi is as follows.

Layer order	Age	Features
Alluvium	Alluvial epoch	Distributed in the surface layer.
Diluvium	Diluvial epoch	Distributed in the plain, and thin.
Irrawaddy formation	Upper miocene and pliocene	Distributed in hills, and distributed under the alluvial and divuvial layers.
Pegu formations	Oligocene and middle and lower miocene	Distributed in the Pegu Yoma uplifts.

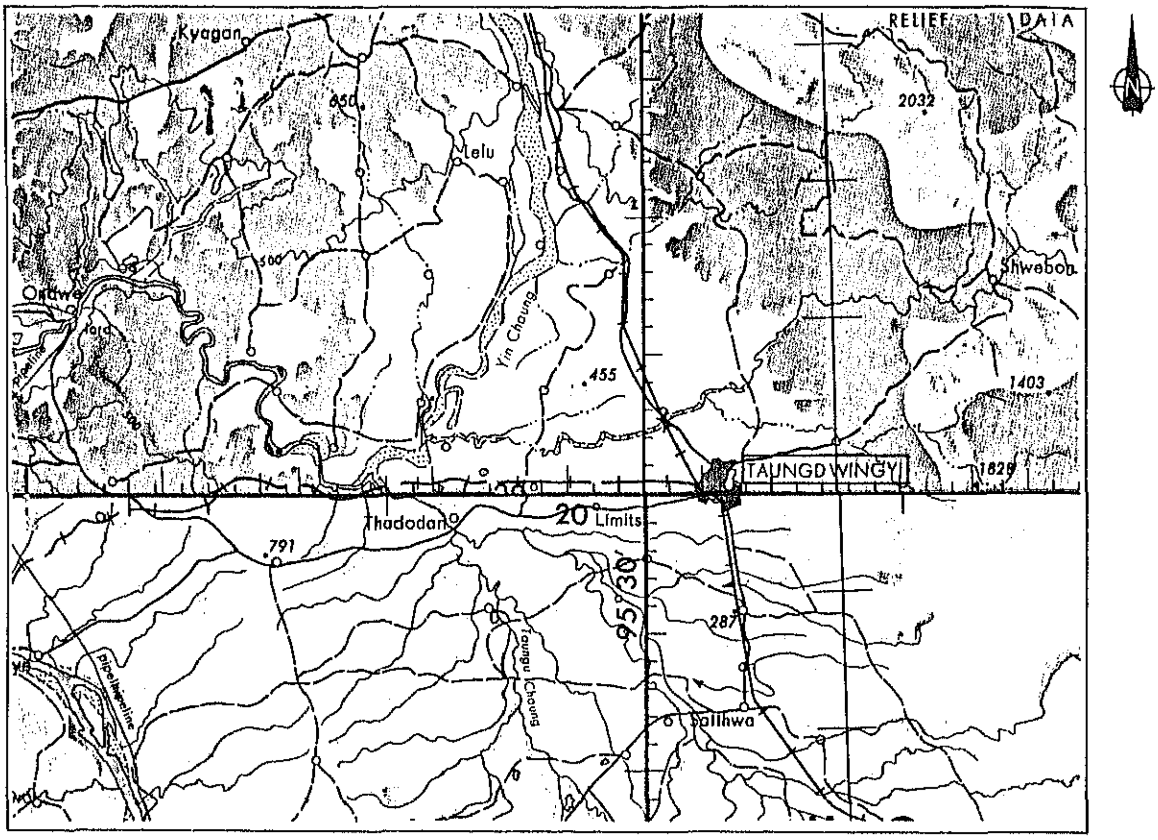


Fig. 4.9.3.1 Topographical Map of Taungdwingyi Scale 1:500,000

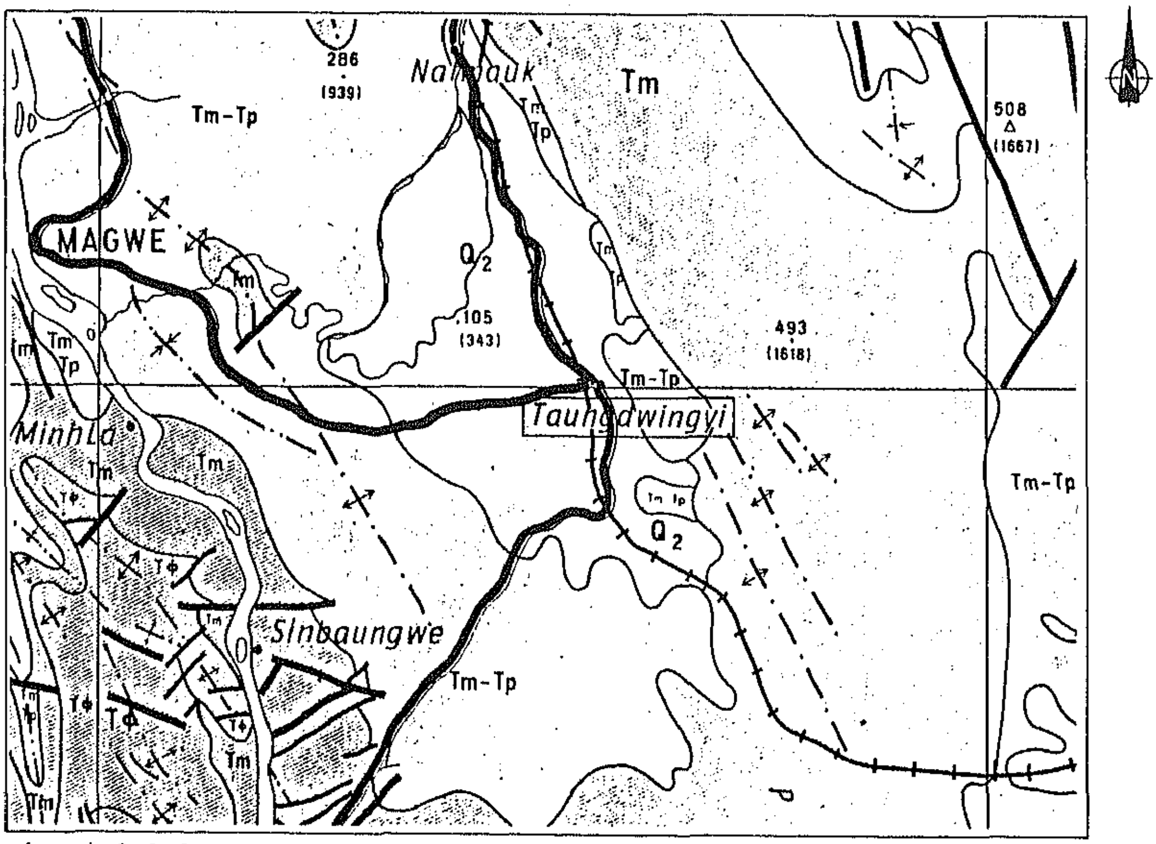


Fig. 4.9.3.2 Geological Map of Taungdwingyi Scale 1:870,000

(2) Hydrogeology

Around Taungdwingyi, 85 wells have been provided for the domestic water supply to many villages by the Rural Water Supply Division of Agricultural Mechanization Department. In addition, some other wells have been installed in the same area by the authorities of Taungdwingyi and the Ministry of Mines. The river is blocked, and hand dug wells are provoided in river beds. The water in the wells has good quality is a whole, but contains sodium and magnesium at some locations. The water level is about 4.5 to 7.5m, but largely varies during the year and dries up frequently in the dry season.

The water from tube wells in the alluvial and diluvial aquifers has better quality than the water from hand-dug wells, but the type containing sodium-magnesium carbonate is predominant. The water from the aquifers of the Irrawaddy formations contains less amounts of solids than the water from hand dug wells and is regarded as the calcium-magnesium carbonate type.

The coefficient of permeability of the highest value in the Taungdwingyi basin is $k = 2.0 \times 10^{-1}$ cm/sec and is seen in the southern part of the basin. In general, the coefficient of permeability is $k = 3.0 \times 10^{-3}$ to 2.0×10^{-1} cm/sec as in the sane layers of the Irrawaddy formations of coarse and medium particles. The coefficient of permeability in the area contained between the Yin Chaung and the Sadon Chaung in the center of the basin is $k = 3.0$ to 6.0×10^{-2} cm/sec. In the limited range of the east side, it is as small as $k = 1.2 \times 2.0 \times 10^{-2}$ cm/sec. The coefficient of permeability of the diluvial layers of the Taunghdwingyi basin is generally $k = 9.2 \times 10^{-3}$ to 2.5×10^{-2} cm/sec.

The depth of the existing wells is about 90m maximum, and generally, the aquifers consist of fine and coarse sand.

Around the Tanugdwingyi area, there are artesian zones, having too aquifers, whose depths are 30 to 60m and over 150m respectively. The discharge of the wells in the artesian zone is 3.4×10^{-3} m^3/sec maximum and 2.8×10^{-4} m^3/sec minimum.

The location for well construction in the present plan are situated in the artesian zone to the east of Taungdwingyi town. The artesian zone is located in the area between the progressively eroded hills of Irrawaddy formation and Kandagyi lake.

There are three tube wells in operation in the pump station owned by TDC. These have aquifers ar about 24 to 30m and at 60 to 85m. The water level in the rainy season gets near the ground surface. The water from the tube well is usually fresh, but at some locations, it contains salts.

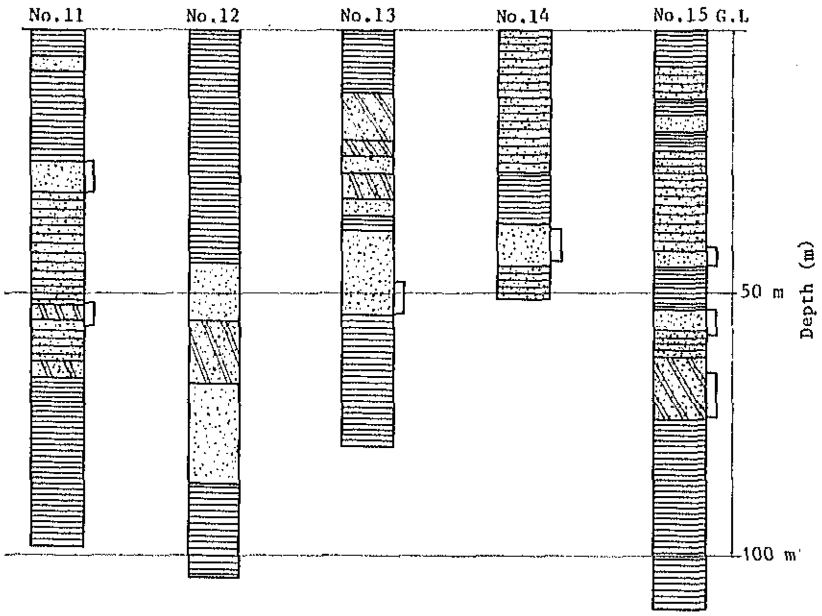


Fig. 4.9.3.3 Well Logs in Taungdwingyi

Fig. 4.9.3.4 shows well logs of the Taungdwingyi area. According to these logs, the aquifers are clay and sand alternates or sand layers with clay mixed. They are aquiclude-impermeable beds and cannot be said to be good aquifers. More than 300 dug wells for shallow layer ground water are distributed. The depth is about 6m. Most of these wells seem to dry up in the dry season. The water from the dug wells contains salts and is not suitable for drinking.

The water level profiles in Fig. 4.9.3.5 show that the groundwater in the Taungdwingyi area flows from the Pegu Yoma uplifts into the basin.

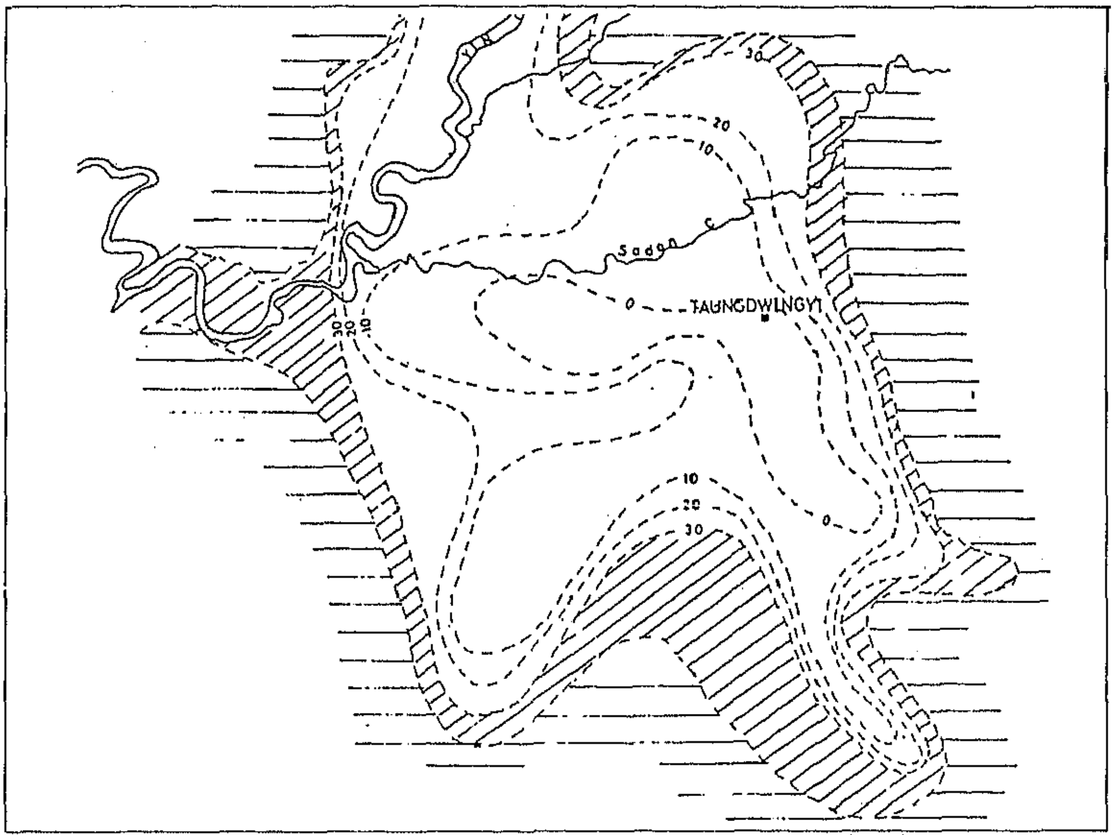


Fig. 4.9.3.4 Ground Water Level Contours of Alluvium/ Irrawaddian Bed Rock Aquifers in Taungdwingyi Basin

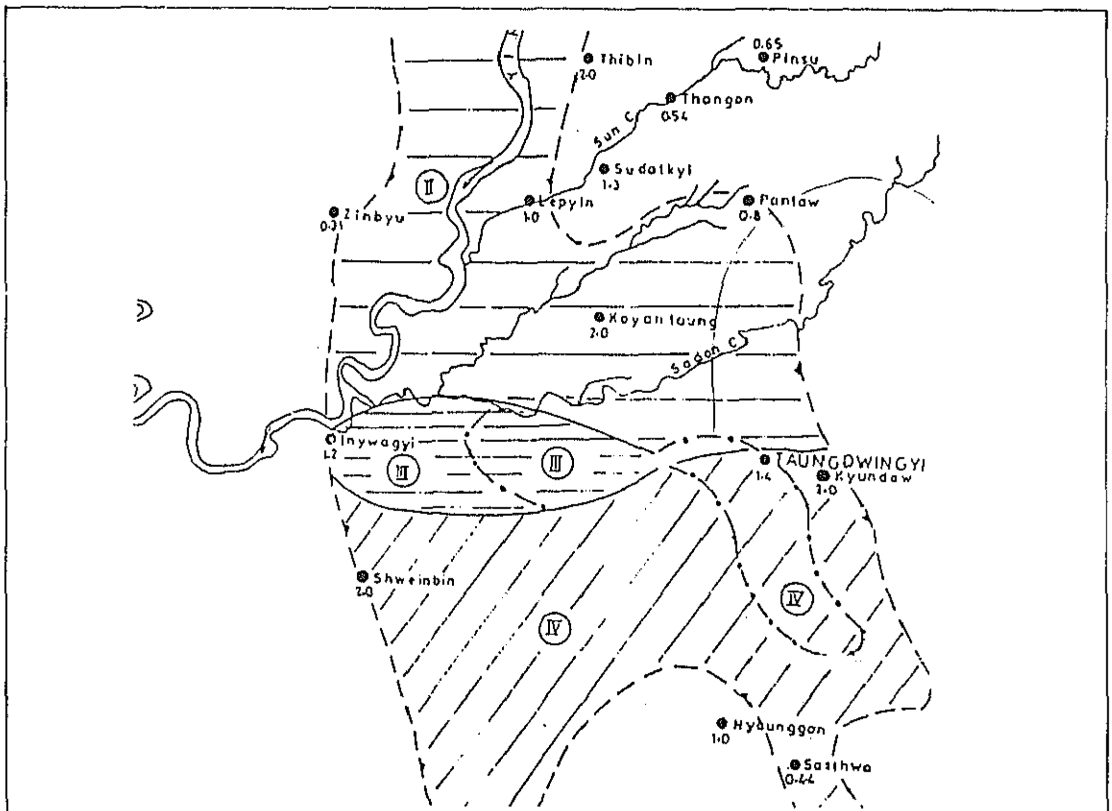


Fig. 4.9.3.5 Ground Water Potential in Taungdwingyi Basin

2) Aquifer

The aquifers are sand and gravel layers of alluvium and diluvium, and sand and gravel layers of the Irrawaddy formations. Any of these layers is mixed in the clay layers, and the thickness varies with the location. According to the existing well logs (refer to Fig. 4.9.3.3), the aquifers are sand and clay alternates, and the sand layers have clay mixed in many cases. As far as it is, seen in the well logs, the depths of the aquifers are not constant, but as a general trend, they are GL-25 to 30m and 40 to 50m, and partly near 70 to 85m.

The east side of the Kandawgyi lake in the Taungdwingyi area is shown as the artesian zone. Thila village, Utanpinsu, and Pinsi Pagoda have springs of 500 to 960 gph and the depth of the aquifer is 40 to 60m. Water temperature is 27°C which is lower than the neighboring wells. EC is about 1,000.

Electric prospecting was carried out at 11 points on the east side of the Taungdwingyi area as shown in Fig. 4.9.3.7.

The results are shown by the resistivity profiles in Fig. 4.9.3.8, and the low resisitivity values for the impermeable beds are also shown. The low resistivity profiles showing the depth are shown in Fig. 4.9.3.6.

The analytical results indicate the following.

① The resistivity in the Taungdwingyi area is low as a whole. The high resistivity as the permeable beds in the shown only in the surface layer.

The permeable bed-aquicluce equivalent layer is distributed in the surface layer and shows 3 to 7 Ω-m. The thickness varies from place to place. The permeable bed equivalent layer shows 7 to 10 Ω-m. The thickness varies with the location. This layer is mixed in the aquiclude equivalent layer or the impermeable bed equivalent layer partly in the lens form.

② The impermeable bed shows 0.1 to 1.0 Ω-m and is distributed in deep portions of this area and slightly rolling.

③ The altitude of the upper surface of the impermeable bed which slows low resistivity is in the condition of ridges extending in the northeast-southwest direction through nearly the center of the area surveyed. The altitude is lowered toward the northwest and the southeast. (Refer to Fig. 4.9.3.6.)

④ The permeable bed-aquiclude equivalent layer is thick except points 6, 7 and 10.

The ground water in this area is stored in the permeable bed-aquiclude equivalent layer, but since the layer consists of sand with clay mixed, or sand and clay alternates, the water quantity is not adequate. The ground water is stored also in the sand and gravel layers mixed in the impermeable bed.

The ground water in this area in artesian wter except in the surface layer.

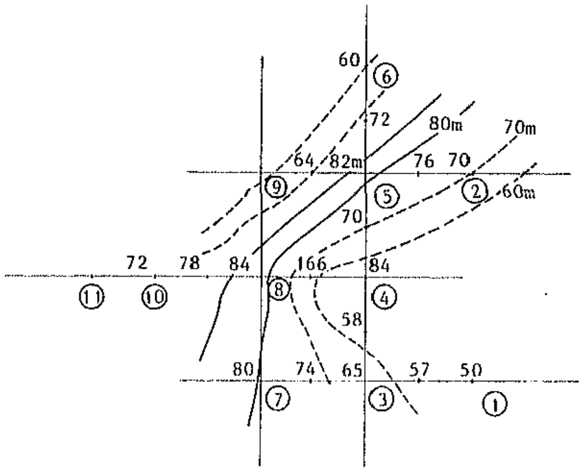


Fig. 4.9.3.6 Ground Level of Surface of Impermeable Bed

The aquifers in the planned area for wells consist of alluvium and diluvium and the Irrawaddy formations. As far as seen in the existing well logs, much fine particles (clay) are contained, and the portion consisting mainly of clay with sand layers or clay and sand alternates corresonds to the aquifer.

The coefficient of permeability calculated from the existing well logs is shown in Table 4.9.3.1.

Table 4.9.3.1 Coefficient of Permeability in Taungdwingyi

Well No.	Aquifer m (cm)	Drawdown S_1-S_2(cm)	Discharge Q (m^3/sec)	Diameter r (cm)	Permeability k (cm/sec)
No. 1	1,200	(2,105)	10,000	15.24	5.44×10^{-3}
No. 3	610	2,135	5,625	15.24	6.04×10^{-3}
No. 4	610	(2,000)	3,750	15.24	4.30×10^{-3}

The coefficient of permeability was calculated in accordance with Thiem's formula, on assumption of the influence area (R) of 500m.

The average value of the coefficient of permeability at the well site is $k = 5.2 \times 10^{-3}$ cm/sec. This value is high as compared with the sand layers of the tertiary period and is about five times in Japan ($k = 1.0 \times 10^{-3}$ cm/sec).

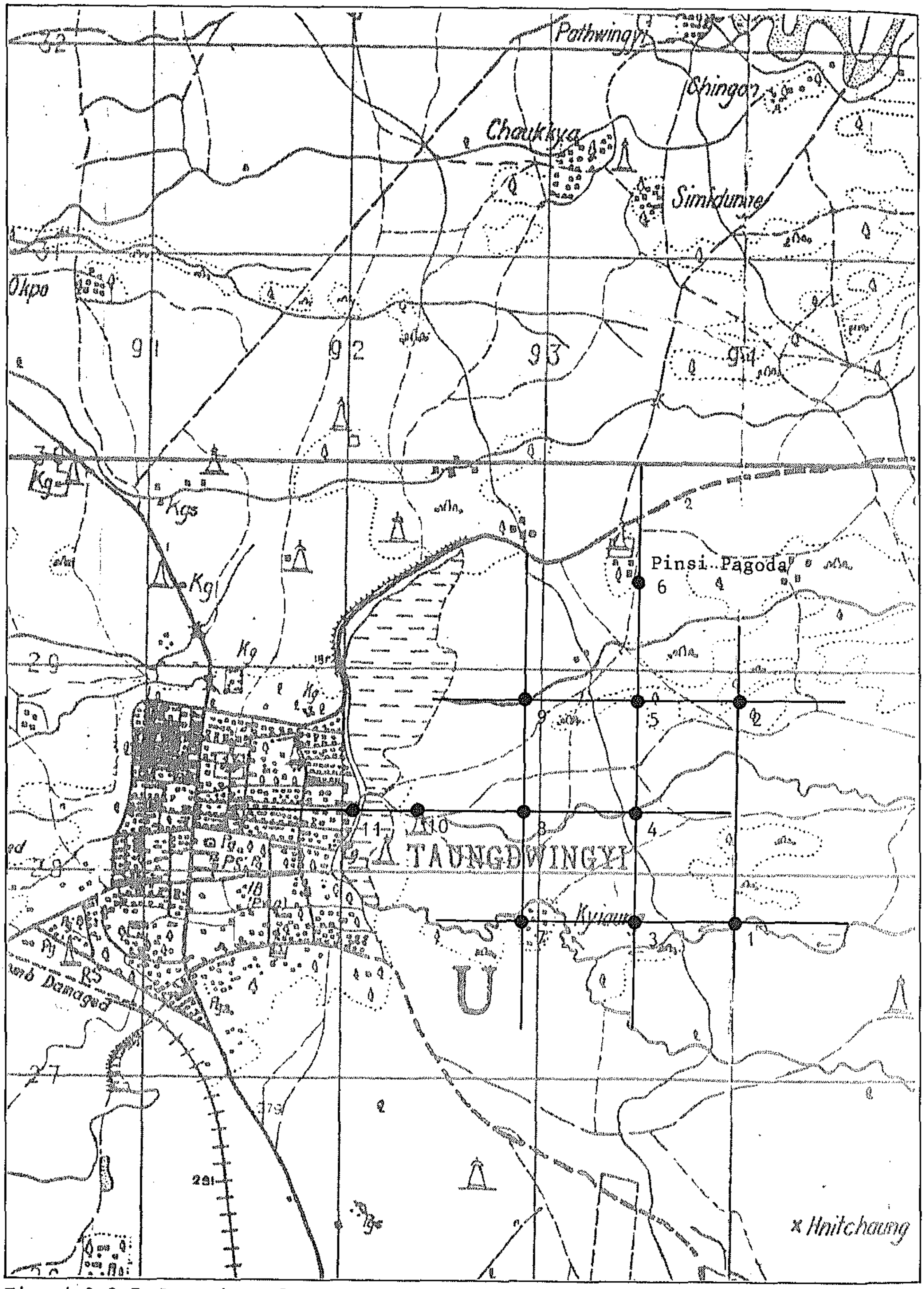


Fig. 4.9.3.7 Location of Geoelectric Prospecting Points Scale 1:25,000

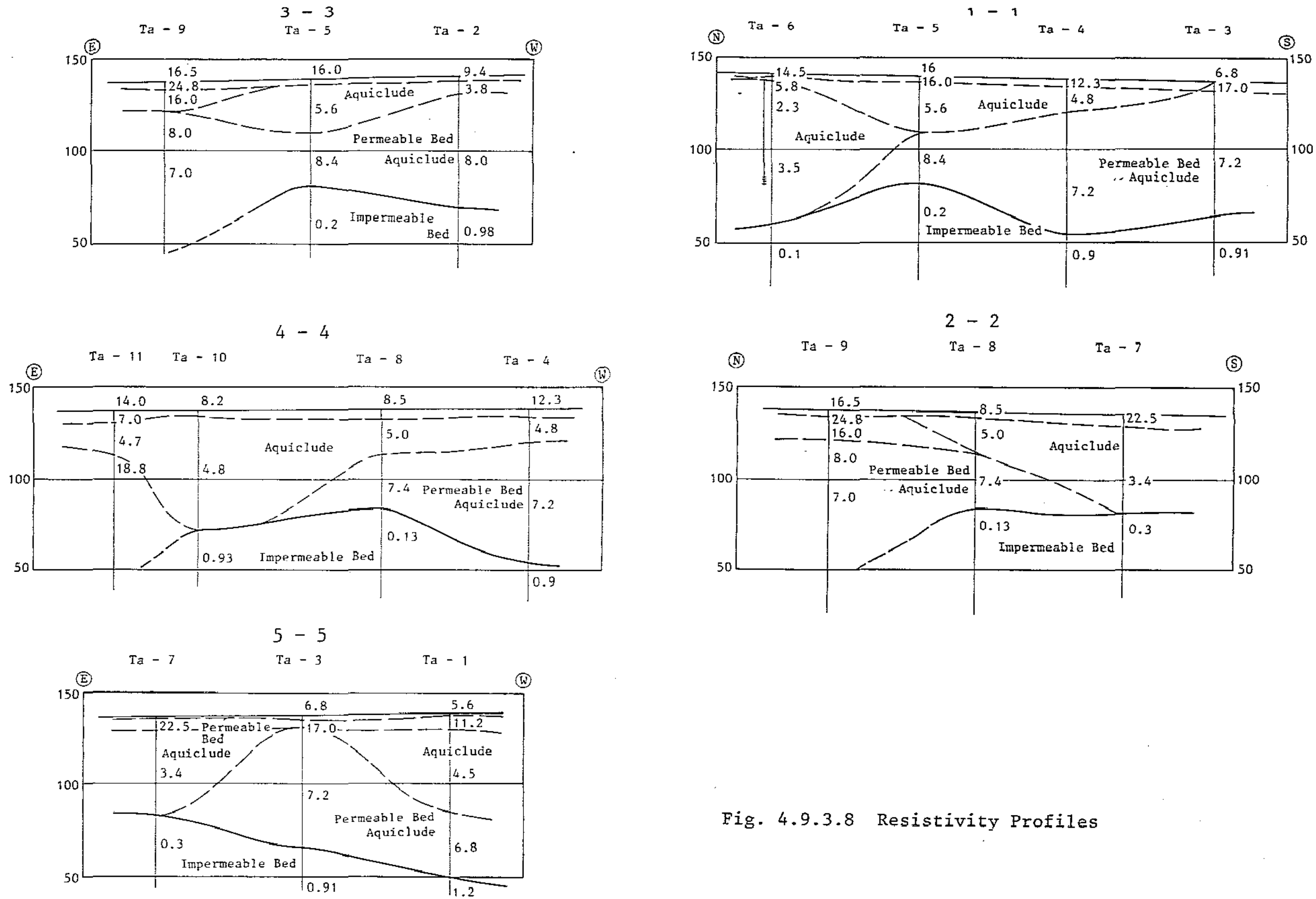


Fig. 4.9.3.8 Resistivity Profiles

3) Ground Water Storage and Water Quality

(1) Ground WAter Storage

The ground water storage is in the form of free and artesian water. At this point, the ground water supply will be calculated on the basis of free ground water.

The annual precipitation P and potential evapotranspiration E are as follows.

Precipitation P = 39.69 inch = 1,008.1 mm

Evapotranspiration E = Ep x 0.7

= 2,040.9 x 0.7

= 1,428.5 mm

(The value of evapotranspiration in Mandalay is used.)

Considering throughout the year, the ground water recharge G becomes as follows.

$$G = P - E$$
$$= 1,008.1 - 1,428.6$$
$$= 420.5 \text{ mm}$$

This measn that the evapotranspiration exceeds the precipitation and therefore, no ground water recharge takes place. Considering the rainy season only the same may be said.

However, in this area, the rainy season and the dry season are clearly discriminated and it will only be necessary this point, the ground water recharge during the rainy sseason (6 months from May to October) will be considered.

Precipitation P = 36.67 inch = 932.4 mm

Evapotranspiration E = 1,162.8 x 0.7

= 813.9 mm

Therefore, the ground water recharge during the rainy season is

$$G = P - E$$
$$= 931.4 - 813.9$$
$$= 117.5 \text{ mm}$$

The groundwater recharge area will be taken as the plain area of alluvium on the east side and the hills of the Irrawaddy formations, less the Pegu Yoma uplifts. This is about 35 km^2. Then, the total recharge is

$$G = 3.5 \times 10^7 \text{ m}^2 \times 0.117\text{m}$$
$$= 4.1 \times 10^6 \text{ m}^3$$

Some of this quantity will flow out to rivers and the net value will accordingly be smaller. However, it will stil be sufficient to make up for the annual pumping quantity $Q = 1.8 \times 10^6\ m^3$.

The ground water storage can be obtained from the value and porosity of aquifers as follows.

$$V = A \times S \times E$$

where A: subject area $5.0 \times 10^6\ m^2$

S: aquifer thickness 30m

E: porosity 10%

$$V = 1.5 \times 10^7\ m^3$$

This value ignores the ground water make-up and flow-out and shows the quantity stored in the present aquifer.

(2) Water Quality

Table 4.9.3.2 shows the results of on-side test and laboratory test of the ground water. This water satisfies the WHO and AWWA standards and is judged to present no problem as drinking water.

In the on-site test, EC is 1,200 to 1,500 μs/cm, pH is 8 and air temperature is 29°C. Dissolved salt concentration is slightly high.

The results of the laboratory test are shown in Table 5.9.3.2.

Table 5.9.3.2 Water Quality

Item \ Location		T.D.C	Pinsi Pagoda
1	Appearance	Clear	Clear
2	Total solids	820	640
3	Total hardness	110	136
4	Permanent hardness	4	6.0
5	Calcium hardness	50	40.0
6	Total iron	0.05	0.06
7	Chloride	4	8.0
8	pH	8	7.9
9	EC	1,500	1,000
10	Temperature	28	

4) Discharge rate per Well, Spacing between Wells, and Well Depth

(1) Discharge rate per Well

The discharge rate per well must be grasped by a pumping test. However, in accodance with Thiem's formula, the discharge rate per well will be estimated. The lowering of water level S is found as 11.78m by the following calculations for the spacing between wells 500m (influence radius 250m).

$$S = R/3000\sqrt{k}$$

where R is 300m and k is 3.5×10^{-4} m/sec.

The pumping quantity is

$$Q = \frac{2\pi Dk\ (H - h)}{2.3\ \log R/r}$$

$$= \frac{2\pi \times 30 \times 5 \times 10^{-5} \times 11.8}{2.3\ \log 250/0.10}$$

$$= 0.0142\ m^3/sec = 920\ m^3/18\ hr$$

Therefore, it is considered that in this area 700 m^3/18 hr can be secured.

(2) Spacing between Wells

Considering the ground formations, conditions of aquifers, and the discharge rate per well and the drawdown of the water level in accordance with the existing data, etc., the minimum spacing between wells will be taken as 500m.

(3) Well Depth

Regarding the well depth, considering the lower limit depth of storage of the aquifer of about 70m, the average depth of production well will be taken as 76m (6m for sand pit).

4.9.4 Planning The Water Supply System

1) Project Area

The dwelling area is divided into the northern part with old town areas and the southern part which is under development. The former has a high population density of 100 persons per ha and the latter has a low population density of 40 persons per ha.

The water supply with the existing facilities is limited to the northern part, and in the other areas, the dwellers rely on the private wells or on vendors by bullock-carts. Under the influence of the earthquakes in 1950, the existing pipes were destroyed to leak and cannot be repaired. It was decided to plan the new system over the entire town area as the project area.

2) Planned Water Supply Population

The present population is 38,563. The average population growth rate for the past 10 years is 1.6%. In determining the planned water supply population, the future growth ratio is adopted as 2.0% through consultation with TDC members.

The planned population y is given by

$$y = 38{,}563\ (1 + 0.02)^8$$
$$= 45{,}183$$

Thus, the planned population is taken as 45200.

3) Planned Water Supply Amount

Planned water supply amount

= Planned water supply x planned daily maximum supply per capita

= 45,200 persons x 105 ℓ pcd

= 4,746,000 ℓ/day

= 4,800 m^3/day

4) Division into Water Supply Blocks

Considering the railways, roads, creeks, and population distribution, the planned water supply area is divided into four water supply blocks. The planning specifications for each block are as follows:-

Table 4.9.4.1 Planning Specifications for Each Block

	Planned water supply population (number)	Water supply area* (ha)	Population density (person/ha)	Planned water supply amount (m^3/day)
A	27,500	149.2	184.0	2,890
B	7,200	101.4	71.0	760
C	8,000	188.8	42.4	840
D	2,500	18.6	134.4	260
Total	27,500	458.0	Ave.60.0	4,750

* *Agricultural lands are not included in the water supply area*

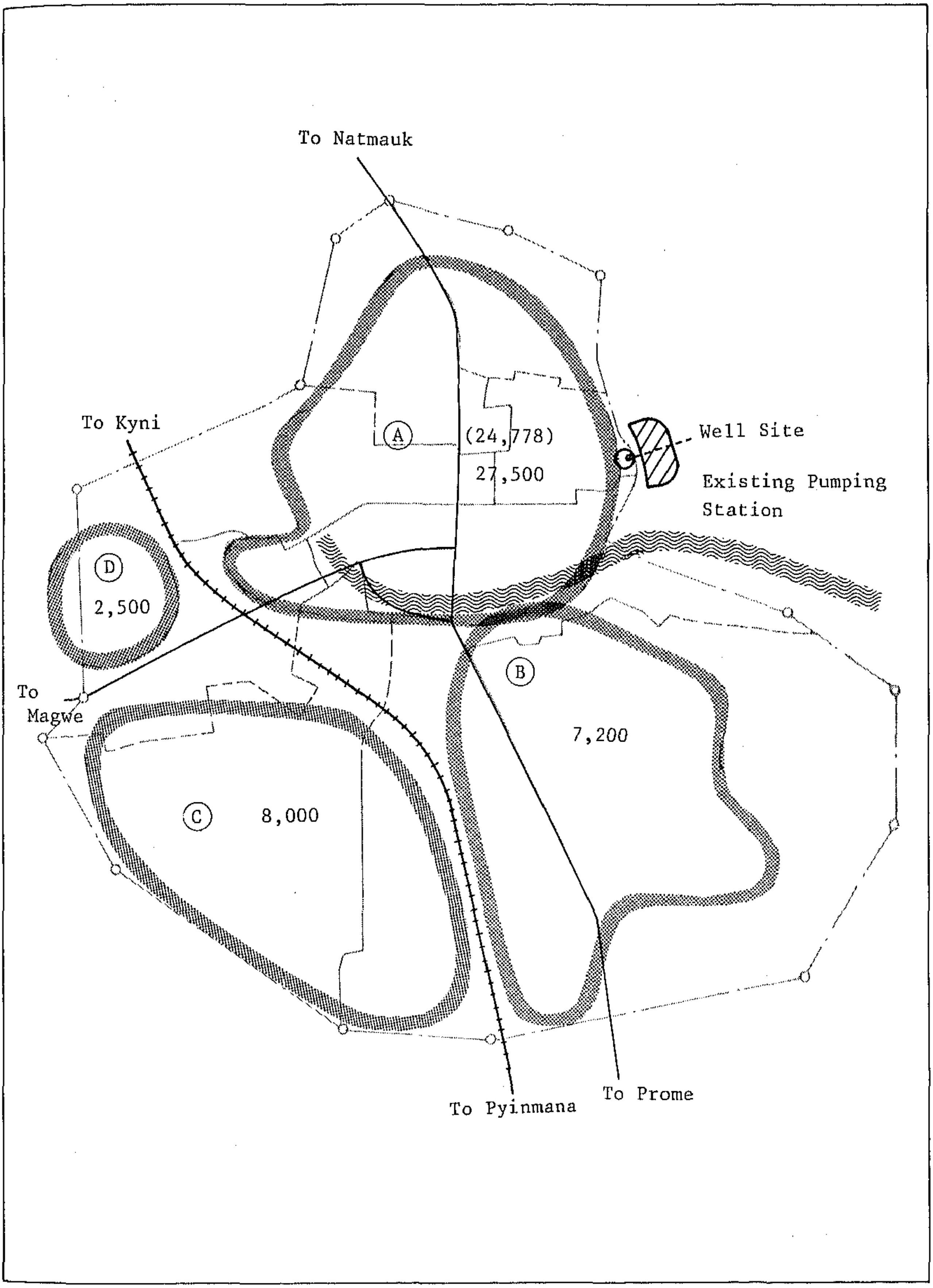


Fig. 4.9.4.1 Distribution of Design Population

5) Facility Planning

The existing water supply facilties are as described above. All the facilities except for deep wells and water supply pipings, have adequate capacities and are expected to be durable. The new system should make maximum use of these facilities. In the following a system flow chart for the new facilities is shown. (Refer to Fig. 4.9.4.2.)

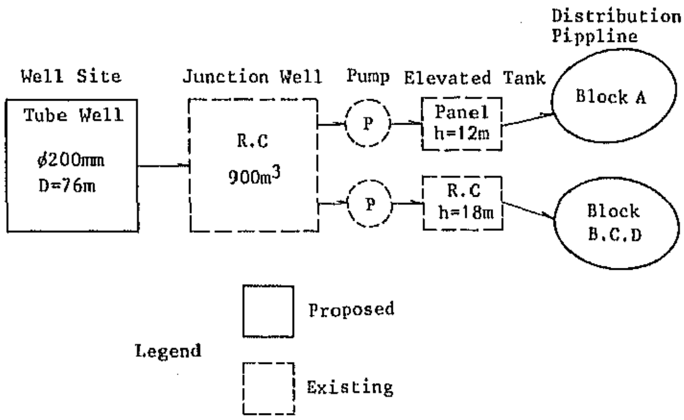


Fig. 4.9.4.2 System of Proposed Facilities

① Intake facility

The planning pumping quantity per well is 700 m^3/day, and the planning water supply amount per day is 4750 m^3/day. Therefore, the number of planned wells N is

$$N = 4750 \div 700$$
$$= 6.9$$

Therefore, the number of planned wells is taken as 7.

② Junction well

The required capacity of the incoming well is equal to 2 hours of the planned maximum water supply rate per day,

$$V = 4750 \div 24 \times 2$$
$$\fallingdotseq 400\ m^3$$

The existing facilities have 900 m^3 capacity which is sufficient.

③ Elevated tank

The existing elevated tanks are a panel tank having 90 m^3 capacity and a concrete tank having 55 m^3 capacity. These tanks have respective heights 12m and 18m, and it is difficult to integrate them into a single system.

Therefore, in the present plan, the higher tank is used for water distribution to blocks B, C and D, and the lower tank is used to block A.

The required capacity of the elevated tank is equal to 30 minutes of the maximum water supply per day. Then,

Panel tank $V = 2890 \div 24 \times 0.5$

$\fallingdotseq 60\ m^3 < 90\ m^3$

Concrete tank $V = (760 + 840 + 260) \div 24 \times 0.5$

$\fallingdotseq 39\ m^3 < 55\ m^3$

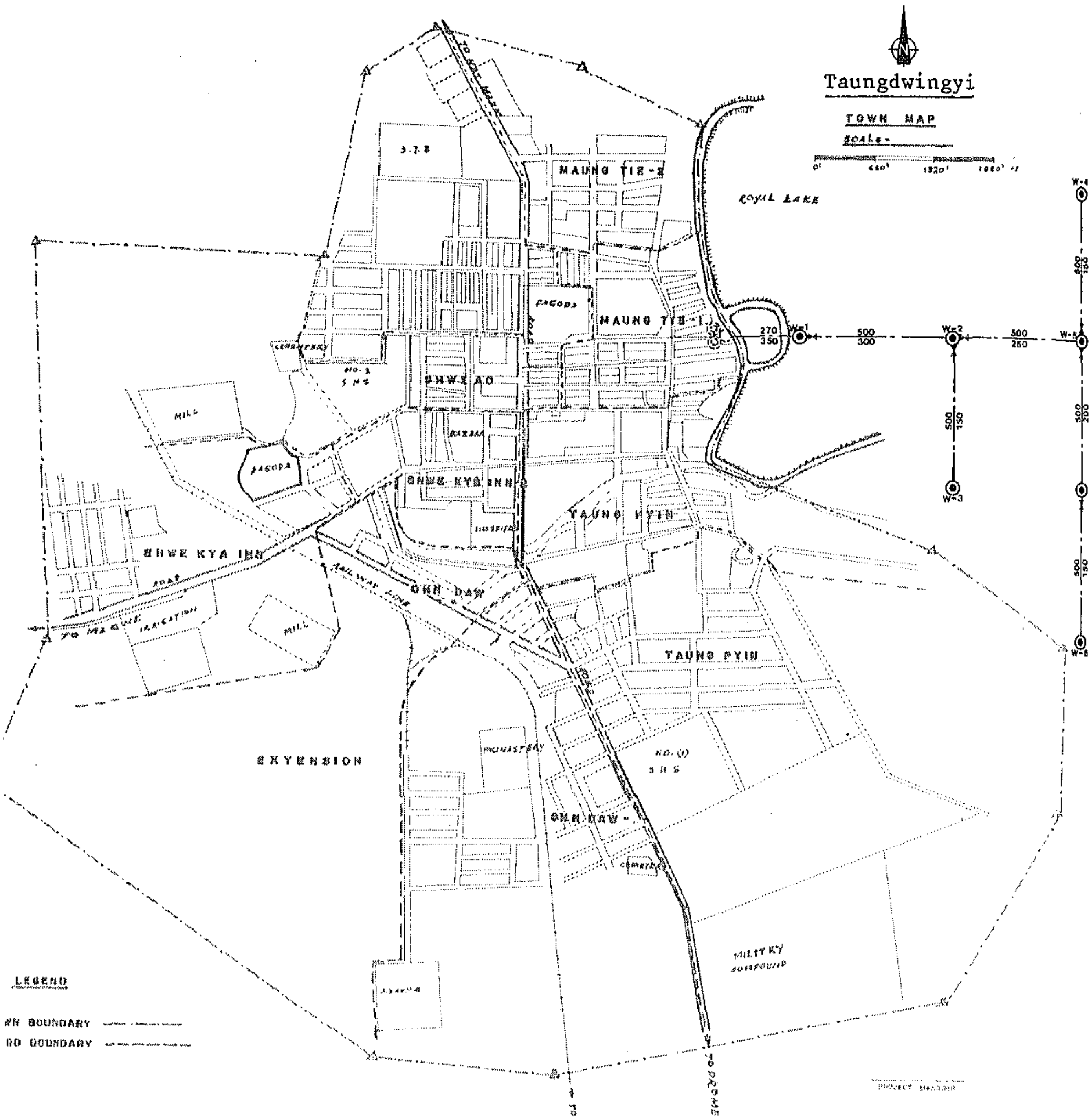
The existing elevated tanks have sufficient capacity.

(4) Water supply piping

The existing pipings leak badly. Therefore, entirely new pipings are planned. Fig. 4.9.4.3 and Table 4.9.4.2 show the layout, pipe diameter and total length of the planned pipings.

Table 4.9.4.2 List of Proposed Facilities

Facility	Item	Classification	No.	Remarks
Water intake facility	Production wells	Planned intake rate 700m^3/d ϕ200mm x H76m	7	Casing H = 56m Screen H = 20m
	Exploration wells	ϕ150mm x H90m	3	Casing H = 70m Screen H = 20m
	Observation wells	ϕ100mm x H76m	6	Casing H = 66m Screen H = 10m
	Intake pumps	ϕ80mmx0.648m^3/minx11kW	7	W-1 to W-7
	Pump rooms	Brick construction 4m x 4m Building area 16m^2	7	
Water transmission facility	Water transmission pipes	ϕ150mm to ϕ350mm T type ductile cast iton pipe class 3	3,270m	
		Various reducers	1 set	
	Sluice valves	ϕ150mm to ϕ350mm	6	
	Air valves	ϕ20mm to ϕ25mm	5	
Water distribution facility	Booster pumps	ϕ200mmx2440m^3/minx22kW	1	
	Distribution pipes	ϕ75mm to ϕ250mm T type ductile cast iron pipe class 3	20,230m	
		Various reducers	1 set	
	Sluice valves	ϕ75mm to ϕ25m	53	
	Air valves	ϕ20mm to ϕ25m	43	
Electric facility	Substation equipment	3ϕ4W 11kV/0.4 100 kVA	1 set	
	Transmission line	OW 22□ to 80□ CV 8□ x 4c	18.0 km	
		Accessories	1 set	



LEGEND

⊕ Ground Water Reservoir

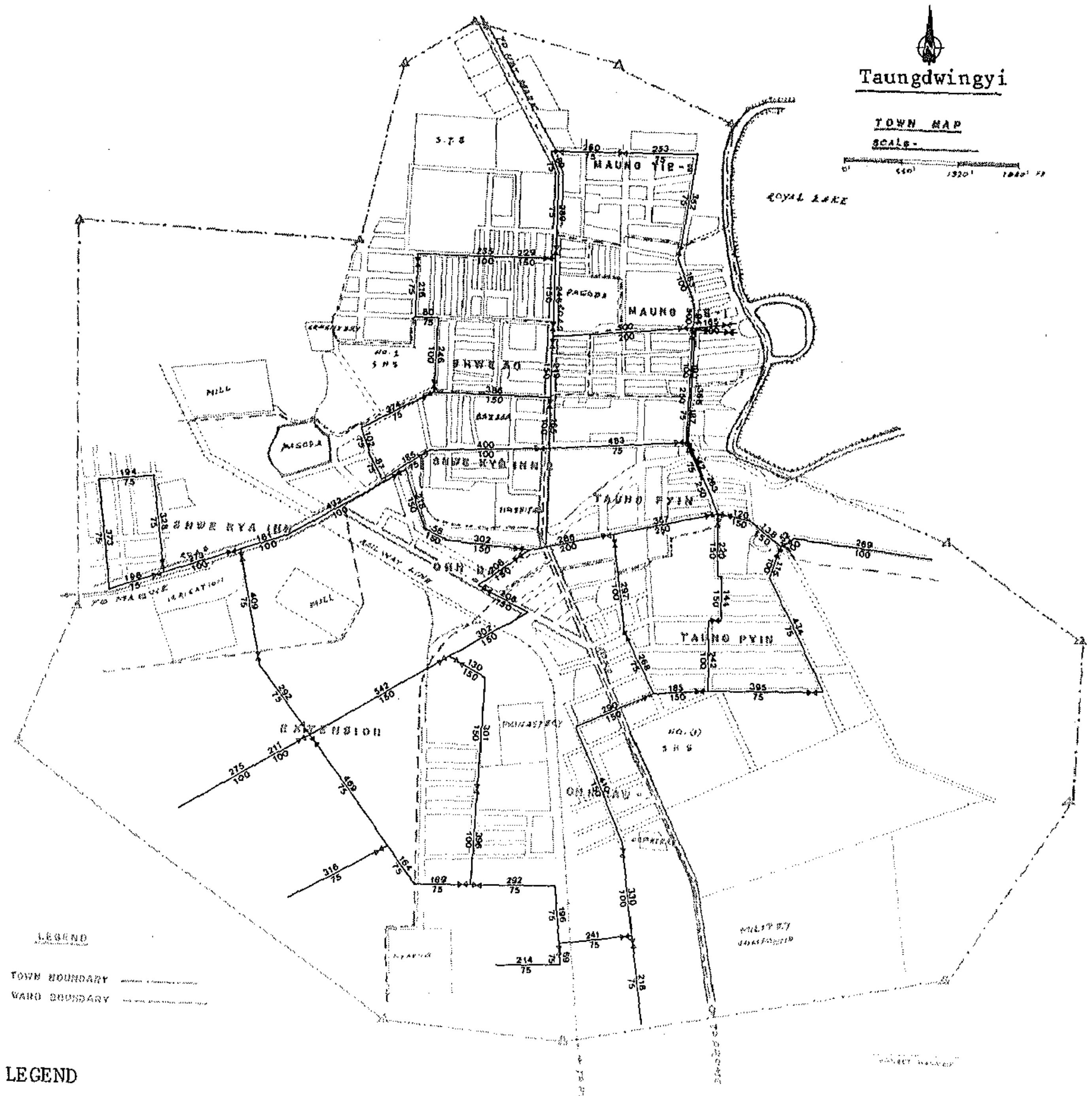
◎ Elevated Tank

⊙ Production Well

– – – Pipeline

—▷◁—Valve

Fig. 4.9.4.3 Layout of Transmission Pipeline



LEGEND

⊕ Ground Water Reservoir

◎ Elevated Tank

⊙ Production Well

--- Pipeline

—▷◁— Valve

Fig. 4.9.4.4 Network of Distribution Pipeline

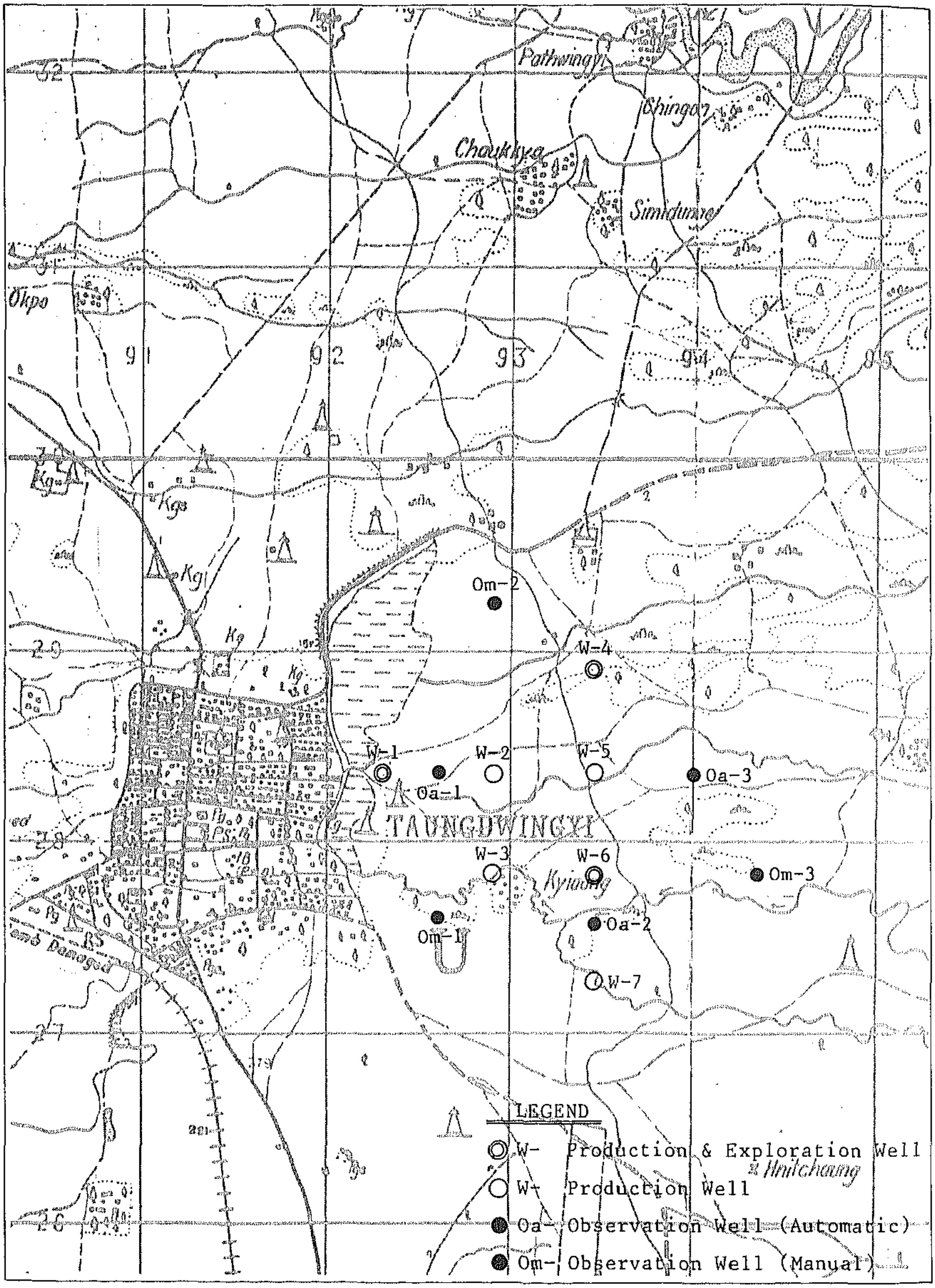


Fig. 4.9.4.5 Layout of Proposed Wells

4.10 Prome and Magwe

4.10 Prome and Magwe

4.10.1 Particulars of the Project

The Government of Japan, in 1981, offered grant aid to the Socialist Republic of the Union of Burma, for part of the equipment and materials necessary for the Project, regarding both towns, Prome and Magwe, in relation to the urban drinking water development programs now being promoted by Burma.

The General Affairs Department (GAD) of Burma is constructing the facilities with these equipment and materials with the aim of completing them in 1986. As of Number, 1984, the works are in progress almost as scheduled and already at the present, water supply has been started to part of planned water supply areas.

However, in Burma, cement for reinforced concrete as the main material for the distribution reservoirs is not satisfactorily available. Moreover, water distribution pipes cannot easily be imported. For these reasons, for the time being, it seems to be difficult to complete the works of all planned water supply areas.

Consequently, the Government of Burma requested the Government of Japan to offer additional equipment and materials, which cannot be produced in Burma, for completing the programs for both Prome and Magwe, on the occasion of calling equipment and materials grant aid for new eight towns.

4.10.2 Contents of the Project

Upon receipt of this call, JICA made an on-site survey in the basic design study and confirmed that the situations are as described in the above "Particulars". Therefore, for the purpose of completing this Project, JICA contemplated grant aid for the equipment and materials which are urgent and cannot be procured in Burma. The outlines of such project are as follows:-

1) Main distribution pipes of total length 33 km, and ancillary materials
2) Panel type elevated tanks
3) Panel type storage tanks

4.10.3 Effects of the Project, and Policies in Future

At the present, the works for almost all water intake facilities and part of water supply facilities are complete, and TDCs of both town have started to supply water to some areas through these facilities although in the direct supply system.

This start-up of water supply is very well accepted by the inhabitants in both towns. Especially, in Magwe, some people hearing this good news started to migrate from the surrounding areas. As a result, the population is increasing rapidly from 49,000 persons in 1981 beyong the planned target, now to exceed 61,000.

From these facts, it may be said that the impacts of this project on the local areas are beyond expectations, and their effects have been adequately demonstrated.

Moreover, it has been confirmed that the equipment and materials offered are being effectively utilized. The dwellers who have not yet received water supply are ardently waiting for earliest possible start of the service. From these facts, it is recommended that the additional equipment and materials should be offered as grant aid for the project.

SCHEDULE SHOWING WORK PROGRAMME AND PROGRESS

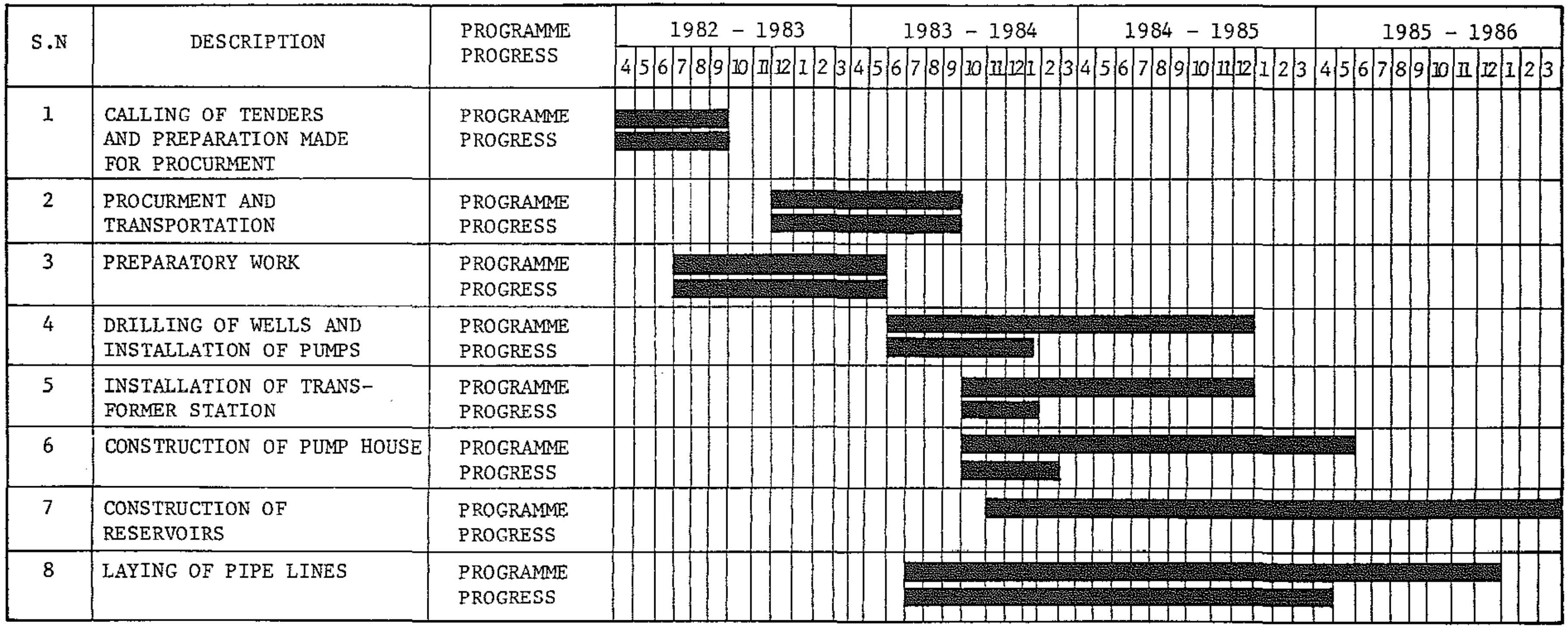
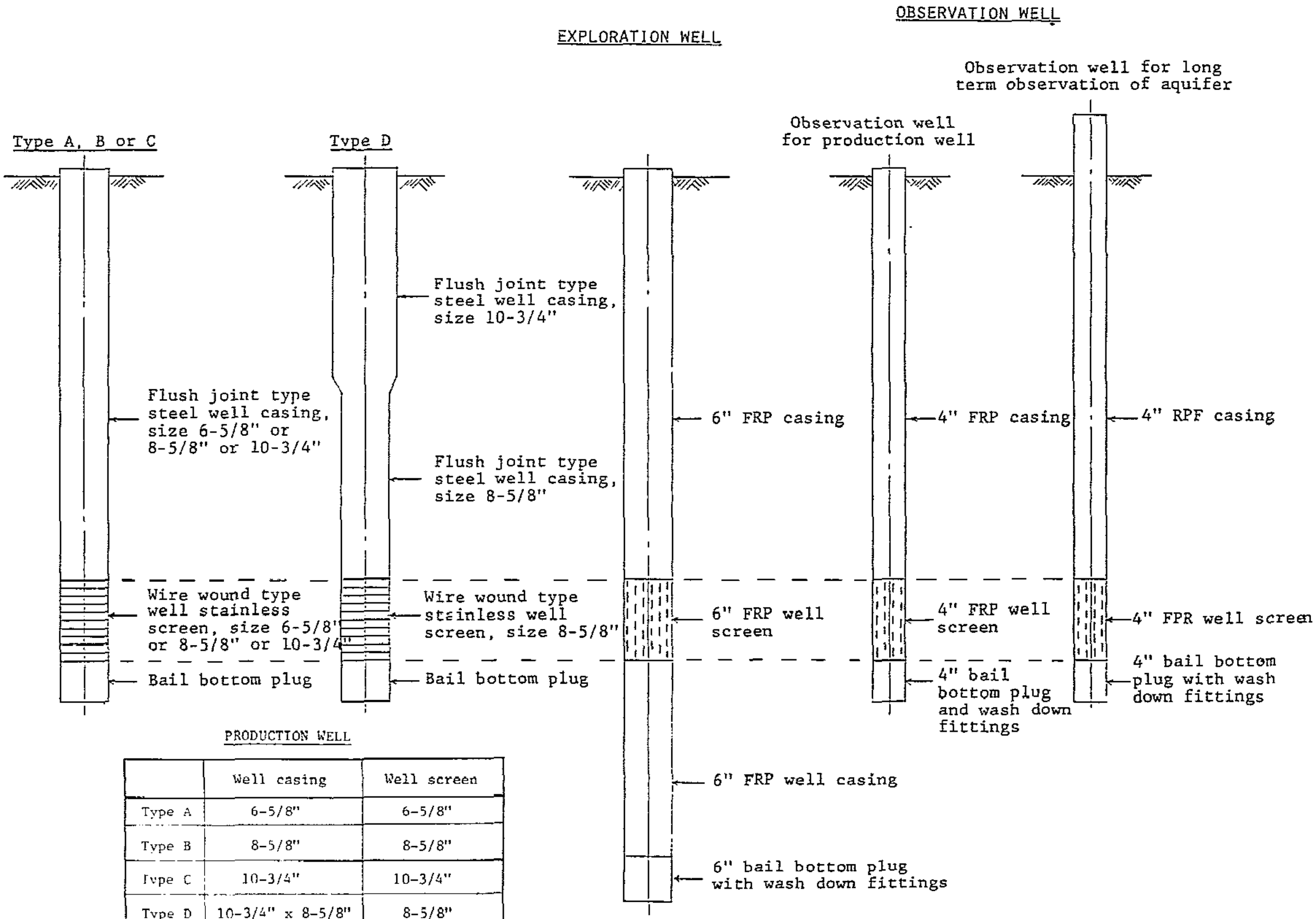


Table 4.10.3.1 Supplementary Equipment and Materials for Prome and Magwe Project

Town	Item	Classification	No.	Remarks
Prome	Ductile Cast Iron Pipes	ϕ100 mm	11,070 m	
		ϕ150 mm	22,780 m	
	Fittings for the above		1 off	
	Panel Tank	160 m^3	1 off	Ground Reservoir
		130 m^3	1 off	"
		25 m^3	1 off	Elevated Tank
		55 m^3	1 off	"
Magwe	Ductile Cast Iron Pipes	75 mm	2,500 m	
		ϕ100 mm	3,500 m	
		ϕ150 mm	5,000 m	
	Fittings for the above		1 off	
	Panel Tank	150 m^3	1 off	Ground Reservoir
		55 m^3	1 off	"
		35 m^3	1 off	Elevated Tank
		55 m^3	1 off	

4.11 Reference Drawings

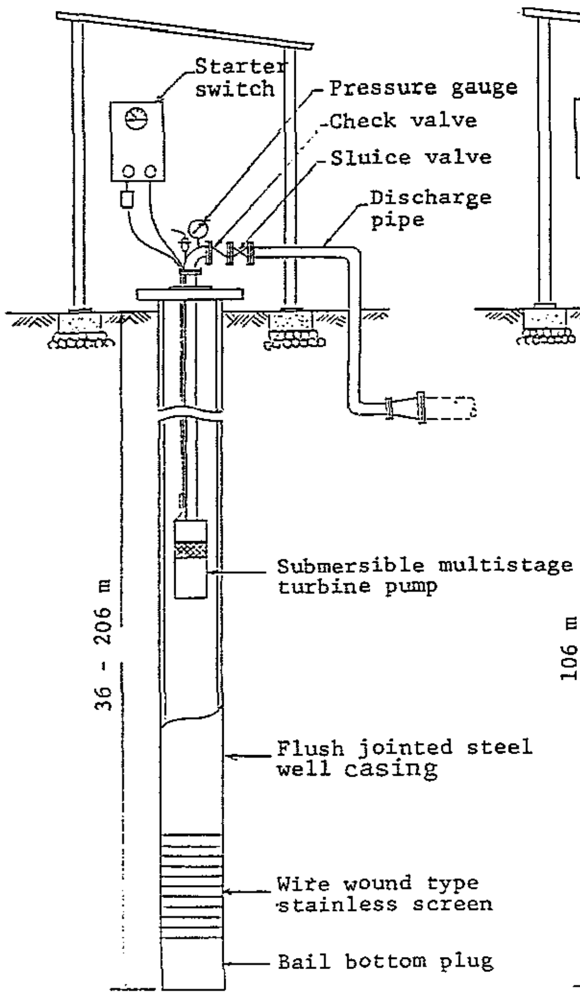


PRODUCTION WELL

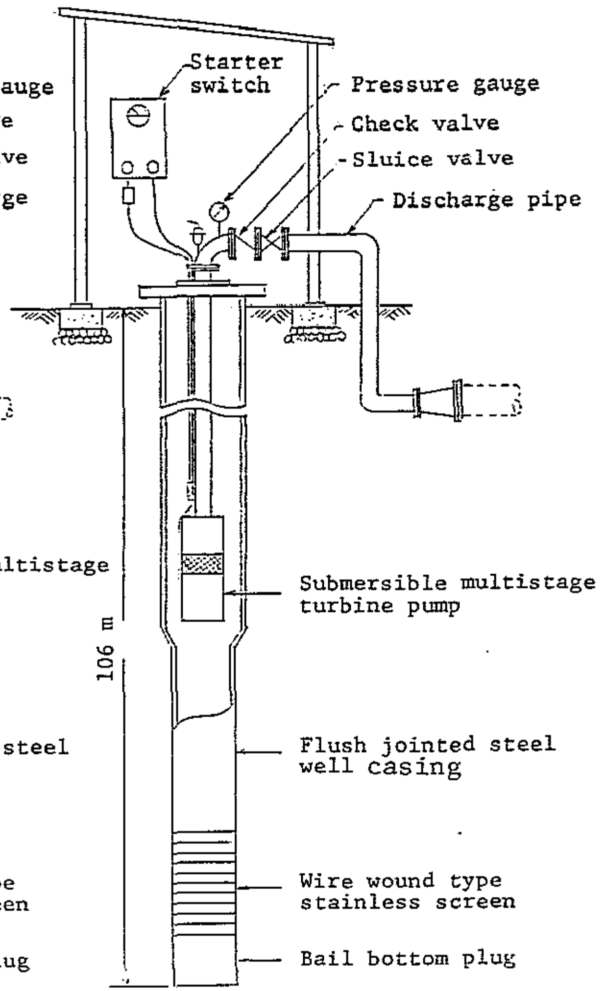
	Well casing	Well screen
Type A	6-5/8"	6-5/8"
Type B	8-5/8"	8-5/8"
Type C	10-3/4"	10-3/4"
Type D	10-3/4" x 8-5/8"	8-5/8"

PRODUCTION WELL

TYPE A, B & C
PRODUCTION WELL

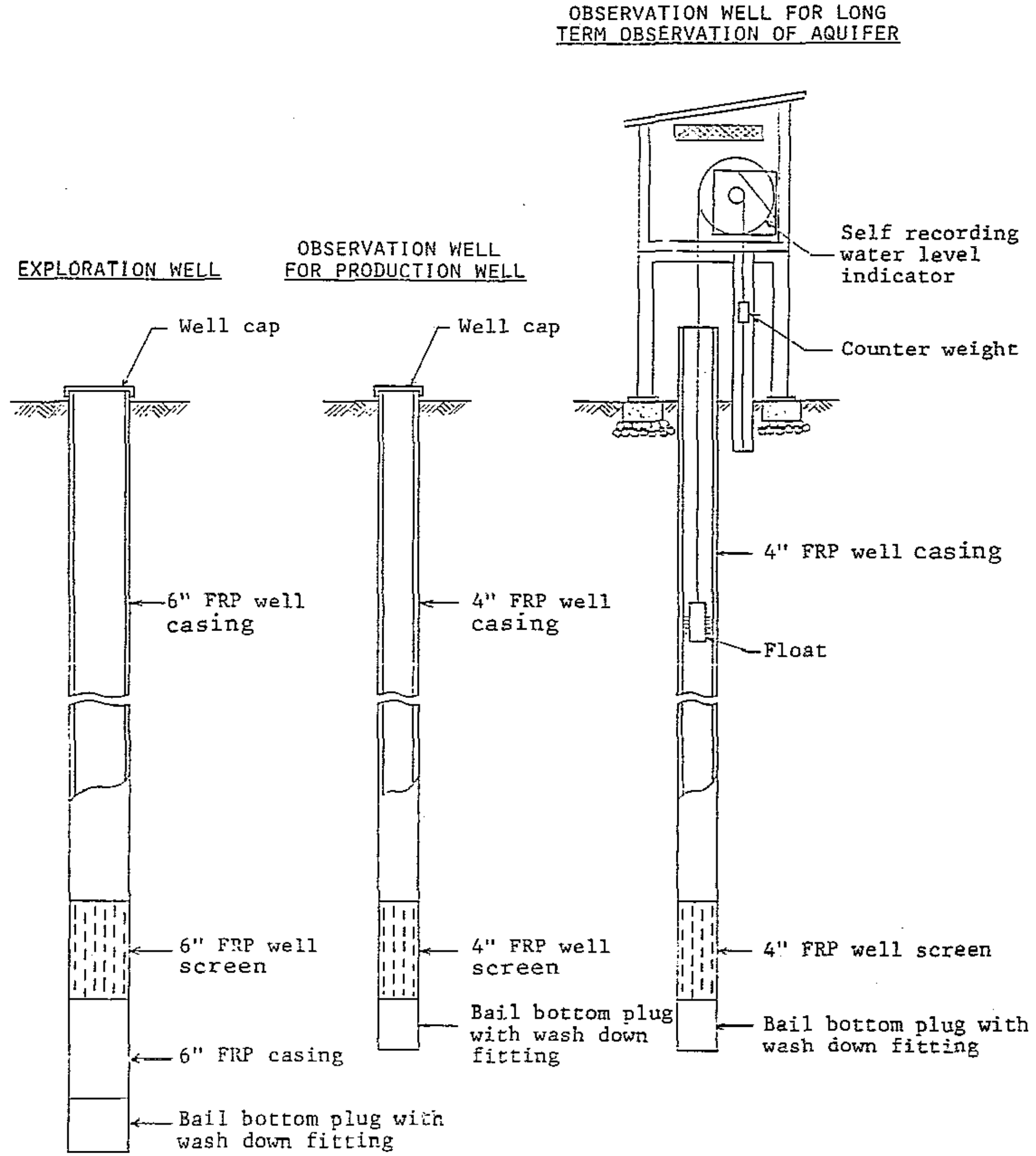


TYPE D
PRODUCTION WELL



	Name of Town	Well size	Depth	No. of well
TYPE A	PYINMANA	6-5/8"	76 m	10
	PYAWBWE	6-5/8"	46 m	15
TYPE B	THAZI	8-5/8"	36 m	5
	SHWEBO	8-5/8"	206 m	9
	TAUNGDWINGYI	8-5/8"	76 m	7
	YAMETHIN	8-5/8"	176 m	4
TYPE C	MONYWA	10-3/4"	56 m	9
TYPE D	PAKOKKU	10-3/4" x 8-5/8"	106 m	7

EXPLORATION AND OBSERVATION WELL



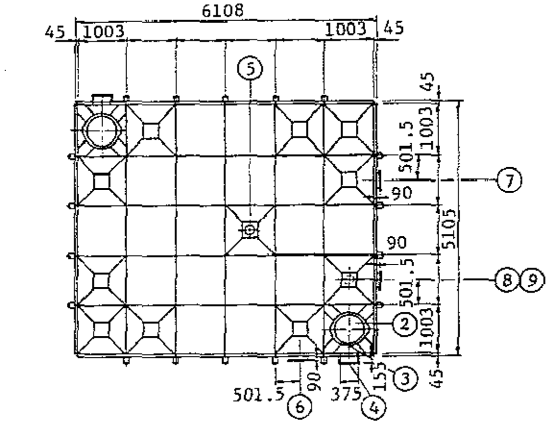
EXPLORATION WELL, SIZE 6"

Town	Depth	No. of well
PYINMANA	90 m	5
PYAWBWE	55 m	8
THAZI	40 m	2
SHWEBO	250 m	5
MONYWA	65 m	5
PAKOKKU	130 m	4
TAUNGDWINGYI	90 m	3
YAMETHIN	220 m	2

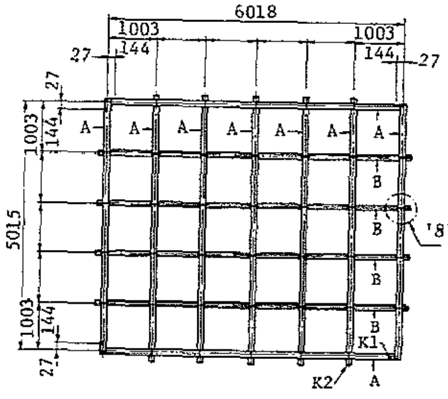
OBSERVATION WELL

Down	Depth	No. of well	
		for production well	for aquifer*
PYINMANA	76 m	4	4
PYAWBWE	46 m	5	4
THAZI	36 m	2	2
SHWEBO	206 m	4	3
MONYWA	56 m	4	4
PAKOKKU	106 m	3	3
TAUNGDWINGYI	76 m	3	3
YAMETHIN	176 m	3	1

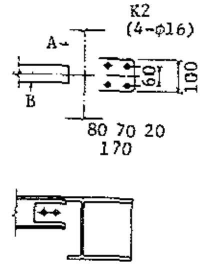
*Note: Self recording type water level indicator shall be installed.



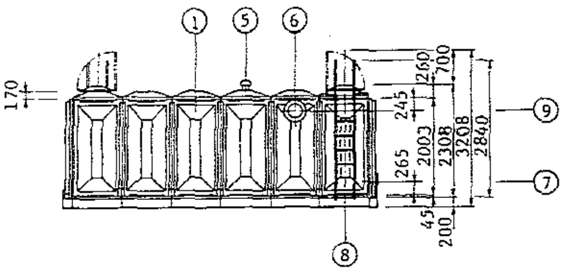
PLAN



STEEL SKID



DETAIL OF 'a'



FRONT VIEW

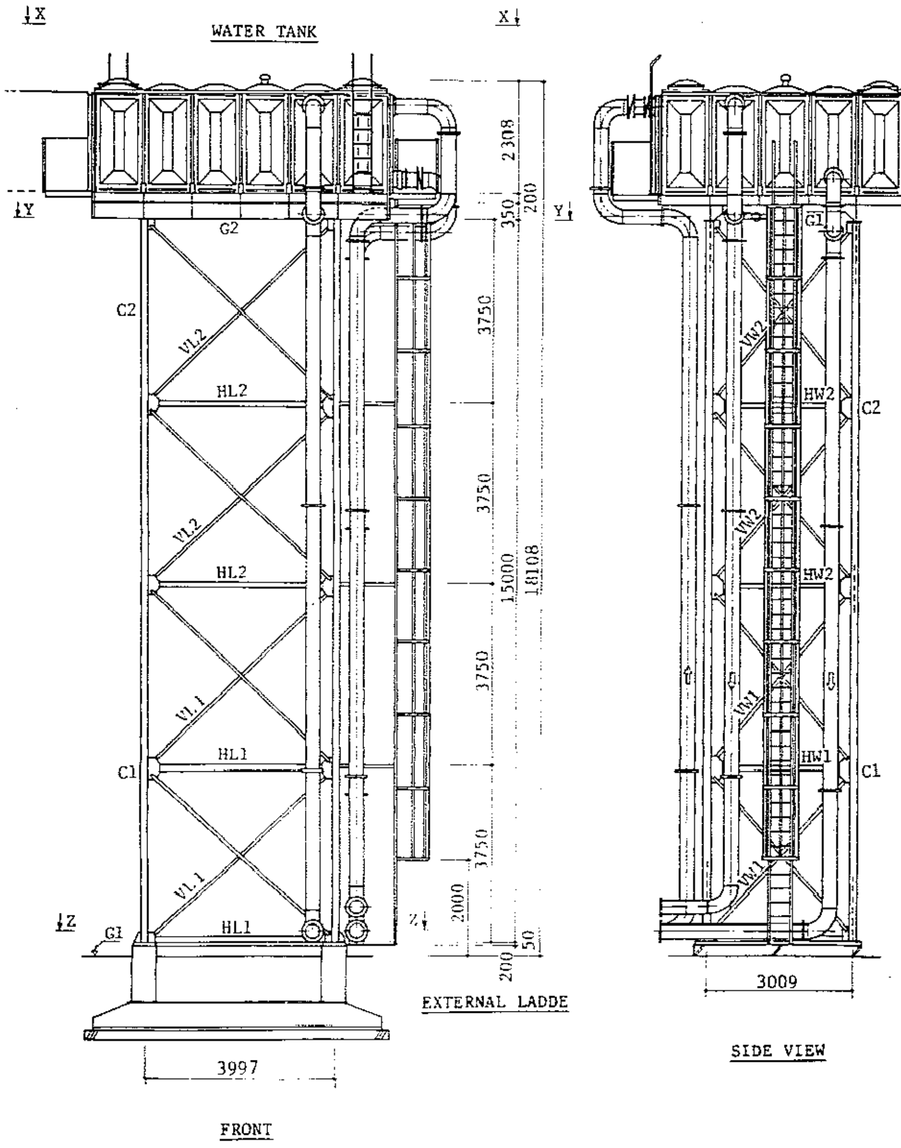
SYMBOL	DIMENSION
A	H-200 x 100 x 5^5 x 8
B	H - 100 x 50 x 5 x 7
K_1	8-φ14 ANCHORSET BOLT HOLES (+M12)
K_2	72-φ16 BLOCK SET BOLT HOLES (+M12)

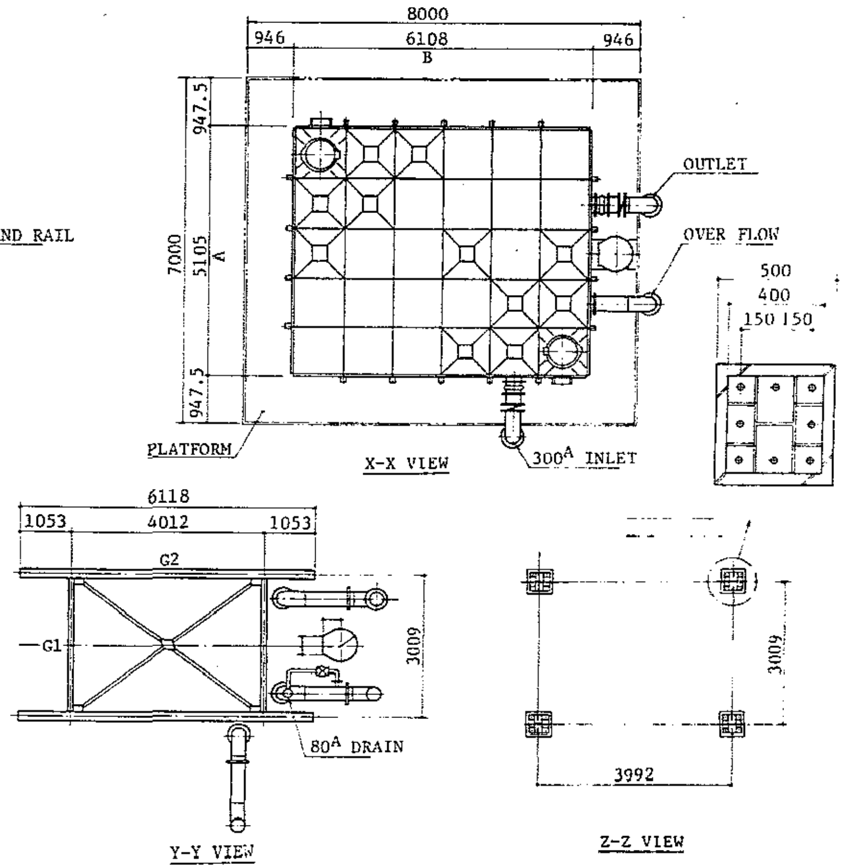
NC	NAME	MATERIAL	QTY	REMARKS
9	OVER FLOW 300A	GRF	1	JIS 10 Kgf/cm^2 FLANGE
8	DRAINAGE 75A	FC	1	"
7	OUTLET 300A	GRF	1	"
6	INLET 300A	GRF	1	JIS 10 Kgf/cm^2 FLANGE
5	AIR VENT 100A	PVC	1	
4	EXTERNAL LADDER	STEEL	2	W 375 x P 300
3	INTERNAL LADDER	PVC	2	W 300 x P 300
2	MANHOLE	GRF	2	φ600
1	WATER TANK	GRF	1	PANEL COLOR VORT

NOTE

1) BOTTON PANEL,

2) ROOF PANEL





SYMBOL	DIMENSION
G1	H-200 x 100 x 5^5 x 8
G2	H-550 x 175 x 7 x 11
d	L-50 x 50 x 6
C1	H-175 x 175 x 7^5 x 11
C2	H-150 x 150 x 7 x 10
VW1	L-75 x 75 x 6
VW2	L-65 x 65 x 6
VL1	L-65 x 65 x 6
VL2	L-50 x 50 x 6
HW1	L-100 x 100 x 7
HW2	L-90 x 90 x 7
HL1	L-150 x 150 x 9
HL2	L-100 x 100 x 7

CITE NAME	CAPACITY	SIZE	Q'TY	TOWER HIGHT	DIMENSION		
					A	B	C
PYINMANA	38.9 m^3	5.0 x 5.0 x 2.0	1	15 m	5105	5105	2048
	12.9	3.0 x 3.0 x 2.0	2	15	5099	5099	2048
	12.9	3.0 x 3.0 x 2.0	1	15	5099	5099	2048
PYAWAVE	25.2	4.0 x 4.0 x 2.0	1	15	4102	4102	2048
	32.6	4.0 x 5.0 x 2.0	1	15	4122	5105	2048
THAZI	30.4	4.0 x 5.0 x 2.0	1	15	4102	5105	2048
SHWEBO	41.8	5.0 x 5.0 x 2.0	1	15	5105	5105	2048
	41.5	5.0 x 5.0 x 2.0	1	15	5105	5105	2048
	43.0	5.0 x 5.0 x 2.0	1	15	5105	5105	2048
MONYWA	30.8	4.0 x 5.0 x 2.0	1	15	4102	5105	2048
	50.5	5.0 x 6.0 x 2.0	1	15	5105	6108	2048

CHAPTER 5

IMPLEMENTATION OF WORKS

5.1 Implementation of Working

5.1.1 Process for Implementation

In this project, on condition that the supply of materials and equipment under the grant aid of the Japanese Government shall be based on the detailed design for water supply system, the more certain cost estimate and the preparations of tender document shall procede to the material supply to each town.

The processes is divided into two stages

The first stage is:

① to supply the additional materials which were not included in the previous execution in the field work in Magwe and Prome,

② to supply materials necessary for study in order to start actual detailed design for each town,

* to supply spare parts and tools for four (4) drilling rigs which have been presented previous for Magwe and Prome project.
* to drill the exploration wells in each of nine towns in this project, in order to get more certain information of water wells to be drilled.
* to have land survey and study of soil conditions around the areas where the water supply facility are to be constructed.
* to include micro-computer systems to be used in the detailed design works.

③ to supply materials and equipment to the town in the project where the detailed design is not necessary in order to construct the facility.

④ to supply new well drilling rigs in order to carry out the implementation of the construction work in nine towns.

⑤ to carry out the detailed design.

The second stage is:

Other than various items in the first stage, the arrangement of change and supplement of materials and parts which may happen to appear after the completion of practical detailed design, on the way of the practical construction work in the field.

5.1.2 Detailed Design

It is necessary to arrange an adequate and rational planning and design in order to execute the implementation of this project more efficiently and effectively.

G.A.D is in charge of the Urban Water Supply Project in the whole country through of Development Committees for all cities and town. However, G.A.D has no technical staffs at the Head Office, and project teams were organized to execute the implementation works for Prome and Magwe at the initial stage of the project (1982). The Project team for each town was composed of technical staffs and engineers who were belonged to R.C.D.C under the jurisdiction of G.A.D, and members of the project team were in charge of the practical works in each town project. Under the jurisdiction of G.A.D, there are two of the City Development Committees (Rangoon and Mandalay) and more than 200 of Township Development Committees, each of which has some of necessary technical staffs: engineers, technicians, hydrogeologists, etc. The total number of these staffs seems short and insufficient to organize the new project terms for the nine towns in this project implementation.

Some of the technical staff of these Development Committees have experiences obtained from international courses or on-the-job training, but they do not seem to be sufficient to carry out the implementation of this big project. The staffs be so qualified as to implementation works totally from the technical speciality point of view, from the starting stage, that is i.e. including arrangement of all materials, that is equipment and labor necessary for initiation of the project and of complicated total scheduling for smooth project implementation.

In consideration of the special feature of the new project for nine towns, it is necessary to complete all construction works efficiently and effectively in a short time schedule in each town simultaneously. G.A.D is strongly requested to seek the cooperation of Japanese consultants for detailed design and for the dispatch of a long-term specialists as supervising adviser.

Previously in the project of Prome and Magwe, all construction works of water supply system and facility were implemented under the responsibility of the Burmese side from the initial stage of detailed design to finalization of the construction of the whole facilities. Recently, the works have been completed partially and water can be supplied in some areas. However, frankly, the detailed design for Prome and Magwe seems almost similar to the basic design. At least, it is different from the detailed design explained in this report.

Consequently, the scheduling of the new project for implementation including the studies for detailed design in the initial stage and following construction works of all facilities for water supply to the nine towns is to be prepared under the condition that the detailed design of this project shall be carried out with Japanese consultants.

Working items necessary for detailed design are pointed out as follows:

1) Survey

(1) Ground Water Survey

Test drillings at two or three sites for each town are to be implemented to confirm the feasibility of ground water intake by deep-wells. Following characteristics of the aquifer are requested to be verified.

* Geological layer condition (electric and density well logging)
* Yields of groundwater
* Water quality

(2) Topographical Survey

* Topographical survey by traverse and level are to be implemented to make a place (scale 1/5000) with 0.5 m of contour on plain areas or 1.0 m contour on hilly areas.
* Detailed survey on the projected site(s) of ground reservoir. Scale 1:200.

(3) Soil Test

Standard penetration testsa of the projected sites of ground reservoir and/or elevated tank.

* Soil strength of reaction
* Type of foundation

(4) Survey for river and railroad crossing

2) Detail Design of Facilities

(1) Intake

* Type of well

  Diameter, Depth of well, Position of strainer, Gravel wall, Pump etc.

* Structure of well

(2) Transmissions

* Design of transmission line
* Structure design of crossings over river, railroad and others
* Protection of bend and water hammer
* Drawings

(3) Strage

* Design criteria

  load, strength of materials, soil condition etc.

* Selection of foundations
* Analysis of structure stability
* Structural analysis
* Temporary and subsidiary construction works
* Drawings

  general view, structural view, bar arrangement, pipe layout, others if necessary

(4) Distribution

* Network analysis
* Other designing jobs required in transmission.

(5) Electric facilities

* Receiving plan
* Receiving facilities
* Transmission facilities
* Distribution facilities

3) Preparation of specification for marerials and equipment.

4) Accounting of materials and equipment.

5) Cost estimates

(1) Mateirals

(2) Equipment

(3) Labor

(4) Others

6) Implementation Plan

* Procedure of construction
* Management of construction
* Construction schedule

7) Operation and Maintenance

(1) Estimate of operation and maintenance costs

(2) Organization of operation and maintenance

* Maintenance and operation flow chart
* Record format of operation
* Record format of well operation

5.1.3 Implementation Schedule

In accordance with the aforementioned method for implementation of the works, a staged construction schedule is shown in tables 5.1.3.1 and 5.1.3.2.

The first stage involves preparations by the Burmese Government; i.e. preparation of tender documents is expected 3 months after the exchange of the E/N, and a month later signing of the contract should take place. Allowing a 3 month period for manufacture of materials and equipment and for delivery, the starting data for actual works including preparatory works should be some 8 months after the Exchange of Notes.

The detailed design works will be carried out in progressive order from those towns where geological and topographical surveys have been completed, and the discharge rate per well has been grasped by the exploration wells. Also, the manufacture of new well driling rigs will take 6 months and delivery by sea and assemble on site a further 2.5 months, making a lapse of 8.5 months after the signing of contracts. This and the fact that the exploration wells selected for the actual scheme might prove unuitable, has led to the use in the proposed drilling works of the 4 drilling machines presented for the Prome and Magwe Project.

Also construction works in regard to the town where detailed design works seem very little it is expected that these will be completed within a month. Furthermore in consideration of climatic factors concerning construction, and maintenance and repair, the period of 8 months should be flexible.

Concerning the second stage, a 3-year period, commencing after the Exchange of Notes has been alloted for completion of the construction works.

Table 5.1.3.1 1st Stage Work Schedule

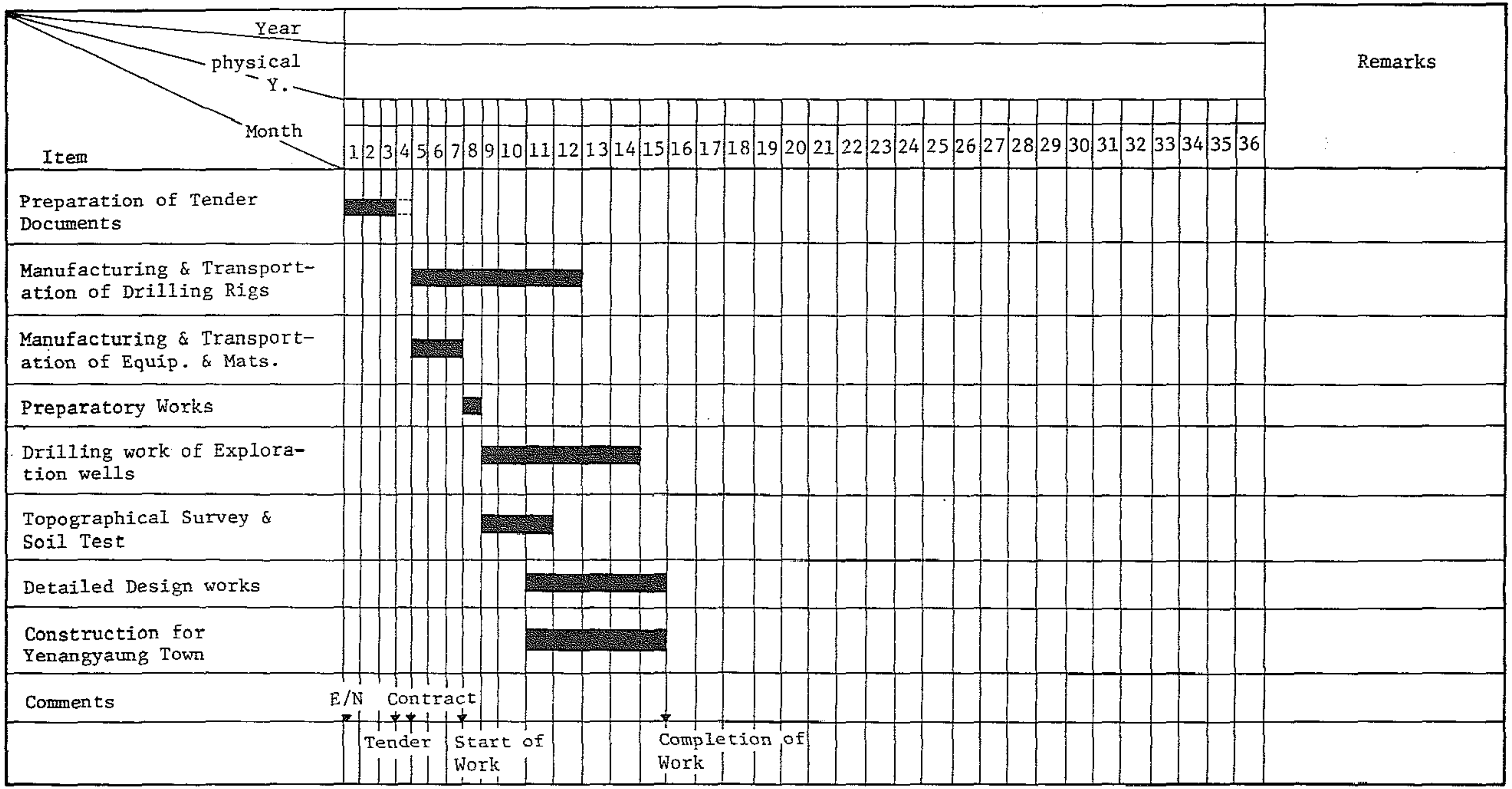
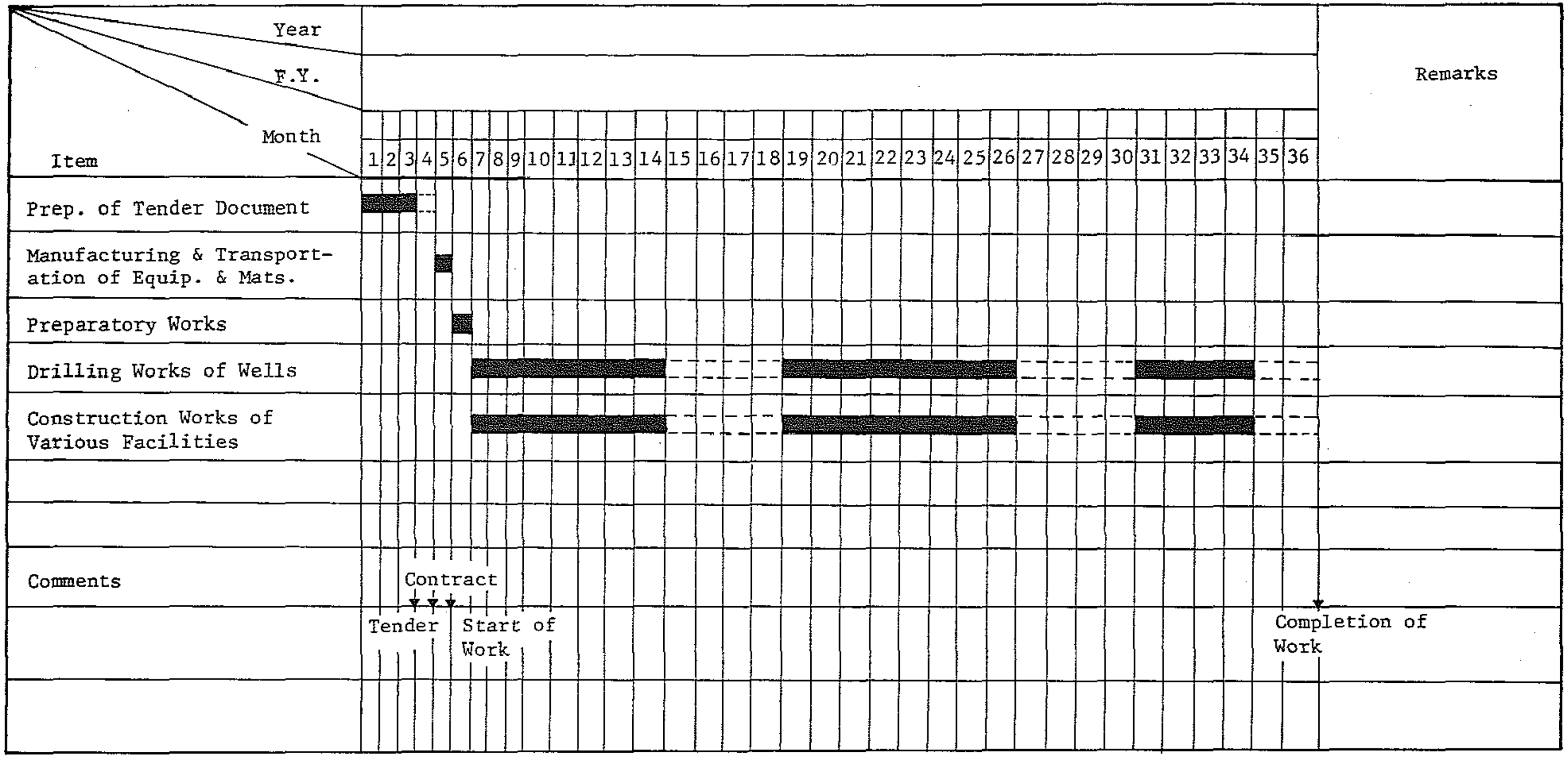
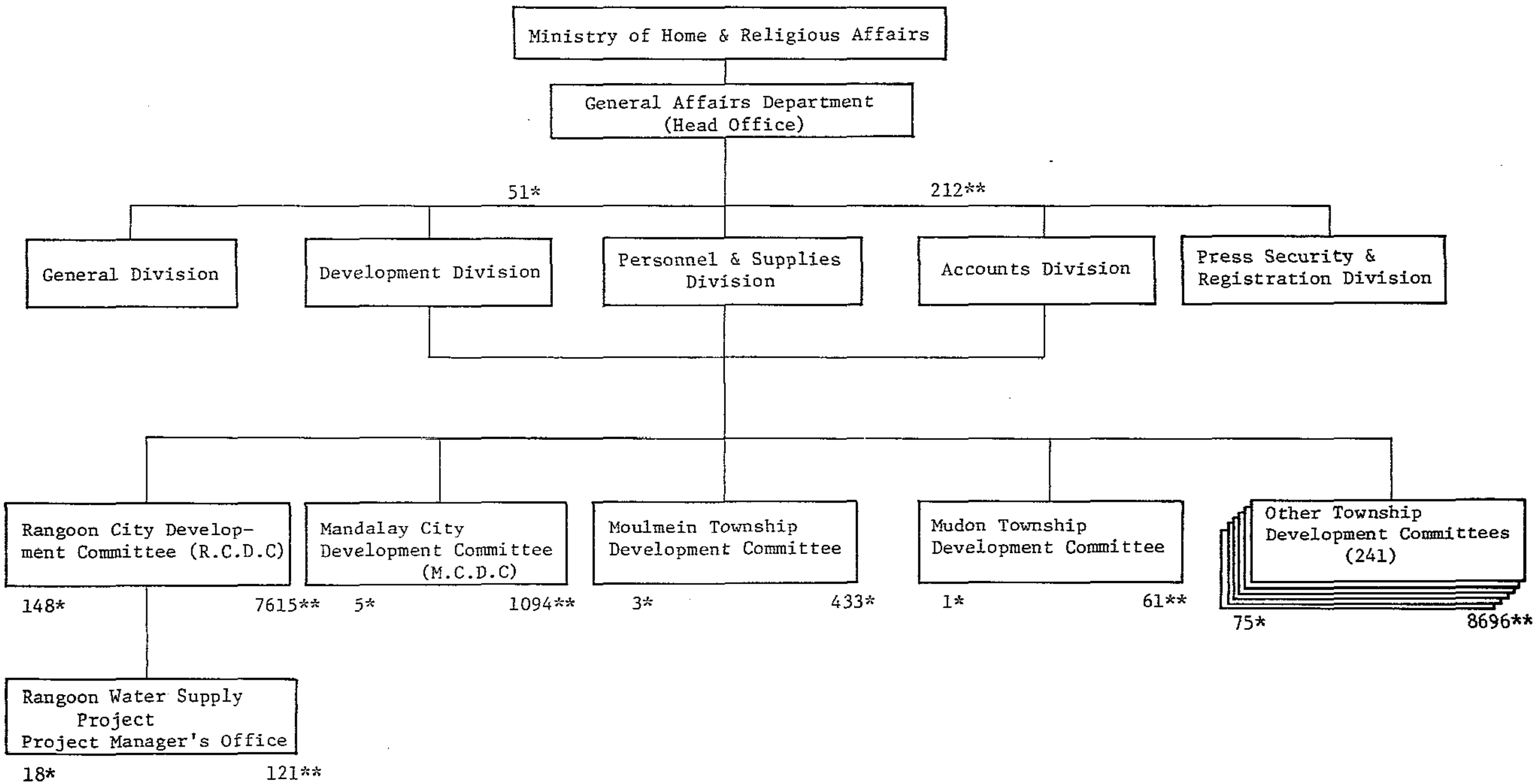


Table 5.1.3.2 2nd Stage Work Schedule





Note * Officers
** Other Ranks

Source: General Affairs Department

Fig. 5.1.3.1 Organizational Chart of GAD

5.1.4 Organization for Implementation

Just like the previous case of Prome and Magwe Project, a Project Technical Advisory Committee, a Project Implementation & Coordinating Committee and a Project Steering Committee should be established. This project should be administrated and promoted by these Committees through the Project Management Offices for all towns.

As shown in the Organizational Chart, it will be preferable to have several Management Offices, each of which manages one group of towns (one to three towns in one group), because there are many towns scattered in a wider area of Central Burma in this project. It seems better to have one headquaters in one group and the implementation work for one group of towns should be covered and controlled by each Management Office. It is very important and better to complete the implementation of various works faster and on schedule efficiently, and it seems quite effective that the Japanese longterm experts should participate in this project from the initial stage.

The Organizational Chart for Implementation of the Project is shown in Fig. 5.1.4.1. In this organization, there are four Management Offices (in Pyawbwe, Taungdwingyi, Pakokku and Monywa) and these are controlled and supervised by a Project Manager in the Central Project Management Office under GAD. In each town, there is a Construction Office, however, if the town has a Management Office, the Construction Office is absorbed into the Management Office. The staff in each construction Office is principally composed of the member as shown below.

Chief Officer	1
Assistant Chief	1
Drilling crew	8 (1 or 2 groups)
Civil Engineers	5
Transportation	3
Labour	20

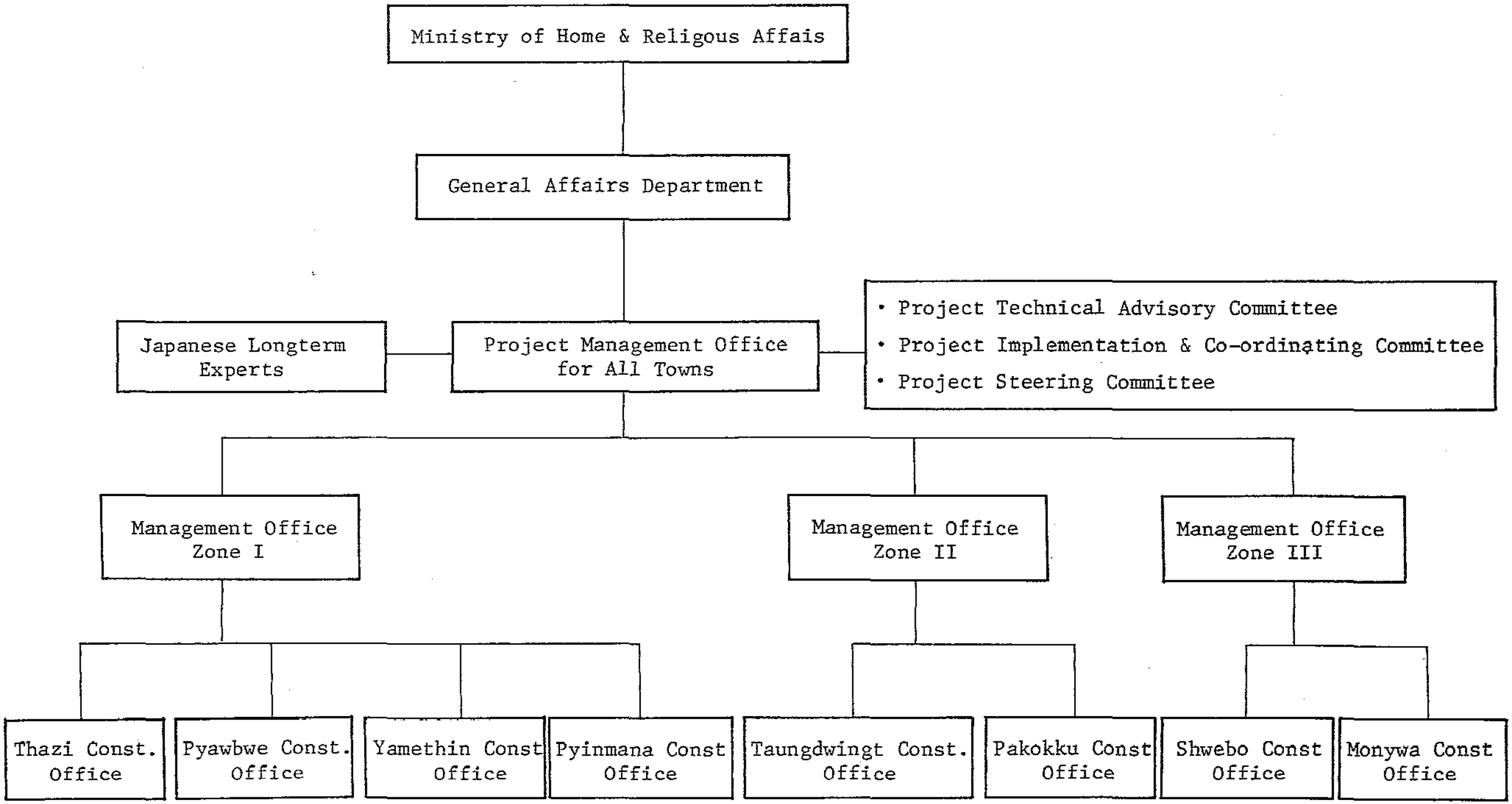


Fig. 5.2.4.1 Organizational Chart of Construction Work

5.2 Maintenance and Management System

Water supply systems are to be provided in each of nine towns of the Project inclusive of existing systems with facilities, and all of these systems and facilities should be maintained and managed adequately, in order that all people living in the towns will be able to enjoy the benefit of safe and good water consistently throughout the year for a long time.

5.2.1 Organization

A Township Development Committee is responsible for the maintenance and management of water supply system, so it is necessary to organize the management group of water supply system of each town as shown below in order to manage them adequately:-

1) To appoint a chief manager of Waterworks Management Organization who controls the management works for each township water supply totally.

2) Under the control of the chief manager of the Organization, one Technical Chief should be assigned as manager of the Technical Section for operation and maintenance. Under the Chief of Technical Section, a Head of Water Supply should be appointed, who will be in change of technical management for operation and maintenance in the range from main pipes of water supply to branched pipelines up to the end of the framework of water distribution including public stands for the use by people. Also another Head on Engineering Section should be appointed who will be in charge of principally any engineering works, especially to watch from the lines and facilties from water sources to water tanks and/or reservoirs.

Also one Section Chief and two Heads shall be appointed as shown in the Cahrt. The Office Work Section in relation to the operation and maintenance will be in charge of office works like accounting and general affairs, then a Head of Accounting and a Head of General Affairs should be appointed as Chief of the Office Works Section.

In consideration of the scale of each town and water supply capacity, the organization and composition of staffs, members of the Management Office should be arranged as shown in Table 5.2.1.1 for operation and maintenance for each Township Water Supply.

Table 5.2.1.1 Manpower Distribution

Work Position \ Town		Pyinmana (59,200)	Yamethin (25,300)	Pyawbwe (28,400)	Thazi (21,400)	Shwebo (57,800)	Monywa (128,000)	Pakokku (81,800)	Yenangyaung (81,200)	Taungdwingyi (45,200)	Total
Executive Officer		1	1	1	1	1	1	1	1	1	9
Secretary		1	1	1	1	1	1	1	1	1	9
Technical Head (Asis. Eng.)		1	1	1	1	1	1	1	1	1	9
Engineer (Sub Asis. Eng.)		2	2	2	2	2	2	2	2	2	18
Accounting & Casher		2	2	2	2	2	2	2	2	2	18
Water Service Section	Jr. Engineer	2	2	2	2	2	3	2	2	2	19
	Fitter	5	2	2	2	5	9	7	7	5	44
	Labour	5	2	2	2	5	9	7	7	5	44
Engineering Section	Jr. Engineer	1	1	1	1	1	2	1	1	1	10
	Fitter	6	3	3	3	6	11	8	8	6	54
	Labour	4	2	2	2	4	8	6	6	4	38
Total		30	19	19	19	30	49	38	38	30	272

( ): Design Population

5.2.2 Administration

Following three (3) are main technical points of the Management Works for water supply;

1) Management of facilities.
2) Management of water quality.
3) Management of sanitation

1) Management for facilities

It is important to keep facilities of water supply in a good condition to meet the demand sufficiently. Therefore it is important to keep and file drawings, technical documents, notes and records to water supply facilities, which are the information initially prepared before construction and/or anything prepared later referring to the operation and maintenance. These data are very important not only for daily maintenance and management, but also to cope with any accidents or emergency.

As the water sources of this project are principally deep-wells, it is quite important to measure every day discharge of water and the water levels in the well that the pump is in operation (dynamic level) and out of operation (static level), in order to secure the stable operation of the water well.

As almost all the pipelines and the framework of destribution pipelines are laid under the ground of town roads, there are some fears for destructin of underground pipes or loosen-out the pipe fittings depending upon the road or traffic condition. The water leakage is also caused by pipe or pipeline damage. These accidents should be discovered as early as possible for repair.

2) Management for water quality

By the use of water supply facility, it is the most important to be responsible for supplying sfe and sufficient water to people and management of water quality is the highest important factor of operation and maintenance of the water supply system and facility. If the groundwater is used the water quality is comparatively. However, it is better to examine the water quality periodically, in order to discover any charge or pollation as earlier as possible.

3) Management for sanitation

The most important objectives of public water supply is to supply safe, hygienic water sufficiently, and to contribute to the improvement of public sanitary condition and quality of life of the citizens. According to these objectives, the management of public sanitation is the most basic and important.

If adequate management and maintenance are neglected, the objectives of the water suplly facility cannot be accomplished. Because almost all water sources in the project are groundwater from deepwells, the chlorination equipment is not furnished normally, but the water can necessarily be sterilized by feeding bleaching powder or hypochorite if some infectious diseases happen to break out.

5.2.3 Operation and Maintenance Cost

Principally, the operation and maintenance cost of water supply facility should be covered by the income of water fee and water tax by each Township Development Committee. In order to execute the Water Rates System for the water supply works, it is necessary to estimate operation and maintenance cost of the water supply system, and on this basis, it is necessary to establish a water rates system, to determine the level of the water fee and water tax.

In each town of this project, rough estimates of the annual costs and expenses for operation and maintenance for one well and those for total of all wells developed in each town are shown in Table 5.2.3.2.

The operation and maintenance costs and expenses for water supply facilties are determined from total expenses for personnel, managers, chiefs and all technical and/or office personnel, maintenance and repair costs of all equipment and facilities, costs for the operation of the pumps, etc. In future, the expenses for public relations and education of the people about water works will be needed and added in the public budget in order to promote and imporove understanding and efficinecy in regard to collection of the water fee and the water tax for the people.

1) Technical personnel overheads

The technical personnel overheads have been estimated from Table 5.2.1.1 which gives the distribution of staff for each town in regard to works connected with water supply. However, in regard to their respective work positions, the annual salary overheads are to be shown below.

A. Sub Assistant Engineer	12,600 (kyat/year)
B. Junior Engineer	10,800
C. Engineer Grade (1)	9,000
D. Engineer Grade (2)	7,200
E. Engineer Grade (3)	5,400
F. Labour	3,600

Table 5.2.3.1 Annual Personnel Cost

	Asis. Eng.	Sub Asis.E.	Jr. Eng.	Fitter (1)	Fitter (2)	Labour	Total
Pyinmana	(1) 8,400	(2) 10,800	(3) 12,000	(6) 10,800	(5) 7,500	(9) 11,700	(26) 61,200
Yamethin	(1) 8,400	(2) 10,800	(3) 12,000	(3) 5,400	(2) 3,000	(4) 5,200	(15) 44,800
Pyawbwe	(1) 8,400	(2) 10,800	(3) 12,000	(3) 5,400	(2) 3,000	(4) 5,200	(15) 44,800
Thazi	(1) 8,400	(2) 10,800	(3) 12,000	(3) 5,400	(2) 3,000	(4) 5,200	(15) 44,800
Shwebo	(1) 8,400	(2) 10,800	(3) 12,000	(6) 10,800	(5) 7,500	(9) 11,700	(26) 61,200
Monywa	(1) 8,400	(4) 21,600	(5) 20,000	(11) 19,800	(10) 15,000	(17) 22,100	(48) 106,900
Pakokku	(1) 8,400	(2) 10,800	(3) 12,000	(8) 14,400	(7) 10,500	(13) 16,900	(34) 73,000
Yenangyaung	(1) 8,400	(2) 10,800	(3) 12,000	(8) 14,400	(7) 10,500	(13) 16,900	(34) 73,000
Taungdwingyi	(1) 8,400	(2) 10,800	(3) 12,000	(6) 10,800	(5) 7,500	(9) 11,700	(26) 61,200
Total	(9) 75,600	(20) 108,000	(29) 116,000	(54) 97,200	(45) 67,500	(82) 106,600	(239) 560,900

2) Electricity Charges

Town	Calculation		Charge(Kyat/year)
Pyinmana	*) 126 KW x 18 hrs x 365 days x 0.30 k/kw		248,346
Yamethin	60	"	118,260
Pyawbwe	103	"	203,013
Thazi	70	"	137,970
Shwebo	132	"	260,172
Monywa	259.2	"	510,883
Pakokku	210	"	413,910
Yenangyaung	165	"	325,215
Taungdwingyi	99	"	195,129
Total			2,412,898

Fig. 5.2.3.2 Electricity Charges for each Town

Pyinmana	15KW x 4 off, 11KW x 6 off
Yamethin	15KW x 4 off
Pyawbwe	7.5KW x 2 off, 5.5KW x 14 off, 11KW x 1 off
Thazi	11KW x 5 off, 15KW x 1 off
Shwebo	11KW x 9 off, 11KW x 3 off
Monywa	22KW x 4 off, 18.5KW x 5 off, 3.7KW x 1 off, 30KW x 1 off, 15KW x 3 off
Pakokku	30KW x 7 off
Yenangyaung	55KW x 3 off
Taungdwingyi	11KW x 7 off, 22KW x 1 off

3) Maintenance Costs of the Respective Towns

Maintenance costs in regard to the water supply works for one year in the respective towns is calculated from the aforementioned electicity charges, technical staff salary overheads and other additional costs, as shown in Table 5.2.3.3.

Table 5.2.3.3 Operation and Maintenance Cost

(Kyat/year)

Item \ Town			Pyinmana (10)	Yamathin (4)	Pyawbwe (17)	Thazi (6)	Shwebo (12)	Monywa (14)	Pakokku (7)	Yenangyaung (3)	Taungdwingyi (8)	Total
Pump Operation and Maintenance Costs	Electrical	Electricity Charge	248,346	118,260	203,013	137,970	260,172	510,883	413,910	325,215	195,129	2,412,898
		Operation and Security	42,219	20,104	34.512	23,455	44,229	86,850	70,365	55,286	33.172	410,192
		Sub Total	290,565	138,364	237,525	161,425	304,401	597,733	484,275	380,501	288,301	2,823,090
	Operation and Maintenance	Maintenance and Repair Costs	40,000	16,000	68,000	24,000	48,000	56,000	28,000	12,000	32,000	324,000
		Electrical Component	9,000	4,500	7,500	5,000	9,500	18,000	14,500	11,500	7,000	86,500
		Sub Total	49,000	20,500	75,500	29,000	57,500	74,000	42,500	23,500	39,000	410,500
	Overall Cost		310,432	147,825	253,766	172,463	325,215	638,604	517,388	406,519	243,911	3,016,123
	Total		649,997	306,689	566,791	362,888	687,116	1,310,337	1,004,163	810,520	511,212	6,249,713
Personnel Overheads			61,200	44,800	44,800	44,800	61,200	106,900	73,000	73,000	61,200	570,900
Office and Accounting Overheads			100,000	50,000	50,000	50,000	100,000	220,000	140,000	140,000	100,000	950,000
Grand Total			811,197	401,489	661,591	457,688	848,316	1,637,237	1,257,163	1,023,520	672,412	7,770,613

( ); No. of Production Wells

CHAPTER 6

EVALUATION OF THE PROJECT

CHAPTER 6 EVALUATION OF THE PROJECT

The effects of the project of the drinking water supply facility can occur in various aspects. The one of these effects, which can be calculated as a profit, is the water charge to be collected from the dwellers.

The water charge in the present system is determined in proportion to the rental fee of the house in the metropolitan district, or is about 10 kyat (about 300 yen) per month in the individual house water supply areas of local cities which have water supply facilities. The water price in water selling in the cities covered by the survey is about 2 kyat per 100 gal.

The GAD, which is the implementing organization of this project, is the bureau which is also in charge of the commodity price adjustment in the country of Burma, and has planned adjustment in the country of Burma, and has planned the water price at the point of time when this facility is completed to be 4 kyat per 1000 gal.

Table 6.1 shows a comparison between the yearly maintenance and management cost and the water charge revenue based on this water price. In this case, the water charge revenue of twice as large can be expected. Therefore, it is judged that, when the water supply facility is started to operate in each city, it is possible with this revenue not only to carry out the maintenance and management, but also to improve the living environments through expanding the water supply facility, consolidating the water drainage facility, and so on.

Table 6.1 Camparion between the maintenance & management cost and water charge revenue by cities

City	Maintenance & management cost, kyat/month	Water supply liable for water charge, 1000gal/month	Water charge revenue, 1000 kyat/month	Ratio of water charge revenue to maintenance & management cost
Pyinmana	67500	40920	163680	242%
Yamethin	33500	17820	71280	213%
Pyawbwe	55100	19800	79200	144%
Thazi	38200	15180	60720	159%
Shwebo	70700	40260	161040	228%
Monywa	136500	89100	356400	261%
Pakokku	104800	56760	227040	217%
Yenangyaung	85300	56100	224400	263%
Taungdwingyi	56100	31680	126720	226%
Total	647700	367620	1470480	227%

CHAPTER 7

CONCLUSIONS & RECOMMENDATIONS

7.1 Conclusions

The basic design study carried out in the present program consists of surveys and analyses on the drinking water development plans of nine cities shown below, and also investigations on the additional equipment and materials aid to two cities, Prome and Magwe, the water supply facility for which are now under construction by the grant of the Japanese government of the fiscal year of 1981.

① Pyinmana	② Yamethin	③ Pyawbwe
④ Thazi	⑤ Shwebo	⑥ Monywa
⑦ Pakokku	⑧ Yenangyaung	⑨ Taungdwingyi

The effects regarding the local city drinking water development in the country of Burma have already been demonstrated in the development of two cities, Prome and Magwe, as described above, and we are confident that similar effects can also be expected for nine cities in the present program.

As a result of the surveys and analyses, it is judged that, upon completion of the drinking water development in these nine cities, it will become possible to supply safe and clean drinking water to about 530000 population, thereby, a drastic reduction of infectious diseases so far caused by the use of unsanitary living water can be expected, significantly contributing to improving the stabilization and improvement of the dwellers' life and improving the environments of health and sanitation in each city, and further to developing these cities.

For two cities, Prome and Magwe, the water supply facility is now under construction, but since the water distribution pipes and the materials for storage tanks including the overhead tanks are not adequately available, the completion of works, initially aimed at, has been seriously delayed.

Therefore, it is desired that the consolidation of the drinking water supply facilities of the nine cities cited above should be realized promptly, and the works for Prome and Magwe should be promptly completed by the additional equipment and materials aid to Prome and Magwe.

7.2 Recommendations

(1) General

As described above, this project is expected to be very effective for the stabilization and improvement of the dwellers' life, improvement of the environments of health and sanitation, and in other aspects. For resolving away various pending items in respect of realizing this project, the government of Burma is planning to set up a waterworks bureau in the GAD which is the implementation organization of this project.

In order to realize this project, it is necessary for the government of Burma to treat the following items previously.

① Buying, compensation, etc. of the construction site for production wells, exploration wells, observation wells, pump houses, storage tanks, overhead tanks, pump stations, electrical equipment, etc.

② Approval of road administrators and adjustments for landowners as to buying of water distribution pipes and water conveyance pipes.

③ Preparation of excavators and equipment and materials for the excavation of exploration wells to be carried out as a leading work.

④ Procurement and construction of the temporary road site for the excavation of exploration wells.

⑤ Procurement of equipment and materials storage yards necessary for construction works, and field construction site.

⑥ Arrangements such as custom clearance and tax-freeing ations to be taken for the equipment and materials imported from Japan.

(2) Construction work period

The works of this project include well construction work, pipe burying work, service reservoir construction work, overhead tank construction work and electrical work. Of these works, it is considered that the well construction work occupies the critical path, and almost other works can be completed by approximately the same time as the well construction work.

The area covered by the project has a considerable rainfall in the rainy season. Therefore, it seems necessary to set up complete execution plans beforehand so that the construction works can be collected in the dry season as far as possible. It is judged to be desirable that the hearly working months should be about 8 months.

(3) Implementation design period

The implementation design of this project will be done while the exploration well, geographical survey and geological survey are carried out as leading works. When concluding E/N, the process plan taking into account the period for these works will be set up.

(4) Maintenance and administration of facilities

The importance of the maintenance and administration of the waterworks is as shown in Chapter 5 "Maintenance and Administration System". For the proper performance of the maintenance and administration of the waterworks, not only the consolidation of management organizations, personnel training and facility administration and operation, but also the security of the maintenance and administration cost by collecting the water charge, are important.

CHAPTER 8

APPENDIX

MINUTES OF DISCUSSION

ON

PRELIMINARY STUDY ON URBAN WATER SUPPLY PROJECT

In response to a request made by the Government of the Socialist Republic of the Union of Burma, Japan International Cooperation Agency (JICA), the official agency responsible for the implementation of economic cooperation program of the Government of Japan, has conducted a preliminary study for the development of urban water supply at the proposed towns in close cooperation with the authorities concerned in the Ministry of Home & Religious Affairs and in the respective towns. (Annex 1)

The study team headed by Dr. Y. Magara, Director, Department of Sanitary Engineering, the Institute of Public Health, Ministry of Health & Welfare, visited Burma from June 18th, 1984 to June 30th, 1984 and completed a series of discussions and site visits with the Burmese team headed by U Tin Htut, Director-General of General Affairs Department (GAD) in the Ministry of Home & Religious Affairs. (A list of members is attached as Annex 2.)

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Both sides herewith confirm the following points:-

1. The towns we have visited are facing a shortage of water and the people in the respective towns are in a serious situation from the point of view of health and sanitation. (Annex 3).

2. As a consequence of our evaluation on the previous grant aid both for Magwe and Prome, we come to a conclusion that the equipments and materials provided have been effectively utilized or well maintained and the related construction has also been implemented without any major delay. In addition, we consider that it is preferable to include some materials, i.e., distribution mains, fittings and valves, in Phase II of the Japanese Grant Aid which were excluded from Phase I.

3. GAD has given priorities to the proposed eight towns as follows by considering the specific situations of the respective towns:-

(a) Pakokku
(b) Monywa
(c) Pyawbwe
(d) Shwebo
(e) Thazi
(f) Pyinmana
(g) Toungoo
(h) Pegu.

However, GAD understands the situation that grant aid may not be carried out according to its list of priority due to the recommendations of the Preliminary Study Team (PST) and/or Japanese Government's budgetary rules on grant aid.

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4. With regard to Toungoo, GAD proposes to drop it from the Pilot Project due to the fact that there is no immediate water supply problem for the town at present. As for Pegu, it is believed that the construction cost for this town's water supply system would be high. Therefore both sides have agreed that a more detailed study should be carried out rather than as part of the Pilot Project scheme under the Urban Water Supply. GAD proposes that the following three towns, namely, Yenangyaung, Taungdwingyi and Yamethin, should be included in the Pilot Project scheme in place of Toungoo and Pegu. PST understands GAD's proposal due to the water shortage conditions of these towns.

5. For the implementation of the Urban Water Supply Project in Phases II and III, the drilling rigs which were presented for the construction of water supply of Magwe and Prome will be utilized.

6. Terms of Reference for the Basic Design Survey are shown in Annex 4.

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7. PST will convey the request of GAD based upon intensive surveys and discussions with the people concerned and recommend that the Government of Japan should make efforts in order to provide safe and clean water to the people.

8. PST would like to express its appreciations for the attention and cooperation given to it throughout its stay in Burma.

(YASUMOTO MAGARA)
Team Leader,
Preliminary Study Team
on Urban Water Supply Project,
JICA.

(U TIN HTUT)
Director-General,
General Affairs Dept.,
Ministry of Home &
Religious Affairs,
Socialist Republic of
the Union of Burma.

Dated Rangoon, June 29th, 1984.

MINUTES OF DISCUSSION

ON

BASIC DESIGN STUDY

FOR

URBAN WATER SUPPLY PROJECT

In response to a request made by the Government of the Socialist Republic of the Union of Burma, the Government of Japan, through the Japan International Cooperation Agency (JICA) which is an official agency implementing the economic and technical cooperation program of the Government of Japan, has conducted a basic design study for the Urban Water Supply Project in Burma.

The Basic Design Study Team (BDST) headed by Dr. Y. Magara, Director, Department of Sanitary Engineering, the Institute of Public Health, Ministry of Health and Welfare, visited Burma from 8th September to 17th November 1984 and carried out a series of discussions, surveys and basic designs on nine towns, namely, Monywa, Pakokku, Pyawbwe, Pyinmana, Shwebo, Taungdwingyi, Thazi, Yamethin and Yenangyaung, from which a preliminary study had been carried out from 18th to

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30th June 1984 in close cooperation with the Burmese side headed by U Tin Htut, Director-General of General Affairs Department (GAD) in the Ministry of Home & Religious Affairs.

Both sides have agreed to recommend to their respective Governments and the authorities concerned to examine the results of the study attached herewith towards the realization of the Project.

GAD expressed its appreciation for the prompt implementation of the basic design on the Project by the Government of Japan, followed by the preliminary study; and BDST in return expressed its appreciation for the attention and cooperation given to it throughout its stay in Burma.

(YASUMOTO MAGARA)
Team Leader,
Basic Design Study Team
on Urban Water Supply Project,
JICA.

(U TIN HTUT)
Director-General,
General Affairs Dept.
Ministry of Home &
Religious Affairs,
Socialist Republic of
the Union of Burma.

Dated Rangoon the 12th November 1984.

A T T A C H M E N T S

1. The water supply project for the towns where the basic design has been carried out should be implemented within a short period in order to provide safe and clean water to the citizens as soon as possible.
2. The basic design has been carried out according to the design guidelines listed in Annex 1, which was agreed to between GAD and BDST.
3. The report of the basic design study shall include the items listed in Annex 2.
4. The draft of the basic design study report will be explained by JICA's mission in January 1985.
5. Following this, the basic design study report will be submitted to the Government of the Socialist Republic of the Union of Burma in February 1985.
6. The following of the detail design whose contents are listed in Annex 3 is a requisite for the successful implementation of the Project.
7. The Government of the Socialist Republic of the Union of Burma will upgrade the Project Implementation Committee in order to implement the Project within a limited time successfully.

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8. The Township Development Committees (TDC's) where a new water supply system is installed shall collect water charges and fees to cover not only for maintenance and operation costs but also for future extension of the systems and provision for waste water drainage facilities. The TDC's also, in collaboration with the Health authorities, conduct public campaigns on the citizens' participation in matters such as saving of water, watching of the systems and hygienic use of water for the maximum effectiveness of the cooperation between the Burmese and Japanese Governments.

9. The Burmese Government shall upgrade the educational and training levels of water supply engineers and/or technicians, both qualitatively and quantitatively, in order to promote the aims and objectives of the International Drinking Water Supply and Sanitation Decade (IDWSSD).

10. The Government of the Socialist Republic of the Union of Burma will take necessary measures listed in Annex 4 on condition that the grant aid by the Government of Japan will be extended to the Project.

Guidelines for Designing of Water Supply System

1. Target Year ... 1990 Fiscal Year

2. Planned service area ... To be decided in each town.

3. Planned service population ... To be decided in each town.

Calculation formula is the following:-

$$Y = Yo\ (1+r)^{x}$$

Y: Population of planned year, after X years from the standard year.

Yo: Population in the standard year.

r: Average yearly increase in the standard year.

4. Planned Supply Amount

1) Planned daily average supply per capita (q_1):
   15 gal. p.c.d. (70 liters) in principle.

2) Planned daily maximum supply per capita (q_2):

$$q_2 = q_1 \times K_1 \quad (K_1 : \text{ratio of load})$$
$$= q_1 \times 1.5$$
$$= 22.5 \text{ gal. p.c.d. (105 liters)}$$

3) Planned average supply per day (q_3):

$$q_3 = q_1 \times \text{Planned service population}$$

4) Planned daily maximum supply (q_4):

$$q_4 : q_2 \times \text{Planned service population.}$$

5. Planned amount of distribution (Q):

$$Q = K \times \frac{Q'}{24} \qquad K: \frac{1}{\text{ratio of load}} = 1.5$$

Q': Planned maximum supply amount per day.

6. Water source: Ground water in principle.

7. Intake facility: Submersible pump in principle.

8. Transmission pipe: Cast iron pipe in principle.

9. Distribution reservoir (Underground)

   Effective volume: 2 hours of planned maximum supply amount per day.

10. Elevated Tank

    Effective volume: 30 min. of planned maximum supply amount per day.

11. Design of distribution pipe

    1) Calculation formula: Hazen & Williams Formula.

    2) Minimum dynamic pressure: 0.4 Kg/cm^2

    3) Minimum diameter for distribution main: 75 m/m (3")

    4) Fire hydrant: The fire hydrant will not be set on the distribution main pipe.

    5) Type of distribution pipe: Cast iron pipe and/or galvanized steel pipe.

12. Water quality: According to WHO guidelines for drinking water quality.

Contents of Basic Design Study Report

1. Executive Summary
2. Background of the Project
3. General Description of the Project
4. Guidelines for designing of water supply system.
5. Detailed exposition of each town.
   1) Outline of the projected area.
   2) Planning of water system.
      (1) Water service area
      (2) Designed population
      (3) Designed water demand
      (4) Water source.
   3) Water resource development plan.
      (1) Hydrogeology
      (2) Aquifer
      (3) Storage and quality of ground water
      (4) Well construction.
   4) Water Supply Facilities Plan.
      (1) Wells
      (2) Transmission
      (3) Distribution
      (4) Electric facilities.
6. Construction, Operation and Maintenance.
   1) Construction cost.
   2) Construction schedule.
   3) Implementation.
   4) Operation and maintenance.

7. Project and Grant Aid

    1) Subject of grant aid

    2) Basic specification and quantity of equipment and materials

        (1) Equipment and materials for drilling

        (2) Equipment and materials for wells

        (3) Transformer and power transmission line

        (4) Pipes and accessaries.

    3) Specification and quality of grant aid. Equipment, materials and others.

8. Effect of the Project.

9. Problems concerning the Project.

Contents of Detail Design

1. Survey

1-1 Ground Water Survey

Test drillings at two or three sites for each town shall be implemented to confirm the feasibility of ground water intake by wells. Following characteristics of the aquifer are requested to be verified.

1) Layer condition (electric and density well logging)
2) Yields of underground water
3) Water quality.

1-2 Topographic Survey.

(1) Topographic survey by traverse and level shall be implemented to make a place (scale 1/5000) with 0.5 m of contour on plain areas or 1.0 m contour on hilly areas.

(2) Detailed survey on the projected site(s) of ground reservoir. Scale 1:200.

1-3 Soil tests.

Standard penetration tests of the projected sites of ground reservoir and/or elevated tank.

Following items shall be decided by the test:-

1) Soil strength of reaction
2) Type of foundation.

1-4 Survey for river and railroad crossing.

2. Detail design of facilities.

1) Intake

(1) Type of well

i. Diameter. ii. Depth of well. iii. Position of strainer. iv. Gravel wall. v. Pump.

(2) Structure of well.

2) Transmissions.

(1) Design of transmission line

(2) Structure design of crossings over river, railroad and others

(3) Protection of bend and water hammer

(4) Drawings.

3) Storage

(1) Study of type of storage tank

(2) Design criteria

(i) load (ii) strength of materials

(iii) soil condition

(3) Selection of foundations

(4) Analysis of structure stability

(5) Structural analysis

(6) Temporary and subsidiary construction works.

(7) Drawings

(i) general view (ii) structural view

(iii) bar arrangement (iv) pipe layout

(v) others if necessary.

4) Distribution

(1) Network analysis

(2) Other designing jobs required in transmission.

5) Electric facilities
   (1) Receiving plan
   (2) Receiving facilities
   (3) Transmission facilities
   (4) Distribution facilities.

4. Preparation of specification for materials and equipment.
5. Accounting of materials and equipment.
6. Cost estimates
   1) Materials
   2) Equipment
   3) Labor
   4) Others.
7. Implementation plan
   1) Procedure of construction
   2) Management of construction
   3) Construction schedule.
8. Maintenance and Operation.
   1) Estimate of maintenance and operation costs
   2) Organization of maintenance and operation.
   3) Manual of maintenance and operation
      (1) Maintenance and operation flow chart
      (2) Record format of operation
      (3) Record format of well operation.

Annex 4

The following arrangements are requested to be undertaken by the Government of the Socialist Republic of the Union of Burma:-

1. To secure the necessary materials (i.e. cement, steel rods and so on) and acquire land for the Project.
2. To exempt from Customs duties, taxes and other levies which may be imposed on the supply for the Project.
3. To ensure prompt unloading, Customs clearance and prompt domestic transportation.
4. To provide and accord necessary permissions, licences and other authorizations required for the execution of the Project.
5. To bear all the expenses necessary for the implementation of the Project other than those to be borne by the Japanese grant aid.

Minutes of Discussion

on the

Draft Final Report of the Basic Design Study

for

Urban Water Supply Project

in the Socialist Republic of the Union of Burma

1. The Government of Japan has sent an Explanatory Team from the Japan International Cooperation Agency (JICA) to the Socialist Republic of the Union of Burma to present and explain the Basic Design Study Report (the Report) on the Urban Water Supply Project (the Project) from 21st February to 27th February 1985.

2. The Team held meetings with the Burmese Government officials and the Project staff to explain and discuss on the Report. As a result of the discussions, both parties have confirmed the following points:-

(a) The Burmese side has agreed in principle to the basic design proposed in the Report.

(b) The Final Report on the Project in English (10 copies) with amendments mutually agreed upon will be submitted to the Government of the Socialist Republic of the Union of Burma by the end of April 1985.

(c) Referring to the Attachments in the Minutes of Discussion dated 12th November 1984, particularly items 6 & 7, it is agreed that the detail design study should be carried out by the Japanese consultants and the Government of the Socialist Republic of the Union of Burma will upgrade the Project Implementation Committee in order to implement the Project within a limited time successfully.

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3. Referring to items 8, 9 & 10 in the Minutes of Discussion dated 12th November 1984, namely, the collection of water charges and fees by the Township Development Committees, the upgrading of the educational and training levels of water supply engineers and/or technicians by the Burmese Government and the bearing by the Burmese Government of all the expenses necessary for the implementation of the Project other than those borne by the Japanese grant aid, it is agreed that they are absolutely essential to the necessary implementation of the Project.

4. Referring to Annex 4 in the same Minutes of Discussion, it is also agreed that these are all major undertakings of the Burmese Government, particularly, with regard to the Burmese undertakings of its finance, the necessary funds will be made available during the construction period.

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A Note regarding technical cooperation is given below:-

Note:

The Burmese side would like to have a Technical Adviser for the Implementation of Water Supply Project and a Specialist for Water Supply Management during the time of the implementation of the Project.

佐々木直義

(NAOYOSHI SASAKI)
Team Leader,
Explanatory Team of the
Draft Final Report on
Urban Water Supply Project,
JICA.

(U SOE MYINT)
Director-General,
General Affairs Department,
Ministry of Home &
Religious Affairs,
Socialist Republic of the
Union of Burma.

Dated Rangoon the 26th February 1985.

LIST OF MEMBERS OF JICA MISSION

Yasumoto MAGARA	Leader	The Institute of Public Health
Naoyoshi SASAKI	Cordinater	Japan International Corperation Agency (JICA)
Mashio YAMAHA	Planning of Water Supply	Kyowa Engineering Consultants Co., LTD. (KEC)
Suenori ISAYAMA	Planning of Water Supply Facilities	KEC
Sadauki KAMIDE	Hydrogeology	KEC
Masayuki TAGUCHI	Planning of Pipelines	KEC
Kazunari SUETSUGU	Construction and Cost Estimation	KEC
Hiroshi HIRAMOTO	Electrical Survey	KEC

LIST OF BURMAS STAFFS CONCERNED

U Tin Htut	Director General, General Affairs Department (GAD), Ministry of Home & Religous Affairs (MHRA)
U Soe Myint	Deputy Director, GAD, MHRA (now in Director General, GAD)
U Aung Shwe	Deputy Director, GAD, MHRA
U Aung Chan Tha	Same as above
U Antt Gyaw	Assitant Director, Foreign Economic Relation Department (FERD), Ministry of Planning & Finance (MPF)
U Than Myint	Chief of Section, FERD, MPF
U Thein Naing	Project Manager, Urban Watger Supply Project, Rangoon City Development Commitee (RCDC)
U D. Aung Ba	Domestic Hydro-geologist Consultant, Mandalay Water Supply Project (MWSP)
U Hla Thwin	Deputy Assistant Director, GAD, MHRA
U Kyaw	Project Engineer, Urban Water Supply Project, RCDC

JICA