Appendix 2. Infiltration Galleries

1. Introduction

Riverbed water is one of the most important water sources presently tapped in the Ilocos Norte area, and more riverbed water is to be developed for water supply. So far three infiltration galleries have been constructed and are in use, and a fourth is under construction. Considering the importance of riverbed water and with an aim of exploring possibility of future utilization of the source, a field investigation including water quality test was conducted in the latter half of July, 1981. The following is findings of major importance of the investigation.

2. Infiltration Galleries

Main features of the infiltration galleries are as follows, of which constructions are shown in Fig 2.

1) Ermita Infiltration Gallery

Construction: 1959

Pump capacity: 1.9 cu m/min = 2,700 cu m/day; present operation
0.6 cu m/min x 19 hrs = 680 cu m/day

Present conditions: Perforated pipes were originally placed without joints, with an end of one pipe being closely placed to an end of the next pipe. Some pipes seem to have been flushed away by floods; presently the collection well takes in surface water of the river.

Water quality: Water taken in has turbidity and also some pollution due to intrusion of contaminated groundwater by domestic waste water.

2) West Riverside Infiltration Gallery

Construction: 1969 (Initially without perforated pipes)
1978 (Perforated pipes were added)

Pump capacity: 1.5 cu m/min = 2,160 cu m/day; present operation
0.95 cu m/min x 19 hrs = 1,080 cu m/day

Present conditions: Present intake capacity is lower than designed.

Water quality: Polluted groundwater seems to be mixed with the gallery water.

3) Bacarra Infiltration Gallery

Construction: 1979

Pump capacity: 2.8 cu m/min = 4,030 cu m/day; present operation
1.4 cu m/min x 19 hrs = 1,600 cu m/day

Present conditions: All facilities are in good order.

Water quality: No abnormal conditions are found.

4) Vintar Infiltration Gallery

Construction: 1981

Present conditions: Construction of the facilities is completed except the pump facility. This system is not equipped with perforated pipes.

3. Analytical Results of Water

3.1 Analytical Results

Major points of analytical results of infiltration gallery water and river water during the survey are as follows:

a) Infiltration gallery water

(1) Ermita gallery water had a high value of turbidity such as 10 to 20 mg/l, when the river water was turbid by rainfalls.
(2) Ermita and West Riverside gallery water had 1,500 to 2,500/ml bacteria and over 500/100 ml coliform groups.
(3) Ermita and West Riverside gallery water had high conductivity such as 650 to 935 μS/cm.

b) River water

(1) Conductivity of the Laoag river water was between 220 - 330 μS/cm.
(2) Turbidity of the Laoag river water was from 22 to 50 mg/l.

Ilocos

The fact that the Erimita and West Riverside gallery water contained higher conductivity than the river water suggests that the gallery water is mixed with water from other sources. Therefore, groundwater which might influence the gallery water was sampled and tested. The test was made by sampling from shallow wells located in Laoag City. The results were as follows:

c) Groundwater

(1) Conductivity of shallow well water ranged from 410 to 1,850 μ℧/cm as shown in Fig 1. Values of conductivity are high in the central area of the poblacion and lower gradually toward the periphery of the area.

(2) Turbidity is not contained in the shallow well water.

3.2 Considerations

a) Turbidity of Ermita Gallery water may be caused by direct introduction of the river water into the perforated pipe or the collection well which was built in the stream.

b) High conductivity, chloride and hardness of the gallery water are supposed to be attributable to inclusion of groundwater from the hinterland. That is because 1) the shallow well water near the galleries showed higher conductivity, and 2) the structure of the pump well and the connection pipe between the pump well and the collection well is designed to allow in the groundwater.

c) A trial calculation was made to know the mix ratio of the riverbed water and the groundwater based on the values of conductivity. The results of the calculation show that the mix ratio is about 1 to 1.

d) Quality of the shallow well water indicates that the groundwater in the area of the Laoag City is highly polluted by domestic waste water.

4. Recommendations

Regarding the present utilization and future tapping of riverbed water, the following are recommended. Among others, chlorination is essential.

a) Erimita Infiltration Gallery

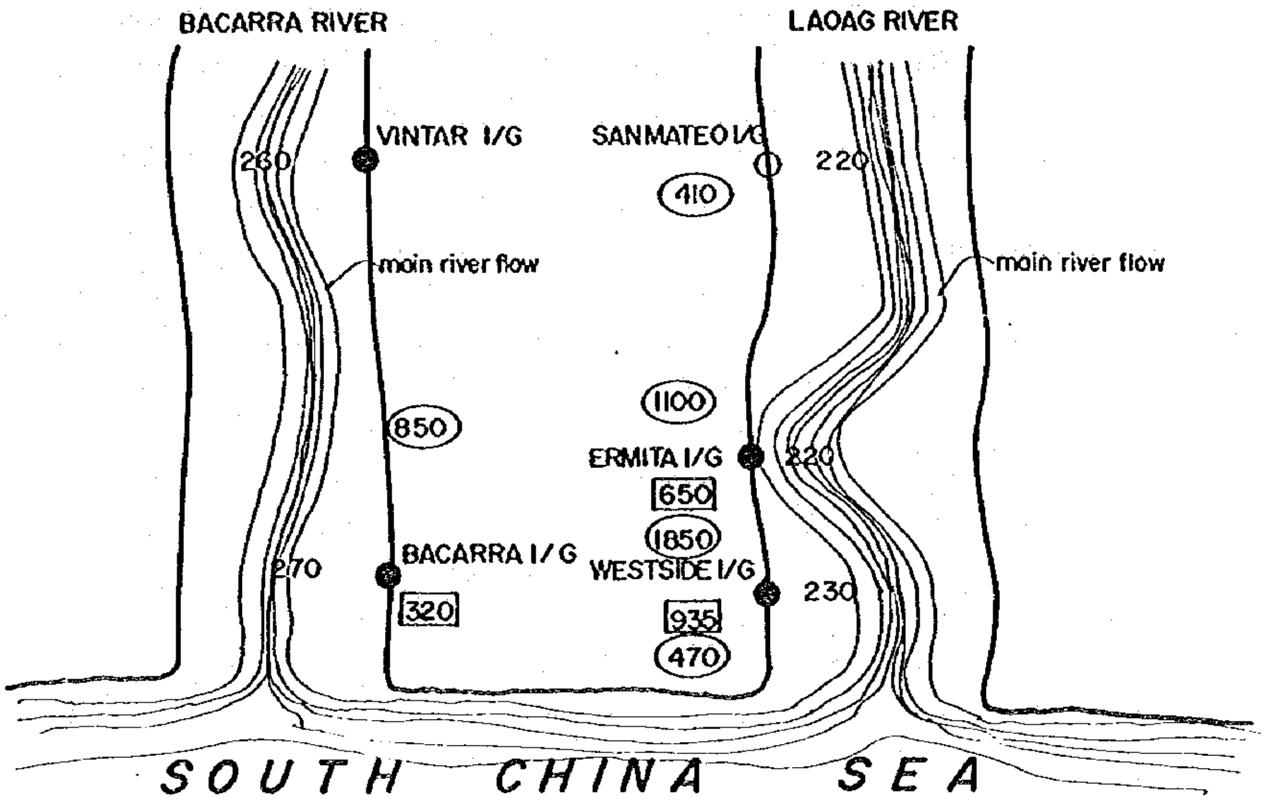
It is advisable to move the existing collection well together with the infiltration pipe from the present site in the main stream to the sand bar that is always exposed except time of flooding in order not to take the surface water (Ref. Fig 1). Chlorination is indispensable all the time. Water quality should regularly monitored.

b) West Riverside Infiltration Gallery

Chlorination and water quality monitoring should be practiced.

c) Bacarra Infiltration Gallery

The same recommendation for the West Riverside Infiltration Gallery applies to this system.



Remarks:

● EXISTING INFILTRATION GALLERY

○ PROPOSED INFILTRATION GALLERY

▭ CONDUCTIVITY VALUE OF WATER OF INFILTRATION GALLERY

⬭ CONDUCTIVITY VALUE OF SHALLOW WELL WATER

) (CONDUCTIVITY VALUE OF SURFACE WATER

UNIT μ℧/Cm.

Fig 1 Distribution of Conductivity in Laoag Area

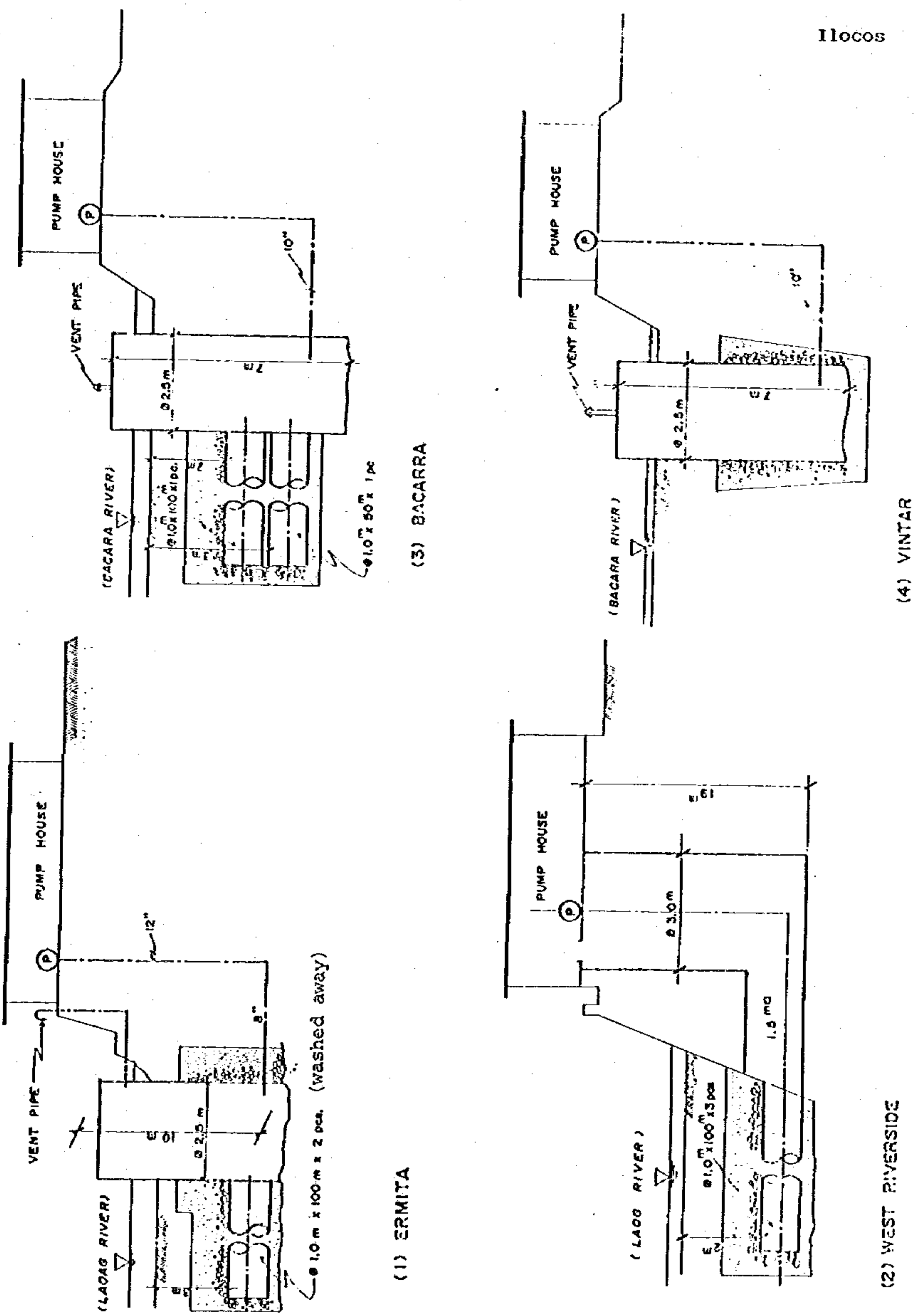


Fig 2 Existing Infiltration Galleries

Appendix 3 Water Pressures on the Transmission Line

Water pressures on the transmission line were checked in the field survey to know the delivery quantity as well as conditions of the pipeline on 27th July 1981.

The time when the investigation was made was during a rainy period, and so the yields of springs were plentiful. At the intake there was a sizable overflow.

As shown in Fig. 1, pressure drop in section (1) is abnormal, and that in other sections appears to be generally normal. In section (1), large leaks were found and further there were some points where air was being sucked from holes pitted in the pipe wall.

Calculated flows of each section are shown in Fig. 1. For calculation, C value was taken from the Methodology Manual of LWUA, and another trial calculation was made assuming a different C value that was considered appropriate. The flows thus calculated are also shown in the same figure.

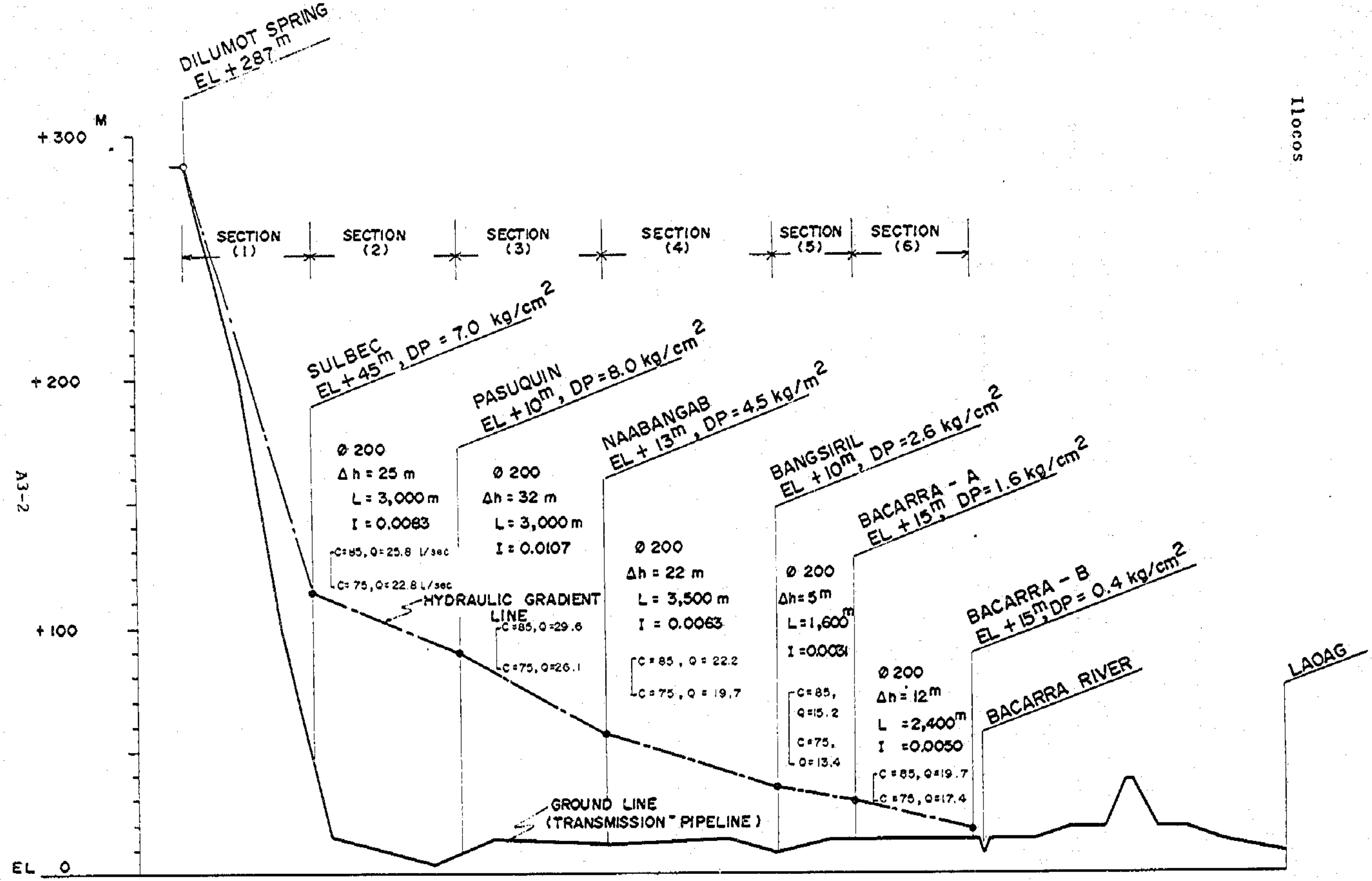


Fig. 1 Profile of Existing Transmission Pipeline

Scale H = 1/100,000
V = 1/2,000

Appendix 4 Variation of Water Pressure in Laoag

To investigate 24 hours pressure variation in the distribution networks in Laoag, the Team made pressure recording at 4 locations as shown in Fig. 1 and 2.

The pressure recorder was set at R-1 in the northern part and R-2 in the center of Laoag poblacion, respectively, which are located near the main transmission pipeline from the Ligao reservoirs. The records indicated almost same variations, although they had different value of pressure. The highest value of R-1 appeared in the period 12:00 noon - 2:00 P.M., about 1.8 kg/sq.cm, and always had enough water pressure. However, R-2 had no pressure in the period 1:00 A.M. - 10:00 A.M.

On the other hand, R-3 and R-4 were selected in the eastern and the western part of poblacion, respectively. R-3 and R-4 had low pressures through all day. Since the location of R-4 is near the West Riverside infiltration gallery, the pressure value varied according to the pumping hours, namely, the pressure starts to rise at 5:00 A.M. and fall at 11:00 P.M.

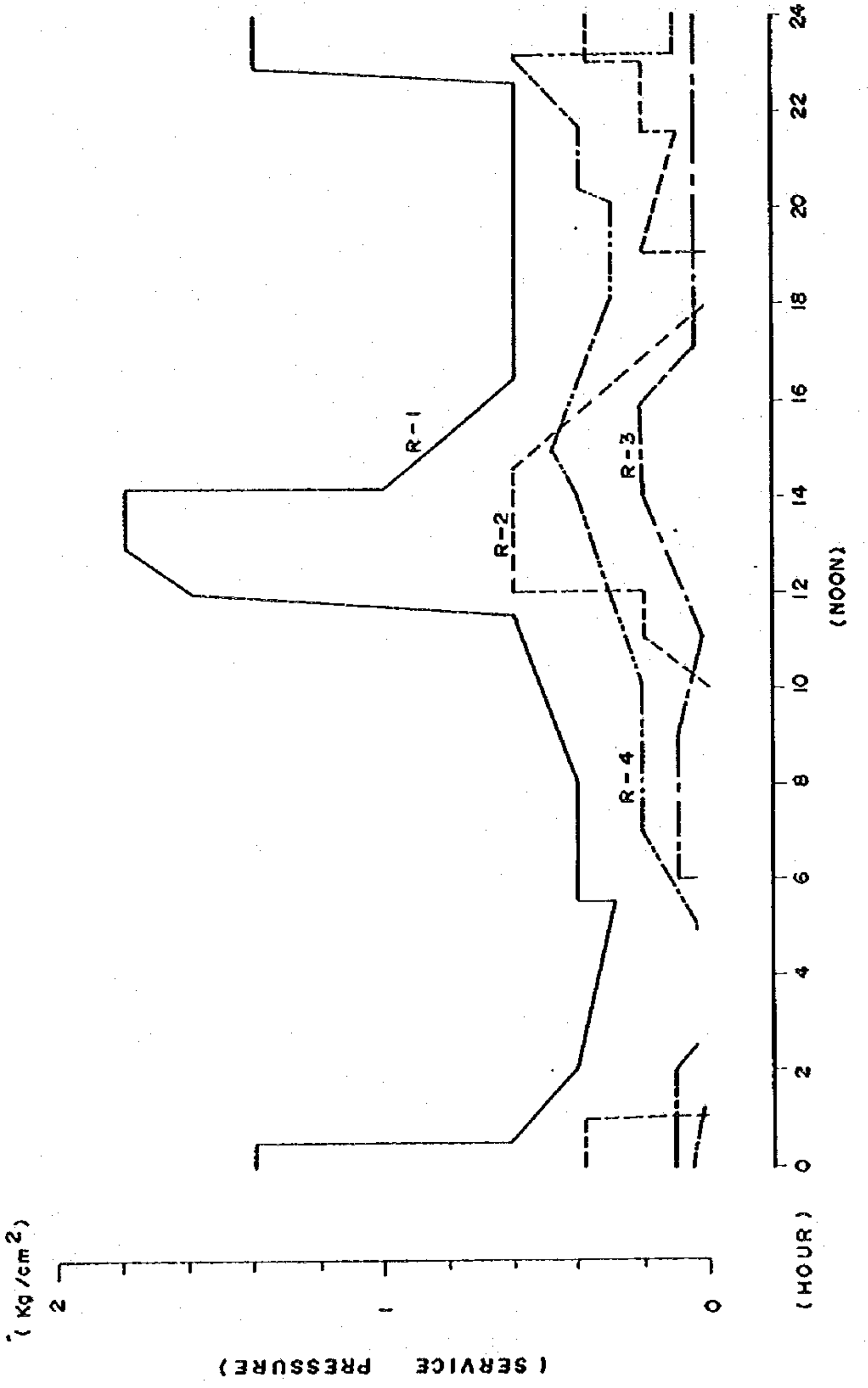


Fig. 1 Variation of Water Pressure in Laoag
(July 1981)

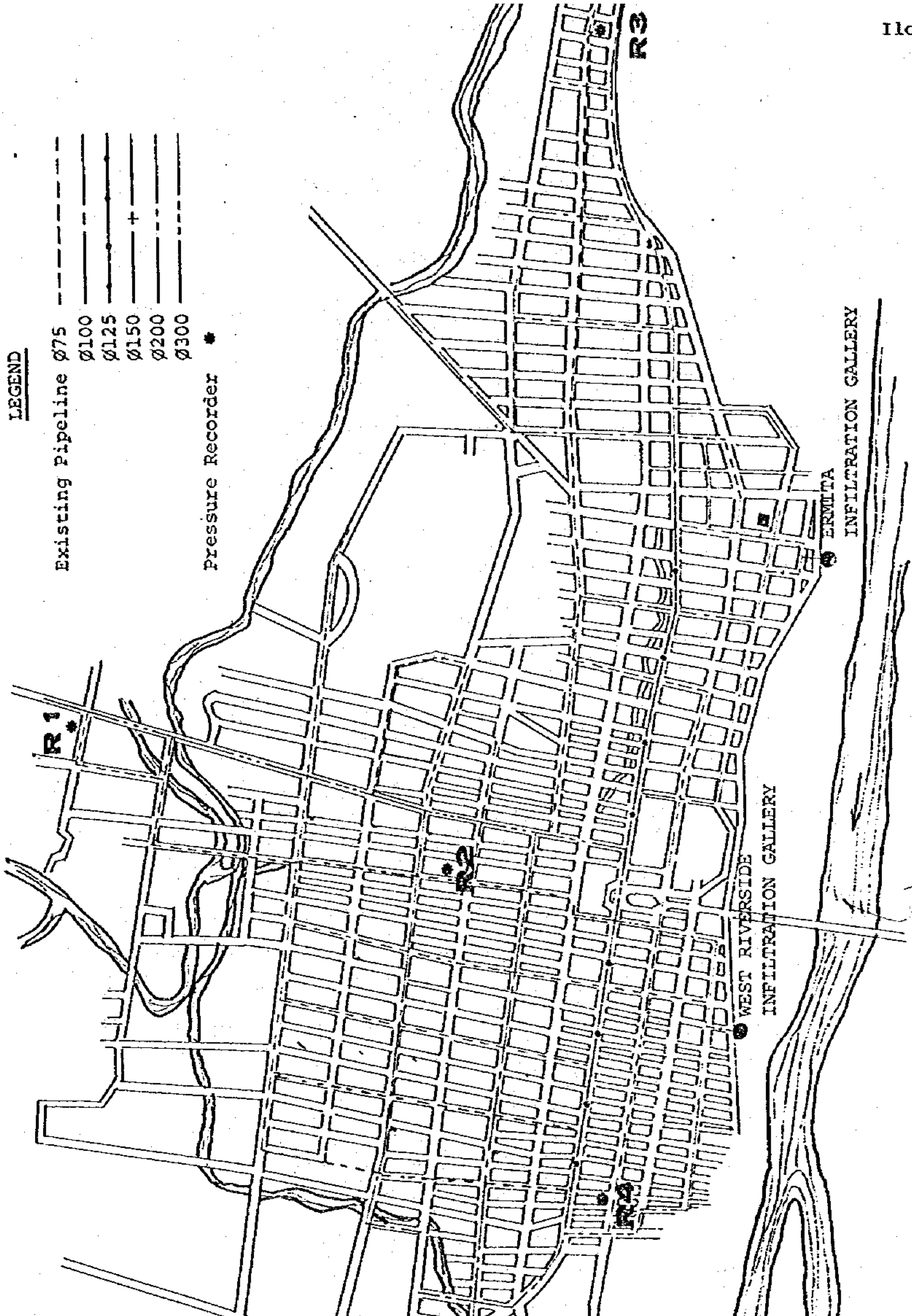


Fig 2 Location of Pressure Recorders Installed

Appendix 5 Study on Water Sources

1. General

Study Area: Laoag City and the municipalities of Pasuquin, Bacarra, Vintar and Paoay.

Purpose of Study: to investigate possible water sources of surface water and groundwater for the use of the Water District.

Method of Study: reconnaissance in the field, analysis of the existing data and geoelectric resistivity survey.

Period of Field Investigations: July through December, 1981.

2. Topography

The survey area has four typical topographies: dunes, alluvium, hills generally ranging in elevation from 30 m to 60 m, and the Ilocos Mountains, of which the highest is about 560 m in elevation.

The dunes stretch along the seashore area, especially developing in the direction of bacarra to Paoay. The dunes can be classified into two groups; one is of recent deposits and the other is of an older origin, probably formed after Pleistocene. The old dunes form the hills of 30 m to 80 m in elevation and have a shape like a narrow belt along the coastline.

Alluvium extends over a vast area in Paoay, and along the Rivers in Bacarra and Laoag. The alluvial plain slopes down gently seaward.

The hills have many small valleys and gentle slopes, which show that the hills have easily been eroded. The contour lines, therefore, are irregular, as shown in Figs 1 and 2.

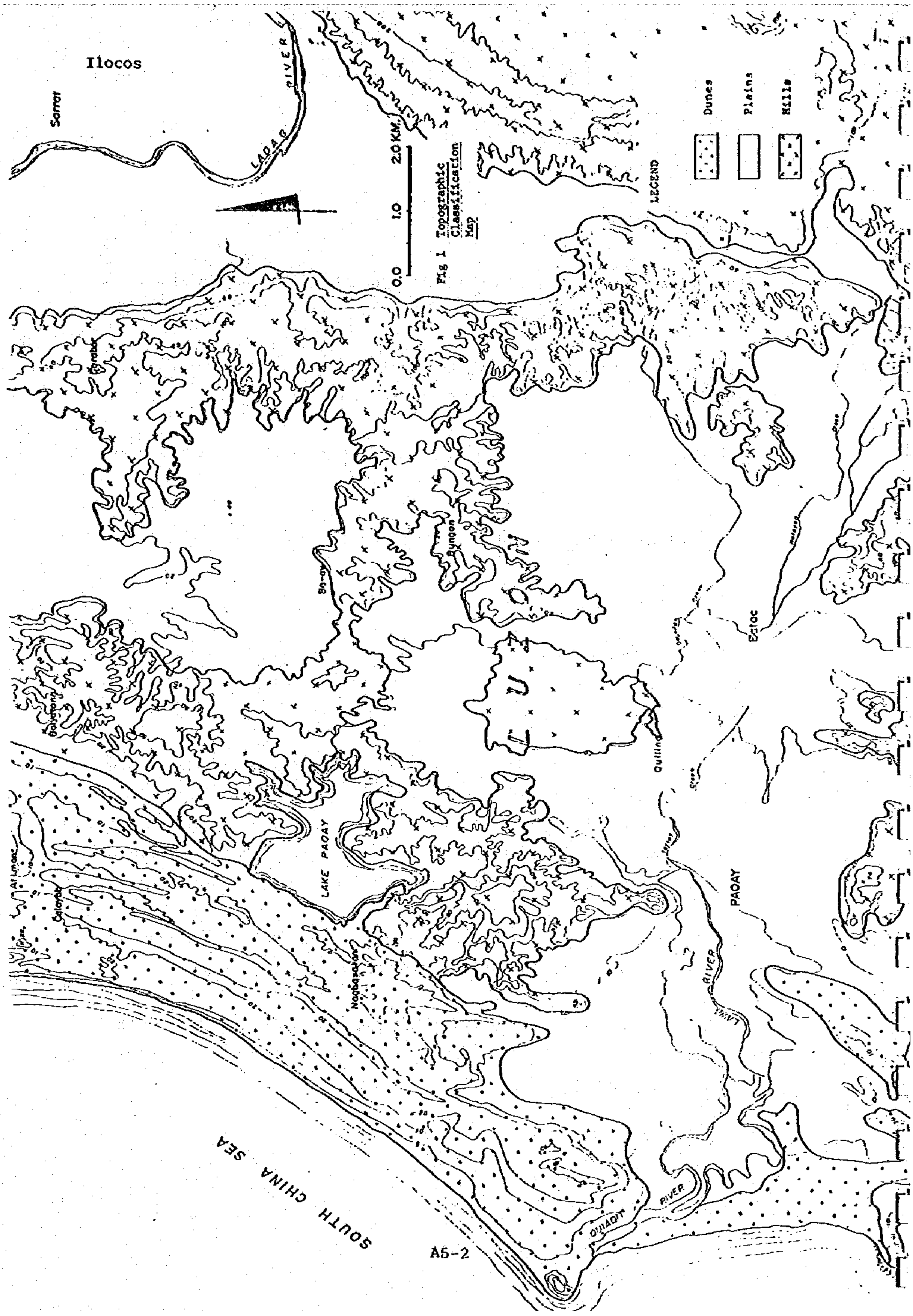


Fig 1 Topographic Classification Map

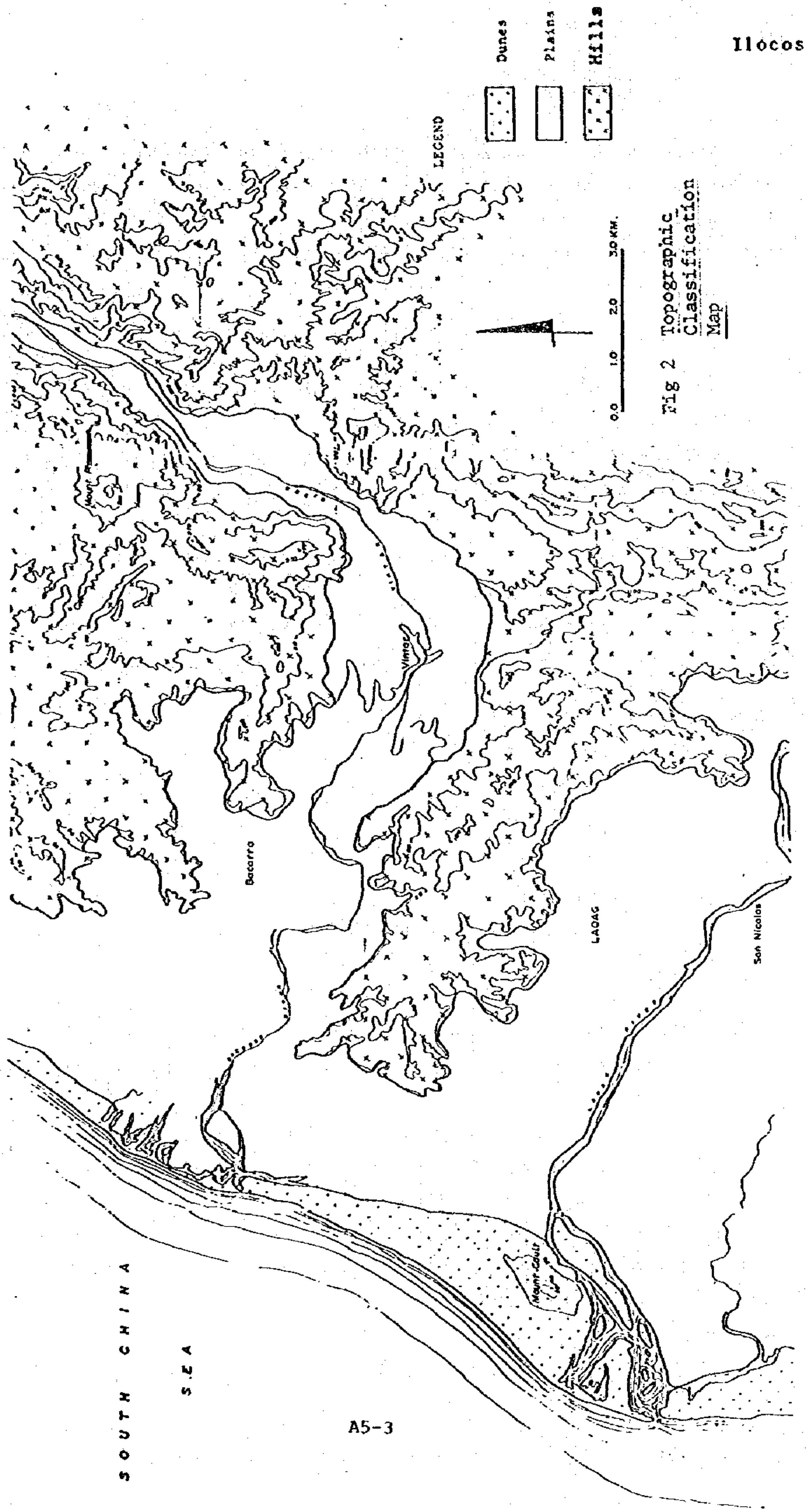


Fig 2 Topographic Classification Map

The mountains exist in the northern part of Pasuquin. Their elevations are high and slopes are steeper. The mountain area has many small streams which drain directly into the sea. The topography, as shown in Fig 3, shows that the formation of these mountains is hard to erode.

3. Geology

The study area has four types of geology, namely, the dunes, the alluvium, the hills consisting of Pliocene-Pleistocene formations, and the mountains formed of Cretaceous-Paleogene igneous rocks. The classification maps of topography, Figs 1 to 3, also explain these geological boundaries.

The present geological survey is carried out in connection with the study of the groundwater conditions, which include structure of groundwater basins, aquifers and water quality, in Paoay and Laoag, and springs in pasuquin. Therefore, geology is explained in the following three areas; (1) Paoay area, (2) Laoag area, and (3) Pasuquin area.

(1) Paoay Area

The area is dominated by dunes near the coastline. The old dunes, as mentioned earlier, are widely distributed in the westside area of Paoay Lake and the southwest of Paoay. They often form small hills with an elevation of about 30 m. The dunes consist of medium sand.

The alluvium is extensively distributed in Paoay and Batac, and composed mainly of silt, sand and gravel.

The hills about 60 m in elevation consist of Pliocene-Pleistocene formations, They are distributed in all areas around Paoay Lake except the west part, and on the north and south side of urban areas of Paoay and Batac. Countless valleys exist in the hills which have been subject to subaerial erosion. Alluvial sediments cover these

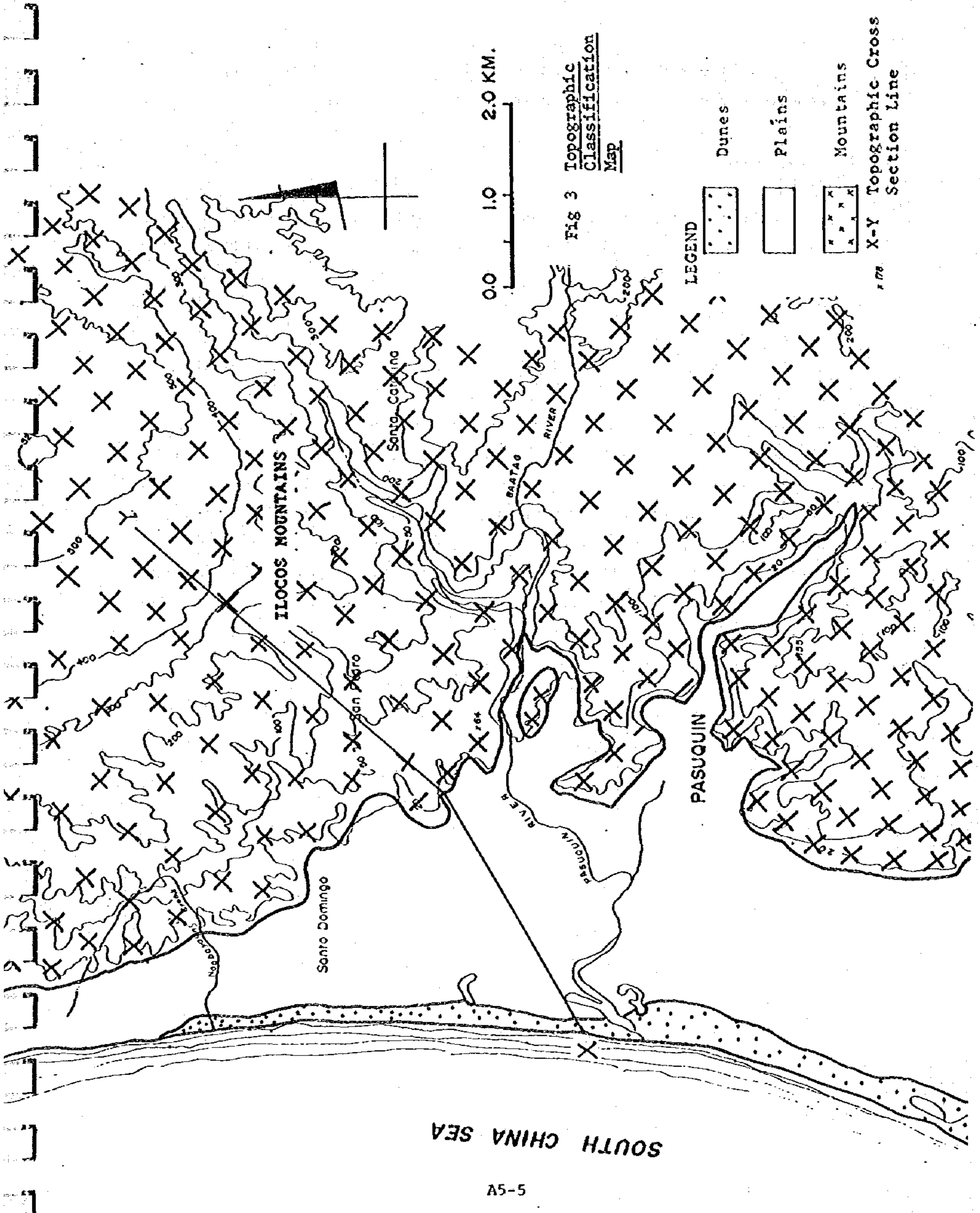


Fig 3 Topographic Classification Map

valleys. Pliocene-Pleistocene formations are made up of clay, silt, sandstone and gravel as found in the field survey.

(2) Laoag Area

The alluvium extends along the Laoag River, and the hills are distributed at its outer area on north and south of the city area.

(3) Pasquin Area

The area is characterized by the mountains with high elevations and steeper slopes. The geological maps (1963)[1/] explain that they are formed of Cretaceous-Paleogene igneous rocks, however, the geological structure is not simple. The geological structure of the mountains from which springs flow out is schematically shown in Fig 4. Lavas occur in the higher portion than about 200 m in elevation, of the mountains. The lavas have many veins of silexite running in random directions. In the quartziferous lavas, a few caves have been formed nearly horizontally. The cause of their formation is estimated to be gaseous and/or hydrothermal actions.

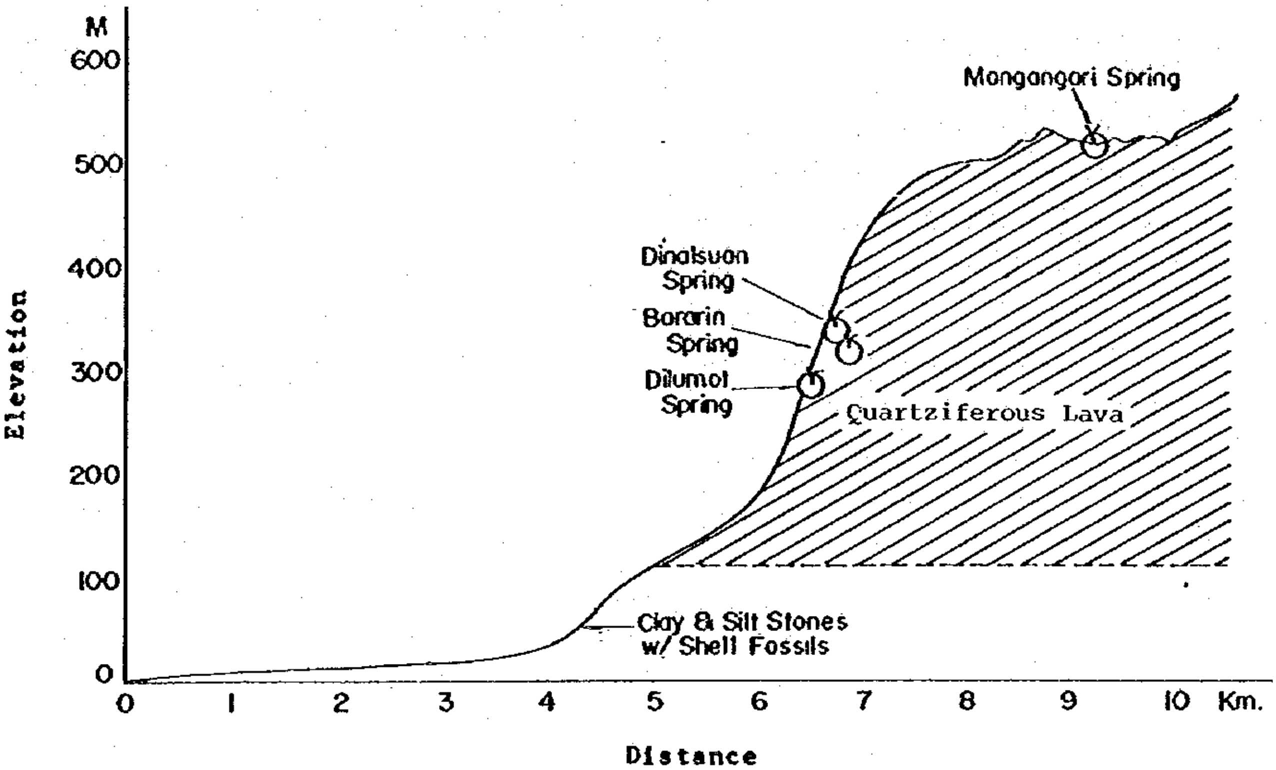


Fig. 4 The Geology and the Location of the Spring of the Pasuquin Mountain

(Topographic Cross Section Line X-Y is shown in Fig 3)

4. Hydrology

4.1 Rainfall

The study area has two pronounced seasons, dry and wet. According to the meteorological observations in Laoag City, the area has an average annual rainfall of 2,098 mm (normal 1951-70)[2/] with an extremely low monthly average of 25 mm from October to April and a very high monthly average of 383 mm from May to September.

4.2 River Flow

Principal River Basins of the Philippines (1976)[3/] shows that the Laoag River has a huge river basin with a drainage area of 1,319 sq km and an estimated annual run-off of 3,225 million cu m, and the Bacarra River has 772 sq km of drainage area and 1,888 million cu m annual run-off.

In this connection, Surface Water Supply of the Philippines (1963, 1966, 1967, 1969)[4/] presents more detailed data of discharges observed at the gauging station of the Laoag River, which are shown in the following Table 1.

Table 1 Daily Average, Daily Maximum and Minimum Discharges of the Laoag River (cu m/sec)

Years	Daily Average	Daily Maximum	Daily Minimum
1963	3,819	4,200	6.2
1966	813	119	6.5
1967	4,278	6,400	6.8
1969	661	980	-
Average	2,393	2,924	6.5

The above observation data have fluctuations in a wide range in monthly average and daily maximum discharge every year. The Laoag River has a large monthly average discharge, Q = 2,393 cu m/sec = 206.8 million cu m/day. Daily minimum average discharge Q = 6.5 cu m/sec = 561,600 cu m /day is fairly large, though it looks small compared with daily maximum.

The Bacarra River has no observation data. Its discharge, therefore, is estimated on the assumption that the River has the same specific run-off as the Laoag River. The discharges of the Bacarra River are assumed to be proportionate to the drainage area. The monthly average, daily maximum, and minimum discharges, thus estimated, are shown in Table 2.

Table 2 Estimated Daily Average, Daily Maximum and Minimum Discharge of the Bacarra River (cu m/sec)

Years	Daily Average	Daily Maximum	Daily Minimum
1963	2,235	2,458	3.6
1966	475	69	3.8
1967	2,504	3,745	4.0
1969	386	573	-
Average	1,400	1,711	3.8

The Bacarra River also has large discharge, of which the daily minimum average discharge is Q = 3.8 cu m/sec = 328,320 cu m/day.

The Lawa River, which flows in Paoay and Batac areas, has a drainage area of 188 km^2. The daily minimum discharge is estimated using the same calculation procedure as that of the Bacarra River under the same assumption. The discharge calculated is 0.90 m^3/sec = 77,760 m^3/day.

4.3 Groundwater

The groundwater conditions in the alluvial area of Paoay and Laoag, together with springs in Paoay, Vintar and Pasuquin are studied, respectively, as below.

(1) Groundwater Conditions in Paoay

Regarding groundwater conditions in Paoay, locations of wells are shown in Fig 5, details of wells in Table 3, and columnar sections of wells in Fig 6. From characteristics of the groundwater conditions and for convenience of explanation, the Paoay study area is divided into four areas, that is, 1) Paoay poblacion and its vicinity (Paoay area), 2) Batac poblacion and its vicinity (Batac area), 3) an area east of the lake (lake area), and 4) an area covered by dunes north of the lake (dune area). In the following, features of the groundwater conditions in four areas will first be described, and then consideration will be given on them.

1) Paoay Area

a. Average concentration of salinity is about 180 ppm as chloride in shallow groundwater, approximately 1,000 ppm in deep groundwater.
b. Formations ranging from 0 m to 8 m are composed of clay and/or clay with sand layers (as an exception, columnar section of No. 11 well which is close to the dunes lacks clay).
c. Formations ranging from 8 m to 43 m are made up mainly of sand and gravel, and are pervious.

2) Batac Area

a. Water quality in shallow groundwater is similar to that in the Paoay area.
b. Formations consist of alternating beds of clay, sand and gravel.

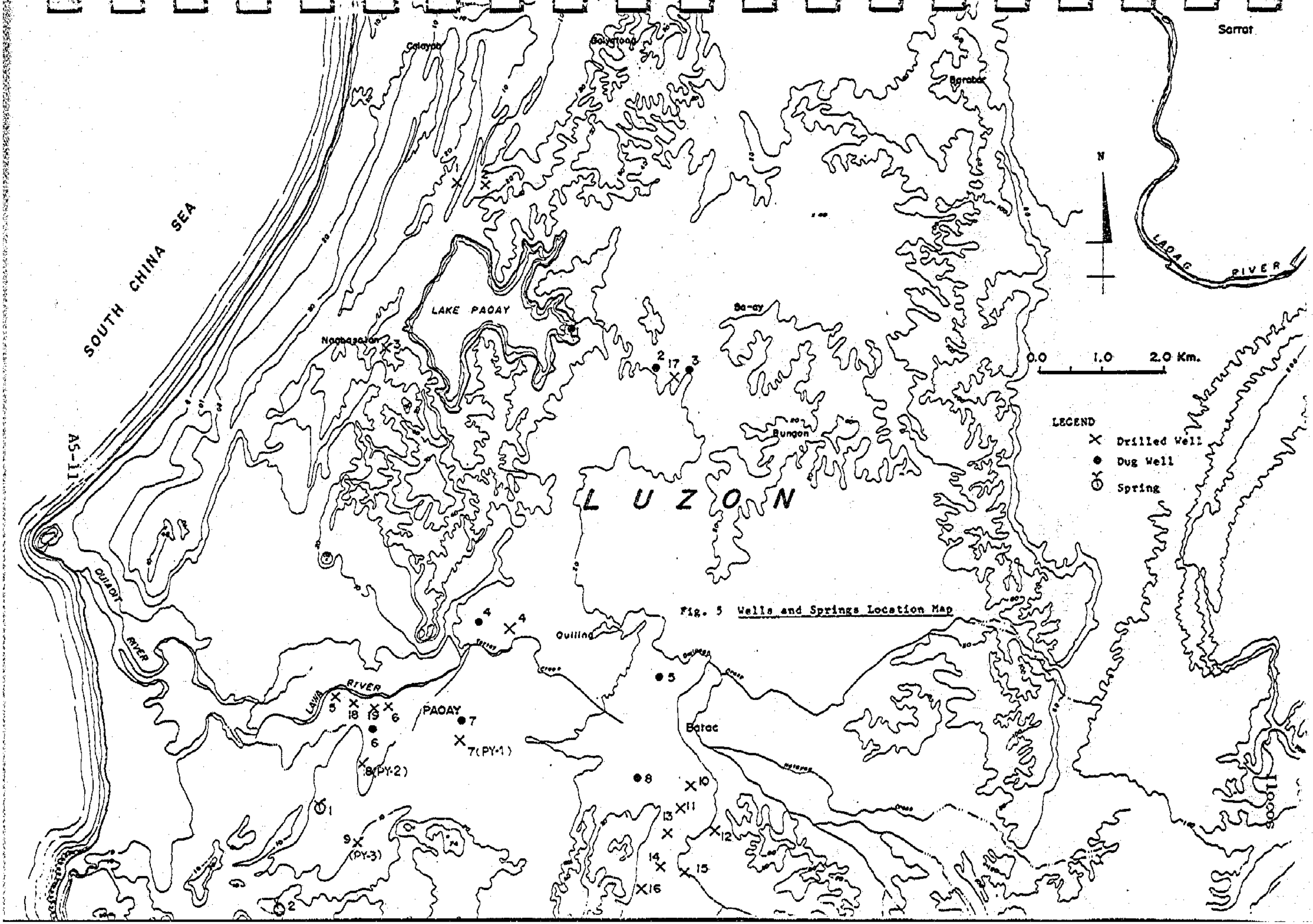


Fig. 5 Wells and Springs Location Map

Table 3 Well and Spring Data in Paoay

Number of Wells	Sampling Date	Casing Diameter	Well Depth	Static* Water Level	Pumping* Water Level	Discharge	Conduc-tivity	pH	Cl^{-1}
Drilled Wells									
1	7-25-81	150 mm	67.07M	5.49M	28.66M	2.65 lps	μℓ/cm	7.5	22.5 ppm
2	7-25-81	150	47.78	2.44	10.22	6.25		7.37	2.5
3		150	31.10	14.02	15.85	7.63			
4		200	36.59	4.57					
5		200	9.15						
6		100	9.76						
7		150	42.68						800
8		150	42.68						
9		150	42.68	1.52	9.15	9.02			1,370
10		150	70.12	4.57	12.2	11.04			
11		150	78.35	4.88	13.72	3.6			
12		150	60.98	4.57	23.48	3.72			
13		150	91.46	1.22	9.76	4.42			
14		150	77.74	1.83	9.76	4.29			
15		200	32.0	4.57	7.93	17.7			
16		150	91.5	0.91	6.40	6.72			
17									
18		100	10.67						
19		100	10.67	2.44	2.74	0.50			
Dug Wells									
1	7-25-81		10.95	5.81			360	7.8	10
2	7-24-81		7.92	10.23			1,900	7.85	
3		1,000						7.65	255.5
4	7-24-81		6.35	1.56			2,400	7.62	395
5	7-24-81	1,060	6.16	1.40			1,700	7.65	122.5
6	7-24-81		4.44	0.49			1,950	7.7	165
7	7-24-81						2,050		
8	7-24-81			0.48			1,750	7.6	125
Springs									
1								7.37	7.5
2	7-27-81						550		10
Other Sources									
LAWA ** River	7-28-81						800	7.7	130

* Static Water Level (G.L. Minus)
Pumping Water Level (G.L. Minus)

** Sampled near the Paoay Poblacion

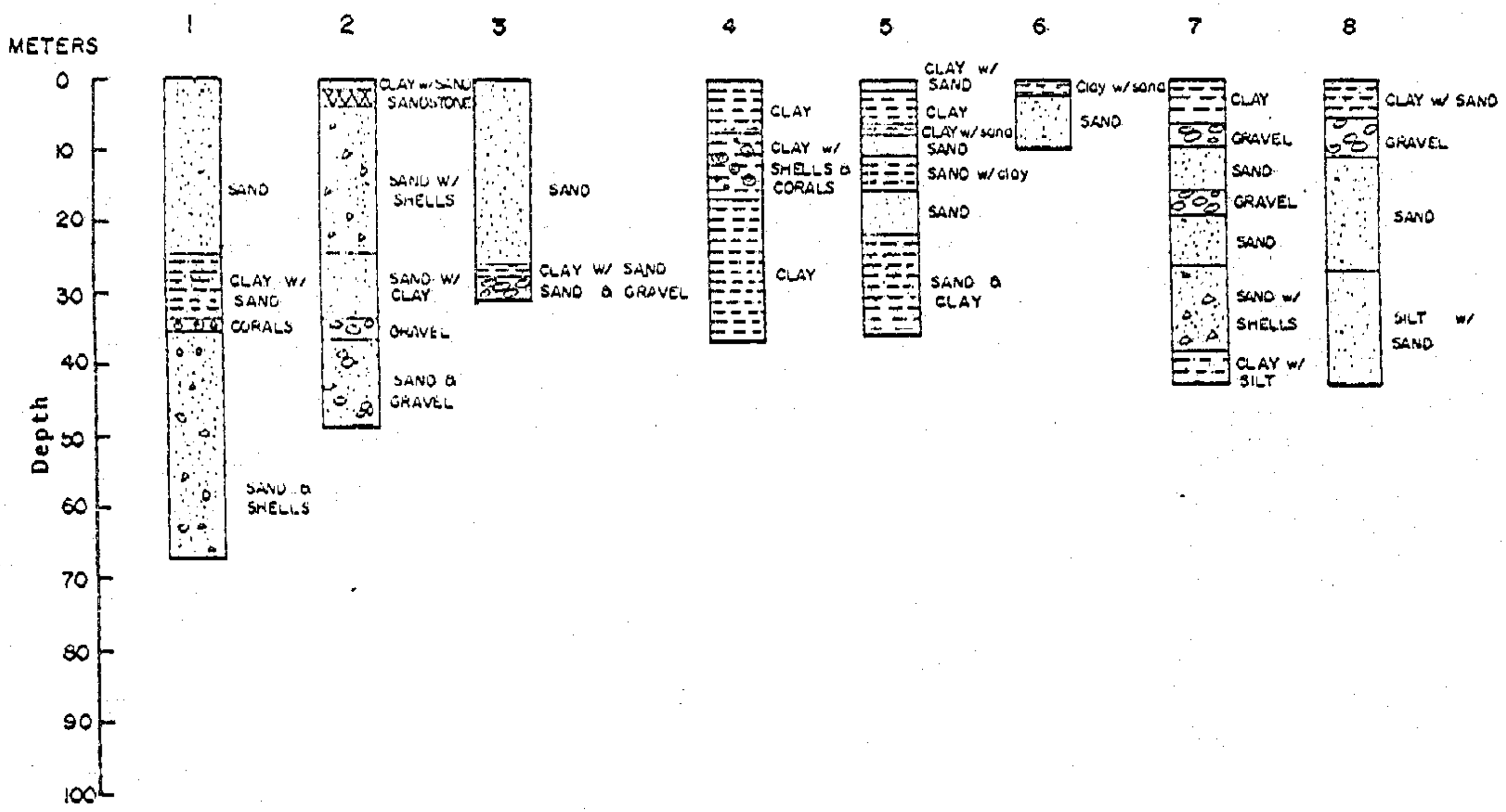


Fig 6-1 Columnar Sections of Wells
(The number is the same as that of the drilled wells shown in Fig. 5)

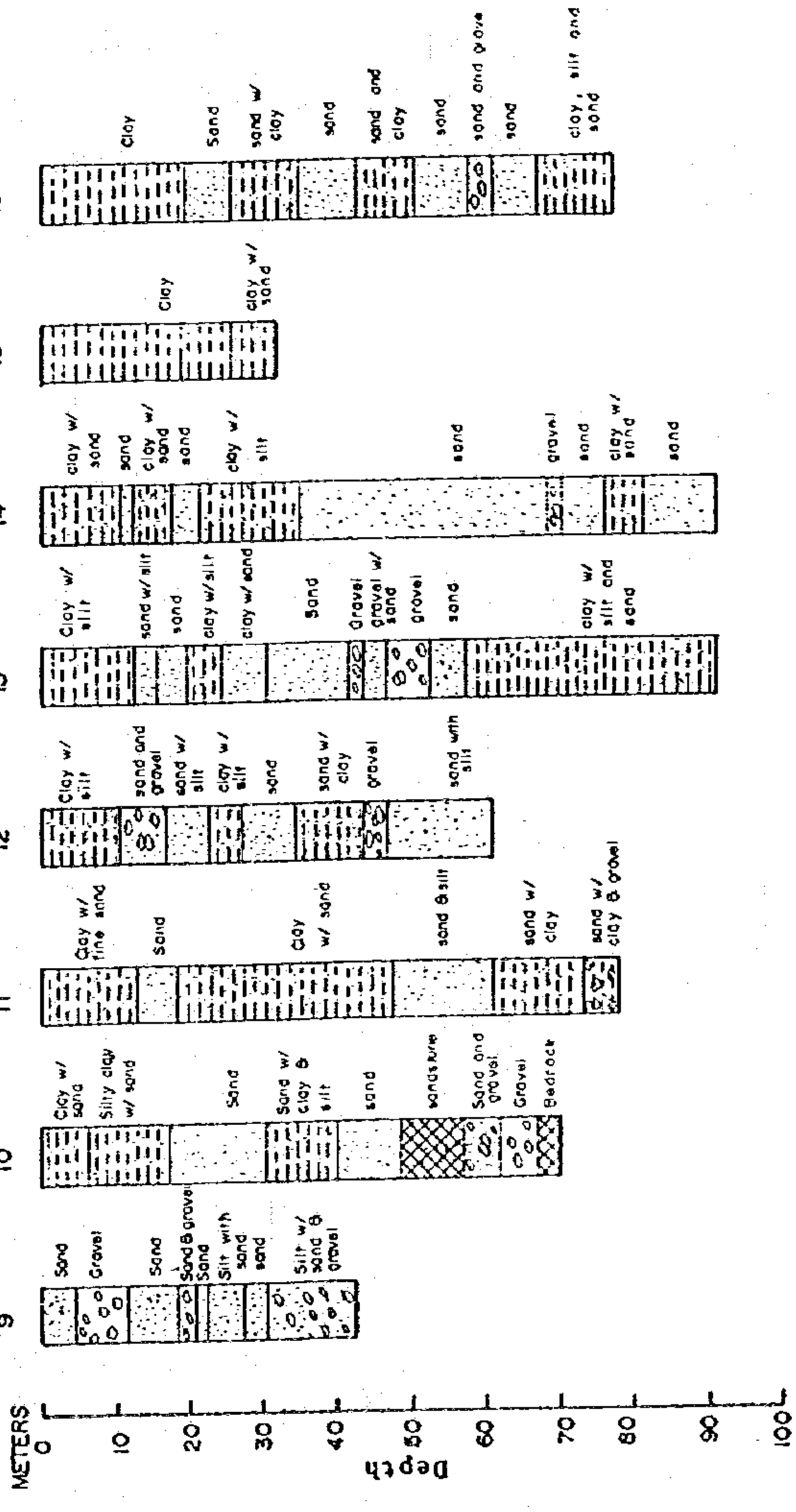


Fig 6-2 Columnar Sections of Wells
(The number is the same as that of the drilled wells shown in Fig. 5)

3) Lake Area

a. Water quality of shallow groundwater in the east area of the lake is similar to that in the Paoay area.
b. The above-mentioned groundwater is in the small alluvium formed by erosion of the hills.
c. Shallow groundwater in No. 1 well, situated within 50 m from the lake shore, has low salinity.

4) Dune Area

a. Deep groundwater has low salinity, 2.5 ppm and 22.5 ppm as chloride.
b. Formations to 67 m in depth consist mainly of sand.

Of all the above descriptions, significant aspects with regard to to groundwater are summed up as follows;

1) Groundwater in deep wells in the Paoay area has salinity of average 1000 ppm.
2) The salinity of shallow groundwater is fairly lower than that of deep groundwater.
3) The groundwater in the dunes has low salinity compared with the groundwater in the alluvium.

As is known in the above, shallow groundwater can be used for drinking, but deep groundwater, if its utilization is required, must further in detail be investigated. With regard to salinity, such aspects as its concentration, its distribution over the area and others give constraints to the use of such groundwater. Among such aspects, the cause of salinity has a bearing on the future variation of salinity, so some consideration is given to conceivable causes as follows.

Though shallow and deep groundwater in alluvium has fairly different salinities, its origin is considered to be same. For existence of salinity in the groundwater, three potential causes will be mentioned, namely, (1) salt transported from the sea by winds, (2) intrusion of sea water, (3) connate water. The first causes will be negated because salt particles are not transported far into inland areas, falling only on seaside area. The second causes will also be negated, for the water level of the shallow groundwater is above sea level. Finally, the third cause may be very probable. As mentioned in the previous paragraph, salinity in the shallow groundwater is fairly lower than that of the deep groundwater. This fact can be estimated as follows: Its may be due to the facts that the connate water in the shallow portion has been diluted by rainfall.

(2) Groundwater Conditions in Laoag

The groundwater conditions in the alluvium distributed along the Laoag River are examined. The area has many deep wells sunk by Ministry of Public Works. Locations of the wells are shown in Fig 7, details of the wells in Table 4, and columnar sections of the wells in Fig 8.

The columnar sections show that the alluvium consists mainly of the following geologies.

1) Layer of sand, and clay or silt is in depth from 0 m to 5m.
2) Layer of sand, sand and gravel, or sand with clay is in depth from 5 m to 80 m.
3) Bed rock is 80 m in depth.

The sand, the sand and gravel, or the sand with clay or silt layers belong to the alluvium. The bed rock is assumed to be the silt and/ or the clay layers of Pliocene-Pleistocene from geological structure in the study area.

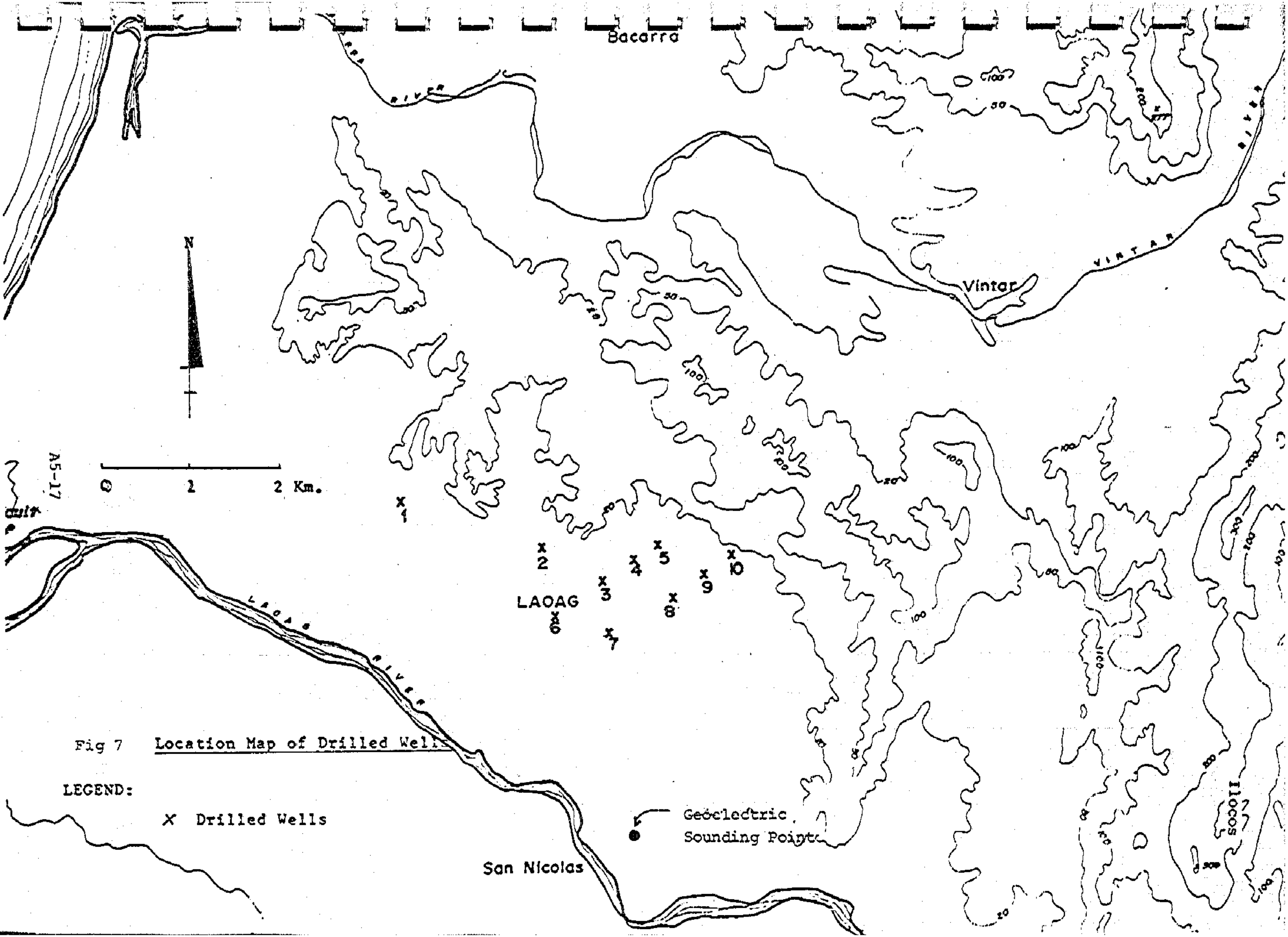


Fig 7 Location Map of Drilled Wells

Table 4 Well Data in Laoag City

Well Number	Sampling Date	Casing Diameter	Well Depth	Static* Water Level	Pumping* Water Level	Discharge	Conductivity	pH	Cl^{-1}
1		150 mm	61.0M	2.44M	16.46M	7.38 lps	μ℧/cm		ppm
2		150	48.78	3.35	11.89	5.36			
3		150	48.78	3.09	12.2	13.0			
4		150	57.93	1.52	9.15	11.18			
5		150	54.88		5.5	7.44			
6		150	86.28	1.22	10.98	12.1			
7		150	53.93	2.74	6.1	7.95			
8		150	46.34	0.20	10.06	6.12			
9	10-16-81	150	48.78	0.91	5.79	10.0	700	7.4	90
10	11-26-81	150	50.3	2.44	8.54	9.58	480	7.5	180

*Static water level (G.L. minus)
Pumping Water level (G.L. minus)

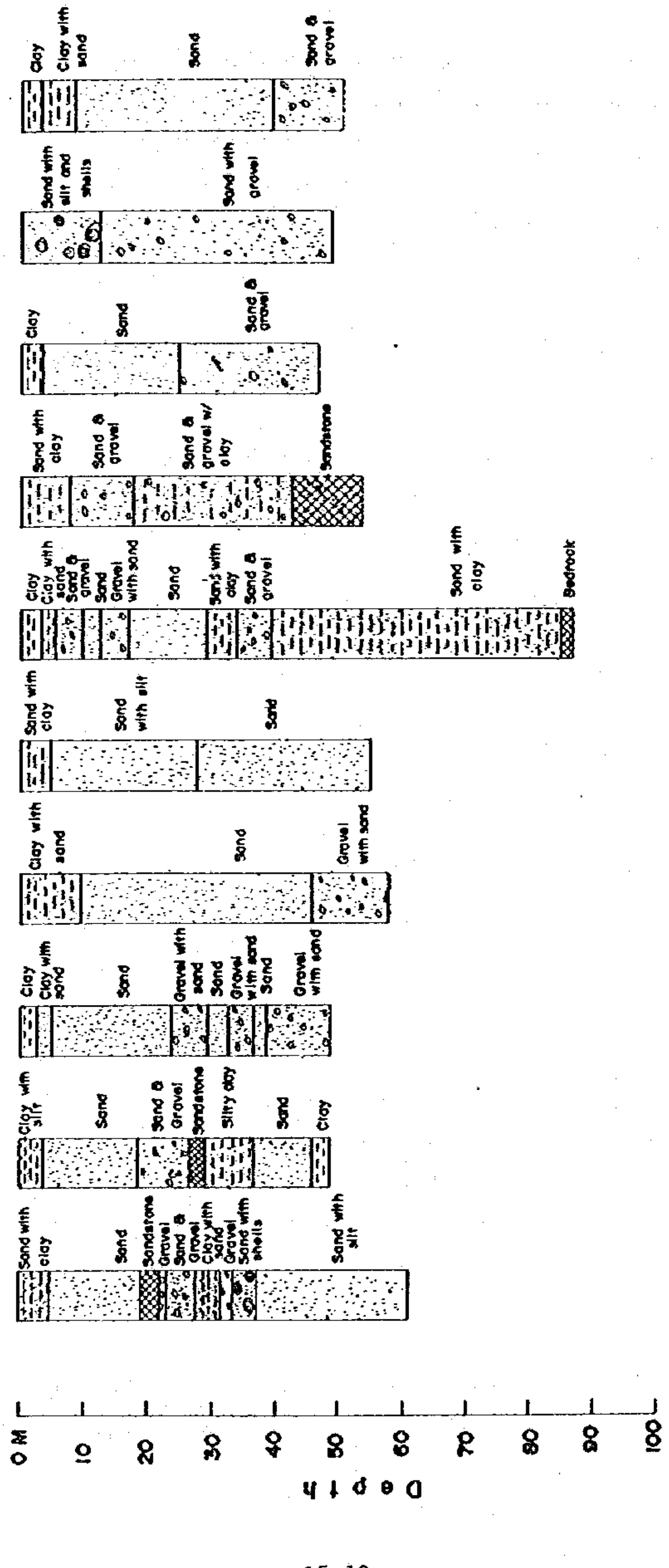


Fig 8 Columnar Sections of Wells shown in Fig 7

Ilocos

The deep wells have strainers in the alluvial deposits. Their static water levels are shallow ranging 1.2 m to 3.2 m below the ground level. Groundwater of the area is in unconfined condition. Water quality of representative wells shows that chloride concentrations are within the range of portable water.

(3) Springs

As regards springs, small spring is located in the hill in Sta. Cruz, south of Paoay. As its catchment area is very small, the yield is not much.

In Vintar and Pasuquin, there are many springs with much discharge, such as the Barangobong spring in vintar, the Dilumot, Bararin and Mangangori springs in Pasuquin.

The springs are found in caves, which are described in 3. Geology, in the mountains in the north of Pasquin. One of such caves, the Bararin spring, has the following dimensions: roughly, 4 m in width, 2.5 m in height and 13 m in length. As the caves have many fissures running in every direction, much groundwater, it is considered, seeps out in the caves.

The discharge of these springs reflects with a good response the changes in precipitation which finds its way into the fissures.

4.4 Lake

Paoay Lake is situated in the northern part of Paoay. It has no streams of inflow and outflow. The area of the lake is about 336 sq km and the water level is around 23 m above sea level.

The depth at five points in the lake, measured in the present field survey, is shown in Table 5 and a fathogram of the lake in Fig 9.

As seen in the table, the biggest depth measured is 5.6 m, and the larger part of the lake has an almost constant depth.

The lake is surrounded by the dunes on the west and by the hills of Pliocene-Pleistocene formation in other areas. The lake water is recharged by surface run-off and groundwater from the hills in addition to rainfall, evaporates from the lake surface, and infiltrates through the dunnes into the sea. The catchment area of the lake is shown in Fig 9, and topographic cross section of that in Fig 10. The catchment area is not large. Due to the poor aquifers of Pliocene-Pleistocene formations and the small catchment area of the lake, the water level of the lake goes down in the dry period.

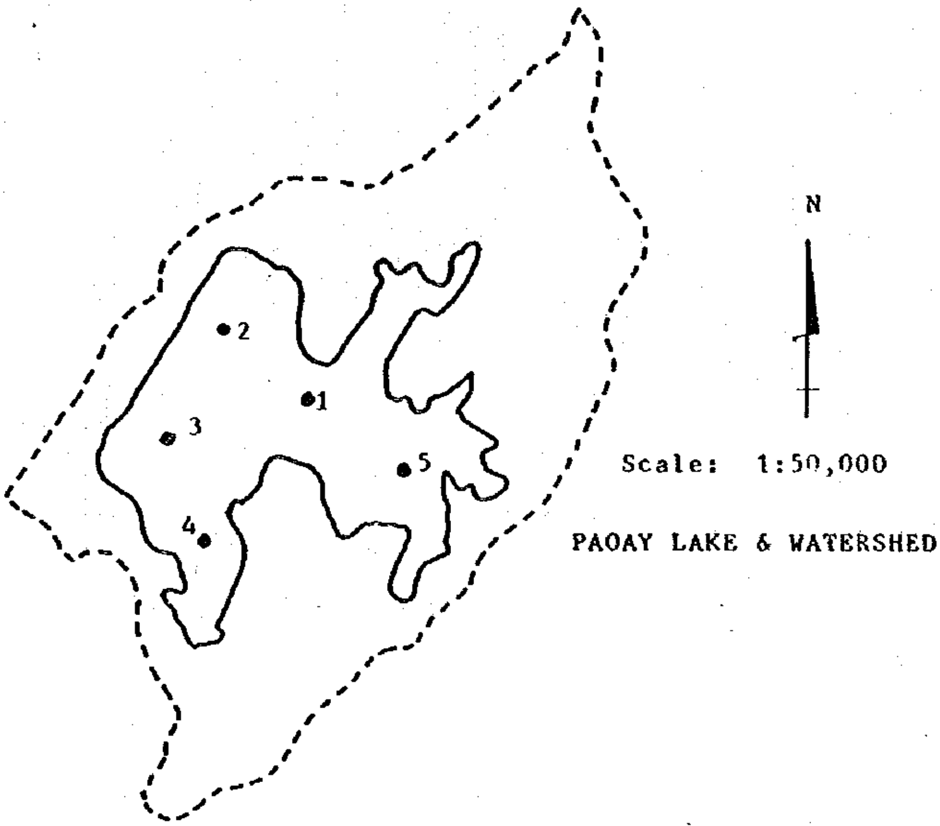


Table 5 Water Depths (See above Figure)

Point No.	Depths
1	5.6 m
2	5.1
3	5.2
4	4.5
5	5.5

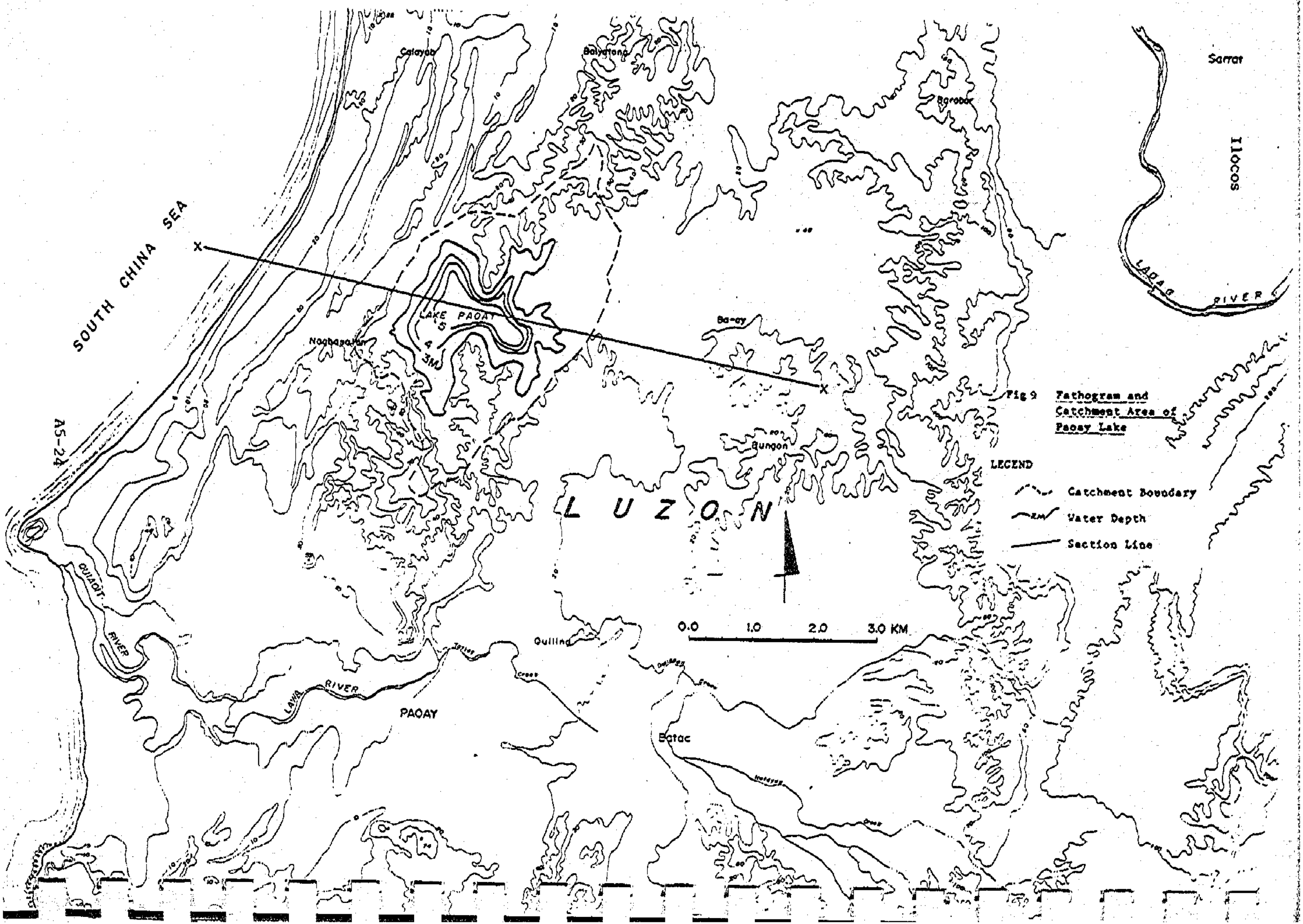


Fig 9 Pathogram and Catchment Area of Paoay Lake

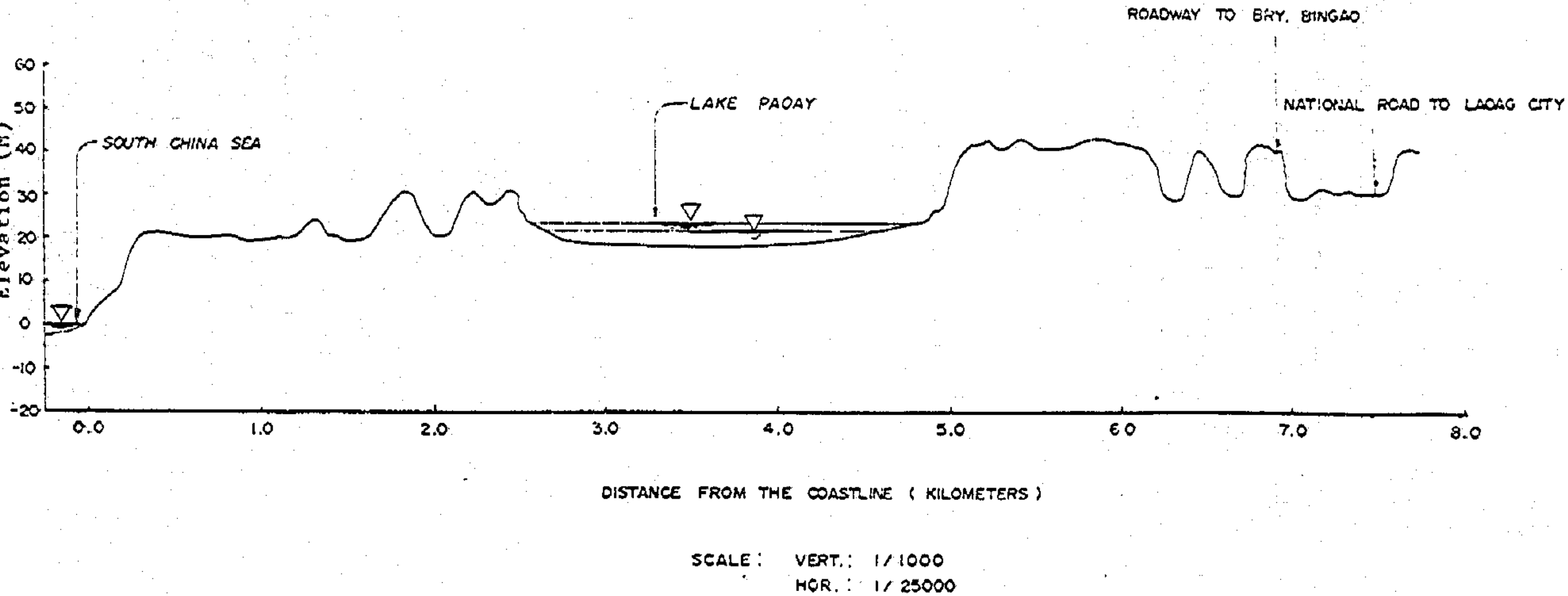


Fig 10 Topographic Cross-section of Paoay Lake
(along Line X - X' in Fig. 9)

5. Hydrogeology

As was stated in 2. Topography, the study area is formed of dunes, alluvium, hills and mountains. Since the hills consist of the old formation of Pliocene-Pleistocene, they have generally no good aquifer.

The alluvium is composed mainly of silt, sand and gravel, and has good aquifers. In the present field surveys, the condition of aquifers was studied in employing geoelectric resistivity survey in Paoay and Laoag as follows:

(1) The Paoay Area

The measured point, and the contour line of the base of the alluvium revealed by the survey, are shown in Fig 11. The deepest portion of the alluvium is from 30 m to 40 m below sea level in the N-S direction reaching the urban area of Paoay and Batac. The depth of the base becomes shallower approaching the hills of the Pliocene-Pleistocene formations.

Analytical results of the geoelectric resistivity survey are also shown in Fig 12. The alluvium (Ql) extends with a thickness from 40 m to 70 m and is underlain by the Pliocene-Pleistocene formation (N-Ql) in the A cross section. In the B cross section, the alluvium is overlain by the dunes with a thickness from 13 m to 15 m in the west of Paoay. The alluvium has a thickness of 24 m to 50 m and are bordered by the hills of Pliocene-Pleistocene formations. In the C cross section, the alluvium is underlain by the upper formation of Pliocene-Pleistocene (N-Q2), forming the hills. The alluvium has a basin elongated in the N-S direction. The groundwater, it is considered, is recharged from the hills and stored in the basin, and flows toward the sea. From the large extent of the alluvium, the groundwater storage is considered to be enormous. The groundwater is at present undeveloped and left for future exploitation.

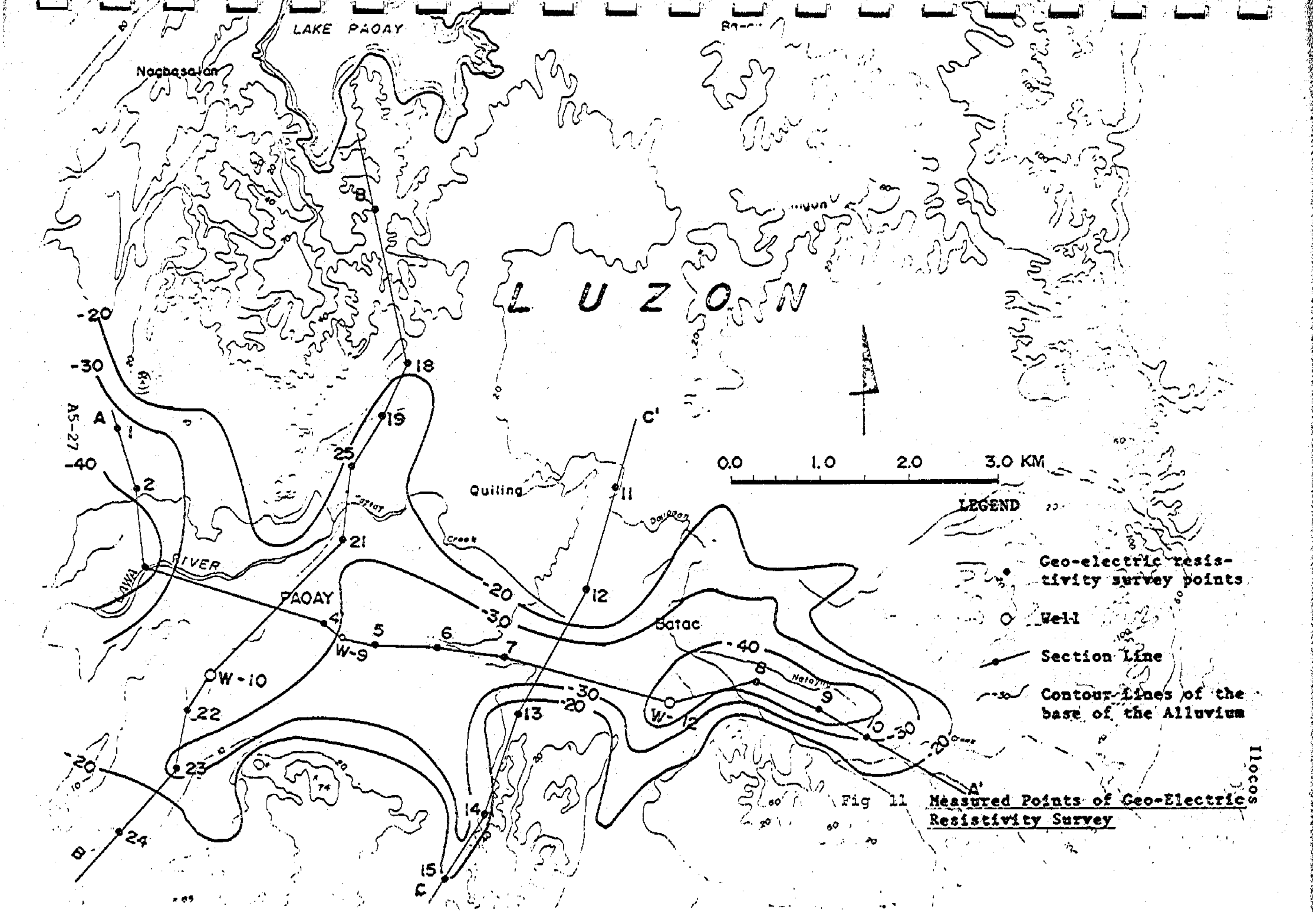


Fig 11 **Measured Points of Geo-Electric Resistivity Survey**

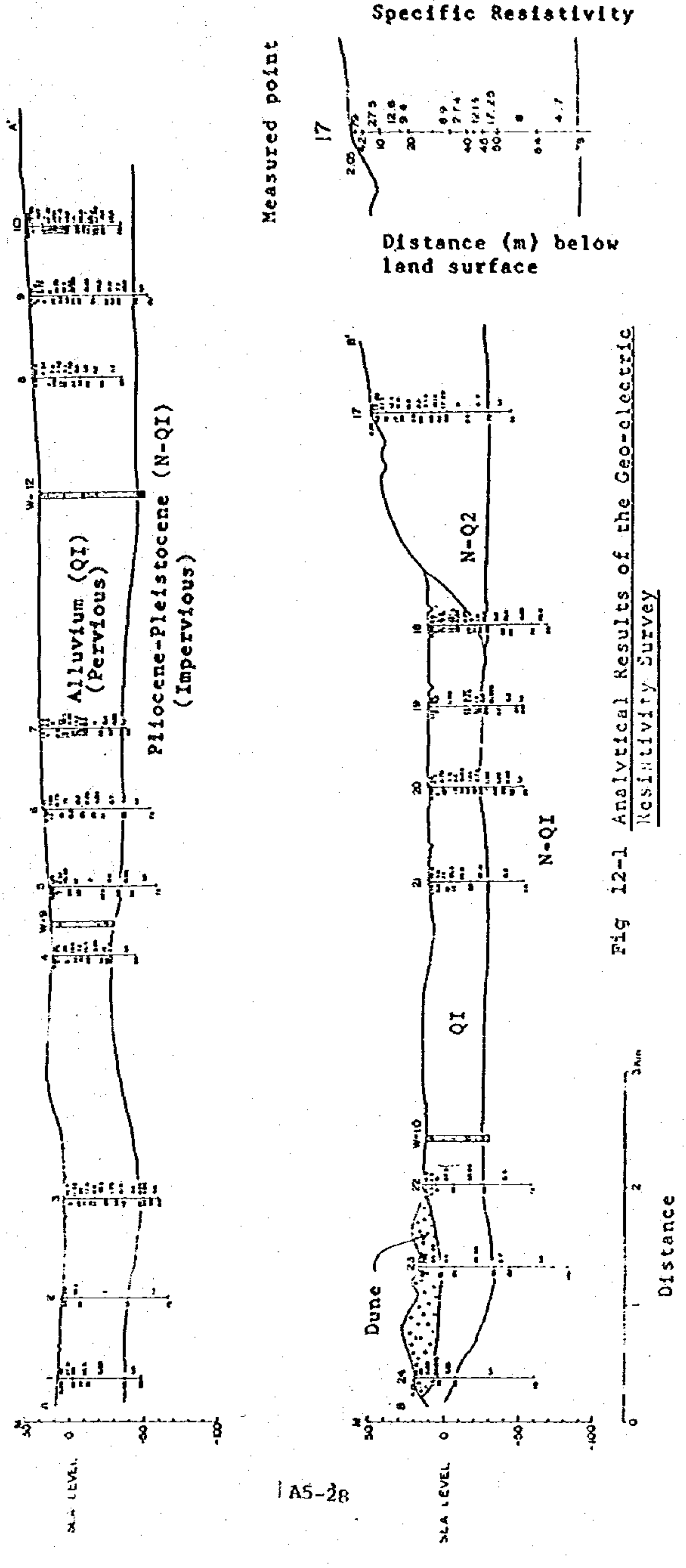


Fig 12-1 Analytical Results of the Geo-electric Resistivity Survey

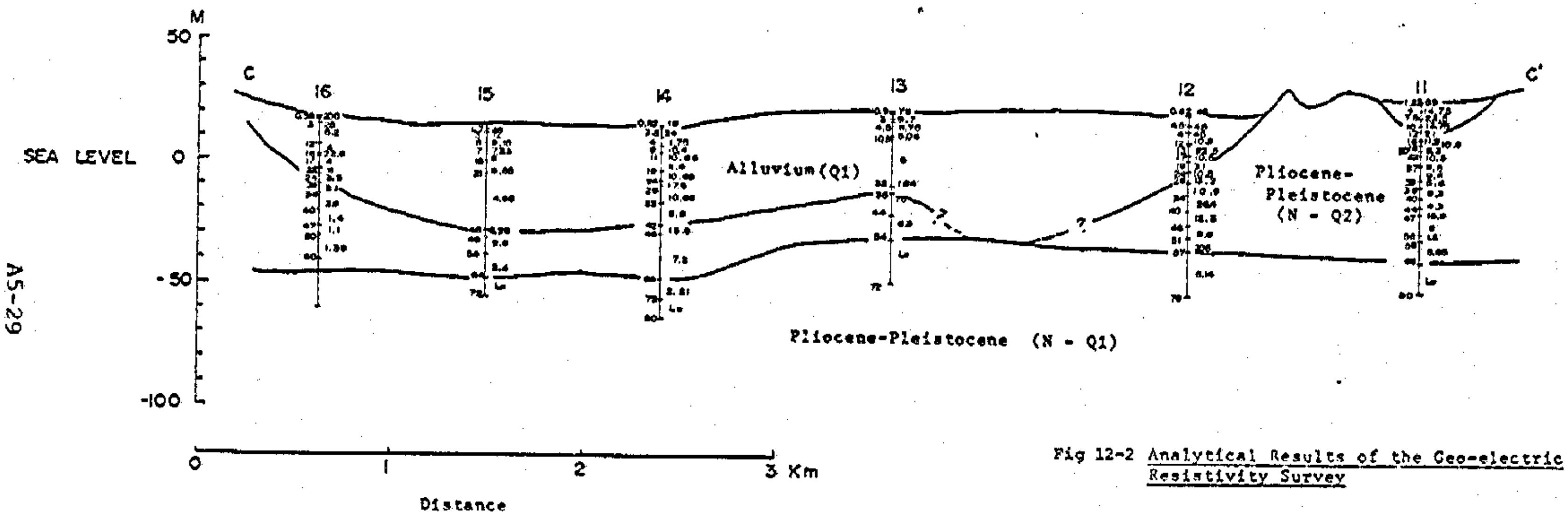


Fig 12-2 Analytical Results of the Geo-electric Resistivity Survey

The dunes are made up of medium sand and have high permeability. Aquifers found in the dunes have groundwater with good water quality, as stated before in deep wells north of the lake. But the availability of such groundwater is not much, because the catchment area is quite limited between the sea and hills.

(2) The Laoag Area

The location of the resistivity survey is shown in Fig 7. The results of the survey show geological structures of alluvium as follows:

1) Layer of sand and gravel is in depth from 0m to 4 m.
2) Layer of gravel and silt is in depth from 4 m to 20 m.
3) Layer of silt and/or clay is in depth more than 20 m.

The sand and gravel layer is of the same origin as the sediments of the present riverbed; the gravel and silt layer belongs to the alluvium, and the silt and/or the clay layer is of sediments of Pliocene-Pleistocene.

6. Evaluation of Water Resources

6.1 Rivers

The river water of the Laoag and Bacarra is one of the important water sources for water supply. Currently, riverbed water is tapped from the two rivers, by means of infiltration gallery.

Both rivers have each a vast drainage area and great discharge. The discharges of the two are 561,000 cu m/day and 328,000 cu m/day, respectively, even at their minimum. Furthermore, the two rivers have wide major beds which are composed mainly of sand and gravel, and exposed all the time only except occasions of flood. Such beds are suited for intake of riverbed water. They are conveniently located fairly close to the densely-populated poblacions in the study area.

As for future utilization of the two rivers for water supply, their riverbed water is most promising. The riverbed water will be taken by way of similar structures to the existing infiltration gallery. A well-designed infiltration gallery will possibly produce more water than the existing one, and the water quality will be improved by locating such structures at an appropriate place and designing a more elaborate construction.

Further, possibility of the Lawa River as a water source for water supply is examined. The estimated daily minimum discharge is 77,000 cu m/day. The quantity is enough for requirement of water supply. Also, the chloride concentration of the river water measured during the field survey was 130 ppm, which is within drinking standard.

Therefore, it is considered that the river has a possibility for utilization of water supply. Before the actual development of the river water, measurements on the discharges and the water qualities will be needed by following reasons,

(1) The area has an extremely low monthly average precipitation of 25 mm during dry season. The season will often have no rain period. Consequently, the discharge of the river water will extremely decrease.
(2) The river may have water pollution due to domestic drainage from the Paoay and the Batac towns.
(3) Water quality was examined on a rainy day when rainfall will dilute the river water.

6.2 Springs

Characteristic features of springs in the mountainous area in the north of the study area are summed up as follows:

1) Most springs flow out of caves formed of quartziferous lavas.
2) Such springs are groundwater flowing through fissures.
3) Spring yields fluctuate with rainfalls.
4) Present usage from the springs is roughly equal to the yield thereof in the dry season.

From the above, it is concluded that the present intake should be continued. And it is recommendable to monitor continuously the intake quantity by installing a bulk meter at the start point of the transmission line.

6.3 Paoay Lake

The lake is considered to be a potential water source for water supply in the Paoay poblacion. Possibility, therefore, as a water source is checked in the following.

First, recharge of the lake is calculated using available data by the following equation.

$$R = P \times A_1 - E_1 \times A_2 - E_2 \times A_3$$

where

R :	Recharge of the lake (cu m)	
P :	Precipitation (m)[1]	2.098
A_1:	Catchment area of the lake (sq m)	11,660,000
E_1:	Annual open pan evaporation[1] (m)	2.149
A_2:	Lake area (sq m)	3,360,000
E_2:	Evapotranspiration (m)	1,504
A_3:	Catchment area less lake area (sq m)	8,300,000

By the above equation and data, recharge is calculated as R = 4,760,000 cu m/year. This recharge balances with the water volume which goes out of the lake, as seepage, into the dunes located west of the lake.

As will be noted in the above calculation, a large amount of water, about 5 million cu m/year is lost from the lake as seepage. On the other hand, also to be noted, evaporation from the lake surface has a far bigger value than evapotranspiration from the land surface. When therefore, the above facts are considered, there appears to be possibility of taking water from the lake without affecting much the present use of the lake. Namely, 1) seepage water may be caught on its way to the sea, or 2) lake water may be directly withdrawn, provided that (I) some area of the lake is reclaimed so as to reduce the evaporation, or (II) some lowering of the water-surface level is allowed so as to decrease the lake surface leading to reduce the evaporation. The above three alternative methods will be checked as below.

---

(1) Precipitation data: the mean value (1951-75)
Open pan evaporation data: the mean value (1961-1965)
Source: Ilocos, Laoag River Basin[5/]

(1) Seepage Water in the Dune

Water requirement of the Paoay poblacion at the end of Phase II is about 0.32 million cu m/year, less than a tenth of the seepage water 4.76 million cu m/year. The seepage takes place all through the dunes west of the lake, with some portion from the lake bottom. This water may be trapped by way of shallow well or radial well or infiltration gallery in the dunes, preferably where outcrops of groundwater are found.

(2) Direct Withdrawal I of Lake Water

When reduction of loss of water by reclamation of the lake surface is made to equal the water requirement, withdrawal from the lake is possible, maintaining the water level of the lake as it is. For this method, an area of 0.5 million sq m of the lake has to be reclaimed as shown in Calculation 1.

(3) Direct Withdrawal II of Lake Water

When the water level of the lake falls, the lake surface area decreases in proportion, resulting in reduction of loss of water by evaporation. If such fall of the water level is permitted until the loss reduction equals the water requirement, withdrawal of water from the lake is possible. The required drawdown of water level is 81.3 cm, as shown in Calculation 2.

When the above three alternatives are compared, the case 1 is more preferable, because it does not require any water treatment and have any adverse effects on fishery in the lake, and further does not affect aesthetically the scenery of the lake and its environment. With regard to construction cost, the three alternatives are considered not much different.

For implementation of any one of the three alternatives detailed investigations of facility design factors are essential. The case 1, especially, requires hydrogeological investigations to determine necessary intake facilities.

Calculation 1. Area to be Reclaimed

The difference between evaporation and evapotranspiration is assumed to be utilized by way of reclaiming a certain area of the lake. If this quantity is made equal to the necessary water withdrawal, the following equation will be formulated.

$$A_r\ (E_1 - E_2) = Q$$

where

A_r:	Area to be reclaimed (sq m)	
E_1:	Annual open pan evaporation (m)	2.149
E_2:	Evapotranspiration (m)	1.504
Q :	Water withdrawal (cu m/year)	320,000

Therefore, A_r is computed as 496,000 sq m.

Calculation 2. Drawdown of Lake Water Level

The area obtained in Calculation 1 is equivalent to an area of the lake surface to be dried up, which can be obtained by lowering the water level by x m. Therefore, the following equation is formulated.

$$x\ a = A_r$$

where

x : Drawdown of water level

a : Decrement of the lake area by lowering water level, which is expressed as

$$a = (A_0 - A_1) / 1\ (m^2/m)$$

where

A_0: Original lake area (3,380,000 sq m)

A_1: Lake area when water level is lowered by 1 m (2,800,000 sq m)

A_r: Area to be dried up (496,000 sq m)

From the above, x is calculated as 0.855 m.

6.4 Groundwater

Groundwater conditions in the Paoay study area are recapitulated from the description in previous subsections of 4.3 Groundwater and 5. Hydrogeology as follows:

1) Paoay Area

a. Deep groundwater near the Paoay poblacion has a rather high salinity of about 1000 ppm.
b. Average concentration of salinity in shallow groundwater is about 180 ppm.
c. Formations in deep portions form good aquifers.
d. Formations in shallow portions make poor aquifers.

2) Batac Area

a. The salinity of shallow groundwater is similar to that in the Paoay area.
b. Formations are made up of alternating beds of clay, sand and gravel.

Shallow groundwater in both the Paoay and the Batac areas is good in water quality, but it is difficult to take groundwater in large quantity from the clay and/or clay with sand layer.

During the present field survey, it was found that the groundwater in the Paoay poblacion which is situated near the seashore is saline, perhaps connate water. Quality of groundwater more inland, however, is not confirmed yet. From the estimated storage and recharge[(2)] of groundwater in the alluvial area, the salinity of groundwater in the Batac poblacion and its vicinity may, it is considered, be possibly lower. Therefore, it is recommended to carry out more detailed investigations of groundwater in the said area by analysis of the existing deep well water and additional test borings.

3) Dune Area

a. Deep groundwater has low salinity.
b. Formations are mainly formed of sand.

The groundwater in dune areas has good water quality. Though its recharge area is limited in only dune areas, the storage and the recharge are estimated to be fairly large for widely distributed dunes.

As the groundwater is considered to have possibility as a water source for water supply. In future, hydrological characteristics in dune areas is recommended to be investigated in more detail.

[(2)] The storage and the recharge of groundwater in the alluvial area are roughly estimated to be 516 million cu m and 112 million cu m, respectively.

6.5 Utilization of the Deep Wells in Laoag

The possibility of utilization of the deep wells for water supply, which have been sunk by MPW but are not put in use yet, is examined as described below.

The groundwater conditions from the previous section 4.3 Groundwater and 5 Hydrogeology are recaptulated as follows:

1) The deep wells have strainers in the alluvial deposits.
2) The alluvial deposits have a thickness about 80 m in the vicinity of Laoag.
3) The alluvial deposits are underlain by the impervious Pliocene-Pleistocene layers.
4) Sediments of the riverbed and the alluvium are common and continuously spread.
5) The groundwater in the alluvial layers is in unconfined condition.
6) The water quality is suitable for water supply.

From the above, especially items 4) and 5), the existing wells will possibly take in groundwater being recharged by the River.

Potential well yield is examined from the following two aspects, (1) well structure, (2) well discharge calculated from maximum inflow velocity (well discharge).

1) Well Structure

All the strainers of the wells are of slotted pipe made by torch-cut, and besides some strainers are situated too shallow, so their production will naturally be limited. If withdrawal is excessive, running water level falls down below the strainer.

2) Well Discharge

On assumptions that maximum velocity flowing into wells is 15 mm/sec, and opening ratio of slotted pipe is 3% of surface area, maximum discharge (Q) is estimated from the following equation:

$$O_A = 2R \times L \times 0.03$$

$$Q = O_A \times V$$

where,

R : Radius of well casing

L : Length of strainer

O_A : Total area of slot openings in slotted pipe

V : Maximum inflow velocity of groundwater through slot openings

Q : Maximum well discharge

As results of the calculation, maximum well discharge (Q) ranges from 330 cu m/d to 660 cu m/d.

Taking into account all the above, the existing deep wells are considered usable for water supply. Allowable productions of the wells determined under conditions of 1) well structure and 2) well discharge as shown above range from 330 cu m/d to 550 cu m/d. However, the actual withdrawal of each well shall be examined in detail by the execution of pumping tests during the stage of detail design.

REFERENCE

1/ Bureau of Mines (1963); The Geological Map

2/ PAGASA (1974); Annual Climatological Review

3/ NWRC (1976); Principal River Basins of the Philippines

4/ DPWTC (1963, 1966, 1967, 1969); Surface Water Supply of the Philippines

5/ NWRC (1979); Ilocos, Laoag River Basin

Appendix 6 Socio-Economic Study

1. Economy of the Study Area

1.1 Primary Industries

The study area, although becoming urbanized, basically depends upon primary industries such as agriculture, forestry, fishery and live-stock raising. (See Tables 1, 2 and 3).

1.1.1 Agriculture and Forestry

Agricultural resources in Laoag are abundant and the fertility of the soil permits an intensive agricultural production. Approximately 37% of the total labor force in the city are farm workers, and about 52% represents the portion of the population dependent on agriculture for their livelihood.

Bacarra, Pasuquin, Paoay, and Vintar are also basically agricultural municipalities, but they depend in part upon forestry. Particularly in Vintar, 55% of its land use is directed to forestry. (See Table 1).

The leading crops of the study area are rice, corn, garlic, tabacco, mango, sugarcane and vegetables (See Table 4). Rice dominates all other, but virginia tobacco is considered important as a money-earning farming.

1.1.2 Livestock and Poultry

Live stock and poultry follow rice and other agricultural products both in value and quantity. They are more lucrative and are contributing to augmentation of the farm income (See Table 5).

1.1.3 Fishery

Fishery is a neglected industry in the study area. It remains a small-scaled coastal fishing, with its catch insufficient to meet the demand of the area (See Table 6).

1.2 Manufacturing

The manufacturing industries in the study area are mostly cottage industries. There are 261 NACIDA° registered cottage industries with a total capitalization of ₱822,961 as of 1979. Most (232 establishments) of them are located in Laoag. The leading types of manufacturing are food-processing, food-preservation, ceramics, wood-crafts and metalcrafts (See Table 7).

1.3 Commerce and Services

Commercial and service establishments in the study area are small-scaled and they amount approximately 2,300 in number. Most heavy trading activities center around the public market in Laoag, which has been developed as the primary distribution center of the province for agricultural products. Commerce ranges from wholesale to retail, and its dealing covers agricultural products and daily necessities mostly. Typical service establishments are of such types as motor-repair shops, restaurants, beauty shops and funeral services.

1.4 Income Distribution

The survey conducted by the National Census and Statistics Office, Ilocos Norte, revealed that the yearly average household income in the Province of Ilocos Norte as a whole amounted to ₱3,226, while that in the urban districts to ₱3,648 and that in the rural districts

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Note: ° National Cottage Industries Development Authority to ₱2,979 (See Table 8). No data were available as to the income distribution of Laoag and the four municipalities under study, with exception only of that for Bacarra which showed that the average household income in the municipality as a whole ₱2,850.04 in 1978, while that in the urban districts ₱4,128.55 and that in the rural district ₱1,890.00.

1.5 Employment

Of the population 10 years old and over, those in the labor force, as revealed by the 1978 Updated Settlement Profile, amounted to 37.3% in Laoag, 40.2% in Bacarra, 35.5% in Paoay, 44.9% in Pasuquin and 48.8% in Vintar. The unemployment rate in the study area ranged from 1.5% (in Paoay) and 9.3 (in Bacarra).

Table 1 Existing Land Uses, 1980

(Sources of Data: Laoag City Development Office and Provincial Executive Office, Ministry of Agriculture)

Existing Land Uses	Laoag City	Bacarra	Pasuquin	Paoay	Vintar
1) Agriculture	10,939 (81.10%)	4,454 (57.40%)	2,556 (13.40%)	2,726 (34.95%)	5,550 (10.62%)
2) Forest Reserve	262 (2.05%)	1,623 (21.08%)	5,190 (27.21%)	1,756 (22.51%)	28,773 (55.06%)
3) Upland Pasture & Open Space	57 (0.45%)	625 (8.12%)	8,145 (42.70%)	1,307 (16.76%)	10,000 (19.14%)
4) Built-Up Areas	1,326 (10.40%)	258 (4.86%)	135 (0.71%)	620 (7.95%)	990 (1.89%)
5) Others	763 (5.99%)	740 (9.61%)	3,049 (15.98%)	2,011 (25.78%)	6,947 (13.29%)
Total	12,747 (100%)	7,700 (100%)	19,075 (100%)	7,800 (100%)	52,260 (100%)

Table 2 Employment Size, Ilocos Norte Province
(Data Source: 1975 Population Census)

1)	Agriculture, Forestry and Fisheries	66.7%
2)	Mining and Quarrying	0.5%
3)	Manufacturing	5.1%
4)	Electricity, Gas and Water	0.3%
5)	Construction	3.8%
6)	Commerce	5.3%
7)	Transportation, Communication and Storage	3.5%
8)	Services	14.8%
	Total	100.0%

Table 3 Workers By Major Industry
[Data Source: Socio-Economic Profiles of Bacarra (1978), Pasuquin (1980) and Vintar (1980)]

		Bacarra	Pasuquin	Vintar
1)	Agriculture, Hunting, Fishing	80.0%	63.4%	79.2%
2)	Mining and Quarrying	-	4.2	0.3
3)	Manufacturing	-	2.6	6.5
4)	Electricity, Gas and Water	-	-	-
5)	Construction	1.2	8.4	4.3
6)	Commerce	2.6	4.2	1.0
7)	Transportation/ Communication and Storage	2.0	1.2	2.3
8)	Services	13.0	13.0	4.1
9)	Not Adequately Described	1.2	2.6	2.3

Table 4 Five Leading Crops of Study Area, 1980

(Source of Data: Laoag City Development Office and Provincial Executive Office, Ministry of Agriculture)

	Name of Crop	Area (ha)	Annual Production (MT)	Annual Yield (MT/ha)
Laoag	1) Rice	3,600.0	14,400	4.0
	2) Corn	580.0	1,160	2.0
	3) Mango, Togue	500.0	1,000	2.0
	4) Garlic	450.0	1,575	3.5
	5) Sugarcane	200.0	800	4.0
Bacarra	1) Rice	4,454.0	18,279.5	4.1
	2) Tobacco	850.0	No data	No data
	3) Garlic	1,000.0	18.0	0.0
	4) Corn	540.0	179.2	0.3
	5) Mango, Togue	270.0	No data	No data
Pasuquin	1) Rice	2,256.9	8,463.6	3.7
	2) Corn	172.7	518.1	3.0
	3) Vegetables	237.4	712.2	3.0
	4) Sweet Peas and Beans	229.4	688.2	3.0
	5) Garlic	327.2	1,636.1	5.0
Paoay	1) Rice	2,148.0	5,370.0	2.5
	2) Corn	1,100.0	1,825.0	1.6
	3) Garlic	850.0	2,550.0	3.0
	4) Sweet Peas and Beans	200.0	160.0	0.8
	5) Vegetable	100.0	600.0	6.0
Vintar	1) Rice	3,046.5	10,061.0	3.4
	2) Corn	572.0	6,006.0	10.5
	3) Garlic	305.5	7,637.5	25.0
	4) Tobacco	288.5	288.5	1.0
	5) Peanuts	235.0	282.0	1.2

Table 5 Livestock and Poultry Animal Population, 1980
(Source of Data: Laoag City Development Office and Provincial Executive Office, Ministry of Agriculture)

	Laoag	Bacarra	Paoay	Pasuquin	Vintar
a. No of Farms	12	No data	5	4	24
b. No. of Animals					
1) Carabao	1,843	2,180	1,405	2,139	4,013
2) Cattle	3,160	843	1,836	9,225	3,726
3) Horse	504	50	-	56	317
4) Swine	4,246	3,928	2,696	4,307	7,410
5) Goats	2,131	939	1,354	765	4,986
6) Chicken	67,775	35,618	14,540	35,621	21,832
7) Ducks	594	594	-	57	-

Table 6 Fishery
(Source of Data: Laoag City Development Office and Provincial Executive Office, Ministry of Agriculture)

	Laoag	Bacarra	Paoay	Pasuquin	Vintar
1) Fishpond/Fishpen operation					
a. Total Area (has)	30.8	2.0	11.5	22.0	-
b. Annual production (MT)	30.0	2.8	12.5	220.0	-
2) Offshore/Coastal Fishing					
a. Total tonnage (fishing vessels)	1,495.2	-	-	-	-
b. Annual fish catch (MT)	1,744.0	-	-	-	-
3) Inland Fishing					
a. Total number (fishing boats)	516.0	-	24	24	No data
b. Annual fish catch (MT)	1,032.0	-	40.0	No data	6,387.5

Table 7 Manufacturing Cottage Industries Registered with Nacida as of 1980
(Source of Data: NACIDA, Ilocos Norte)

	No. of Operators	Employment	Capitalization
Laoag	232	1,300	₱752,061.00
Bacarra	29	58	70,900.00
Paoay	-	-	-
Pasuquin	-	-	-
Vintar	No data	No data	No data

Table 8 Income Distribution, Ilocos Norte, 1980
(Source of Data: National Census and Statistics Office, Ilocos Norte)

Income Class	Urban		Rural		Total	
	Percent	Ave. Value	Percent	Ave. Value	Percent	Ave. Value
Under ₱249	1.64%	₱ 180	5.77%	₱ 118	4.24%	₱ 127
₱250-499	6.27	408	5.77	425	6.1	418
₱500-999	8.20	757	12.50	727	10.91	736
₱1,000-1,999	24.59	1,489	25.96	1,437	25.46	1,456
₱2,000-2,999	26.23	2,457	14.42	2,349	18.79	2,405
₱3,000-4,999	11.48	4,171	14.42	3,941	13.33	4,014
₱5,000-7,499	13.11	6,365	12.50	5,764	12.73	5,993
₱7,500-9,999	1.64	7,583	5.77	8,286	4.24	8,186
₱10,000-14,999	3.28	12,680	2.89	13,096	3.03	12,930
₱15,000-19,999	1.64	16,992	-	-	0.60	16,992
₱20,000-& over	1.64	25,200	-	-	0.60	25,200
Average value per family		₱3,648		₱2,979		₱3,226

Ref:

	Urban	Rural	Total
Average value per family in Bacarra	₱4,128	₱1,890	₱2,890

Source of Data: Socio-Economic Profile of Bacarra, 1978.

Table 9 Labor Force and Employment (Percent)

(Source of Data: 1975 Population Census)

	Laoag	Bacarra	Paoay	Pasuquin	Vintar
1) Population 10 years old and over	100.0	100.0	100.0	100.0	100.0
2) In the labor force	37.3 a/	40.2 a/	35.5 a/	44.9 a/	48.8 a/
- Employed	34.9	36.4	34.9	41.7	43.2
	(93.4 b/)	(90.7 b/)	(95.8 b/)	(92.9 b/)	(88.5 b/)
- Unemployed	2.4	3.7	0.5	3.2	5.6
	(6.6 c/)	(9.3 c/)	(1.5 c/)	(7.1 c/)	(11.5 c/)
3) Not in the labor force	62.6	59.8	64.4	55.5	51.5

Note: a/ Labor participation rate
b/ Employment rate
c/ Unemployment rate

2. Social Background

2.1 Ethnical and Cultural Characteristics

The original inhabitants of the study area were told to be predominantly Malays. Their cultural characteristics are, as other neighboring areas, largely influenced by the Spaniards who dominated the area more than four hundred years.

The Spaniards found that the inhabitants of the area were diligent and orderly and had a district character and culture much different from their fellow countrymen in the South - - with a different dialect called Ilocano.

Ilocano is now the major dialect of the study area, and is used as the mother tongue by nearly 99% of the population (See Table 10).

The study area is one of few localities wherein Roman Catholic outnumber Aglipayans (81,382 vs. 42,269), and this is considered to be attributable to strong family and ancetral ties. As shown in Table 9.10, however, this is overwhelmingly so only in Laoag and Bacarra. In Paoay, Pasuquin and Vintar, Aglipayans outnumber Roman Catholic (See Table 11).

2.2 Population Structure

As shown in Table 12, the study area has slightly more female than males (48.45% vs. 51.55%), with exception only of Vintar (50.09% vs. 49.91%). More than half of the population in the area are under 20 years old (See Table 13). Of the total population of the area, 67.31% are living in rural areas and 32.69% in urban area (See Table 12).

2.3 Educational Attainment Level

The educational attainment level of the study area is among the highest in Ilocos Norte Province (See Table 14). More than half of the academic degree holders of the province are living in this area, while its population 6 years old and over is no more than 38.43% of that in the province. This is partly due to the fact that the area includes Laoag City, the political, economic and cultural center of the province, whose academic degree holders number 4,319 or 67.54% of the areas' total.

2.4 Dwellings

As the household-to-dwelling units ratio in Table 15 shows, dwelling units outnumber the households in the study area, with exception only of Paoay. It is reported that while the dwelling conditions in Urban districts are getting tighter, the number of vacant dwellings in rural districts are increasing (See Table 16).

As shown in Table 15, single units prevail in Laoag City and in any municipality of the area. Duplex type also abound, but there are some apartments and other types of dwellings but a negligible number of barong-barong. From the viewpoint of construction materials used, most of houses in the poblacions are of strong and mix types, while local light materials such as nipa, and cogon abound in the rural areas.

Table 10 Population by Mother Tongue (Ethnic Origin), 1975
(Source of Data: 1975 Population Census)

Ilocos Norte			
Total	371,724		
Ilocano		365,239	(98.26%)
Apayo or Isneg		1,843	
Tagalog		1,415	
Itneg or Tinggian		719	
Chinese, Mandarin		390	
Others		3,961	
Laoag City			
Total	66,259		
Ilocano		64,856	(97.89%)
Tagalog		581	
Chinese, Mandarin		343	
Pampango		110	
Others		950	
Bacarra			
Total	22,118		
Ilocano		21,943	(99.21%)
Tagalog		54	
Aklanon		24	
Others		97	
Paoay			
Total	15,994		
Ilocano		15,902	(99.42%)
Tagalog		31	
Pangasinan		22	
Others		39	
Pasuquin			
Total	16,258		
Ilocano		16,018	(98.52%)
Tagalog		104	
Cebuano		29	
Bicol		24	
Others		83	
Vintar			
Total	14,142		
Ilocano		14,072	(99.51%)
Tagalog		23	
Cebuano		13	
Others		34	

Table 11 Population Classified by Religion

(Source of Data: Census of Population 1970)

	Raman Catholic	Protestant	Iglesia ni Cristo	Aglipayan	Islam	Budhist	Others	None
Bacarra	14,869	743	354	3,961	-	-	809	-
Laoag	48,108	1,637	1,061	10,468	21	92	315	25
Paoay	6,511	191	204	8,260	-	-	52	-
Pasuquin	5,683	256	621	8,092	-	-	123	-
Vintar	6,211	833	517	11,488	-	-	310	96
Total	81,382	3,660	2,757	42,269	21	92	1,609	121
Ilocos Norte	162,294	10,754	7,651	157,594	21	92	1,609	121

Table 12 Total, Urban and Rural Population by Sex, 1980
(Source of Data: 1980 Population Census)

	Total Population			Urban Population			Rural Population		
	Both Sexes	Male	Female	Both Sexes	Male	Female	Both Sexes	Male	Female
Laoag	69,659	33,240	36,419	32,365	15,016	17,349	37,294	18,224	19,070
Bacarra	23,369	11,387	11,982	8,001	3,740	4,281	15,368	7,647	7,721
Paoay	17,016	8,102	8,914	0	0	0	17,016	8,102	8,914
Pasuquin	17,813	8,833	8,980	4,837	2,229	2,608	12,976	6,604	6,372
Vintar	23,356	11,700	11,656	4,217	2,007	2,210	19,139	9,693	9,446
Total	151,213	73,262	77,951	49,420	22,992	26,248	101,793	50,270	51,523

Table 13 Population by Age Group, 1975
(Source of Data: 1975 Population Census)

Classification	Laoag	Bacarra	Paoay	Pasuquin	Vintar
All Ages	66,259	22,118	15,994	16,258	21,655
Under 1	1,678	586	337	425	585
1 - 4	6,716	2,352	1,532	1,799	2,332
5 - 9	8,448	3,094	1,907	2,191	2,885
10 - 14	7,924	2,831	1,876	2,090	2,706
15 - 19	7,070	2,387	1,581	1,684	2,161
20 - 24	5,796	1,684	1,158	1,227	1,546
25 - 29	4,596	1,410	962	1,044	1,334
30 - 34	3,854	1,330	929	891	1,263
35 - 39	3,643	1,213	859	951	1,252
40 - 44	2,790	918	705	665	942
45 - 49	2,464	940	701	599	883
50 - 54	2,606	832	728	609	876
55 - 59	2,168	634	690	529	779
60 - 64	2,147	646	623	494	754
65 - 69	1,630	567	503	383	525
70 - 74	1,277	423	435	335	394
75 - 79	597	261	205	169	210
80 - 84	360	114	125	105	115
85 and Over	375	96	138	128	113

Table 14 Population 6 Years Old and Over by Highest Grade Completed, 1975
(Source of Data: 1975 Population Census)

	Laoag City	Bacarra	Paoay	Pasuquin	Vintar	Total	Ilocos Norte
No Grade Completed	6,478	2,341	1,922	1,752	2,530	15,023	42,923
Elementary							
1st - 3rd grade	8,507	3,427	2,080	2,619	3,444	20,077	59,170
4th grade	4,671	1,780	1,482	1,527	2,184	11,644	35,225
5th grade	3,199	1,141	913	1,036	1,121	7,410	22,082
6th & 7th grade	11,861	4,205	3,326	2,729	4,910	27,031	66,281
High School							
1st - 3rd year	6,435	2,211	1,400	1,582	1,557	13,185	32,388
4th year	4,795	1,396	1,127	1,108	890	9,316	21,479
College (No Degree)							
1st - 3rd year	4,175	991	579	687	653	7,085	14,918
4th year or Higher	580	103	85	43	61	872	1,822
Academic Degree Holder	4,319	753	466	402	455	6,395	11,483
Not Stated	1,099	173	336	170	348	2,126	4,876
Total	56,119	18,521	13,716	13,653	18,153	120,162	312,647

Table 15 Dwelling Conditions, (1980)

(Source of Data: 1980 Population Census and 1978 Updated Settlement Profiles)

	Laoag	Bacarra	Paoay	Pasuquin	Vintar
1) Number of Households	13,675	4,643	3,349	3,466	4,675
2) Number of Dwelling Units	13,682	4,712	3,275	3,556	4,689
3) Households-to-Dwelling Units Ratio	0.999:1	0.985:1	1.002:1	0.975:1	0.997:1
4) Percentage Distributing of Dwelling Units by Type of Dwelling					
a. Single	94.4%	98.6%	97.7%	97.1%	98.3%
b. Duplex	2.2	0.6	0.8	1.1	0.8
c. Barong-Barong	1.8	0.3	1.2	1.4	0.7
d. Other types	1.6	0.4	0.3	0.3	0.2
5) Percentage Distribution of Dwelling Units by Type of Roofing Materials					
a. Aluminum/Galvanized iron	81.5%	85.6%	64.0%	66.2%	82.3%
b. Asbestos	0.9	less than 0.1	less than 0.1	less than 0.1	less than 0.1
c. Tile/Concrete	0.5	0.2	0.8	1.1	0.4
d. Cogon	12.0	12.1	34.3	30.2	16.9
e. Nipa	4.8	1.6	0.9	2.1	0.2
f. Others	0.3	0.5	less than 0.1	0.4	0.2

Table 16 Number of Dwelling Units Occupied and Vacant, 1980
(Source of Data: 1980 Population Census)

City/Municipality	Total	Occupied	Vacant
Laoag	13,682	13,323	359
Bacarra	4,712	4,559	153
Paoay	3,275	3,190	85
Pasuquin	3,556	3,406	150
Vintar	4,689	4,581	108

3. Infrastructure

3.1 Land Transportation

Laoag City is served by three PAL flights per week which connects the city to Manila. The city is also served by inter-provincial bus-lines which connect the city with the rest of Luzon.

The study area is being served by approximately 600 mini-buses and jeeps which continuously plying various routes, and by nearly 1,000 motorized tricycles providing spot-to-spot transportation.

The main mode of transportation is that of motorcycles, followed by tricycles and jeepeneys with a small percentage of the population owning cars (See Table 17).

3.2 Roads

The road network of the study area totals 1,250 kilometers. National roads extend 169 kilometers, of which 56.5 kilometers are concrete or asphalt faced. The picture of road condition in the study area looks favorable in comparison with other provinces (See Table 18).

3.3 Waterworks and Sewerage

The study area is being served with a provincial water supply system, with exception of the Municipality of Paoay. The provincial water supply service is, however, poor as delineate in PART ONE. The area does not have sewerage systems. Some residents utilize septic tanks but because of their prohibitive cost, most cannot afford.

3.4 Irrigation Systems

The study area employs both the communal and canal irrigation systems maintained by different private associations and the National Irrigation Administration (NIA). As shown in Tables 19 and 20, there are four NIA systems extending 3,357 hectares and 219 private systems extending 5,857 hectares (See Tables 19 and 20).

3.5 Power

The study area is presently served with electric power by the Ilocos Norte Electric Cooperative (INEC), a semi-governmental entity, which in turn buys its electric power of public consumption from the National Power Corporation (NAPOCOR). As shown in Tables 21 and 22, the ratio of member households to total households amounts to 64.73%. The consumption of the area during the period July 1980 to June 1981 totalled 13,586.493 Kwh, the breakdown of which by type of consumer were:

Residential	56.38%
Commercial	18.64%
Public Building	17.73%
Street Light	1.76%
Industrial	5.49%

The schedule of electric rates, as listed in Table 23, shows that residential consumers using 10 Kwh or less shall be charged ₱7.40 monthly and those using more than 10 Kwh shall be charged ₱0.74/Kwh (See Tables 21, 22 and 23).

Table 17 Transportation Resources in the Study Area
(Source of Data: Bureau of Land Transportation)

Particulars	Number
1) Private jeeps/cars	1,147
2) Public passenger vehicles	672
3) Tricycles	1,261
4) Cargo trucks/buses	980

Table 18 Road Length Source Conditions

	Sourface Conditions			
	Total Length (km)	Gravel & Earth (km)	Asphalt (km)	Concrete (km)
Laoag				
1) National Road	33.333	1.396	16.489	15.448
2) City Raod	61.041	54.037	5.035	1.979
3) City Street	67.441	51.348	12.137	3.957
4) Barangay Road	173.717	173.717	-	-
Total	335.532	280.498	33.661	21.384
Bacarra				
1) National Road	7.500	-	-	7.500
2) Provincial Road	17.310	7.310	2.000	2.000
3) Municipal Road	34.070	34.070	-	-
4) Barangay Road	174.120	194.120	-	-
Total	226.000	215.5	2.000	2.000
Paoay				
1) National Road	15.5	0.5	12.0	3.0
2) Provincial Road	12.8	7.0	1.8	4.0
3) Municipal Road	96.941	76.941	-	-
4) Barangay Road	132.84	130.44	2.4	-
Total	238.081	214.881	16.2	7.0
Pasuquin				
1) National Road	50	28	-	22
2) Provincial Road	63.8	62.408	1.392	-
3) Municipal Road	12.658	6.588	6.07	-
4) Barangay Road	128.981	128.411	0.57	-
Total	255.439	225.407	8.032	22
Vintar				
1) National Road	None	-	-	-
2) Provincial Road	60.5	51.3	7.6	1.6
3) Municipal Road	15.0	9.2	4.7	1.1
4) Barangay Road	120.0	120.0	-	-
Total	195.5	180.2	12.3	2.6
Ground Total	1,250,552	1,120.986	40.532	54.984

Table 19 Irrigation Systems in the Study Area Maintained by National Irrigation Administration as of May 28, 1981
(Source of Data: National Irrigation Administration)

System	Municipality	Service Area (Has.)
1) Laoag-Vintar RIS	Vintar	422
	Bacarra	70
	Laoag	1,799
2) North Main Canal & Pasuquin Extn. I.S.	Vintar	81
	Bacarra	452
	Pasuquin	137
3) Bonga Pump No. 2	Laoag	194
4) Bonga Pump No. 3	Laoag	202
Total		3,357

Table 20 Irrigation Systems in the Study Area Maintenanced by Private Associations
(Source of Data: National Irrigation Administration)

Location	No. of System	Area (Has.)
Laoag City	2	61.42
Bacarra	36	2,362.36
Paoay	19	779.10
Pasuquin	54	1,190.76
Vintar	108	1,463.9
Total	219	5,857.54

Table 21 Number of Consumers Receiving Electric Power Service, (June 1980)
(Source of Data: Ilocos Norte Electric Cooperative, Inc.)

Municipality	Population	Potential No. of Household	Member	Connection
Bacarra	23,369	4,643	2,734	3,137
Laoag City	69,659	13,675	10,213	11,583
Paoay	17,026	3,349	1,821	1,518
Pasuquin	17,813	3,466	1,932	1,749
Vintar	23,356	4,675	2,597	2,464
Total	151,223	29,808	19,297	20,451

Number of Consumers Receiving Service in the Province of Ilocos Norte, (June 30, 1981)
(Source of Data: Ilocos Norte Electric Cooperative, Inc.)

Type of Consumer	
1) Residential	45,663
2) Commercial	
a. Small	154
b. Big	207
3) Industrial	6
4) Irrigation	9
5) Public Bldgs. & Facilities	480
6) Street Lights & Security Lightings	963
7) Others (Specify)	-
Total	46,519

Table 22 Annual Consumption of Electricity, (July 1980 to June 1981)
(Source of Data: Ilocos Norte Electric Cooperative, Inc.)

Municipality	Type of Consumers					Total Amount (Kwh)
	Residential (Kwh)	Commercial (Kwh)	Public Building (Kwh)	Street Light (Kwh)	Industrial (Kwh)	
Laoag City	5,296,041	2,416,339	2,228,612	136,896	530,106	8,207,165.86
Bacarra	950,053	29,790	15,487	21,617	1,159	796,219.04
Pasuquin	507,829	26,020	23,253	43,857	195,968	612,648.41
Paoay	404,832	49,618	121,600	8,404		472,348.33
Vintar	500,671	10,316	19,611	28,434		450,795.62
Total	7,659,426	2,532,083	2,408,563	239,208	727,213	₱10,539,177.26

Table 23 Electricity Rates, Ilocos Norte
(Source of Data: Ilocos Norte Electric Cooperative, Inc.)

1) Residential & Public Buildings	
A. Consumers using 10 Kwh or less	₱ 7.40
B. Consumers using more than 10 Kwh	0.74/Kwh
2) Commercial	
A. Small	
Minimum Bill (25 Kwh or less)	19.25
Excess 25 Kwh	0.77/Kwh
B. Large	
Minimum Bill (50 Kwh or less)	₱39.50
Excess 50 Kwh	0.79/Kwh
3 Phase Connections - with demand charge	
Exclusive use of transformer - with demand charge	
3) Industrial	
A. Below 25 Demand	
Minimum Bill	₱300.00
Demand Charge	15.00/kw
Energy Charge	0.66/Kwh
b. 25 Kw & Above Demand	
Minimum Bill - 150 Hrs. of Billing Demand	
Demand Charge	₱ 15.00/kw
Energy Charge	0.71/Kwh
4) Irrigation	
A. Big Pumps (75 & Above HP Rating)	
Demand Charge	₱ 15.00/kw
Energy Charge	0.68/Kwh
B. BISA Pumps (FSDC Assisted)	
Minimum Bill	₱ 10.00/hp/mo.
Energy Charge	0.63/Kwh

4. Public Health

4.1 Causes of Morbidity

As shown in Tables 24 - 28, the figures from the City Health Department of Laoag and the Provincial Health Center reveal that Gastro-Enteritis ranked second among the ten leading causes of morbidity in the City of Laoag for the past five years and ranked first in the municipalities of Bacarra and Pasuquin, second in the municipality of Paoay and fourth in the municipality of Vintar.

With the desire to make the city and the municipalities "more healthy" districts, the City Health Department and the Provincial Health Center are developing such programs as immunization, seasonal vaccination and other relevant services to augment the needs of the people in this field. Those department and center officials are, however, of the opinion that the supply of adequate clean water is the pre-requisite.

4.2 Health Facilities

The City of Laoag has eight (8) hospitals including a medical college hospital, and the four municipalities in the study area depend upon the City of Laoag for hospital services. The Municipality of Bacarra, however has a hospital(See Table 29).

4.3 Sanitary Toilets

The percentage of households with sanitary toilets is less than 50% in the City of Laoag and the municipalities of Bacarra, Paoay, and Vintar. The exception is the Pasuquin whose percentage exceeds 80% (See Table 30).

Table 24 Leading Causes of Morbidity in the City of Laoag
(Rate per 100,000 Population)
(Source of Data: City Health Center of Laoag)

	Causes	1975-1979 5-Year Average	1980
1)	Influenza	42.82	431.31
2)	Gastro-Enteritis	360.92	364.13
3)	Bronchitis	134.47	134.36
4)	Pneumonia	107.58	115.55
5)	P.T.B.	97.67	36.74
6)	Neoplasm	31.14	51.06
7)	Broncho Peneumonia	22.65	-
8)	Hepatitis	15.57	-
9)	Measles	14.15	22.84
10)	Whooping Cough	12.73	2.68

Table 25 Leading Causes of Morbidity in the Municipality of Bacarra (Rate per 100,000 Population)
(Source of Data: Provincial Health Center of Ilocos Norte)

	Causes	1975-1979 5-Year Average	1980
1)	Gastro-Enteritis	643.58	539.17
2)	Tuberculosis (all forms)	634.17	907.18
3)	Influenza	484.40	547.73
4)	Bronchitis	267.02	179.73
5)	Dysentery	36.80	-
6)	Pneumonia	26.53	17.12
7)	Measles	9.41	12.83
8)	Whooping Cough	8.58	560.57
9)	Leprosy	3.42	4.28
10)	Typhoid/Para-Typ. Fever	0.86	34.23

Table 26 Leading Causes of Morbidity in the Municipality of Paoay
(Rate per 100,000 Population)
(Source of Data: Provincial Health Center of Ilocos Norte)

	Causes	1975-1979 5-Year Average	1980
1)	Bronchitis	1,265.87	32.26
2)	Gastro-Enteritis & Col	1,238.83	567.70
3)	Influenza	1,207.10	4,178.42
4)	Tuberculosis (all forms)	673.48	311.47
5)	Pneumonias	47.01	29.38
6)	Measles	31.75	82.28
7)	Whooping Cough	4.70	-
8)	Syphilis	4.70	-
9)	Typhoid/Para-Typ. Fever	2.35	29.38
10)	Dysentery (all forms)	2.35	5.76

Table 27 Leading Causes of Morbidity in the Minicipality of Pasuquin (Rate per 100,000 Population)
(Source of Data: Provincial Health Center of Ilocos Norte)

	Causes	1975-1979 5-Year Average	1980
1)	Gastro-Enteritis & Col.	1,052.04	35.93
2)	Influenza	709.59	381.74
3)	Bronchitis	288.55	600.68
4)	Tuberculosis (all forms)	247.01	392.97
5)	Pneumonia	113.40	89.82
6)	Tetanus	47.17	89.82
7)	Measles	29.19	145.96
8)	Neoplasms, Malign	11.23	11.23
9)	Malaria	10.10	33.68
10)	Infectious Hepatitis	4.49	39.29

Table 28 Leading Causes of Morbidity in the Municipality of Vintar
(Rate per 100,000 Population)
(Source of Data: Provincial Health Center of Ilocos Norte)

	Causes	1975-1979 5-Year Average	1980
1)	Influenza	546.33	64.22
2)	Tuberculosis (all forms)	481.25	37.25
3)	Bronchitis	304.85	179.83
4)	Gastro-Enteritis & Col.	214.08	98.48
5)	Leprosy	296.28	188.39
6)	Pneumonia	205.51	235.86
7)	Measles	171.26	132.73
8)	Malaria	114.75	423.87
9)	Mumps	40.25	-
10)	Whooping Cough	7.71	8.56

Table 29 Health Facilities
(Source of Data: Provincial Health Center of Ilocos Norte)

	Number
The City of Laoag	
1) Hospital	8
2) Others	17
The Municipality of Bacarra	
1) Hospital	1
2) Others	7
The Municipality of Paoay	
1) Hospital	-
2) Others	7
The Municipality of Pasuquin	
1) Hospital	-
2) Others	5
The Municipality of Vintar	
1) Hospital	-
2) Others	6

Table 30 Number of Households and Percent of Households with Sanitary Toilets
(Source of Data: City Health Center of Laoag, Provincial Health of Ilocos Norte)

The City of Laoag	Number	Percent
Total Households	12,386	
1) Households with flush & water-sealed toilets		40.60
2) Households with open pit toilets		47.28
3) Others		12.12
The Municipality of Bacarra		
Total Households	4,465	
1) Households with flush & water sealed toilets		45.23
2) Households with open pit toilets		28.26
3) Others		26.51
The Municipality of Paoay		
Total Households	3,250	
1) Households with flush & water-sealed toilets		19.85
2) Households with open pit toilets		59.31
3) Others		22.84
The Municipality of Pasuquin		
Total Households	3,477	
1) Households with flush & water-sealed toilets		81.15
2) Households with open pit toilets		12.91
3) Others		5.94
The Municipality of Vintar		
Total Households	4,563	
1) Households with flush & water-sealed toilets		18.60
2) Households with open pit toilets		51.35
3) Others		30.05

Appendix 7 Design Criteria for Planning

To prepare the master plan and the preliminary design of feasibility study on a standardized basis, the following design criteria are worked out. In preparing these criteria, due consideration has been given to the design criteria that were made by LWUA and compiled in the Technical Standard Manual. And to make the present criteria more realistic and workable, the local conditions including that of the existing water supply facilities, in particular are taken into account.

1. (Per capita Consumption) For planning of the district water supply system, average daily per capita consumptions for each study area are projected based on records of different WDs. In this study the values tabulated in Appendix 8 shall be used as a basis for unit consumption figures.

2. (Peak Factor) Since no data on maximum day and peak hour demands in each study area are available the following demand factors shall be used.

Average day demand	1.00
Maximum day demand	1.20 x average day demand
Peak hour demand	1.50 x average day demand

3. (Capacity of the Facilities) The capacity of the water source and transmission facilities shall be determined based on Maximum day demand.

   The distribution facilities shall be designed based on Peak hour demand.

4. (Water Pressure) Maximum static pressure on a pipeline shall not exceed 7 kg/sq cm. In case unavoidable, special device shall be installed to keep the water pressure within the said limit.

Minimum water pressure at pipe ends of the distribution system shall not be less than 7 m in head, as far as practicable.

5. (C Value) C value to be used for hydraulic calculation of new pipe shall be:

Pipe Size (mm)	C Value
600 and over	130
500 - 250	120
200 - 100	110
75	100
All sizes of PVC	140

C value for old pipe shall be determined according to the conditions of pipe.

6. (Pipe Material) Pipe materials shall be selected from the following: ACP, CIP, DCIP, Steel Pipe, PVC.

In selecting pipe materials, the following shall be taken into consideration:

1) Maximum static pressure and water hammer impact which the pipeline is to be subjected to.
2) Conditions of the road under which the pipeline is to be laid.
3) Corrosiveness of the soil in which the pipeline is to be burried.

7. (Fire Hydrants) Standard spacing of fire hydrants shall be 150 m. Size of pipe on which the fire hydrant to be installed shall be 150 mm and above. In case fire hydrant is considered indispensable due to the conditions of the locality, 100 mm pipe may be utilized for installation of the fire hydrant.

8. (Valves, Air Valves, and Drain Pipe) Valves shall be installed at the following points:

Transmission pipelines:	strategic operating points at about 2 km intervals.
Distribution mains :	all main crosses and branches and at about 300 m intervals.

Air valves shall be installed at the top of vertical curves of pipelines.

Drain pipes shall be installed at the bottom of vertical curves of pipelines, where draining from the pipeline is possible.

9. (Storage Capacity) The capacity of a distribution reservoir shall be equivalent to 8 hours quantity of maximum day demand including water for fire fighting and water for emergency.

The said capacity can be split into plural numbers of reservoir in accordance with the needs of the locality.

10. (Meters) All production of the water source facilities and distribution shall be metered. For this purpose, bulk meters shall be provided at appropriate and convenient places to measure.

House meters shall be installed at all service connections.

Appendix 8 Procedure of Projections of Population and Water Demand [1/]

A. Population Projection

General

To estimate the study area population which is one of the basic factors of water requirement, the past census made by the National Census and Statistics Office (NCSO) is used as the most reliable demographic data.

The total study area population is projected on the basis of separate projections for the city core or poblacion and for the rural barangays within the study area. The method of past trend extrapolation is applied for population projection of such "micro-economic" areas of barangays in this study.

To determine future growth rates for each barangay the following factors are considered:

1. Existing and proposed land use plans (residential, commercial, industrial, institutional and agricultural zones)
2. Physical limits (barriers) to the geographical development of the area.
3. Population density. (persons per ha)
4. Housing patterns.
5. Existing and proposed transportation and communication facilities. (road network, etc)
6. Possible migrations within the municipality and the region,
7. Family planning program of the Government.

Remarks: 1/ In the course of the work of preparing the master plan for water supply of the four WDs in the three provincial areas (Ilocos Norte WD in Ilocos Norte Province, Legaspi City WD and Daraga WD in Albay Province, and Tagbilaran WD in Bohol Province), this procedure of projections of population and water demand is established as a general concept to be applied to the four WDs.

Ilocos

Total Municipal Population

In projecting the municipal population, the following steps are observed:

1. Using available past census data, a trend analysis on past growth rates and the factors which might have influenced them is performed. Past population trend of the municipality is shown in Table 1.2.2 thru Table 1.2.6. (See 2.2 Population, Part One: General)
2. Future growth rates up to the design year are projected based on the field conditions and future development as well as data obtained in step 1 above.
3. The population for each design year is obtained using the projected average annual growth rates in step 2 above. The population in each design year is tabulated as shown in Table 2.3.1 The past and future trends are graphically shown in Fig. 2.3.1. (See 3.1 Population Projection, Part Two: Master Plan)

Barangay Population

1. Using the same method outlined for municipal population projections, the population for each barangay covered by the municipality is projected.
2. Since the total annual population of all the barangays should equal to the total annual municipal population, barangay population is revised where applicable and necessary. Population projection for each barangay is shown in Table 2.3.2 thru Table 2.3.6. (See 3.1 Population Projection, Part Two: Master Plan)
3. Population density of each barangay is checked.

As an example of the high growth of population in the study area, the high series of NEDA-POPCOM projection is introduced herein, which is considered to be a useful data for a sensitivity analysis of the population projection. While the low growth of population in the study area is projected with an assumption that the average growth rates from one design year to another design year may differ by 10 to 20 per cent from the medium growth of projection made in this study. The high and low growth of populations are shown in Table 2.3.7 and Table 2.3.8. (See 3.1 Population Projection, Part Two: Master Plan)

Served Population

At present, the served area of the city/municipality is mostly concentrated on the poblacion or the central urban area, where the middle-high income groups are usually found.

A percentage of population served is estimated in each design year based on the present population served, data gathered in the field, cost and availability of the water from sources. The served population as well as the served area [1/] for Phase I (1987) is decided based on a concept that the purpose of this Phase project is to satisfy the present water requirement which has not been met in recent years due to deterioration of the water supply facilities, by rehabilitation, improvement and some additional works, within as short a period as possible. It is the goal of this study, however, to be able to extend improved water services (Level III system services) to no less than 70 percent and 80 percent of the population in the served area by Phase II (1993) and the master plan period (2010) respecitvely.

Remarks: 1/ Served area for this study is discussed in 2.2 Served Area, Part Two: Master Plan.

B. Water Demand Projection

General

Future water demand is projected by category of water use and area of water demand. The categories adopted are 1) domestic, 2) commercial and industrial and 3) institutional water demands. Unaccounted-for-water is also estimated and totalled to the above demands. The water demand areas adopted for projection are poblacion or urban area and rural barangays. The urban area includes the neighboring barangays of the poblacion where applicable.

Historical consumption data are not available because the current supply does not cover all the consumers with service connections and no records of meter reading are obtained. Therefore, potential/theoretical demand for the study area is considered as for the present consumption.

The potential demand as an average per capita demand for the study area is estimated based on the similar WDs records [1/] of consumption and the classification of WDs stipulated in the Design Manual of LWUA. The result of classification of WDs for the present study is shown in Table A.8.3. The average per capita water demands for the urban and rural areas are estimated respectively and shown in Table A.8.4 and Table A.8.5.

Domestic Demand

The projected demands for domestic water are based on the average per capita consumption and the projected served population in the study area. As mentioned in the preceding paragraph, data on present average domestic unit consumption for the study area are not available, then the consumption records of different WDs are referred

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Remarks: 1/ Ref. Table A.8.1 Per Capita Consumption in Existing Water District (1978) and Table A.8.2 Average Unit Consumption by WD classification in 1978.

so that present unit consumption in the similar city/municipality is to be applied for the potential unit consumption for the study area. The future unit consumption which will represent an average consumption in the urban area are projected based on the said potential consumption as shown below:

City/Municipality	1978 (lpcd)	1987 (lpcd)	1993 (lpcd)	2010 (lpcd)
Ilocos Norte				
Laoag	128	128	135	155
Pasuquin	100	105	115	140
Bacarra	100	105	115	140
Vintar	100	105	115	140
Paoay	100	105	115	140
Legaspi	135	135	148	175
Daraga	135	135	148	175
Tagbilaran	128	128	135	155

Domestic consumption projections for the rural area are projected using the same method for the urban area projections, however, only a single series unit domestic consumption is estimated to adopt for all the study areas. The domestic unit consumptions are projected as follows:

	1980 (lpcd)	1987 (lpcd)	1993 (lpcd)	2010 (lpcd)
All rural area	60	69	78	100

The potential unit consumption in 1980 is estimated based on the experiences in the rural water supply programs in the Southeast Asian countries. Future unit consumptions are projected on the basis that the unit consumptions will increase at a growth rate of 2.0% per annum in the period 1980-1993 and 1.5% per annum in the period 1993 -2010, respectively.

Commercial and Industrial Demand

Reliable data on present commercial and industrial water consumption of the study area are not available. Therefore, the following assumptions are employed for the future demand projections. According to the experience in the Philippines, there is a relation between the level of commercial and industrial activities and the service area population. These ratios vary from a minimum level of 0.3 commercial and industrial connections per 100 inhabitants to a maximum level of 1.2 connections per 100 inhabitants.

To estimate future commercial and industrial demands in the study area the following connection densities and unit consumptions are assumed:

Connection Density Ratio

		Group II	Group III	Group IV
(a) 1980 Density Ratio		-	-	-
(b) Density Increase Coefficient for year				
	1987	1.4	1.2	1.0
	1993	1.6	1.4	1.0
	2010	2.5	2.0	1.2

Group II : Legaspi and Darage

Group III : Laoag and Tagbilaran

Group IV : Bacarra, Pasuquin, Vintar and Paoay

Unit Consumption per Connection

Years	Unit Water Consumption (m^3/day)
1987	1.2
1993	1.5
2010	2.0

Based on the above assumptions, unit commercial and industrial consumptions as per capita consumptions for the future design years are obtained and shown below:

Commercial and Industrial Consumptions (lpcd)

Years	Group II	Group III	Group IV
1987	17 (13)	14 (11)	12 (11)
1993	24 (16)	21 (16)	14 (12)
2010	50 (29)	41 (26)	24 (17)

( ) Percentage to the per capita domestic consumption

Institutional Water Demand

Institutional water consumers include schools, churches, public administration buildings and hospitals. It can be assumed that all institutional establishments within the future service area will be connected. Based on this consideration and referring to the socio-economic data, one institutional connection per 2000 inhabitants is employed to be served in the study area. Unit consumption for the institutional connection will be as follows:

Year	1987	1993	2010
Unit Institutional consumption (m^3/day)	4.0	6.0	8.0
Coverted to per capita consumption (lpcd)	2.0	3.0	4.0

Unaccounted-for-Water

Unaccounted-for-water including wastage, leakage and water losses are estimated as follows. During the field investigation the unaccounted-for-water measurement in the study area was not able to undertake because the supply capacity had not fully met with the requirement and no water condition in the distribution network was chronically observed.

Based on the experience, the following values for unaccounted-for-water (percentage of the total water production) may be assumed for the future design years:

Year	1987	1993	2010
System with old and new pipelines in 1987	34	25	20
System with new pipelines in 1987	22	20	20

Total Water Demand

The projected unit consumption figures for domestic, commercial and industrial, institutional, and unaccounted-for-water have been presented in the preceding sections. The compiled projected unit consumption and supply requirements are listed in Table A.8.4 and Table A.8.5.

The average day demand and supply requirements for the study area are projected based on the above unit consumption and supply requirements and the projected served population. The consolidated projection of average day water demands for the study area are shown in 3.2 Water Demand, Part Two: Master Plan.

Table A.8.1 Per Capita Consumption in Existing Water District (1978)

Water District	Total Population (1978)	Served Population (1978)	Number of Service Connection	Average Consumer per Connection	Average Metered Use per Connection (m^3/month)	Per Capita Consumption (lpcd)	Water District Group
1. Bacolod	222,740	47,410	4,375	10.8	46.8	144	I
2. Davao	482,230	33,672	5,466	6.2	37.6	202	I
3. Zamboanga	261,980	37,846	9,818	3.9	50.0	427	II
4. Cebu	625,350	85,358	12,496	6.8	42.9	210	I
5. Lipa	105,940	9,066	1,273	7.1	30.1	141	II
6. Tarlac	158,340	5,615	942	6.0	26.7	148	II
7. Cabanatuan	113,810	21,327	2,848	7.5	42.2	188	II
8. Gapan	53,840	4,750	589	8.0	13.5	56	IV
9. Bislig	56,840	4,284	865	5.0	23.3	155	III
10. Urdaneta	64,880	3,203	441	7.3	25.1	115	III
11. Silay	104,550	6,142	984	6.2	39.8	214	III
12. Calamba	96,310	6,174	1,135	5.4	26.3	162	II
13. Cotabato	66,756	14,586	1,900	7.7	28.4	123	III
14. Roxas	71,049	8,240	1,028	8.0	32.8	134	III
15. Baybay	66,596	5,138	1,153	4.5	16.2	120	III
16. San Fernando	97,800	10,632	1,445	7.4	26.4	119	II
17. Olongapo	143,279	43,806	6,375	6.9	42.2	204	I
Average				6.7	32.4	168.4	

Ilocos

Table A.8.2 Average Unit Consumption by WD Classification in 1978

WD Group 1/	Accounted-for-water 2/ (lpcd)	Unaccounted-for-water- 3/ (lpcd)	Total (lpcd)
I	190	127	317
II	152	101	253
III	144	96	240
IV	112 4/	75	187

1/ Refer to Design Manual of LWUA

2/ Based on records of different WDs

3/ 40% of the total is applied

4/ No data but estimated

Table A.8.3 Classification of Water Districts According to Future Requirements

City/Municipality	1975 Urban Income	Urban Households with Refri-gerators	Urban Households with Flush Toilets	1975 Business Index	1980 Cost of Water Source of Supply	1980 Served Population	Total Points	Group
Ilocos Norte								
Laoag	10	8	6	11	14	8	57	III
Pasuquin	6	7	6	4	20	5	48	IV
Bacarra	8	7	6	4	17	5	47	IV
Vintar	6	6	5	4	14	5	40	IV
Paoay	6	6	5	2	11	5	35	V
Legaspi	10	8	6	16	20	9	69	II
Darage	6	8	6	16	20	8	64	II
Tagbilaran	10	8	6	16	11	8	59	III

Note: The grouping of WDs, based on the range of total points under the 5 criteria, is a follows:

Group	Total Points
I	70 and above
II	60 - 69
III	50 - 59
IV	40 - 49
V	39 and below

Table A.8.4 Laoag (Group III) Average Unit Consumption and Supply Requirement

Category/Year	1978	1987	1993	2010
Domestic, lpcd	128	128	135	155
Commercial/Industrial, lpcd	14	14	21	41
(% of domestic)	(11)	(11)	(16)	(26)
Institutional, lpcd	2	2	3	4
Accounted-for-water, lpcd	144 1/	144	159	200
Unaccounted-for-water, lpcd	96	74	53	50
(% of production)	(40)	(34)	(25)	(20)
Total unit demand requirement, lpcd	240 2/	218	212	250

1/ Based on records of different WDs.

2/ Estimated as potential/theoretical requirement.

Table A.8.5 Pasuquin, Bacarra, Vintar and Paoay (Group IV) Average Unit Consumption and Supply Requirement

Category/Year	1978	1987	1993	2010
Domestic, lpcd	100 1/	105	115	140
Commercial/Industrial, lpcd	10	12	14	24
(% of domestic)	(10)	(11)	(12)	(17)
Institutional, lpcd	2	2	3	4
Accounted-for-water, lpcd	112	119	132	168
Unaccounted-for-water, lpcd	75	61	44	42
(% of production)	(40)	(34)	(25)	(20)
Total unit demand requirement, lpcd	187	180	176	210

1/ Potential/theoretical requirement

Table A.8.6 Rural Barangays Average Unit Consumption and Supply Requirement

Category/Year	1980	1987	1993	2010
Domestic, lpcd	60 1/	69	78	100
Institutional, lpcd	2	2	3	4
Accounted-for-water lpcd	62	71	81	104
Unaccounted-for-water, lpcd	21	20	20	26
% of Production	(25)	(22)	(20)	(20)
Total unit demand Requirement. lpcd	83	91	101	130

1/ Potential/theoretical requirement

Appendix 9 Basic Cost Data

This appendix 9 presents basic cost data which are applied to cost estimates of the present feasibility study. Basically the unit costs are taken from the Methodology Manual of LWUA, as far as applicable. However, unit costs not included in the Manual are taken from prevailing prices in the Philippines as of July 1981. Further, some of breakdown ratios presented in the Manual have been modified so as to fit the present case.

Table 1 shows the prevailing land prices in each location of the present projects. Table 2 Labor Costs and Table 3 Unit Prices for Civil Works are quoted from the Manual for reference. Table 4 shows percentages of Foreign and Local components of various work items which are used in the present feasibility study. These percentages are obtained adjusting the percentages of corresponding work items in the Manual.

Table 1 Land Prices of Study Area

Location	Prices (pesos/sq m)
Mountainous area	20
Unirrigated rice field	25 - 30
Irrigated rice field	35
Poblacion	100 - 200

Table 2 Labor Costs

Items	Unit	Rates (Pesos)
Unskilled*	per day	20 - 25
Skilled **	do	40 - 45

* Mason, Pipe fitter, Pipe layer, Excavator, etc.

** Carpenter, Tinsmith, Supervisor of labors, etc.

Table 3 Unit Prices for Civil Works

Items	Unit	Rate (Pesos)
Earth Work		
Common excavation	cu m	40
Hardpan excavation	do	65
Trench excavation	do	55
Rock excavation	do	95
Backfill dumpted	do	15
Backfill compacted	do	70
Disposal material	do	12
Gravel blanket	do	80
Concrete Work		
Concrete 4,000 psi	cu m	880
Concrete 3,000 psi	do	740
Formwork vertical	sq m	60
Formwork horizontal	do	100
Reinforcement bars	kg	10

Table 4 Components of Breakdown Used in Cost Estimates

Items	F/C	L/C
Deep well	29%	71%
Deep well pumping station	56	44
Transmission/distribution pumping station	60	40
Transmission/distribution pipeline	67	33
Valve	73	27
Service connection	77	23
Fire hydrant	66	34
Reservoir, chamber, etc.	25	75
Bulk meter	80	20
Chlorinator	90	10
Vehicle	50	50