REPUBLIC OF INDONESIA

MINISTRY OF PUBLIC WORKS
DIRECTORATE GENERAL OF
WATER RESOURCES DEVELOPMENT

FEASIBILITY STUDY
ON
THE LANGKEMME IRRIGATION PROJECT

ANNEX-III

GEOLOGY
SOIL MECHANICS
HYDROPOWER
LAND CONSERVATION
PROJECT ECONOMY AND
FINANCE

MARCH 1981

JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO JAPAN

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Glossary of Terms and Abbreviation

1. Local Administrative Organization

Kabupaten (Kab.)	:	District
Kecamatan (Kec.)	:	Sub-district
Desa	:	Village
Bupati	:	Chief of Kabupaten
Camat	:	Chief of Kecamatan
Kepala Desa	:	Chief of Desa

2. Organization for Irrigation and Agricultural Development

DPU	:	Ministry of Public Works
DGWRD	:	Directorate General of Water Resources Development
P3SA	:	Sub-directorate of Planning and Programming
PLN	:	Public Corporation of Electricity
BRI	:	Indonesia People's Bank
BIMAS/INMAS	:	Mass Guidance for Self-sufficiency in Food
DOLOG	:	Provincial Rice Purchasing Agency
BUUD/KUD	:	Village Unit Executive Body/Agricultural Cooperative Organization
P3A	:	Water User's Association
BPP	:	Rural Extension Center

3. Other Local Terms

Polowijo	:	Second Crops, Planted after Harveste of Wet Season Paddy
Pelita I	:	First Five-Year Development Plan
Pelita II	:	Second Five-Year Development Plan
Pelita III	:	Third Five-Year Development Plan
PPL	:	Field Extension Worker
PPM	:	Extension Supervisor
PPS	:	Subject Matter Specialist

4. Area and Volume

m^2	:	square meter
ha	:	hectare
km^2	:	square kilometer
l	:	liter
m^3	:	cubic meter
t	:	ton

5. Derived Measures based on the Same Symbols

m^3/sec	:	cubic meter per second
t/ha	:	ton per hectare
m^3/km^2	:	cubic meter per square kilometer
mm/day	:	millimeter per day
l/sec/ha	:	liter per second per hectare
l/day	:	liter per day
m^3/km^2/year	:	cubic meter per square kilometer per year
meq/100g	:	milli-equivalent per 100 gram of soil
km/sec	:	kilometer per second
kg/cm^2	:	kilogram per square centimeter
cm/sec	:	centimeter per second
t/m^3	:	ton per cubic meter
t/m^2	:	ton per square meter

6. Electric Measures

kV	:	kilovolt
kW	:	kilowatt
kWh	:	kilowatt-hour
MW	:	megawatt
kVA	:	kilovolt ampere
Hz	:	Hertz

7. Currency

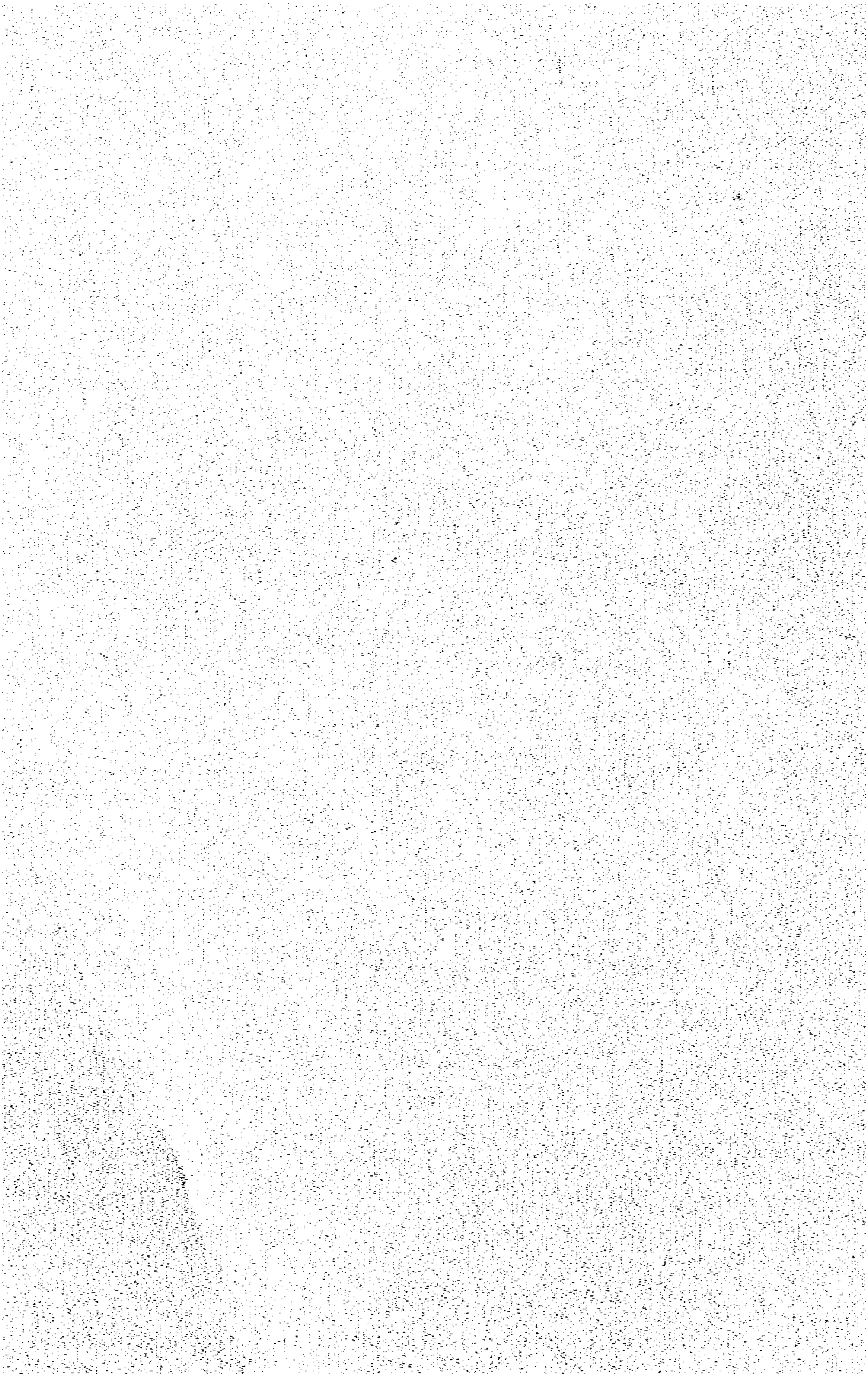
US$	:	United States Dollars
Rp	:	Rupiah

US$1 = Rp 625

8. Others

%	:	percent
No.	:	number
Nos.	:	numbers
vs.	:	versus
MSL	:	Mean Sea Level

CHAPTER VI GEOLOGY



CHAPTER VI GEOLOGY

6.1 GENERAL GEOLOGY

Base rock in the project area and the relevant watershed is mainly composed of limestone, andesitics, coral limestone and sedimentary rocks originated in the Tertiary. These base rocks are usually covered by fan and terrace deposits originated in the Quaternary in the flat plain.

Limestone mainly distributes in the watershed of the Pising river, a tributary of the Sero river. The watershed discloses the oldest geology in the investigated area in this study, originated in the Eocene and/or Mid. Miocene. The limestone outcropped in the watershed assumes dark milky white and is much massive, hard and well-compacted.

Andesitics mainly comprise andesite, its tuff and tuff breccia, originated in the Oligocene and/or Miocene. The andesite is relatively homogeneous and hard. It assumes dark grey to dark green. Tuffs consist of ordinary tuff, tuff breccia and conglomerate, the textures of which range medium to coarse grain matrix. The tuffs are generally soft and less coherent as compared with the andesite. These andesitics are considerably massive without any obvious bedding and their weathered zones are relatively thin. They compose the base rocks in the hilly ranges extending westward of the proposed main canal route.

Coral limestone originated in the Pliocene and/or Pleistocene is generally yellowish, fossiliferous and relatively hard but it is likely to be rather porous and much permeable. In fact, in the area bedded with the limestone, some springs are fed by the seapage water out of the rock. The coral limestone is broadly distributed at the skirt of the mountain and hilly areas covered with andesitics. Meanwhile, it forms the base rock of the project area developed for paddy field.

The sedimentary rocks comprise poorly cemented mudstone, sand stone and conglomerate, sometimes interbedding a skin bed of tuffs. They are deemed to be deposited in the same geological age to the coral limestone. These sedimentary rocks spottily distribute in the gently slanting slopes, and low hilly ranges. Most of their dips usually disclose nearly horizontal, excepting sharp dips cropped out in the vicinity of the confluence of the Langkemme and Sero rivers.

Fan and terrace deposits and alluvial soil broadly extend in the flat area, covering these base rocks. The permeability coefficient of terrace deposits is estimated at "6×10^{-3} to 3×10^{-4} cm/sec" on the basis of the drilling data undertaken in March, 1980 and in the course of this study. General geology around the project area is presented in Fig. 6.1.1.

6.2 GEOLOGICAL INVESTIGATION

Surface geological investigations are made along main canal routes, and at the major intake structures sites and the relevant watersheds. Geological maps and profiles are prepared on the Langkemme Intake site, the Jupang Intake site and the tunnel site. Core drillings are undertaken in the following sites and lengths in the course of this study.

Site	Nos. of Hole	Total Length
Langkemme Intake Site	4	43
Tunnel	5	125

As mentioned in the succeeding section, laboratory rock test is also performed in Japan on the drill cores collected by the Government in March 1980.

6.3 GEOLOGY OF RESPECTIVE SITES

6.3.1 Langkemme Intake Site

The base rock at the Langkemme intake site is sedimentary rocks mainly composed of "mud stone" originated in the Pliocene and/or the Pleistocene. The base rock continuously crops out at the left side riverbed. The bedding plane of the base rock sharply dips to northward with about 70 degrees dominantly strikes N 70°W in accordance with the direction of river channel. The geology of the intake site is illustrated in Fig. 6.3.1.

According to the drilling data, Lugeon value of the mudstone bedded in the riverbed is relatively high, ranging from 30 to 75. A laboratory rock test is also made in Japan on the drill cores collected about one km upstream of the proposed Langkemme intake weir in March 1980. According to the outcomes of the test, P-wave velocity of the mudstone is 2.1 km/sec and unconfirned compression strength ranges from 110 to 140 kg/cm^2.

At the both river banks of the site, terrace sediments being composed of relatively well compacted gravels layer are deposited with a thickness of about 10 m. The permeability coefficient at this layer is estimated at the order of 6×10^{-3} to 3×10^{-4} cm/sec. The riverbed at the site is covered with rocks of 2 to 3 m in diameter and cobbles. The thickness of the deposits is less than 2 m.

The rocks bedded in the riverbed are generally classified into soft rock and semi-hard rock but it is relatively hard and cemented excepting about 50 cm of weathered surface. As clarified through rock test, the physical and mechanical properties of these rocks are sufficiently available for the foundation of the proposed Langkemme intake weir. The geological profile along the proposed weir axis is shown in Fig. 6.3.2.

6.3.2 Jupang and Pising Intake Sites

The base rock at the Jupang Intake Site is composed of massive tuff brecola, one of andesitics originated in the Oligocene and/or the Miocene. The riverbed at the site is covered with considerable sized rocks and cobbles of various andesitics, the thickness of which are estimated at three meters, more or less. Talus deposits disclose on the slope of both riverbanks at the site; the deposits on the slope of the left bank are not so thick. The geological condition at the site is much favourable for the foundation of structures since the proposed intake structures are relatively small scaled. The geology of Jupang intake site is given in Fig. 6.3.3 and the geological profile along the proposed weir axis is also shown in Fig. 6.3.4.

While, limestone originated in the Eocene and/or the Miocene is bedded at the site of Pising intake structure. The stone is massive and relatively hard. In due consideration of the geological condition at the site, small scaled gabion-type weir is recommendable.

6.3.3 Tunnel Site

Around the proposed route of tunnel, there distribute various rocks, such as andesitics, coral limestone, sedimentary rocks and fan deposits. The surface observatory investigation and drilling data conclude that most of the tunnel would be excavated partly on the stratum of sedimentary rocks and mostly on that of sandstone; the inlet of the tunnel would be excavated on the stratum of the andesitics.

Sedimentary rocks in the tunnel site are rather soft and less coherent as compared with those in the Langkemme weir site. The stratum of the sedimentary rocks is covered with thick residual soil zone of 15 to 20 m. Such weathered and weak stratums might be encountered in the course of the tunnel excavation. According to the Lugeon test undertaken in the course of drilling, high permeability is expected at the stratum of the tunnel outlet. Ground water might spout inside the tunnel during excavation, resulting in lowering the ground water surface. The geological profile along the proposed tunnel axis is shown in Fig. 6.3.6.

6.3.4 Hydropower Station Site

At the site of the hydropower station located at the junction of the Baruttunge river, hard and massive andesite is bedded at about one meter below the surface soil. But, at the hilly side in which penstocks of the station would be proposed, the base rock is composed of coral limestone which is yellowish, fossiliferous and rather porous. The limestone is covered with talus deposits and weathered zone of about one meter thick.

6.3.5 Aqueduct and Syphon Sites

The project area are mainly covered with fan, terrace and fluvial deposits being composed of sand and gravel, and there exists no weak alluvial layer as extending around the Lake Tempe. Geologically, whole sites proposed for the crossing structures such as aqueduct and siphon are provided with much favourable condition for the foundation.

6.4 LABORATORY ROCK TEST

6.4.1 Tested Core

The laboratory rock test is made to grasp the physical and mechanical properties of the weakly cemented sedimentary rocks which broadly distribute at the Langkemme Intake site. The tested samples are picked out from the representative cores drilled by the Government in March, 1980 at about one km upstream from the proposed intake site for the Langkemme Irrigation Project. The test was made at the laboratory of Nippon Koei in Tokyo, Japan.

6.4.2 Test Items and Quantities

Both physical and mechanical properties of the selected rock cores are tested in the laboratory. The test items and quantities are as listed below:

Test	Quantities
(1) Physical Test	
i) Apparent specific gravity test	6 nos.
ii) Water absorption test	6 "
iii) Porosity test	6 "
(2) Mechanical Test	
i) P & S Waves velocity test	6 "
ii) Brazilian test	6 "
iii) Unconfined compression test	6 "

All the rock tests in the laboratory are compiled in the attached Data Book. Six samples consisting of a tuff breccia, a sand stone, a breccia, a siltstone and two mudstones are tested on both physical and mechanical properties of rocks. The results of the tests are summarized in Table 6.4.1.

6.4.3 Summary of Test

(1) Physical properties

Apparent specific gravity widely ranges from 2.08 to 2.42 among the test samples of the same rock. The value shows rather smaller than that of the ordinary sedimentary rocks, the apparent specific gravity of which ranges 2.2 to 2.7. As a result, the porosity is much higher compared with the ordinary sedimentary rocks.

(2) Mechanical properties

P & S waves velocities of the tested samples range from 1.8 km/sec to 3.4 km/sec. While, the values of unconfined compression test of each samples vary between 70 kg/cm^2 and 330 kg/cm^2. Judging from these tested values, the sedimentary rocks destributing in and around the project area seem to be still weakly cemented.

Table 6.4.1 Summary of Rock Test

For Reporting

Date of Reporting : Sept. 1980

Name of Survey & Locality								
Sample No.			B-1	B-1	B-2	B-2	BL-3	B-5
Location No. & Depth			9.30	15.70	16.50	17.80	17.70-18.00	19.30
Rock Name in Lithology			Tuff Breccia	Sand Stone	Breccia	Silt Stone	Mud Stone	
Observation			It's graysh brown a little uneven and have no crack.	It's gray, have uniform rough grain size and no crack.	It's gray, have no crack.	It's gray, had cracks after saturating.	It's gray, have uniform fine grain size and smooth surface.	It's gray, have uniform fine grain size and smooth surface.
Condition of Specimen in Rock Test		Moisture Anisotrory	Sat.	Sat.	Nat.	Sat.	Nat.	Nat.
Apparent Specific Gravity G			2.188	2,417	2,158	2.129		
Density		y (g/cm³)	2.175	2,414	2,369	2,109	2,083	2,200
Natural Water Content		Wn (%)	6.3	6.4	4.9	6.8	8.0	7.3
Water Absorption		Wsat (%)	10.3	8.0	9.9	15.0		
Apparent Porosity		n' (%)	20.4	17.8	20.3	27.8		
P & S Waves Velocities Test of Rock	P Wave	Vp (km/sec)	3,201	3,384	3,103	1,752	2,143	2,176
	S Wave	Vs (km/sec)	1,868	1,943	1,847	0,988	1,253	1,234
	Dynamic Modulus of Elasticity	Ed (kg/cm²)	1.92×10^5	2.33×10^5	2.02×10^5	5.32×10^4	8.28×10^4	8.64×10^4
	Dynamic Poison's Ratio	UD	0.242	0.254	0.226	0.267	0.240	0.263
Tension Unconfined Compression	Unconfined Compressive Strength	Oc (kg/cm²)	329.0	290.0	287.4	68.6	141.5	116.6
	Static Modulus of Elasticity	Es (kg/cm²)	9.35×10^4	9.54×10^4	2.57×10^5	1.32×10^4	5.28×10^4	3.81×10^4
	Static Poison's Ratio	Us						
	Brazilian Tensile Strength	O'$_t$ (kg/cm²)	26.1	30.2	37.4	6.0	5.0	21.6

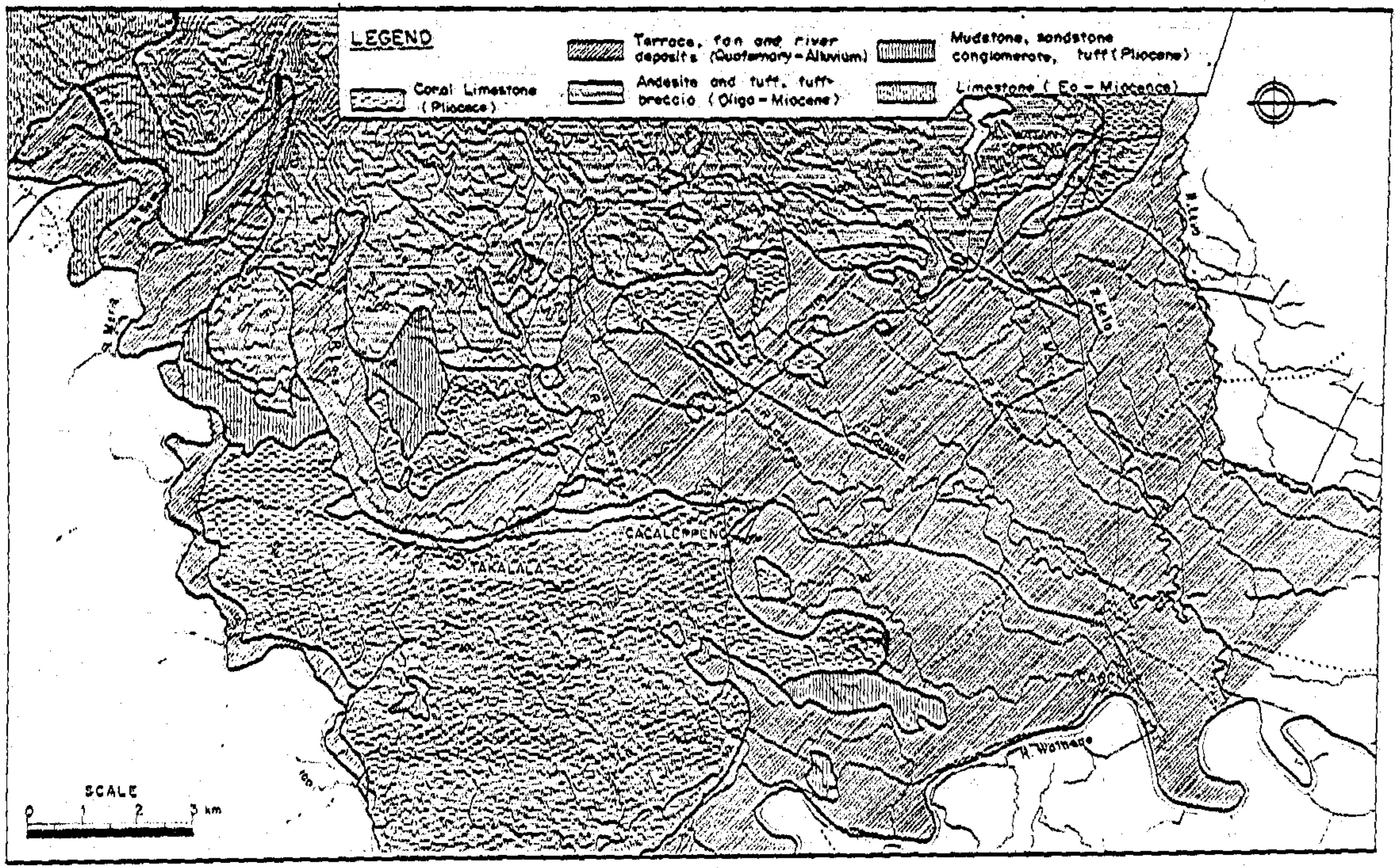


Fig. 6.1.1 GEOLOGICAL MAP

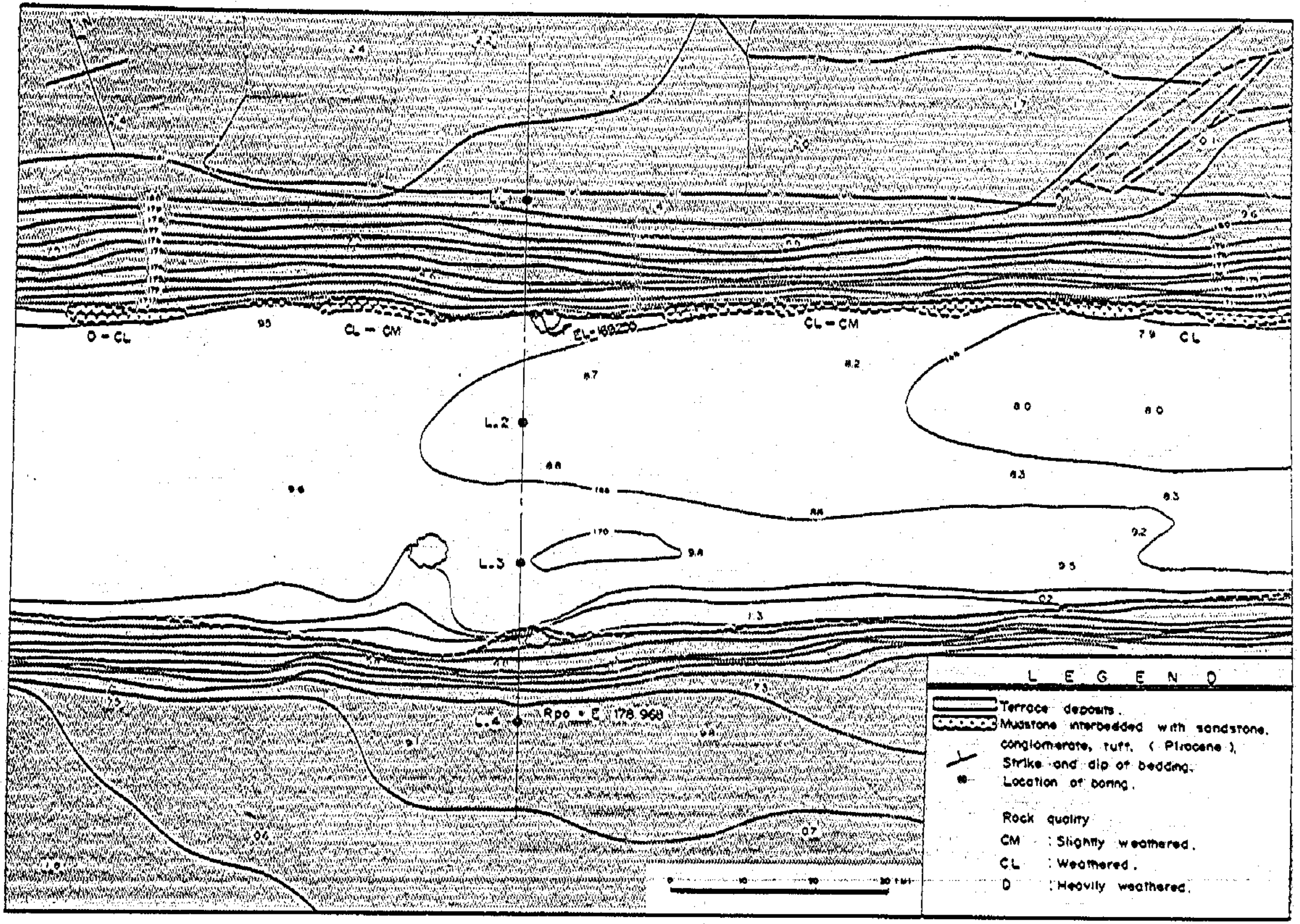


Fig. 6.3.1 GEOLOGICAL MAP OF LANGKEMME INTAKE SITE

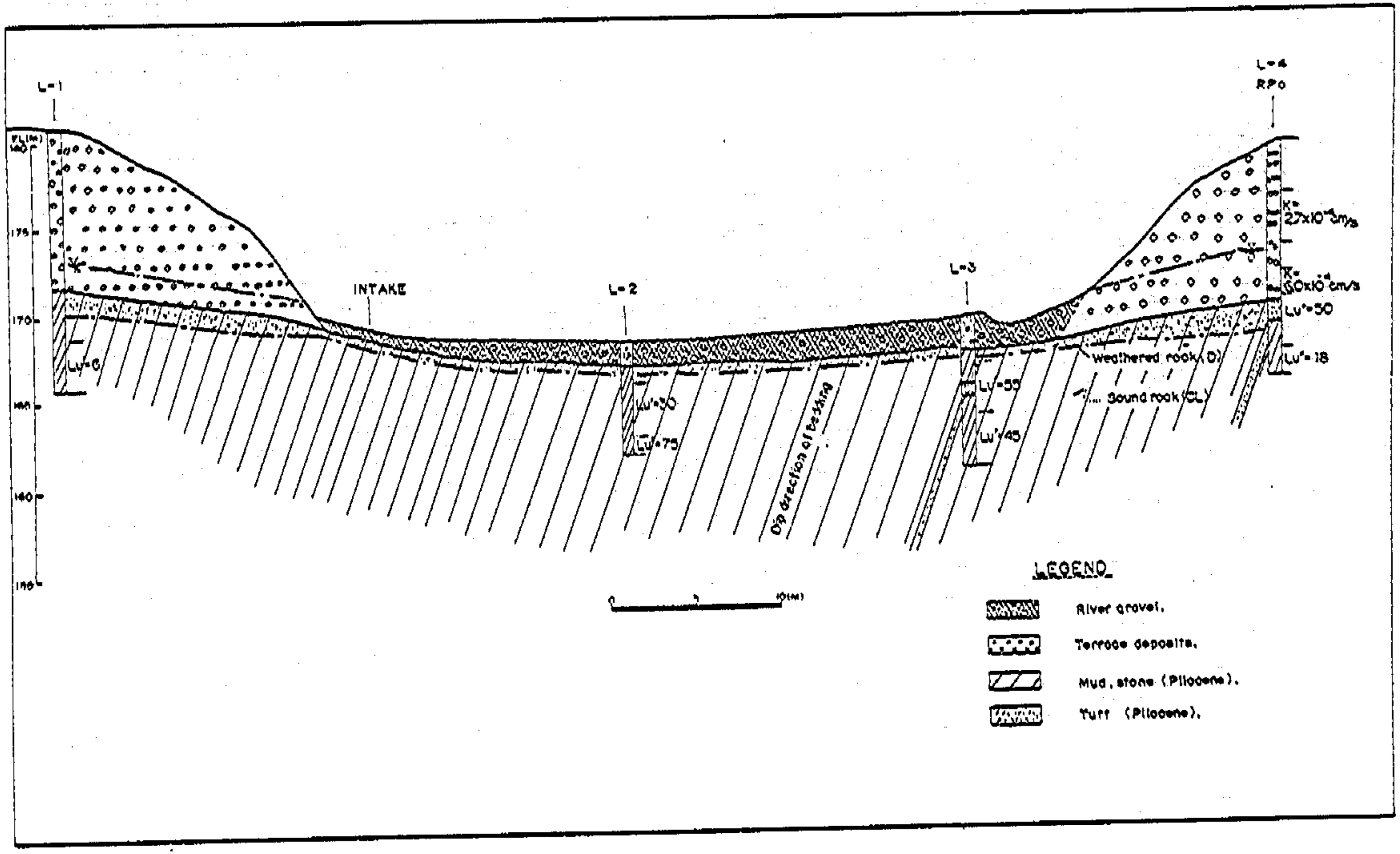


Fig. 6.3.2 GEOLOGECAL PROFILE OF LANGKEMME INTAKE SITE

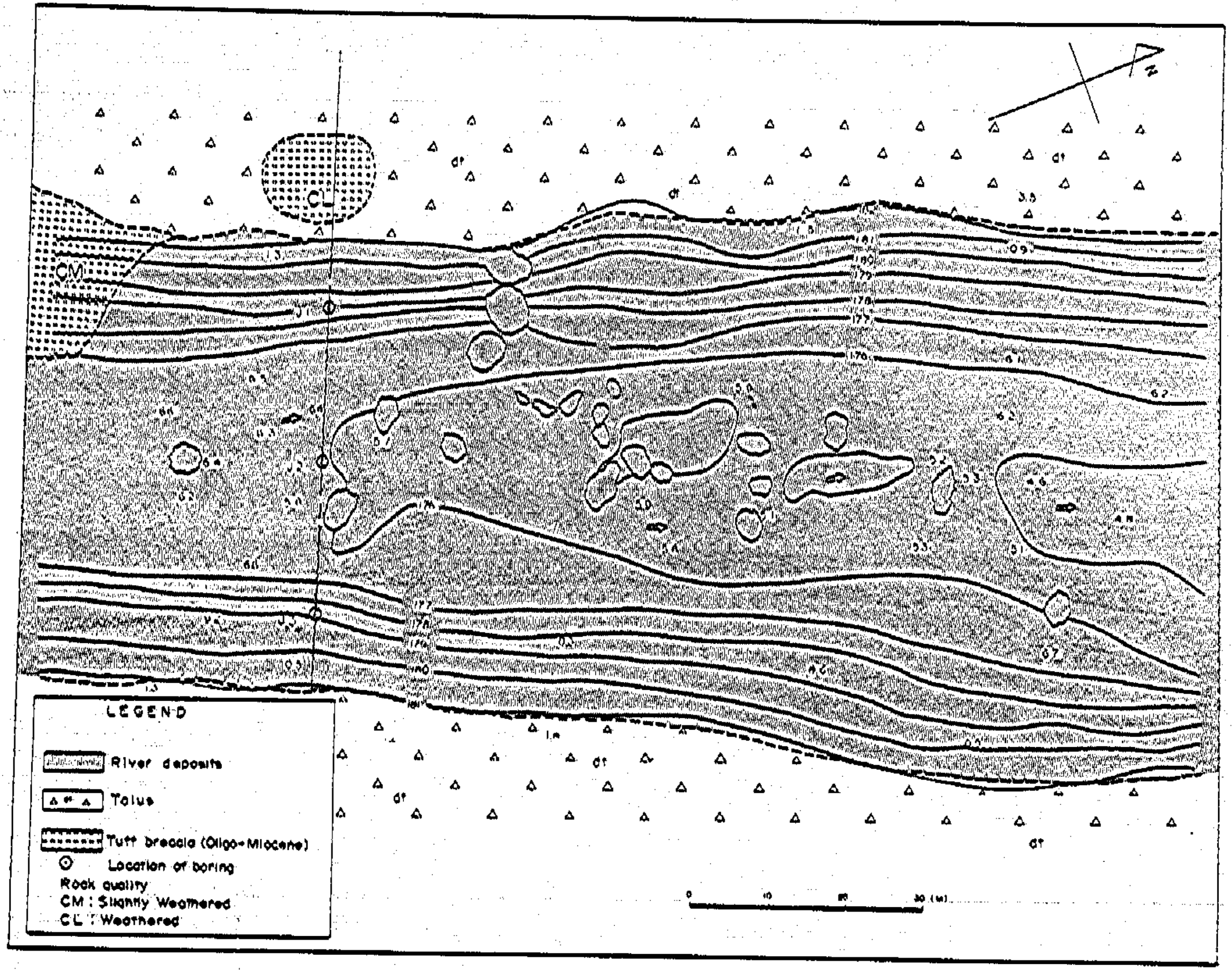


Fig. 6.3.3 GEOLOGICAL MAP OF JUPANG INTAKE SITE

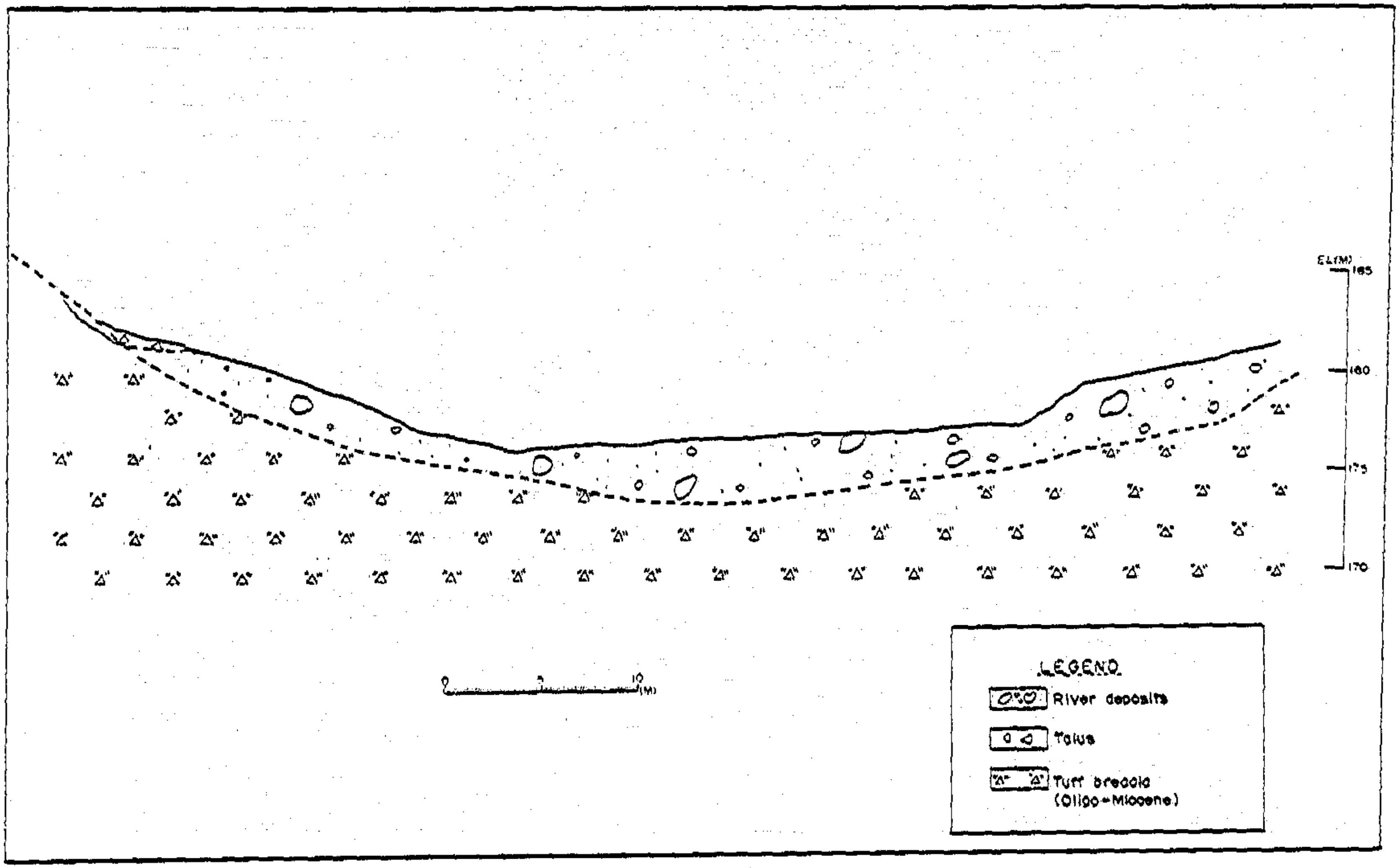


Fig. 6.3.4 GEOLOGICAL PROFILE OF JUPANG INTAKE SITE

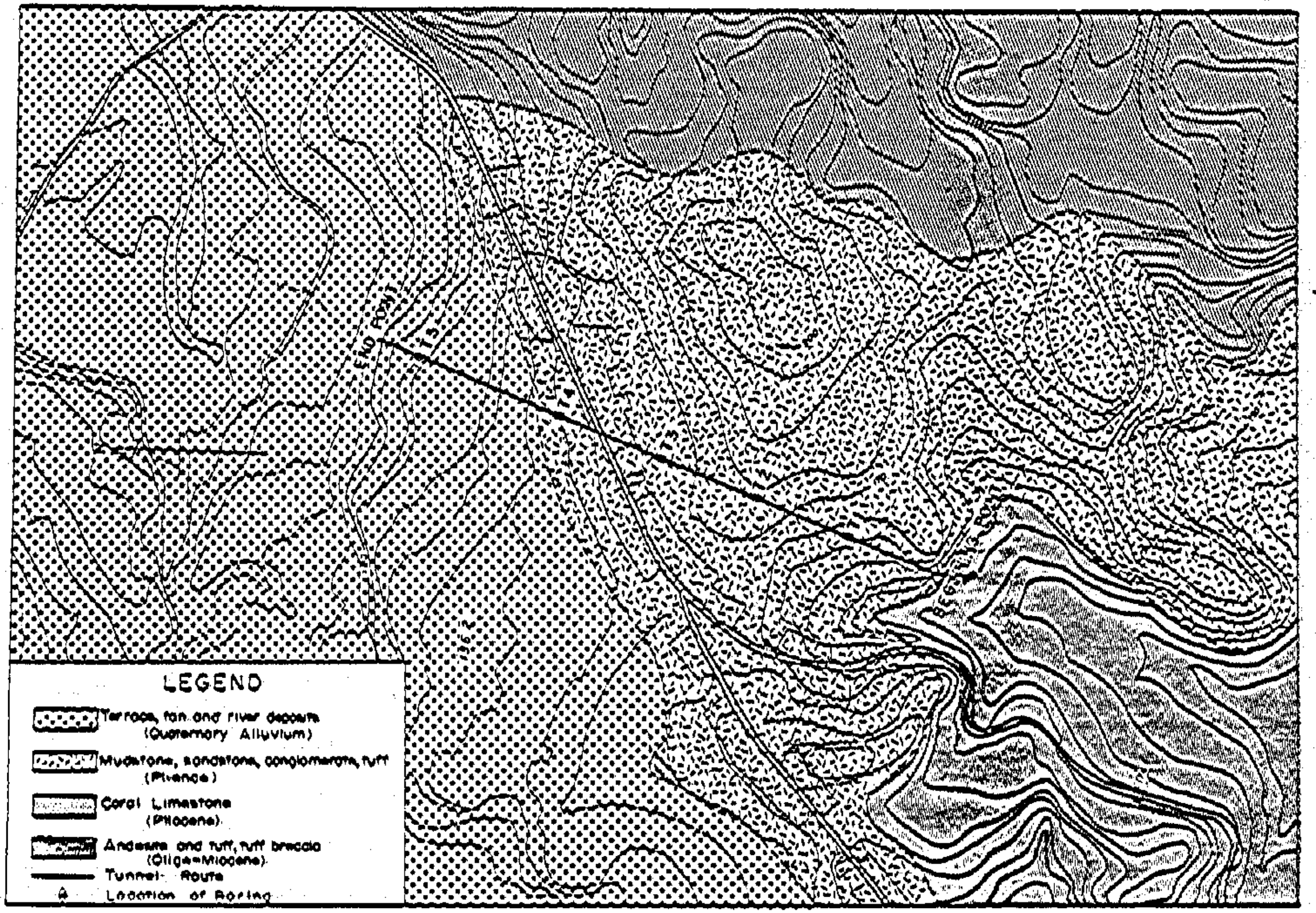


Fig. 6.3.5 GEOLOGICAL MAP OF TUNNEL SITE

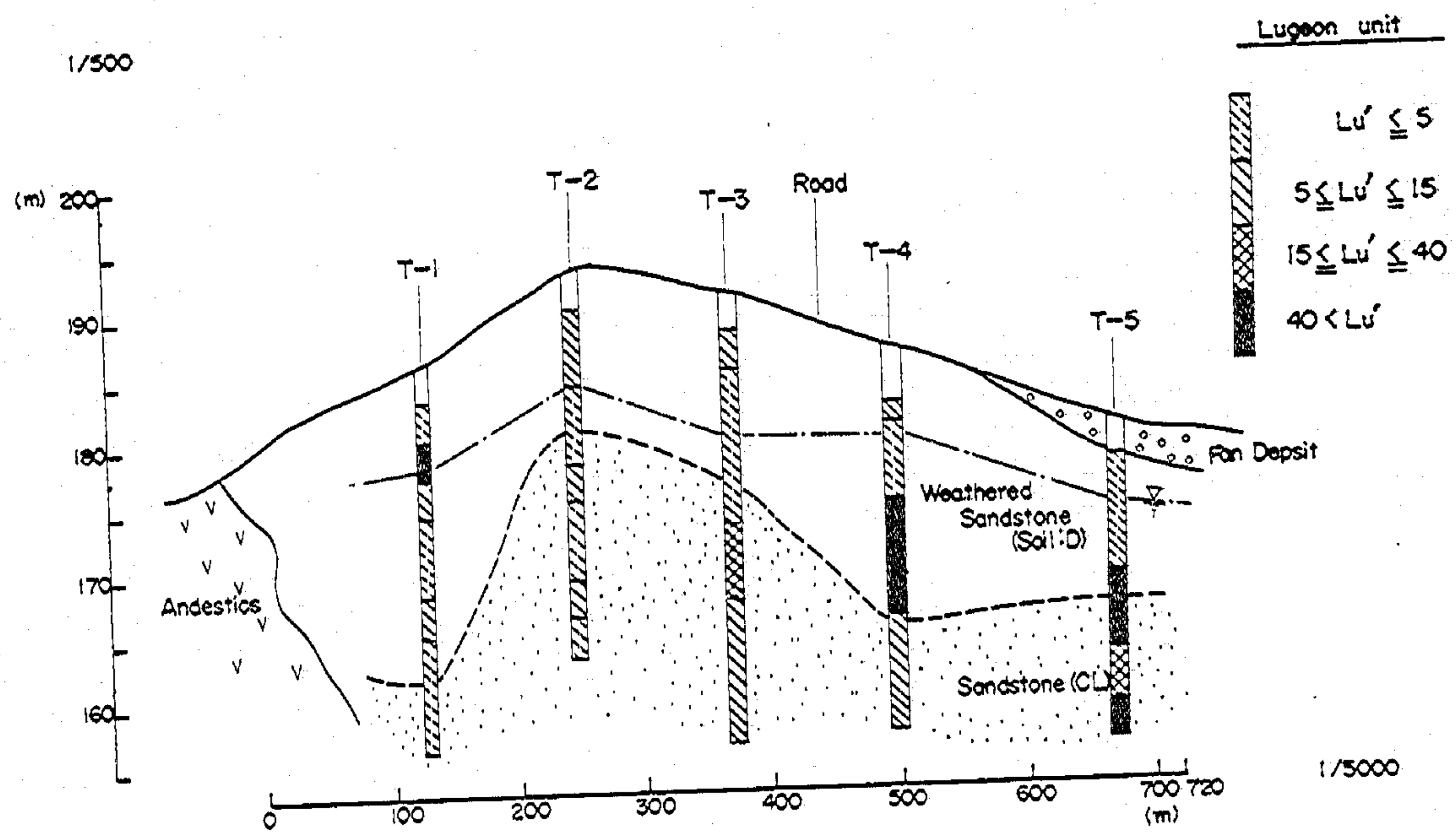


Fig. 6.3.6 GEOLOGICAL PROFILE OF TUNNEL SITE

CHAPTER VII SOIL MECHANICS

CHAPTER VII SOIL MECHANICS

7.1 FOUNDATION ALONG CANAL ROUTE

Most of main canal routes are aligned across paddy field. As shown in Fig. 7.1.1, 14 test-pits are dug along the canal routes for observation of soil profile and sounding test. Top layer of paddy field is composed of blakish alluvial fan deposits. According to the results of sounding test by cone penetrometer, the bearing capacity of the fan deposits is too small to construct heavy and/or rigid canal structures thereon; the N value might be assumed to be less than 10. Table 7.1.1 presents the details of cone penetration tests undertaken in this study.

The profiles of the pits compiled in the attached Data Book show that diluvial terrace deposits are developed under the fan deposits. The diluvial layer is relatively firm and well-compacted. The N-value of the layer is estimated at greater than 30. The layer is favourable for the foundation of the related structures such as siphon, aqueduct, chute, check and so forth. Three meters must be excavated at least from the surface of paddy field to obtain a stable and firm foundation for the structures.

Some alignments of the main canal pass through skirts of hill and hillside. Talus deposits and residual deposits dominantly develop and bed rock crops out in places along these alignments. Those deposits would not fulfill the requirement of bearing capacity for the foundation of canal structures. But stable and bearable foundation is surely obtainable by about four meters' excavation below the surface of those deposits.

7.2 CONSTRUCTION MATERIALS

7.2.1 Materials for Canal Embankment

As given in the Chapter V "Construction Plan", the canal embankment would be executed by maximum use of the in-situ materials excavated in canal section for cost-saving of the project. The available materials along the canal route are classified into four (4) groups as mentioned below;

(1) Alluvial fan materials

This is a fine soil and mainly consist of silt and clay. It has a high plasticity and a high dry strength. Its color in moist condition is glossy dark grey or dark brown. Cracks caused by drying shrinkage are usually observed in the deposit layer of this material. This material is usually distributed over the alluvial fans. Thickness of the layer ranges from 0.3 meter to 2 meters, mostly less than one meter. Paddy cultivation are extended over this layer.

(2) Diluvial river terrace material

This is a mixture of brown sandy clay, gravel, cobbles and sometimes boulders. Particles over gravel have a medium to poor gradation and they are subrounded. Canal bank constructed by such a naturally graded materials can not attain sufficient impermeability. Cobbles in the materials have to be dug out for stable embankment works. This material is deposited at the thickness of more than five meters beneath the alluvial fan layer.

(3) Talus material

This is also a mixture of brown colored silty clay or sandy clay, gravel and cobbles. But gravel and cobbles are subangular shaped and well-graded. The content of gravel and cobbles are not so high as that of terrace material. This material is distributed near the foot of hills.

(4) Residual material

Residual materials are roughly divided into two groups. One is a strongly weathered fine soil, having as similar properties as the alluvial fan materials excepting its color. The other, not so strongly wethered as the former, mostly consists of sand and moderate amount of silt and clay. These materials are distributed on the hillsides.

7.2.2 Borrow Pit Materials

Some canal routes might be proposed on the rock foundation where no impervious material is available. Nine sites for borrow pits are selected through field inspection as shown in Fig. 7.1.1 to obtain the embankment materials along the main canal routes. The materials from borrow pits mainly comprise talus and residual materials. Expectable volumes are estimated as shown in Table 7.2.1 along with the longitudinal numbers shown in Fig. 7.1.1.

7.2.3 Concrete Aggregates

Seven tributaries of the Walanae river traverse across the project area from Southwest to Northeast. The Langkemme and Sero rivers broadly bound the project area in the South. All of these riverbeds are thickly covered with sand and gravels, and pebbles and cobbles. These riverbed deposits are much favourable for the aggregates for concrete and wet masonry, and for the construction of gabions.

(1) Tributaries

To examine the quality of gravel, water absorption and specific gravity test are performed on the samples taken from the riverbed. The results are as shown below comparing with the standard requirement from ASTM.

Item	Tested Date	ASTM Standard Requirement
Water Absorption	1.41 to 2.95	less than 3.0
Specific Gravity	2.54 to 2.73	larger than 2.50

The results on both tests fulfill the standard requirement of ASTM. Therefore it is concluded that gravel from the tributaries are much suitable for concrete coarse aggregates. Specific gravity of sand in the tributaries are also tested and it ranges from 2.69 to 2.71. It is also suitable for concrete fine aggregates. The details of these tests are given in the attached Data Book.

In the tributaries, there exist much amount of cobbles whose grain sizes are eligible for mason and gabion. The content of cobbles would range from 10 to 80 percents. The quality of cobbles is likely to be better than that of gravel in view of construction materials for mason and gabion.

Estimated volumes of concrete aggregates available in the five crossings of Langkemme main canal and tributaries are as shown below.

No. of Crossing	Volume ($\times 10^3 m^3$)	Longitudinal canal
I	23	L0
II	36	K20
III	31	H50
IV	49	H10
V	18	P50

Remarks: - Volume in the table are those estimated within the distance of one km from the canal route.

- Number of crossing are specified in Fig. 7.1.1.

(2) Intake sites of Langkemme and Sero rivers

Four intake weirs are proposed on the Langkemme and Sero river systems. Each intake site is thickly deposited with gravelly materials mainly consisting of boulders. Sands and gravels suitable for concrete aggregates are partly deposited in a small amount of 50 to 100 m^3. The volume of sands and gravels available within half km from each intake site is estimated to be less than 1000 m^3. However, their qualities are considerably suitable for concrete aggregates judging from their appearances.

While, considerable amount of cobbles and boulders are widely scattered on each intake site. These cobbles and boulders are of high quality mainly originating from andesite. In view of availability of construction materials, masonry works are recommendable for the construction of intake weir and related structures.

(3) Belo river

The Belo river, a tributary of the Walanae river, flows eastward along the northern boundary of the project area. The river has a wider channel. Large amount of sediments are habitually rushed and deposited in the riverbed during flood season. The materials deposited in the Belo river are not so coarse as compared with those in other rivers and are much suitable for concrete aggregates. Considerable amount of aggregates seem to be endowed in this riverbed. Recently, DPU has produced aggregates in the middle reach of this river for road construction, etc. The potential volume of concrete aggregates is roughly estimated at about 100 x $10^3 m^3$ within the distance of one km from the Langkemme main canal.

7.3 SOIL TEST

7.3.1 Test Item

To clarify physical and mechanical properties of soil materials distributed in the project area, samplings for laboratory test are made at the test pits dug along the Langkemme main canal. Test items and quantities are listed below.

Test Item	Quantity	Remarks
1. Specific gravity		Fan soil -- 5 nos.
2. Particle-size analyses	17 nos.	Terrace soil -- 5 nos.
3. Water content		Talus soil -- 3 nos.
4. Atterberg limit		Residual soil -- 4 nos.
		Fan and residual soil -- 2 nos., respectively
5. Compaction	10 nos.	Terrace and talus soil -- 3 nos., respectively

7.3.2 Test Results and Discussion

The details of test results are arranged in the data sheets and compiled in the attached Data Book. The summary of test is given in Table 7.3.1. The results are briefly mentioned below and followed by discussion.

(1) Specific gravity test

The results of specific gravity test for soil particles are as summarized below.

Soil	Lowest	Highest	Mean
Fan soil	2.41	2.62	2.52
Terrace soil	2.37	2.54	2.46
Talus soil	2.52	2.74	2.60
Residual soil	2.47	2.66	2.54

The mean value of specific gravity ranges from 2.46 to 2.60, showing a little bit lower value than that observed generally in inorganic soils (ranging 2.6 to 2.8). In compaction test, therefore, unusual tendency is seen in some samples, in which the compaction curve becomes exceedingly close to the zero-air-void curve drawn by using the specific gravity obtained in the test.

The low specific gravity seems to be due mainly to insufficient boiling time. When an oven-dried clayey sample is used for the test, as it is in this time, much boiling time is needed to saturate the voids completely with water and to separate soil particles individually. If the boiling time is not sufficient, the test result would show the value of specific gravity which partially included the effect of small entrapped air in the void, resulting in lower value. According to many report in Japan, 2 to 3 hours of boiling time is needed for oven-dried coarse soils and much more hours, for fine soils to obtain an accurate value of specific gravity. On the other hand, as reported by the laboratory, the value tabulated above are obtained from the boiling time of only 5 to 15 minutes.

If a soil contains considerable amount of organic matter, it indicates lower value of specific gravity than that of inorganic soil. According to the result of organic matter content test, however, fan soil in the project area looking like an organic soil, contains a negligible amount of organic material (only 1.3 percent). Another three soils tabulated above are also considered not to contain organic material, judging from their appearance and the result of Atterberg limit test. Furthermore, as compiled in the Data Book, these soils indicate specific properties on compaction, such as relation between the compaction curve and the zero-air-void curve, and the degree of saturation at the maximum dry density. In the light of above discussion and such properties of compaction as clarified through soil tests, the specific gravities of soils sampled in the project area would range from 2.6 to 2.7.

(2) Particle-size analyses test

All samples used for the particle-size analyses are soils passing two mm sieve and do not contain gravels. Their gradations do not coincide with their natural ones. However, tested samples of fan soil and residual soil are considered to have similar gradation with natural ones, judging from the test pit observation.

Fan soil is the finest soil in the project area. It mainly consists of silt and clay. The total content of them is approximately ranging from 75 to 90 percents. Silt content is usually superior to clay content in case of fan soil. Sand content ranges from 10 to 25 percents. Although gravel content is not tested for the reason mentioned above, it is estimated to be less than 10 percents of the total amount of soil.

Terrace soil mostly consists of silt and clay, when gravel content is disregarded. The total content of silt and clay ranges approximately from 45 to 74 percents, mostly being more than 60 percents. Sand content is 25 to 55 percents. If gravel content is taken into account, each content listed above would be reduced to a half or more. Based on the result of visual inspection at test pits and exposed area, the content of gravel including cobbles and boulders is roughly estimated to be 50 to 70 percents in the natural gradation.

Talus soil also mostly consists of silt and clay in test samples. The content of silt and clay widely ranges from 50 to 90 percents. Sand content is 10 to 45 percents. Natural talus soil seems to have 10 to 50 percents of gravel content.

Residual soil can be classified into two groups. One mostly consists of sand and moderate amount of silt and clay. The other has the similar gradation with that of fan soil.

(3) Water content test

The results of water content test are summarized below. The samples tested are those passing 4.8 millimeter sieve.

Soil	Water Content (%)		
	Lowest	Highest	Mean
Fan soil	33	48	41
Terrace soil	21	47	38
Talus soil	28	40	34
Residual soil	28	49	35

As far as water content is concerned, no great difference is seen among these soils, expecting that fan soil shows a little higher water content than others.

(4) Atterberg limit test

The results of Atterberg limit test are summarized as follows.

Soil	Liquid limit (%)			Plastic limit		
	Lowest	Highest	Mean	Lowest	Highest	Mean
Fan soil	80	106	90	54	73	62
Terrace soil	56	94	79	30	46	41
Talus soil	52	85	67	29	57	38
Residual soil	64	123	78	28	81	47

(5) Compaction test

The results of standard Proctor compaction test for all samples are shown below, in which mean values are indicated for all items.

Soil	d/1 max (t/m3)	Wopt/2 (%)	Wn/3 minus Wopt (%)	Wn minus W95/4 (%)	Wn minus W90/5 (%)
Fan soil	1.40	28.5	10.9	5.9	2.2
Terrace soil	1.34	33.5	12.0	6.1	1.5
Talus soil	1.45	27.3	7.1	1.5	- 2.3
Residual soil	1.34	31.1	7.7	2.5	- 1.3

Remarks:
/1 : Maximum dry density
/2 : Optimum water content
/3 : Natural water content
/4 : Highest water content to obtain 95 percents of d max
/5 : Highest water content to obtain 90 percents of d max

Both fan soil and terrace soil show fairly large difference between Wn and Wopt : 1 and 12 percent, respectively. Considering actual placement condition during rainy season, it is readily anticipated that the placement water content can be hardly controlled to decrease to the optimum water content. In addition, earth works handling these soil are not necessarily avoidable during rainy season because most of canal are proposed across the paddy field where fan soil and terrace soil are scattered beneath. Therefore, it is not appropriate for these soils to increase their in-situ dry density to such high value as the maximum dry density. As the difference between Wn and W90 are only two percents for these soils, 90 percents of the maximum dry density is considered to be one of proper values which can be attained easily in compaction control. However, such a low density is not recommendable, due to the problem of cracking to be caused by shrinkage after drying, especially for fan soil. After all, 95 percents of maximum dry density are recommendable for density control during embankment work. In this condition, the reasonably high density would be attained.

Talus soil has higher maximum density and smaller difference between Wn and Wopt than those of fan soil and terrace soil. There exists no serious problem as for the use of talus soil for embankment.

Residual soil has as similar d-max Wopt as those of terrace soil, and difference between Wn and Wopt is not so large. The result on the difference between Wn and Wopt tabulated previously is a mean value of two samples which show extremely different values; one is similar to fan soil, and the other has a tendency that Wn is smaller than Wopt. This fact suggests that some of residual soils need sufficient airing and the others need watering during embankment work.

7.4 ANALYSES

7.4.1 Soil Classification

From the results of particle-size analyses and Atterberg limit test, the unified soil classification could be done as follows:

- Fan soil
  Every fan soil is classified into CH

- Terrace soil
  Most of terrace soils tested in the laboratory are classified into CH. However, natural soils observed in the field contain considerable amount of gravels and cobbles, sometimes boulders. Where these contents would be accounted, natural terrace soils would be classified into GC and SC.

- Talus soil
  Most of talus soils tested are also classified into CH, and partly SC. As natural soils have some amount of gravels and cobbles, they will be classified into many items such as CH, SC and GC, but SC is dominant.

- Residual soil
  Residual soils are classified into two groups. One is CH group which is distributed on the gentle slope. The other is SC group which is mainly distributed on the moderate to rather steep slopes.

7.4.2 Stability of Slopes

(1) Stability of embankment slope

The shearing strength parameters, cohesion and angle of internal friction, to examine the stability of embankment slope, are usually determined from the results of shear strength test. However, as the shear strength test are not made in this study, the following values are assumed for these parameters;

- Cohesion CN = 3.0 t/m^2
- Angle of internal friction Fn = 5^o

The parameters are for fan soil in unconsolidated and undrained conditions and the said soil is considered to have the weakest shearing strength among all of the soils distributed in the project area.

The results obtained by using Talor's method of slope stability are shown below. Required angles for embankment slopes are given with a safety factor of 1.5 against circular sliding.

2 m	4 m	6 m
90^o	90^o	84^o
(1 : .0)	(1 : 0.0)	(1 : 0.11)

From the viewpoint of practical canal construction, it is hardly possible to made an embankment slope almost vertical. Further more it should be considered that the canal embankment will frequently suffer alternate repetition of drying and swelling which will cause failur of steep slope. It is, therefore, recommended that the slope angle of embankment be designed with 34 degrees (1 : 1.5).

(2) Stability of cut slope

The sounding test with a portable cone penetrometer is carried out on natural soft soils. From this test, following equation is obtained.

$$qc = 10 + 3 \cdot z \quad (t/m^2)$$

Where qc : Cone bearing value (t/m^2)
z : Depth from surface (m)

Concerning the alluvial and diluvial natural fine soils, we can assumed the undrained strength C, the cohesion for zero angle of internal friction, as follows.

$$C = \frac{qu}{2} = \frac{1}{2} \cdot \left(\frac{qc}{5} \right) = \frac{qc}{10}$$

Where, C : Cohesion (t/m^2)
qu : Unconfined compression strength (t/m^2)

By using the above two equations and Talor's method of slope stability, it is presumed that the vertical cuts in natural soft soil still have much safety even with considerable height. However, it is also recommended that cut slope in soft soil be designed with 34 degrees (1 : 1.5) as well as embankment slope. In addition, design angles of cut slope for another firm soil and rocks is recommended as follows.

Soil or rock	Design Angle of Cut Slope	
Soft soil	34^{o} (1:1.5)	fan soil and soft residual soil
Medium to firm soil	34^{o} to 45^{o} (1:1.5 to 1.0)	terrace soil, talus and
Weathere rock	51^{o} to 63^{o} (1:0.8 to 0.5)	
R o c k	63^{o} to 73^{o} (1:0.5 to 0.3)	

7.4.3 Leakage through Canal

(1) Leakage through canal embankment

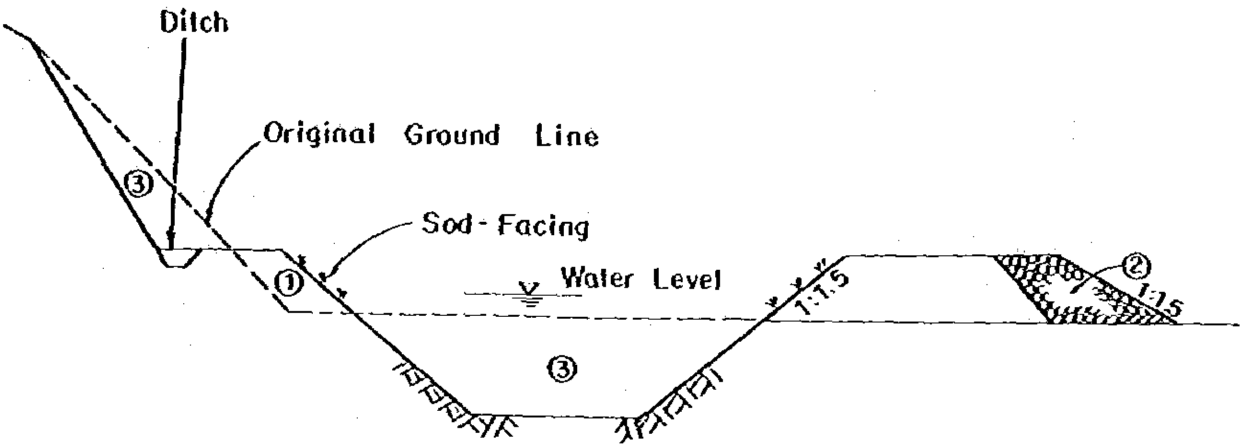
Fan soil and some residual soils like fan soil are readily assumed to have low permeability, such as being less than 1 x 10^{-6} cm/sec from the result of gradation. Terrace and talus are also considered to have low permeability, if cobbles larger than 10 cm are removed. Both soils are estimated to contain about 30 percents and 20 percents of cobbles in volume on an average, respectively. Some residual soils which are mostly composed of sand usually have low natural water content below the optimum water content. If the embankment is compacted to give the degree of saturation less than 75 percents, it will not expected to have low permeability. But this problem is easily settled by adopting the watering process during embankment work. Therefore, no serious problem would be anticipated as far as the leakage through canal banks is concerned.

(2) Leakage through foundation of canal

In this investigation, in-situ permeability tests were carried out at the bottoms of the test pits. The values of permeability range from 1 x 10^{-5} to 5 x 10^{-5} cm/sec. They are reasonably low for the foundations and negligible amount of leakage is expected. Concerning the foundation proposed on terrace deposits along the riverside and limestone bedrock, however, considerably high permeability is anticipated. To prevent high leakage from these foundation, it is recommended that they should be covered with such impervious facings as wet mason for sloping portion and soil concrete for flat portion.

7.5 TYPICAL CANAL SECTION

Based upon the results of soil test and detailed field investigation, a typical design section of canal would be recommended as shown below.



Remarks

(1) Soil Embankment

Cobbles larger than 10 cm, are removed to maintain imperviousness of canal banks. The embankment is desired to be compacted at the more than 95 percents of d max with the degree of saturation more than 75 percents to keep high resistance against drying shrinkage, swelling and sliding. The portion above wetted perimeter of canal should be sodded to protect canal facing from shrinkage and erosion.

(2) Cobble embankment

Cobbles and boulders removed from (1) are used for the embankment (2) to construct the canal economically and to get high resistance against sliding of outer slope.

(3) Excavation

If the foundation of canal is much gravelly or cracky and porous, it should be covered with an impervious materials. The canal route to be lined are identified as listed below through field investigation. (Each identified location, to be referred to Fig. 7.1.1)

Langkemme Canal : A0 to A50, C50 to D0, I5 to I10

Sero Canal : a0 to a50, i0 to i40, f20 to g10, i30 to i40, i50 to j0

The slope angle of cut depends on the geological features as previously mentioned. At the boundary of the cut and the natural slope, the shoulder ditch is desired to protect the cut slope from erosion.

Table 7.1.1 Cone Penetration Test

Location	A	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV
Depth	qc	qc	qc	qc	qc	qc	qc	qc	qc	qc	qc	qc	qc	qc	qc	qc
(m)	(kg/cm^2)	(kg/cm^2)	(kg/cm^2)	(kg/cm^2)	(kg/cm^2)	(kg/cm^2)	(kg/cm^2)	(kg/cm^2)	(kg/cm^2)	(kg/cm^2)	(kg/cm^2)	(kg/cm^2)	(kg/cm^2)	(kg/cm^2)	(kg/cm^2)	(kg/cm^2)
0.1	3.3	3.3	2.31	-	-	-	-	11.22	-	1.32	-	-	-	-	6.60	
0.2	8.58	4.62	6.60	-	-	-	-	16.50	13.20	1.98	-	9.24	-	-	5.28	
0.3	11.22	6.93	Stone	8.65	9.90	13.86	6.60	17.82	15.84	3.30	2.64	9.24	6.60	3.96	5.94	
0.4	12.54	10.33		8.56	14.52	14.85	7.26	15.18	11.88	4.95	3.63	9.24	11.88	7.26	6.60	
0.5	Stone	12.87		9.90	13.20	15.84	8.25	14.52	Hard	8.58	2.64	Stone	13.86	8.56	3.96	
0.6		17.16		9.24	13.20	15.84	8.58	15.18		10.56	5.28		15.84	12.54	5.28	
0.7		Stone		Hard	18.48	14.52	9.90	12.54		10.56	7.92		Stone	13.20	5.94	
0.8					Hard	14.84	13.86	10.56		13.86	8.58			Stone	5.28	
0.9						15.80	15.18	10.23		16.50	8.25				6.60	
1.0						Stone	16.50	10.56		17.82	9.24				7.26	
1.1							17.16	9.24		18.84	9.24				7.26	
1.2							Stone	11.88		Hard	9.90				9.24	
1.3								11.88			11.22				8.58	
1.4								12.54			12.54				11.22	
1.5								10.56			14.19				14.52	
1.6								14.52			15.18				15.84	
1.7								10.56			15.84				17.16	
1.8								10.56			18.48				Hard	
1.9								12.54			18.48					
2.0								11.88			Hard					
Place	Paddy Field	Paddy Field	Paddy Field	Paddy Field	Paddy Field	Paddy Field	Paddy Field	M.S	M.S	Paddy Field	Paddy Field	Paddy Field	Paddy Field	Paddy Field	Paddy Field	
Surface Condition	Wet	Moist	Wet	Dry	Dry	Dry	Dry	Dry	Dry	Moist	Dry	Dry	Dry	Dry	Moist	

Table 7.2.1 Estimated Volume of Borrow Pits

Canal	Longitudinal number	Estimated volume ($\times 10^3 m^3$)	Remarks
Langkemme	B20	50	Talus
	B70	80	Residual
	C10	50	Talus
	D0	100	Residual
	I10	40	Talus
Sero	b50	240	Residual
	140	30	Talus
	h0	10	Residual
	i40	60	Talus

Table 7.3.1 Summary of Soil Test

Location	Sample No.	A50	A90	A90	D45	B65	D10	E3	F15	F18	F18	H50	H50	I15	J10	K0	K0	L10
		d=0.8m	d=0.8m	d=1.8m	d=1.5m	d=1.0m	d=1.0m	d=1.6m	d=1.5m	d=0.5m	d=1.7m	d=0.5m	d=1.5m	d=0.8m	d=0.8m	d=0.3m	d=0.8m	d=1.0m
Gradation (Passing # 4): 4.76 — 2.0mm	%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.0 — 0.074mm	%	24.66	20.90	19.91	45.44	63.78	26.04	11.30	11.64	40.70	23.68	21.82	7.60	26.20	55.18	25.00	37.62	24.42
0.074 — 0.005mm	%	29.34	52.10	40.06	22.56	8.22	38.96	50.70	66.36	37.30	51.32	48.18	62.40	45.80	17.82	53.00	40.38	31.58
0.005mm —	%	46.00	27.00	40.00	32.00	28.00	35.00	38.00	22.00	22.00	25.00	30.00	30.00	28.00	27.00	22.00	22.00	34.00
D60	mm	0.026	0.026	0.022	0.105	0.26	0.035	0.020	0.160	0.105	0.039	0.036	0.020	0.060	0.25	0.036	0.060	0.03
D30	mm	-	0.0123	0.0013	0.0032	0.0131	0.0033	0.003	0.125	0.005	0.004	0.005	0.004	0.010	0.009	0.022	0.015	0.002
D10	mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Consistency: Liquid Limit W_L	%	93.80	80.00	84.50	52.40	64.20	83.20	84.50	112.50	68.20	66.70	85.00	106.25	63.80		92.00	55.50	83.70
Plastic Limit W_P	%	49.72	20.60	30.90	23.79	35.98	37.51	27.57	31.67	25.95	29.01	23.53	33.41	34.25		30.70	25.17	38.91
Plastic Index I_P	%	44.08	59.40	53.60	28.61	28.22	45.67	56.93	80.83	42.25	37.69	61.47	72.84	29.55		61.30	30.33	44.79
Specific Gravity Gs		2.372	2.615	2.532	2.531	2.471	2.453	2.520	2.655	2.511	2.511	2.485	2.412	2.744	2.473	2.540	2.543	2.436
Natural Water Content W_n (Passing # 4)	%	47.44	34.05	33.49	34.94	28.37	35.41	40.36	49.07	31.66	32.47	48.39	44.72	27.65	20.87	44.03	43.93	40.83
Proctor Compaction: Opt. Water Content W_{opt}	%	32.3	25.5	-	20.3	33.0	38.0	34.0	29.1	-	-	-	31.5	27.5	-	-	30.3	-
Max. Dry Density $\gamma_{dmax.}$	%	1.29	1.49	-	1.59	1.32	1.33	1.32	1.35	-	-	-	1.30	1.45	-	-	1.39	-
$W_n - W_{opt}$	%	15.1	8.6	-	14.6	-4.7	2.6	6.4	20.0	-	-	-	13.2	0.2	-	-	13.6	-
Unified Classification		CH	CH	CH	CH	SC	CH	CH	CH	CH	CH	CH	CH	CH	SC	CH	CH	CH
Remarks		Terrace Soil	Fan Soil	Fan Soil	Talus Soil	Residual Soil	Terrace Soil	Talus Soil	Fan Soil	Fan Soil	Fan Soil	Fan Soil	Fan Soil	Talus Soil	Terrace Soil	Fan Soil	Terrace Soil	Terrace Soil

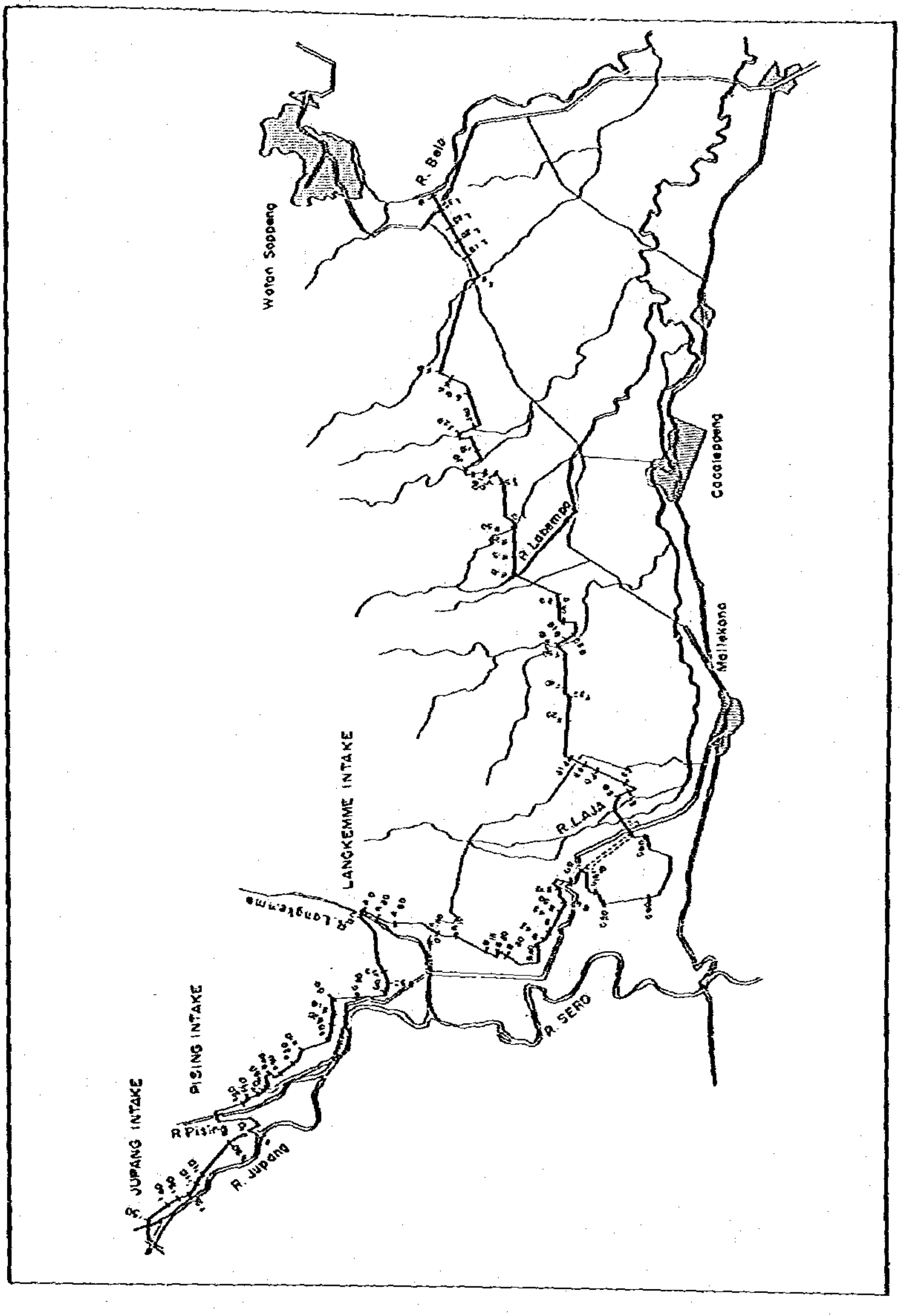


Fig. 7.1.1 PITS AND INVESTIGATION SITE

CHAPTER VIII HYDROPOWER

CHAPTER VIII HYDROPOWER

8.1 PRESENT SITUATION

8.1.1 Existing Cennae Hydropower Station

The station constructed in 1973 by the British Aid and operated by the PLN., is located close to the Kampung Cennae at left bank of the Langkemme river. The intake structure of the station is commonly used with the DPU Cennae semi-technical irrigation scheme. The station is operated about 14 hours per day on an average during wet season by discharging excess water of the Cennae Irrigation scheme. Actually, its daily operation is sometimes limited less than five hours even during wet season. The station has never generated during drought season owing to the depleted flow in the Langkemme river. An engine-drive generator is installed to supplement electric power supply during the drought season. The hydro-power plant installed in the station is investigated and summarized in Table-8.1.1 and illustrated in Fig. 8.1.1.

8.1.2 Existing Distribution System

The power distribution system in the project area consists of a six kilo-volt and a low voltage distribution line as an isolated system. Main features of the existing distribution lines are summarized as follows:

(i) 6 kV line

- (a) Section : Watu village Cennae - Tettikenrarae village Takalala
- (b) Voltage : 6 kV
- (c) Frequency : 50 Hz
- (d) Length : About 10 km
- (e) Number of circuit : Single circuit
- (f) Conductor : Hard drawn copper conductor, 35 sq.mm

(ii) Low tension line

- (a) Location : Watu village Cennae and Tettikenrarae village Takalala
- (b) Voltage : 200 - 127 V, 3-phase, 4-wire system
- (c) Frequency : 50 Hz

8.1.3 Influences on the Station by Implementation of the Langkemme Irrigation Project

The water available for the existing micro hydropower station is clarified under both without- and with-the-project conditions. Then, the possible operation periods are calculated under the both conditions. The following assumptions are given to make above mentioned studies.

- Water requirement for the existing micro hydropower station is 1.0 m^3/s based on the inspection of the plant.
- Water requirement for the existing DPU Cennae semi-technical irrigation scheme is 0.2 m^3/s.
- Intake efficiency of the existing Langkemme intake facilities is 80 %.

(1) Available water for the existing micro hydropower station

i) Available water without project

The available water for the existing micro-hydropower station is given by the equation below.

$$Qp = Ql \times Ei - Qc$$

Where,
- Qp : available water for hydropower (m^3/s)
- Ql : discharge in the Langkemme river (m^3/s)
- Ei : intake efficiency (= 80 %)
- Qc : diversion requirement for Cennae scheme(= 0.2 m^3/s)

The available water (Qp) is calculated in 10-day basis for five years from 1975 to 1979.

ii) Available water with project

The available water is represented by the following two equations. The smaller value of Qp is applicable.

$$Qp = (Qt + Ql + Qs) \times Ei - Qi$$
$$Qp = Ql \times Ei$$

Where,
- Qp : available water for hydropower (m^3/s)
- Qt : discharge in tributaries (m^3/s)
- Ql : discharge in the Langkemme river (m^3/s)
- Qs : discharge in the Sero river (m^3/s)
- Ei : intake efficiency (= 80 %)
- Qi : diversion requirement for the Project (m^3/s)
  $Qi = (Qe/1,000) \times 6,400$ ha
- Qe : seasonal unit diversion requirement (l/s/ha) (see Table 4.1.22 in Annex II, Chapter-IV)

The available water (Qp) is calculated in 10-day basis for the same five years as without Project.

(2) Possible operation period of the existing micro hydropower station

The possible operation period of the existing micro hydropower station is illustrated in Fig. 8.1.2 of both without-the-Project and with-the-Project conditions. The summary is as follows:

Year	Without Project		With Project	
			month,	(%)
1975	8.0	(67)	10.0	(83)
1976	7.7	(64)	8.0	(67)
1977	10.0	(83)	10.0	(83)
1978	12.0	(100)	12.0	(100)
1979	9.3	(78)	9.7	(81)
Average	9.4	(78)	10.0	(83)

8.1.4 Replacement of Hydropower Plant

In the early stage of the study, it is considered that the operation of the micro-hydropower plant be remarkably influenced with the implementation of the project and be replaced for compensation. As previously discussed, the present operation of the station would be ensured and rather improved even after the completion of the project. This is mainly attributable to the Sero river diversion. No replacement of the existing hydropower plant would be proposed with the implementation of the Langkemme Irrigation Project.

8.1.5 Present Power Consumption

Daily average of peak demand, generated energy, etc. in the Cennae power station are as illustrated in Fig. 8.1.3. The maximum power demand is recorded at about 47 kW. About 40 kW, out of the generated power are delivered to Takalala by a single-circuit 6 kV distribution line of about 10 km long and the remaining about 6 kW, to Cennae by a separate low voltage distribution line of 220 - 127 V.

Present contracted consumers are 291 households in total, 220 households in Takalala and 71 households in Cennae. The generated power is consumed mainly around the station and the market at Takalala. Per capita annual power consumption at both villages is estimated at about 123 kWh in power energy and 23 kW in peak power at present. Tariff structure of PLN is very complicated as shown in Table 8.1.2 according to category of consumers.

8.1.6 Power Demand and Future Development

A remarkable growth of power demand will be surely caused by election of new power plant and extension of distribution system in and around the Kampung Cennae, Takalala, Congko and Jennae. But the capacity to be newly developed is unable to cover the increased demand

and, in addition, it is quite difficult to get new power source from other circuit grids, because the existing distribution system is completely isolated from the other grids.

Small scale power plant and supply system are under construction in the Kampung Jennae: a diesel engine generator of 100 kVA is isolatively proposed for the Kampung Jennae and Takalala together with new distribution lines of 6 kV of 3.3 km long. (see Fig. 8.1.3). Furthermore, low tension distribution system is also under construction from the Kanpung Takalala to Jennae.

8.2 HYDROPOWER DEVELOPMENT PLAN IN THE LANGKEMME CANAL SYSTEM

8.2.1 Available Head

A micro hydropower station is proposed in the Langkemme main canal system, taking into account of the effective use of hydraulic head caused in the system. A lot of drop structures are proposed in the Langkemme main canal to dissipate excess hydraulic energy which is available for hydropower generation. Based on the result of the topographic survey along the route of main canal, a site potential for hydropower generation is selected at the boundary of the Kecamatan Liliriaja and Mario Riwao, close to the Baruttunge river. According to the detailed topographic survey, it is clarified that about 11 m of hydraulic head are available in gross at the selected site. The topographic condition at the site is as illustrated in Fig. 8.2.1.

8.2.2 Available Discharge

Seasonal fluctuation of the discharge in the main canal at the proposed site is by-monthly clarified according to the following procedure, consequent on the analysis of hydrology and irrigation requirement:

- The discharge data of the Langkemme and the Sero river in 1976, which is the droughtest year for recent 5 years, are picked out and summed up,

- The dependable flow on the both river is by-monthly estimated by multiplying the summed-up river flows by the intake efficiency of 80 %,

- The maximum dependable flow would be limited within the maximum conveyance capacity of 5 m^3/sec, and

- The monthly fluctuation of discharge at the proposed site are modified by multiplying the dependable flow by the commanding ratio of 77 %, because the Langkemme main canal (from the intake to the site) irrigates about 23 % of the whole project area.

The monthly discharge available for the power generating is estimated based on the above procedure and summarized as follows:

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Q (cu.m/sec)	3.1	2.9	3.0	3.2	2.8	3.5	3.1	2.0	1.3	2.1	2.7	3.6

Note: Daily maximum water flow ..... 3.9 cu.m/sec (estimated as four hours at the evening)

8.2.3 Development Plan

In view of the present pattern of daily load curve (Fig. 8.2.2) a peaking period of around four hours seems to be appropriate. The generating plant installed in the station should be given a capacity for peak power generation in due consideration of the fluctuation of irrigation water supply, because no water would be additionally allocated to the power generating. On the basis of the available discharge estimated in the previous section, the monthly generating output and dependable energy production are estimated as shown in Table 8.2.1 (1). At the maximum available discharge of 3.9 m^3/sec (equivalent to 77 % of the maximum intake capacity), the daily maximum output of about 315 kW would be generated. The annual energy production at the station would amount to about 2,000 MWh per annum. (See Table 8.2.1 (2)).

8.2.4 Design and Cost Estimate of Power Station

(1) Power house

A floor space of about 70 m^2 would be required for the proposed power generating plant. As shown in Fig. 8.2.3, the substructure of about 3 m below existing ground level would be constructed by reinforced concrete on the base rock. The superstructure of about four m would be mainly built by brick works.

(2) Power generating equipment

Hydraulic turbine

The hydraulic turbine to be installed at the power station would be tubular type with a draft tube. Owing to the fluctuation of the irrigation water, the turbine would vary from a peaking water flow of 3.9 cu.m to a minimum flow of 1.3 cu.m at around 11 m gross head. As the result of the examination of the design condition, daily peaking flow of 3.9 cu.m at 11 m gross head is adopted for four hours.

The turbine would be given 500 rpm rated speed and 315 kW rated output at 3.9 cu.m and 11 m head, and at minimum water flow of 1.3 cu.m, the output of the turbine will be calculated as about 83 kW. (See Fig. 8.2.4). The following are the items which were taken into consideration on selection of the hydraulic turbine to be installed in the power station.

(i) Basic data

Maximum water flow (daily peak)	3.9 cu.m
Minimum water flow (in September)	1.3 cu.m
Gross head	11 m

(ii) Type: Tubular

(iii) Speed: 500 rpm

(iv) Output: 315 kW

(v) Draft head: Maximum 1 m

Alternator current generator

The generator to be installed at the power station would be horizontal shaft coupled with gear (speed increaser), having 1,000 rpm of the speed and being rated at 400 kVA, 380-220 V, 3-phase synchronous generator, 50 Hz and 0.8 power factor. The terminal voltage of generator is selected at 380-220 V as the most economical voltage for the proposed capacity.

Step-up transformer

The step-up transformer to be installed at the power station would be rated at 400 kVA, 50 Hz, 3-phase two windings, 380-220 V delta to 6 kV star connected outdoor, self-cooled type.

(3) Distribution line

The generated power would be supplied to surrounding villages by newly, installing 6 kV distribution line including step-down transformer. The new distribution line would be connected to the existing 6 kV line extending from Cennae to Takalala. Typical assemblies for 6 kV distribution line is shown in Fig. 8.2.5. The networks of distribution line after the completion of the new hydropower system are laid out in Fig. 8.2.6.

(4) Construction cost

The total construction cost of the generating equipment and power transmitting facilities is estimated at US$1,211,000 comprising the foreign currency portion of US$655,000 and the local currency portion of US$556,000 equivalent. The summary of the estimate is given below.

The prices for the generating equipment, distribution line are estimated refering to the current prices in the Japanese market in October 1980. It is assumed that the custom duties on the imported plant and materials would be exempted.

Item	Foreign Currency (10^3x US$)	Local Currency (10^3x US$)	Total (10^3x US$)
I. Generating Equipment	454	83	537
II. Distribution 6 kV (8 km W/Tr. 400 kVA) L.T. (8 km W/service wire)	96	460	556
III. Engineering & Administrative Expenses	105	13	118
Grand Total	655	556	1,211

(5) Constsruction plan

Almost all of construction works are affected by dry and wet seasons, especially, building construction works. Transportation of the generating facilities is often interrupted by heavy rain during wet season. The construction plan should be prepared in due consideration of the climatic conditions in this project area.

Power generating equipment

Working time is estimated at about seventeen months including manufacturing, transportation and erection at site.

6 kV distribution line

The route of the 6 kV distribution line from Cennae to Takalala run through the paddy field and along the road. While, the 6 kV distribution line from the proposed power station to existing 6 kV distribution line would be constructed through the forest and along the road which is newly constructed. The construction works are possible even in the rainy season.

Transportation

All equipment and materials would be unloaded at Pare-Paré port which has unsufficient unloading capacity for the power plant for the project. The equipment and materials unloaded at Pare-Pare port would be transported to the site by trailor.

Construction time schedule

Overrall schedule including design, manufacturing, transportation, field construction, erection, etc., is barcharted as shown in Fig. 8.2.7.

8.2.5 Anticipated Benefit

(1) Value of generated power

The value of the new hydropower is measured based on the cost required for the production of the equivalent energy by the least cost alternative means. Two units of diesel engine-generator plants with a capacity of 320 kW are equivalent to the alternative of the proposed hydropower generating plant; one unit would be considered for stand-by because engine generator might be frequently shutdown for maintenance. The capacity value is estimated as the alternative cost as shown below:

Foreign currency	US$560,000
Local currency	US$ 15,000
Total	US$575,000
Per kW Installed	US$898/kW

Annual fixed cost

Interest and depreciation (Capital Recovery)

8 % for foreign currency	US$ 50,000
8 % for local currency	US$ 1,400
Fixed O & M (20 % of the construction cost)	US$115,000
Total	US$116,400

Capital recovery factor (30 years)

8 % : 0.08883

Annual fixed cost per kW installation US$260/kW

The following adjustments are made for the difference between hydro and diesel plant.

	Hydro (%)	Diesel (%)
Distribution Loss	15	15
Forced Outage	0	12
Overhaul and Inspection	2	8
Auxiliary Power Use	2	4

$$\text{Compensation Factor} = \frac{(1-0.15)(1-0)(1-0.02)(1-0.02)}{(1-0.15)(1-0.12)(1-0.08)(1-0.04)}$$

$$= 1.236$$

Capacity value = 260 x 1.236 = US$321.4/kW

(2) Energy value

Energy value is estimated as follows:

Energy cost

Fuel cost : 0.08 US$/l
Fuel consumption : 0.28 l/kWh

Requested fuel cost per kWh is estimated at US$0.0224.

Adjustment in difference between hydro and diesel plant is also applied to fuel consumption:

	Hydro (%)	Diesel (%)
Distribution Loss	15	15
Auxiliary Power Use	2	4

$$\text{Compensation Factor} = \frac{(1-0.15)(1-0.02)}{(1-0.15)(1-0.04)} = 1.02$$

Energy value = 0.0224 x 1.02 = US$0.0228/kWh

(3) Annual benefit

On the basis of the capacity value and energy value calculated above, annual benefit from the new hydro power station is estimated at US$114,000 as shown below:

Capacity benefit

233 kW x US$321.4/kW = US$74,886

Energy benefit

2,036,700 kWh x 0.85 x US$0.0228/kWh = US$39,471

(0.85 : Distribution loss excluded)

Total annual benefit

US$114,375

Table 8.1.1 Existing Micro Hydropower Equipment

1. Water Turbine		
Type	:	Horizontal Shaft, Francis Type (No. 6153)
Year of Manufacturing	:	1971
Rated Speed	:	628 r.p.m.
Rated Head	:	12.5 m
Rated Output	:	134 BHP (Approx. 100 kW)
Name of Maker	:	GILBERT GILKES and GOLDEN LTD., KENDAL ENGLAND
2. Governor		
Type	:	Oil Pressure Governor (No. 1128)
Size	:	B
Capacity	:	900 Ft. Lb
Name of Maker	:	GILVERT GILKES and GOLDEN LTD., KENDAL ENGLAND
3. Inlet Valve		
Type	:	JFPG
Bore	:	24
Max. Water Pressure	:	150
Name of Maker	:	ELLIOTT and GARROOD LTD., BECCLET SUFFOLK
4. Generator		
Type	:	TBT.600.C (No. 61034), 3-phase, 50 Hz, 1,000 r.p.m. 220/127 V
Year of Manufacturing	:	1971
Capacity	:	112 kVA (P.F.: 0.8) = 89.6 kW

5. **Distribution Cubicle** (Ottermill)

Following meters were mounted on the front of the cubicle.

kWh x 1
kW x 1
A x 1
V x 1
Hz x 1

6. **Step-up Transformer**

3-phase, 50 Hz, 6,000/220 V, 100 kVA, ONAN

Impedance	:	4.85%
Vector Symbol	:	Yd11

Table 8.1.2 Tariff Structure of PLN

STRUKTUR
TARIP DASAR LISTRIK 1980

NO.	KODE TARIP BARU	BATAS DAYA		BEA BEBAN Rp./kVA	BEA PEMAKAIAN Rp./kWh	TB (TAMBAHAN BIAYA) Rp./kWh
1.	S_1	s/d	200 VA	*)	-	abonemen *)
2.	S_2	250 VA s/d	200 VA	1,600	12	3
3.	R_1	250 VA s/d	500 VA	2,800	23	6
4.	R_2	501 VA s/d	2,200 VA	2,800	31	8
5.	R_3	2,201 VA s/d	6,600 VA	2,800	36	9
6.	R_4	6,601 VA keatas		2,800	46	11.50
7.	U_1	250 VA s/d	2,200 VA	2,800	38	9.50
8.	U_2	2,201 VA s/d	200 kVA	2,800	39	10
9.	U_3/TM	201 kVA keatas		1,750	WBP = 43 LWBP = 27	7
10.	U_4	-		-	100	25
11.	H_1	250 VA s/d	200 kVA	2,800	32	8
12.	H_2/TM	201 kVA keatas		1,750	23	6
13.	I_1	3.8 kVA s/d	99 kVA	1,750	WBP = 24 LWBP = 15	5
14.	I_2	100 kVA s/d	200 kVA	1,750	WBP = 26 LWBP = 17	5
15.	I_3/TM	201 kVA keatas		1,600	WBP = 24 LWBP = 15	5
16.	I_4/TT	5,000 kVA keatas		1,500	WBP = 22 LWBP = 14	5
17.	G_1	250 VA s/d	200 kVA	2,800	26	6.50
18.	G_2/TM	201 kVA keatas		1,500	WBP = 26 LWBP' = 17	4.50
19.	J	-		-	26	6.50

*) Tarip S_1

	TDL'80	TB	Jumlah
60 VA	= Rp. 620.--/bulan	Rp. 90.--/bulan	Rp. 710.--/bulan
75 VA	= Rp. 775.--/bulan	Rp. 115.--/bulan	Rp. 890.--/bulan
100 VA	= Rp. 1,000.--/bulan	Rp. 150.--/bulan	Rp. 1,150.--/bulan
125 VA	= Rp. 1,275.--/bulan	Rp. 190.--/bulan	Rp. 1,465.--/bulan
150 VA	= Rp. 1,500.--/bulan	Rp. 225.--/bulan	Rp. 1,725.--/bulan
175 VA	= Rp. 1,725.--/bulan	Rp. 265.--/bulan	Rp. 1,990.--/bulan
200 VA	= Rp. 2,000.--/bulan	Rp. 300.--/bulan	Rp. 2,300.--/bulan

CATATAN:

WBP = Waktu Beban Puncak (18.00 - 22.00 Waktu setempat)
LWBP = Luar Waktu Beban Puncak (22.00 - 18.00 Waktu setempat)

LEGEND

KODE TARIP BARU	: New Tariff Cord
BATAS DAYA	: Power Limit
BEA BEBAN	: Constant Tax
BEA PEMAKAIAN	: Use Tax
TB (TAMBAHAN BIAYA)	: Supplement Tax
s/d	: To
abonemen	: Subscription
keatas	: Over
WBP (Waktu Beban Puncak)	: Peak Time
Waktu setempat	: Time in the Site
LWBP (Luar Waktu Beban Puncak)	: Off Peak Time
TDL (TARIP DASAR LISTRIK)	: Electric Power Rate
Jumlah	: Total
S	: Society (Hospital and Mosque)
R	: House Hold
U	: Commercial
H	: Hotel
I	: Industry
G	: Government Office
J	: Streetlight
TM	: Middle Capacity
TT	: Big Capacity
bulan	: Month
CATATAN	: Remarks

Table 8.2.1 (1) <u>Water Flow and Generating Output</u>

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Q (Cu.m)	3.1	2.9	3.0	3.2	2.8	3.5	3.1	2.0	1.3	2.1	2.7	3.6
Pt (kW)	264	244	254	273	234	312	264	157	90	167	225	312
Pg (kW)	245	226	235	253	217	289	245	146	83	155	209	289

Pt : Water Turbine Output
Pg : Generator Output
Peaking Flow: 3.9 Cu.m/sec

Table 8.2.1 (2) <u>Daily and Monthly Dependable Output</u>

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
MWh/day	6.16	5.78	5.96	6.32	5.60	7.04	6.16	4.18	2.92	4.36	5.44	7.04	66.960
MWh/M	190.96	161.84	184.76	189.60	173.60	211.20	190.96	129.58	87.60	135.16	163.20	218.24	2,036.7

Operation Hour

Peak : 18.00 PM - 22.00 PM (Output 315 kW at 3.9 Cu.m)

Off Peak: 22.00 PM - 18.00 PM

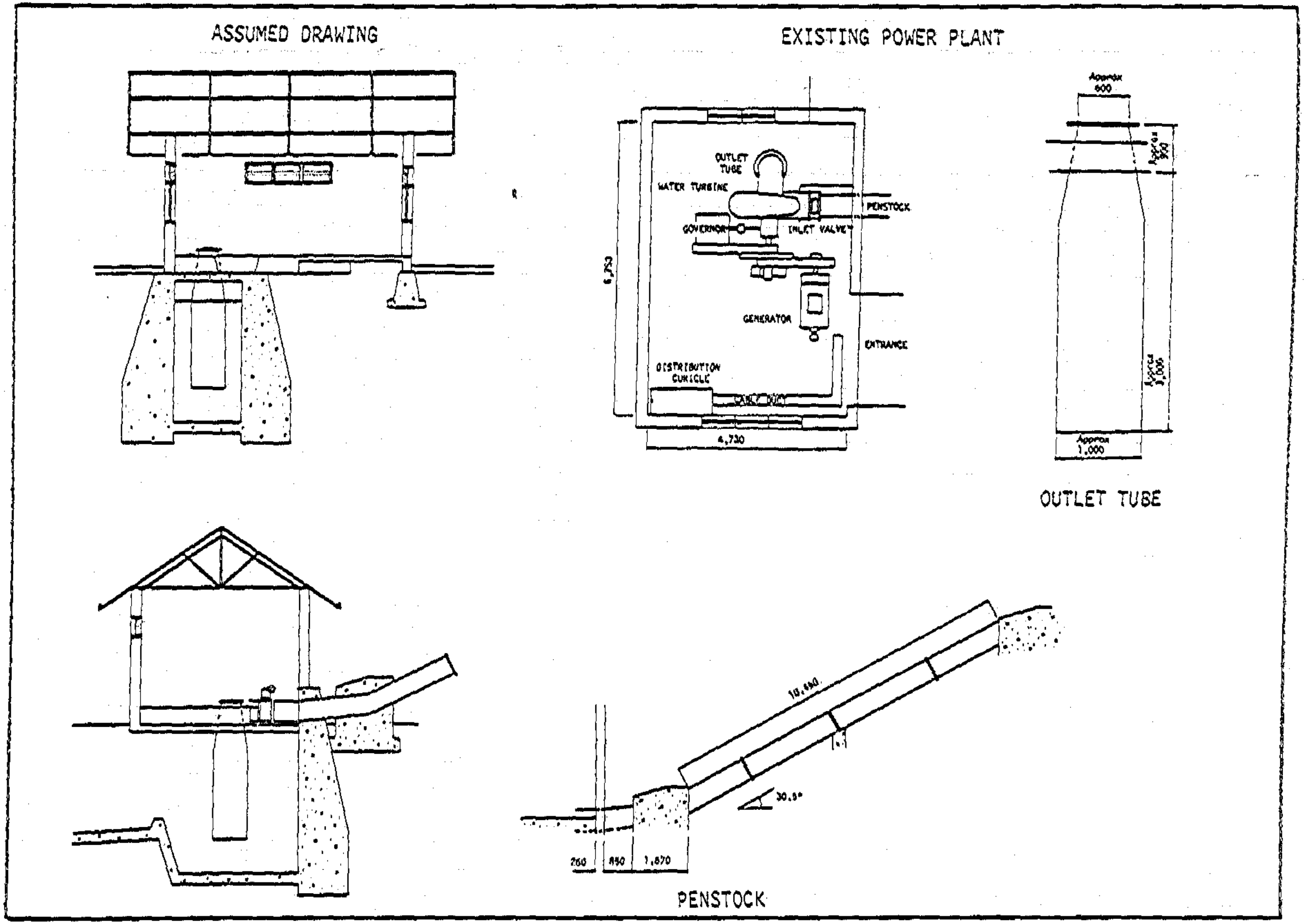


Fig. 8.1.1 POWER HOUSE

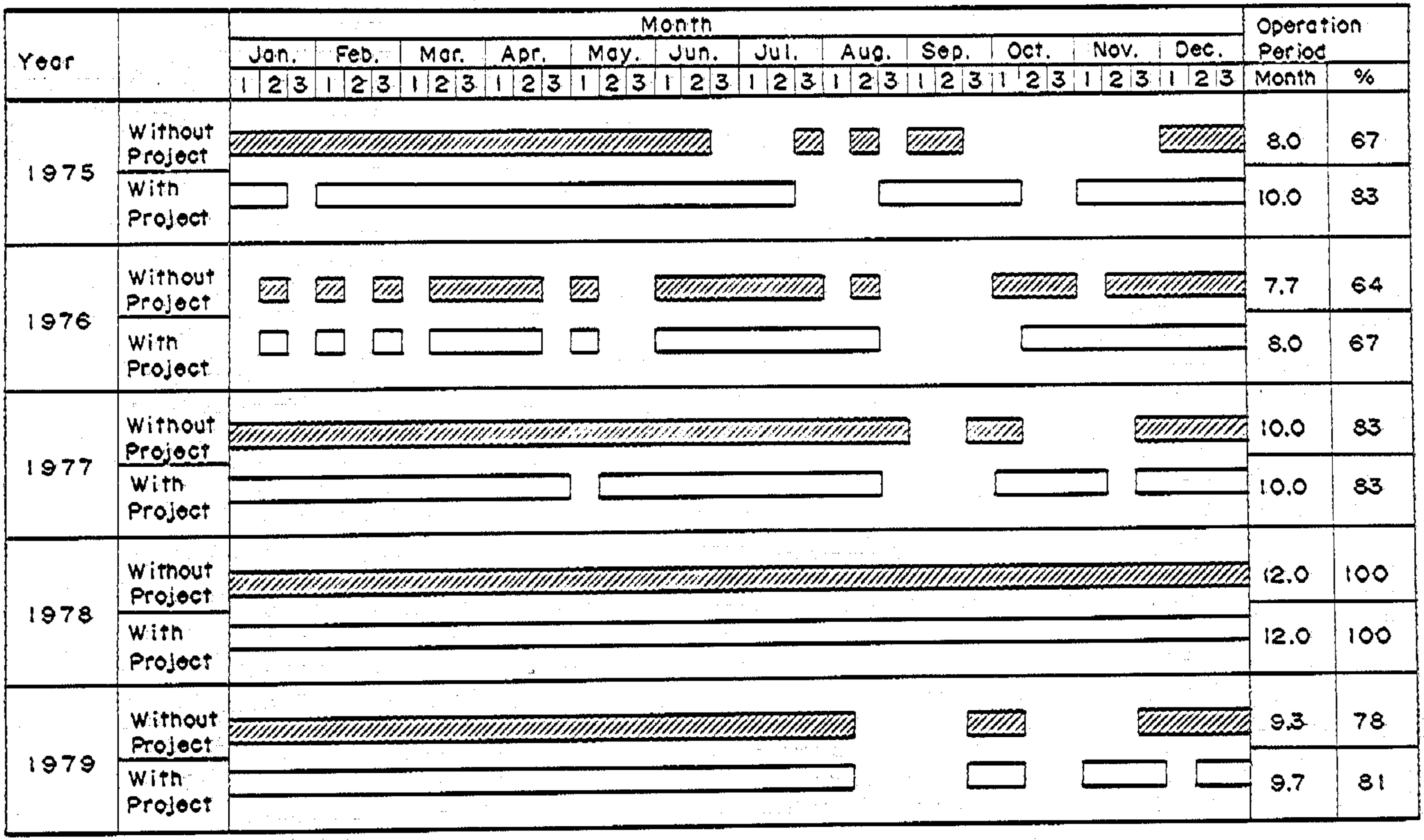


Fig.8.1.2 POSSIBLE OPERATION PERIOD OF EXISTING MICRO HYDROPOWER STATION

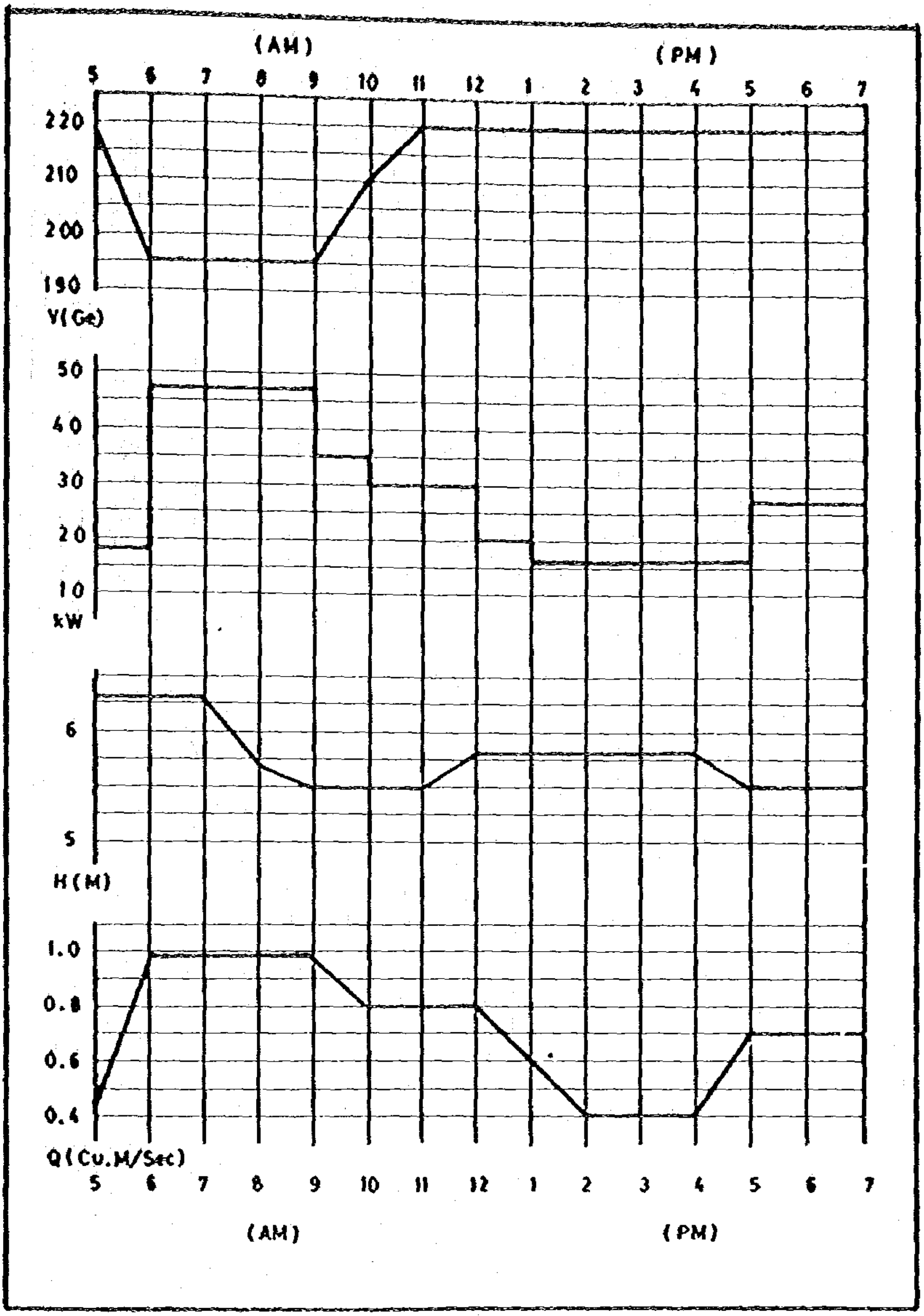


Fig. 8.1.3 DAIRY AVERAGE DEMAND

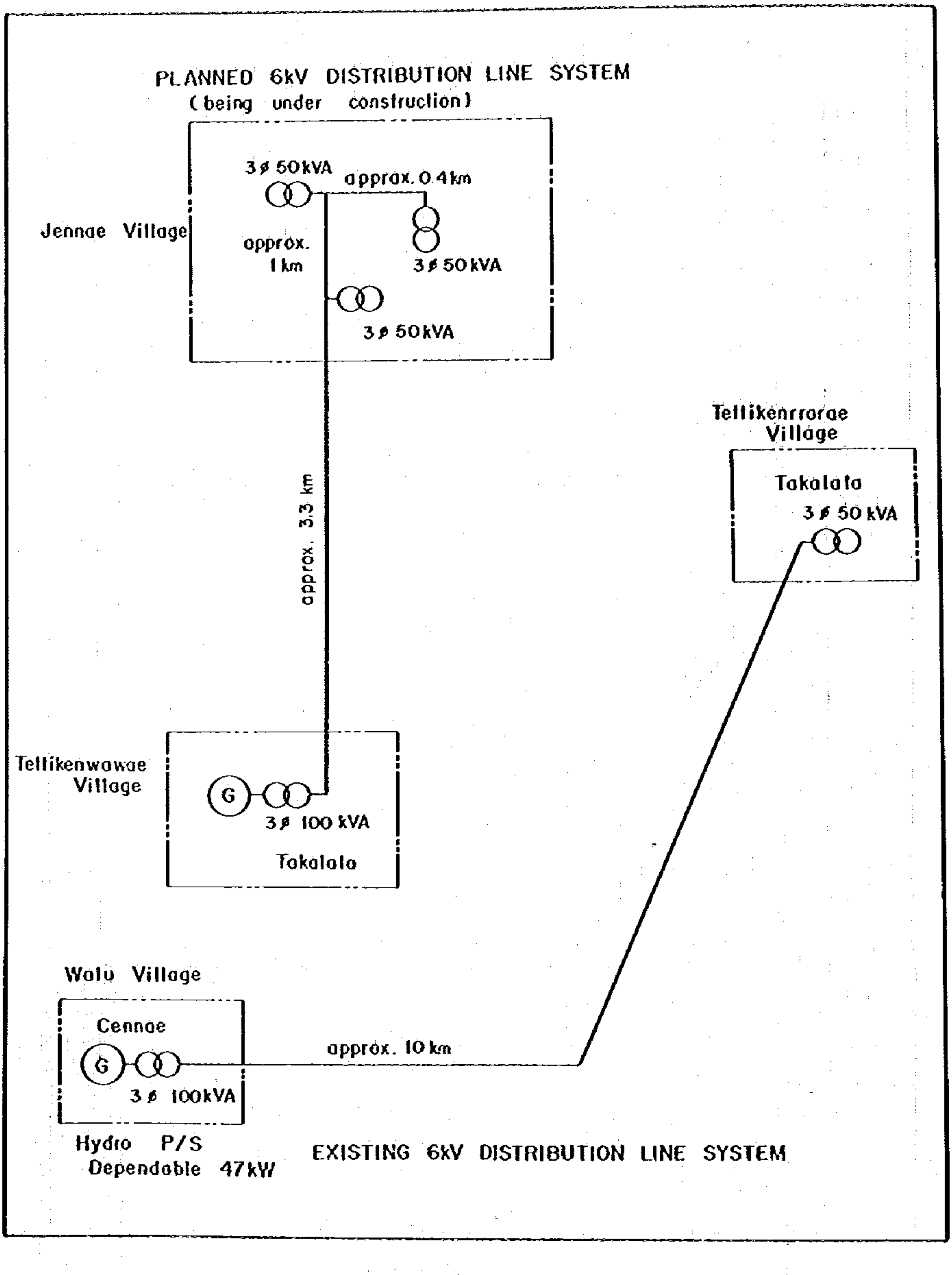
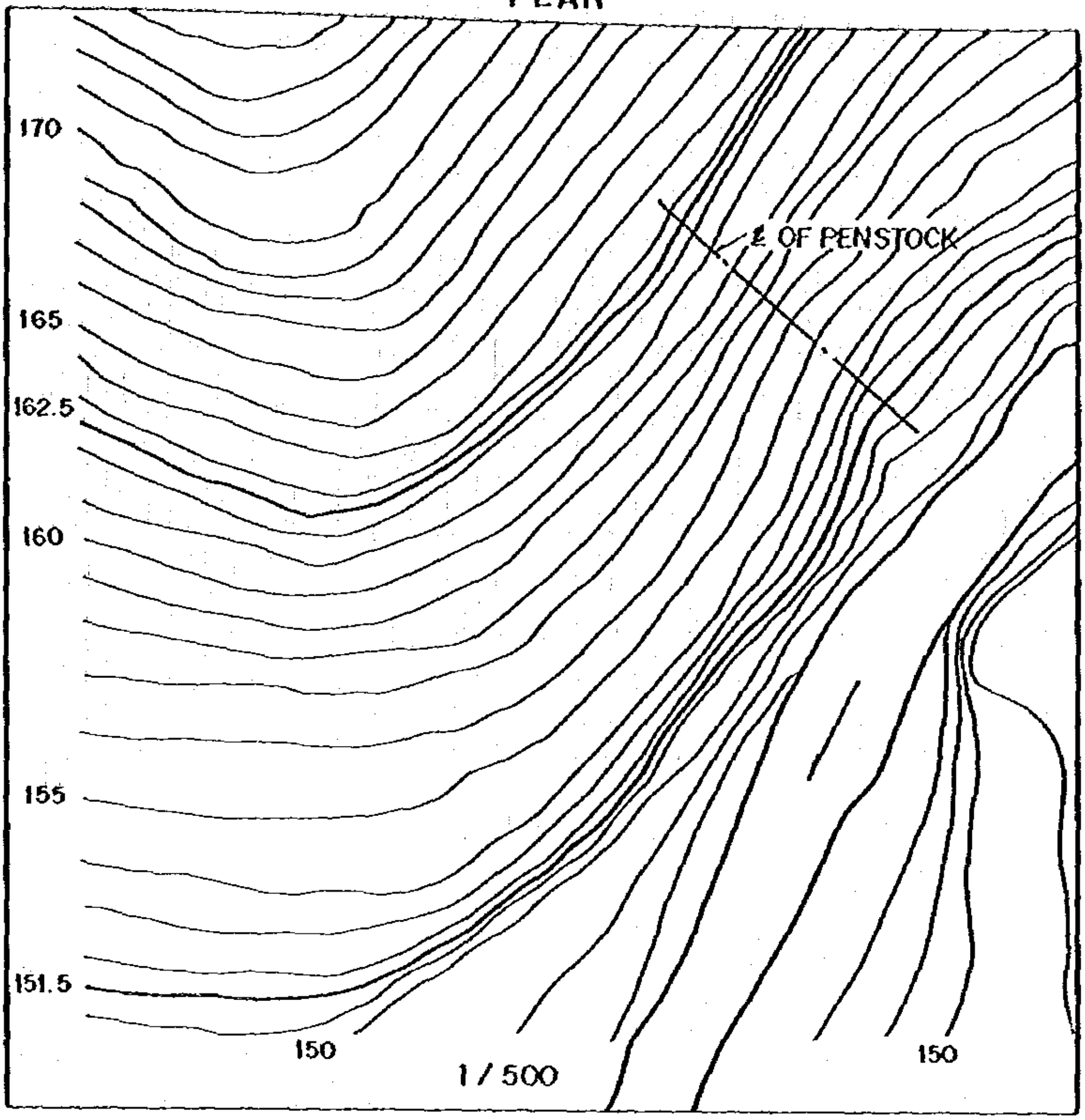


Fig.8.1.4 EXISTING & UNDER-CONSTRUCTION POWER SUPPLY SYSTEM

PLAN



CROSS SECTION

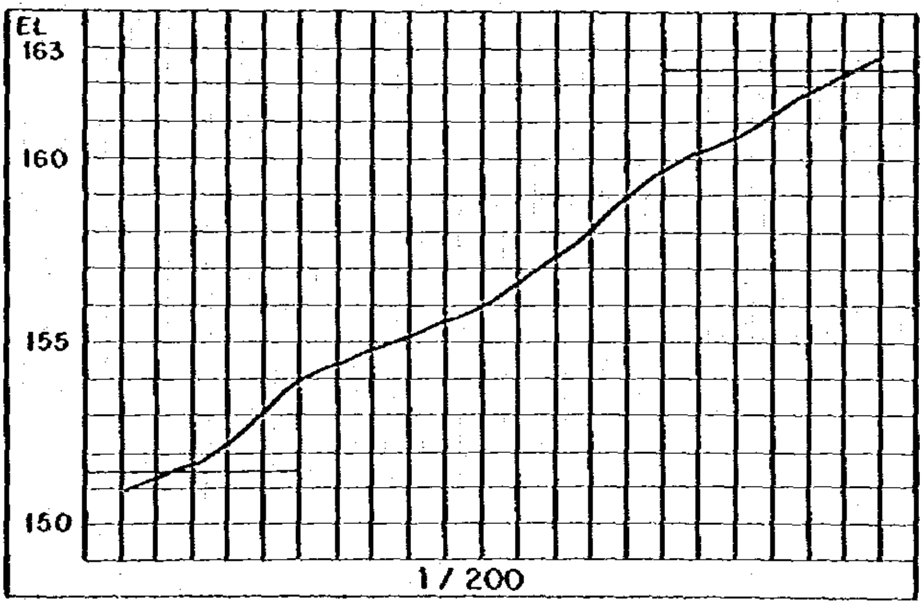


Fig.8.2.1 TOPOGRAPHIC CONDITION AT PROPOSED STATION

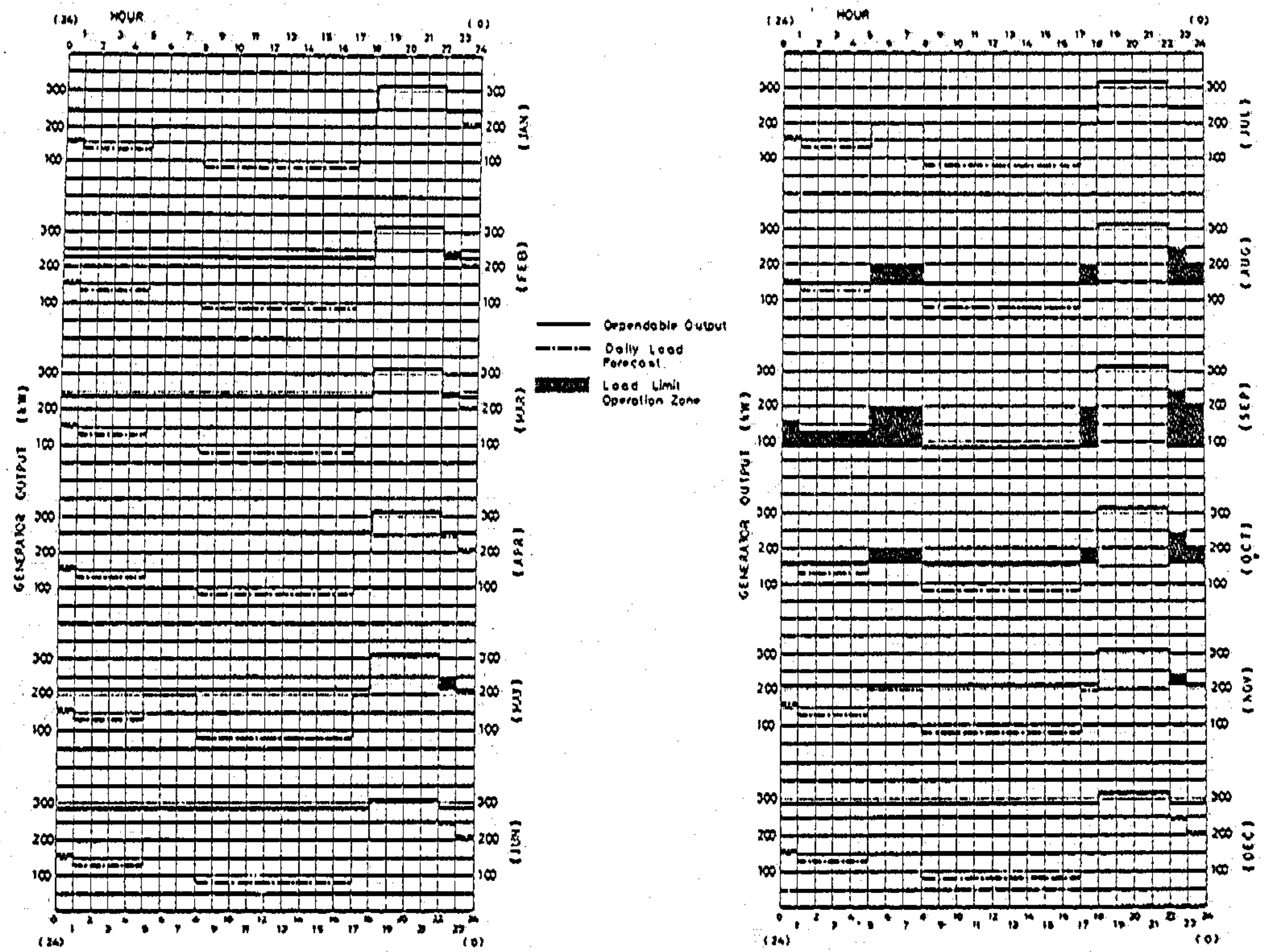


Fig. 8.2.2 DAILY LOAD FORECAST OF MONTHS

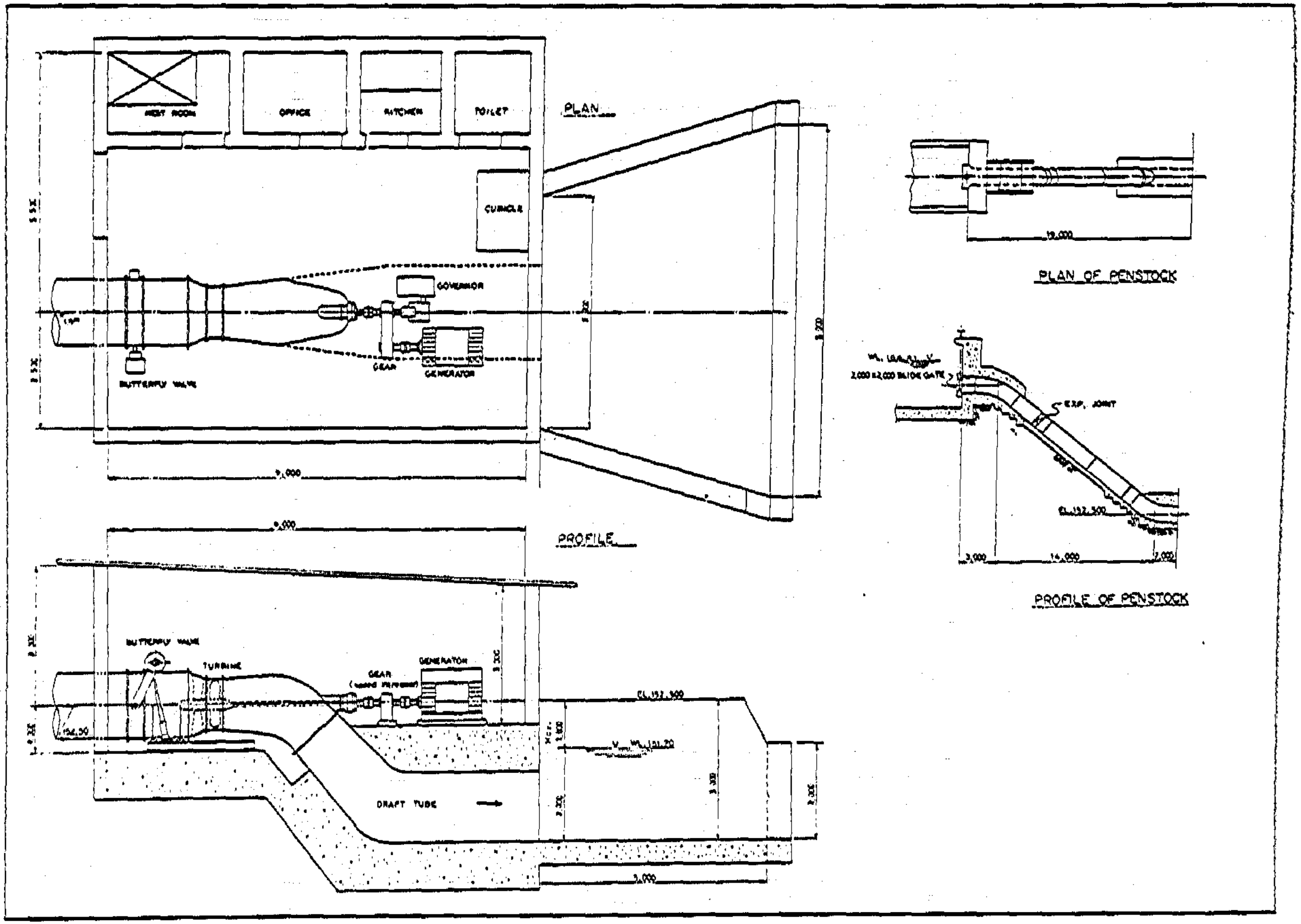


Fig. 8.2.3 PROPOSED POWER HOUSE

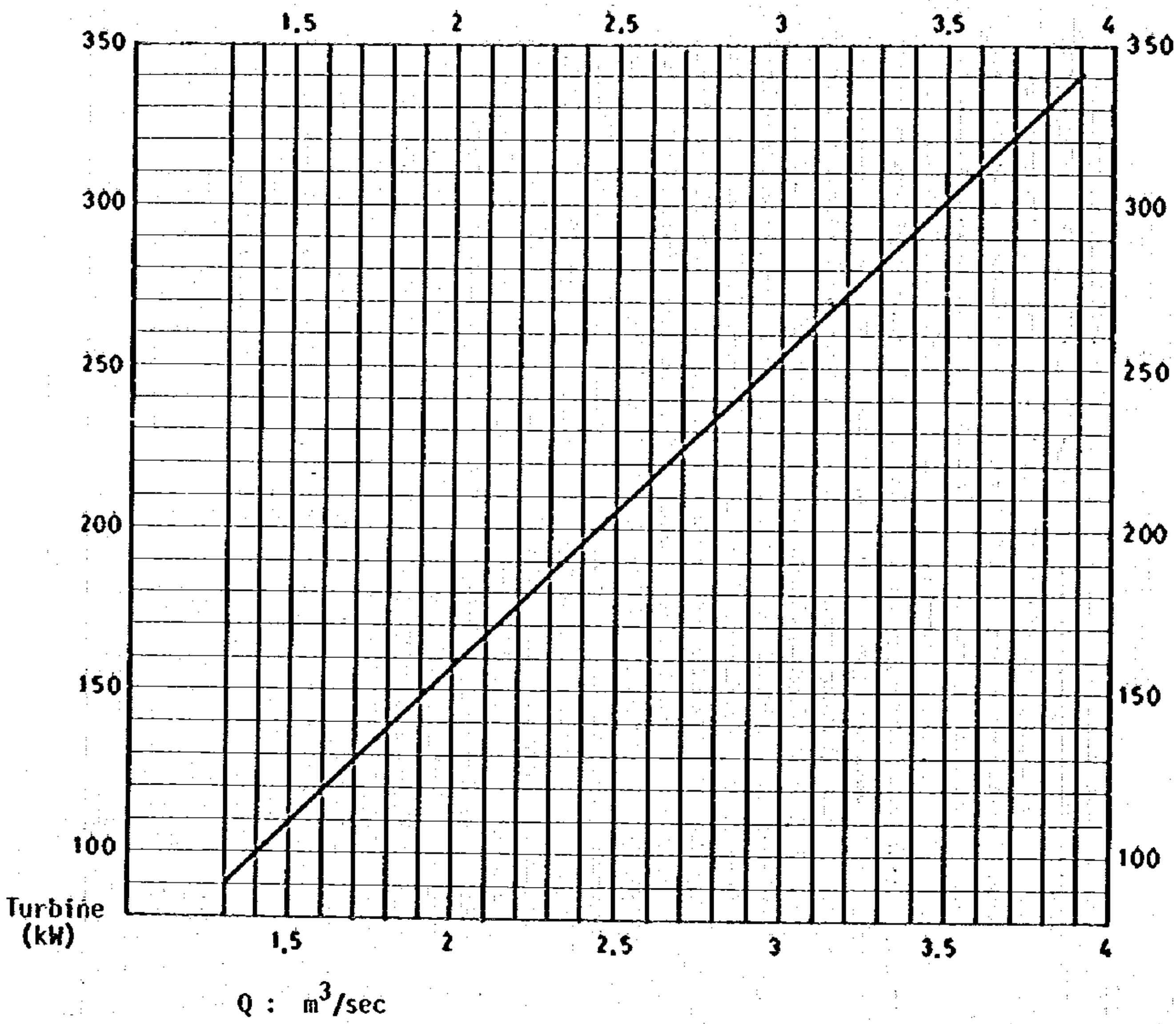


Fig. 8.2.4 Q-P CURVE ON HYDRAULIC TURBINE

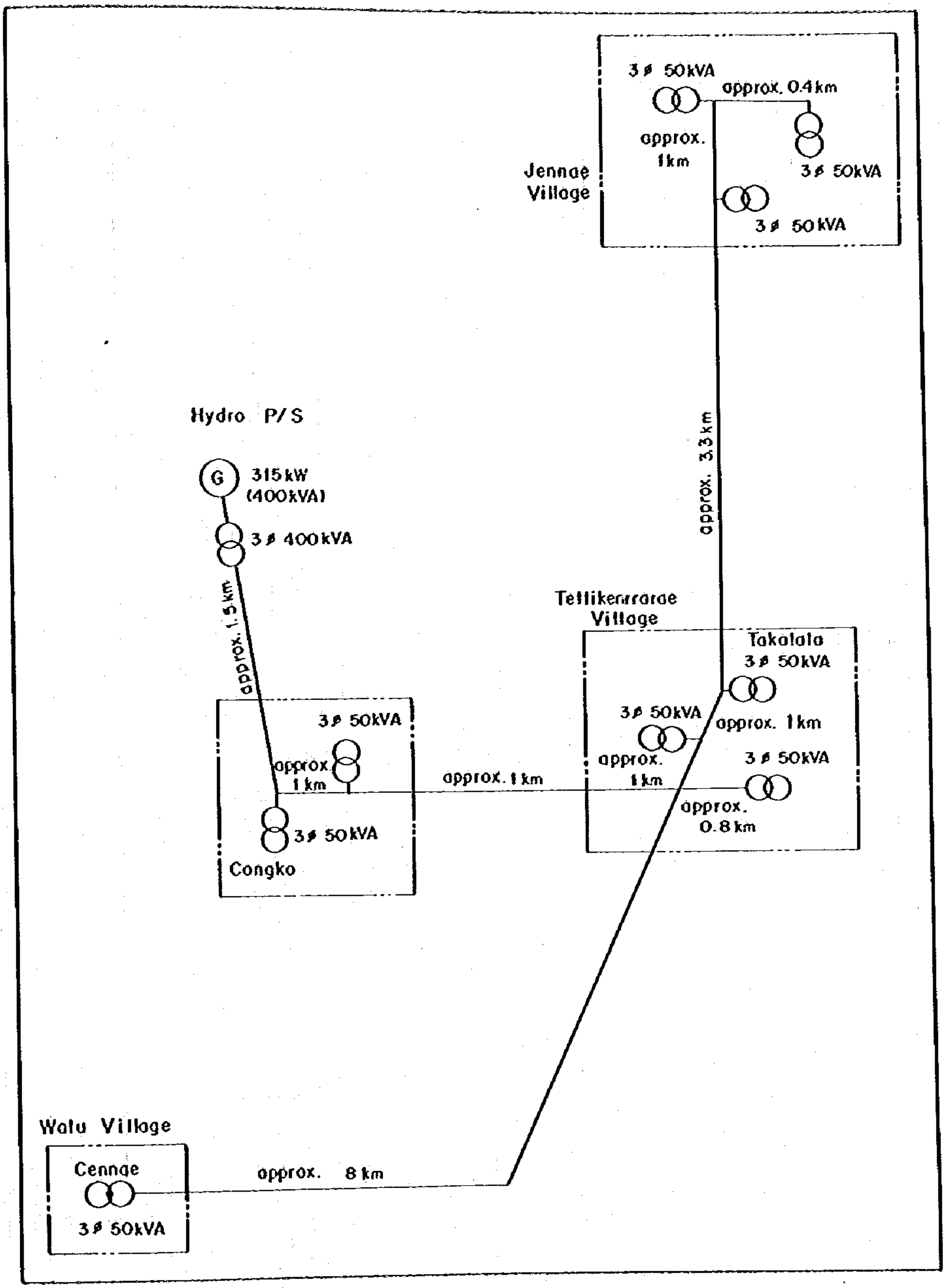


Fig.8.2.5 6kV DISTRIBUTION LINE SYSTEM

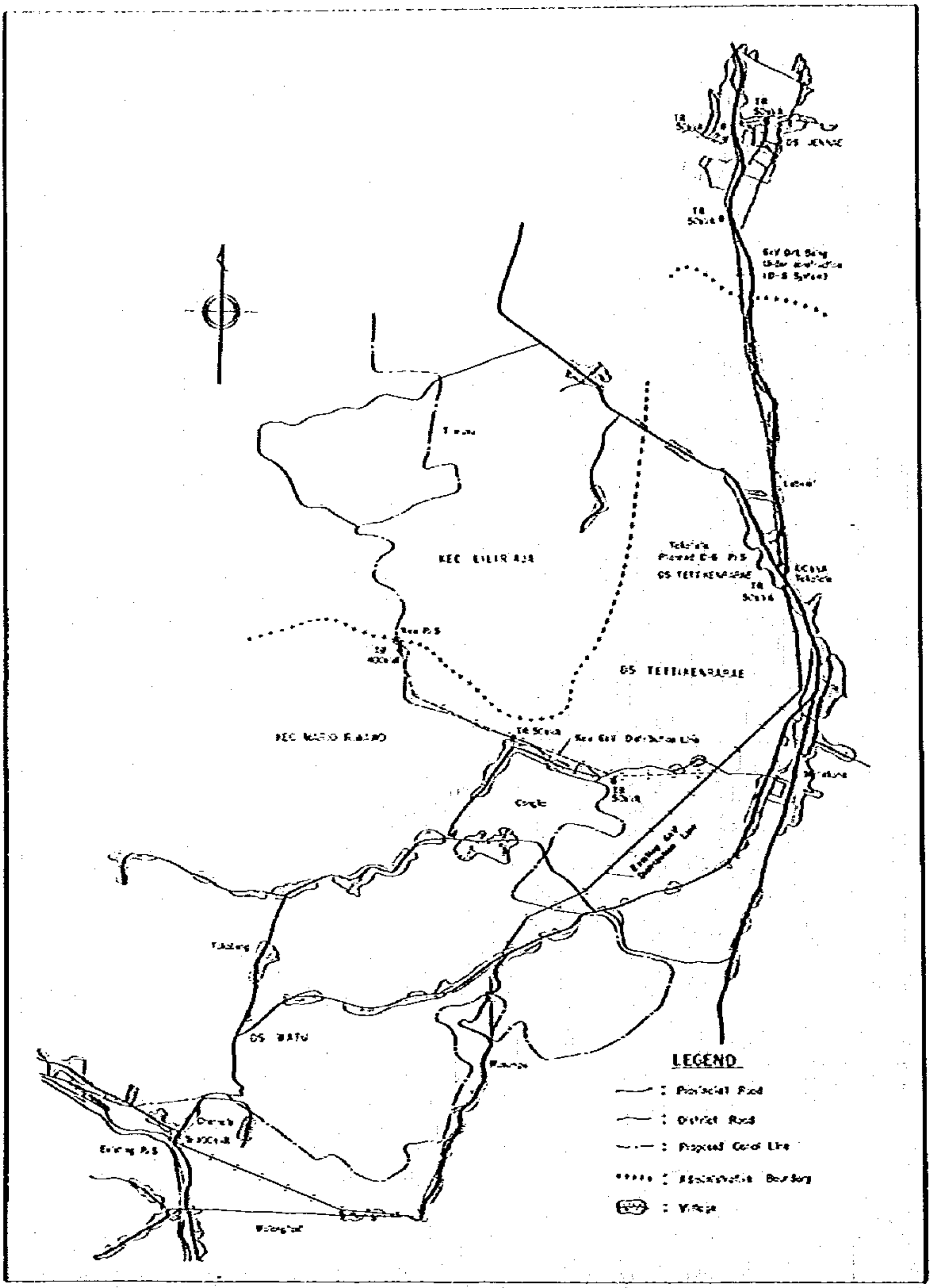


Fig. 8.2.6 NETWORKS OF PROPOSED DISTRIBUTION LINE

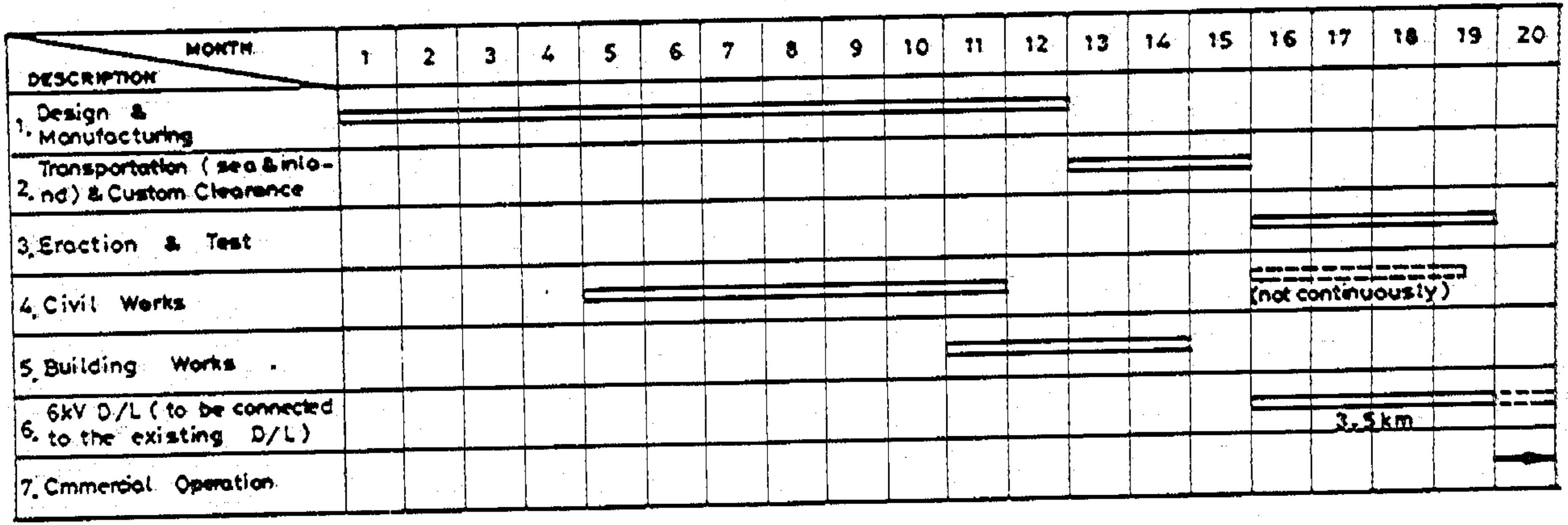


Fig.8.2.7 CONSTRUCTION TIME SCHEDULE

CHAPTER IX LAND CONSERVATION

CHAPTER IX LAND CONSERVATION

9.1 GENERAL

The water sources for the Langkemme irrigation project would mainly depend on the Langkemme river, the Sero river and seven tributaries of the Walanae river. The catchment areas of these rivers are:

Langkemme river	104 Km2
Sero river	306 Km2
Seven tributaries of the Walanae river	104 Km2
T o t a l	514 Km2

The major objectives of the present study are (1) to clarify the existing condition of relevant watershed and present land-use, and (2) to study the possibility of reforestation and construction of Sabo dams for the conservation of water resources and (3) to prepare a recommendation on the measures for land conservation in each watershed of the rivers relevant to the project.

The present status of the said catchment areas has been studied mainly on the basis of aerial photoes and topographic maps scaled 1/25,000. Field inspection has also been made to check the preliminary results of photo interpretation, and data on afforestation, land conservation, erosion control, etc. have been collected mainly from the Ministry of Agriculture, South Sulawesi Province and the Bila - Walanae branch office of "Pimpinan Proyek Perencanaan dan Pembinaan Reboisasi dan Penghijauan Daerah Aliran Sungai (DAS)" (Project for planning and establishment of Reforestation in watershed areas).

9.2 PRESENT CONDITION OF WATERSHED

9.2.1 Langkemme River

Two major tributaries of the Langkemme, the Kasi and the Lairi rivers, originate in the Mt. Niniconang of 1,474 m in altitude and flow down into the Langkemme river, joining many small tributaries. The total length of the Kesi and Lairi rivers is about 27.5 Km and 17.3 Km, respectively. The Langkemme river further flows down about 12 Km to join the Sero river and change its name into the Mario river. The total watershed of the Langkemme river system is about 104 Km^2 at the confluence with the Sero river. The lowest elevation of 130 m is found at this confluence.

The watershed of the Langkemme river system is mostly regarded as the mountains and is topographically classified into three types, i.e., cliff, steep slopes and moderate slopes. The cliff areas extend mainly along the main stream of the Langkemme river. The steep slopes between 15 % and 30 % occupies about 80 % of the total area. The moderate slopes less than 15 % extend mainly along the lower reaches of the Langkemme river. The area with moderate slopes is about 5 % of the total area.

The base rocks in the watershed are andesides, coral limestone and weakly cemented sedimentary rocks. The andesides (andesite and tuff) are widely distributed in the upper region of the watershed. The coral limestone, covering upper part of the andesides, is sporadically found along the lower reaches of the Langkemme river. The weakly cemented sedimentary rocks are distributed in the southern part of the catchment area.

Most of the Langkemme watershed are covered with forest and bush. The present land-use in the watershed area is summarized as follows:

Land-use category	Area (ha)	Proportional extend (%)
Forest	7,270	69.0
Bush and scrub	1,930	18.5
Grassland	790	7.6
Agricultural land	410	4.0
- Paddy field	(160)	(1.6)
- Upland field	(230)	(2.2)
- Orchard	(20)	(0.2)
Total	10,400	100.0

At present, the agricultural activities are limited to the areas extending along the lower reaches of the main stream of the Langkemme river. Most of the watershed have not been developed owing to lack of access and are maintained as primeval forest and bush comprising a wide variety of trees and shrub.

9.2.2 Sero River

The Sero river system comprises two major tributaries, i.e., Jupang and Pising. The Jupang river, covering the largest watershed of about 269 Km^2 in the Sero river system, originates in Mt. Malempong of about 1,350 m in altitude and flows down about 30 Km from south to north. The Pising river has a watershed of about 37 Km^2 and originates in Mt. Dua of 996 m. It flows down about 10 Km from west to east and join into the Jupang river. After the confluence of the Jupang and Pising rivers, the stream changes its name into the Sero rivers and meanders about three Km to join the Langkemme rivers.

The watershed of the Jupang river is topographically divided into three types, i.e., mountain, upland and lowland. The mountainous area has a great range of topography in elevation, comprising cliff, talus, steeply dessected mountain slopes and rough broken slopes. The muntainous area occupies about 70 % of the watershed. The upland area consists of wide variety of hillrocks with steepest slopes between 15 % and 30 % and range of elevation being moderate. About one-third of these uplands are presently used for cultivation of coconuts, banana, maize, groundnuts and tobacco. These upland areas occupy about 20 % of the total area. The lowland areas extend along the many tributaries of the Jupang river and most of them are used as paddy field at present. It occupies about 10 % of the whole watershed.

The watershed of the Pising river has been well developed for agricultural production. About two-third of the area is put under cultivation of crops due to its moderately undulating topography and the southern one-third of the area is mountainous and is mostly covered with bushes and grasses. There is no forest in this watershed.

The watershed of the Jupang river is mostly covered with limestone (Pliocene). Alluvial deposits are observed along the lower reaches of the Jupang river and its tributaries. In the watershed of the Pising river, andesides and sedimentary rocks are predominant with relatively deep surface soils. The present land-use in the watershed area of the Sero river system is summarized as shown below:

Land-use category	Area (ha)	Proportional extend (%)
Forest	6,880	22.5
Bush and scrub	7,390	24.2
Grassland	13,000	42.5
Agricultural land	3,330	10.8
- Paddy field	(1,920)	(6.3)
- Upland field	(1,190)	(3.9)
- Orchard	(220)	(0.6)
Total	30,600	100.0

In recent years, the forest and bush lands extending along the district roads have been gradually reclaimed for shifting cultivation and this rapid reclaimation has already caused serious erosion problems. In addition, it is pointed out that the forest and bush lands are gradually depleted by over-grazing of cattle and sheep.

9.2.3 Seven Tributaries of the Walanae River

The seven tributaries of the Walanae river originate in the western hilly ranges and flow down along shallow vale from west to east and finally debouches into the Walanae river. They are from north to south:

Rivers	Catchment area (Km2)
R. Belo	31
R. Maccope	11
R. Panincong	12
R. Congkai	13
R. Labemba	17
R. Baruttungnge	11
R. Maddenra	9
Total	104

These watershed areas of seven tributaries are topographically divided into two groups, i.e., upland and lowland. The upland area has moderately undulating topography with the steepest slopes less than 30 % and occupies about 95 % of the total watershed. The lowland extend along the tributaries. Most of them are presently used as irrigated paddy fields. The lowland areas are about five % of the whole watershed. The most of the upland areas are geologically covered with andesites and tuff. Limestones are sporadically observed, but not predominant. Alluvial deposits are developed on the lowland area. The present land-use in the watershed areas of seven tributaries are as follows:

Land-use category	Area (ha)	Proportional extend (%)
Forest	3,520	33.8
Bush and scrub	2,530	24.4
Grassland	3,060	29.4
Agricultural land	1,290	12.4
- Paddy field	(340)	(3.3)
- Upland field	(800)	(7.7)
- Orchard	(150)	(1.4)
Total	10,400	100.0

In this area, shifting cultivation is common. The forest areas are gradually depleted and soil erosion has become rather serious.

9.3 WATERSHED MANAGEMENT PLAN

9.3.1 Basic Concept

In the watershed area, forests play the important role for conservation of soil and water resources. The forests generally fix the soils on the sloping lands and control the excess percolation and surface runoff. As a result, the forests lower the maximum flood runoff and also stabilize the minimum discharge of the rivers. The forest prevent the watershed from soil erosion; therefore, the runoff water would be kept clean with good water quality. The forest areas in each watershed are:

Watershed	Catchment area (ha)	Forest area (ha)	Proportional extend (%)
Langkemme	10,400	7,270	69.0
Sero	30,570	6,880	22.5
Seven tributaries	10,400	3,520	33.8

It seems that there is some correlation between the land-use condition, especially area of forest, in each watershed and hydrological characteristics of river runoff. The watershed of the Langkemme river is mostly covered with forest and bush, and has almost no problem for soil and water conservation. The watershed of the Sero river system has been progressively reclaimed for shifting cultivation. The forest resources are gradually depleted and are not easily regenerated under present condition. The existing conditions of the watershed of the seven tributaries are almost same as that of the Sero river. Urgent measures for soil and water conservation will be required for the watershed areas of the Sero river and seven tributaries. With this in view, the basic concept for watershed management would be as follows:

(1) Soil and water conservation will have to be made through overall watershed management including reforestation, erosion control works and construction of Sabo dams.

(2) In due consideration of existing conditions of watershed areas, the first priority must be given to reforestation.

(3) The present unrestricted cutting of trees in the forest areas will have to be controlled by the Department of Forestry. In particular, the trees on the ridges will have to be maintained. Once such trees are cut, natural regeneration is very difficult because of limited availability of soil moisture.

(4) Since over-grazing of livestock animals in the bush and grassland will cause damage to the newly-planted trees, animal grazing will also be controlled by the government officials.

(5) The erosion control works will be necessary in the seriously affected areas. The establishment of sand prevention forest and hillside wicker work will be recommendable for this purpose. The construction of Sabo dams will not be necessary at present but will have to be studied in the future.

9.3.2 Reforestation

On the basis of basic concept mentioned above, the following reforestation plan is considered:

(1) Tree species

The tree species to be introduced should have the following characteristics:

a. multiplication of seedlings is easy and not expensive,

b. rapid multiplication is possible in a short period, and

c. seedlings could be easily grown under present unfavourable condition.

In due consideration of these principles, it is recommended that various leguminous trees and "Pinus merkusii", Indonesian pine tree, be introduced to the watershed area. The leguminous trees have an advantage of nitrogen fixation and make the soils fertile. It is recommended that the leguminous trees be planted mainly around the present agricultural lands. The Pinus merkusii can be grown well even on the very thin soils. Its growth is very rapid. According to the information from DAS, it grows upto 20 m within seven years after transplanting. The Pinus merkusii is better grown in high altitude area. It is therefore recommended that Pinus merkusii be introduced to the mountainous areas.

(2) Areas for reforestation

It is proposed that forest area should be expanded upto about 70 % of total watershed areas. In the Langkemme watershed, reforestation work will not be necessary, because it is already covered with forest at present. The reforestation work will be made only to the watershed areas of the Sero rivers and seven tributaries of the Walanae river. The total area to be envisaged for reforestation will be about 18,000 ha as shown below:

Sero river	:	14,300 ha
Seven tributaries	:	3,700 ha
Total		18,000 ha

(3) Nursery requirement

The nursery will have to be established at the rate of one nursery per about 2,000 ha, taking transportation of seedlings into consideration. About 20 nurseries will be needed in total. The proposed planting density will be 4 m x 4 m. The unit seedling requirement will be about 1,000 per ha under the assumption that survival rate is about 60 %. The proposed nursery will have to produce 2,000,000 seedlings in total. Taking five years for reforestation work, the annual production requirement for seedlings will be 400,000 per nursery. The size of nursery will be 0.5 - 1.0 ha.

The seedlings will be grown in the nursery for 6 months from April/May and transplanted in November/December. The nursery will have to be possibly irrigated, though permanent irrigation facilities are not required. The planting holes will have to be dug as deeply as possible in order to increase the survival rate.

(4) Preliminary cost estimate for reforestation

According to the past experiences of DAS for reforestation, costs for establishment and operation/maintenance of nursery amount to about Rp.40 per seedling on an average. For planting the seedlings, one labourer can transplant 50 - 100 seedlings in a day. On the basis of these information, the cost required for the envisaged reforestation is roughly estimated as follows:

Item	Amount (US$ eq.)
Establishment of 20 nurseries	512,000
Planting cost	256,000
Other miscellaneous cost (20 % of above)	152,000
Total	920,000

(5) Organization for reforestation

All the reforestation works will have to be carried out by the DAS project which was enforced by the Presidential Degree No.8 in 1976. The project aims at reforestation of about 40 million ha of bare lands extending all over the country. The project has been jointly managed by BAPPENAS and Ministries of Agriculture, Finance, Public Works, Interior and Environment. In the South Sulawesi Province, there are three branch offices of the DAS project, i.e., Jeneberang, Sadang and Bila-Walanae. The total area of reforestation envisaged by these branch offices are about 600,000 ha. The areas under present study belong to jurisdiction of the Bila-Walanae branch office.

CHAPTER X PROJECT ECONOMY AND FINANCE

CHAPTER X PROJECT ECONOMY AND FINANCE

10.1 ECONOMIC EVALUATION

The economic benefit is worked out on the basis of the Price Prospect for Major Commodities, IBRD, 1980 and agro-economic study. The economic project cost is worked out based on the cost financially estimated at 1980 price level as compiled in ANNEX II, CHAPTER IV. The economic feasibility of the Project is evaluated in terms of economic internal rate of return (IRR).

10.1.1 Economic Benefit Flow

Irrigation benefit by each crop is estimated at the full development stage in CHAPTER II and given in Table 2.6.2. The irrigation benefit expectable under each Work Division is also worked out and compiled in Table 2.6.2 (2) (3) and (4). To obtain economc flow of the project, per-hectar direct benefit is re-arranged as given in Table 10.1.1, based on the Table 2.6.2.

It is assumed that the project would be implemented in 1982 fiscal year. The second paddy in 1983 would be partially planted and partial irrigation benefit would initially accrue in 1984. The area to be benefited would be extended year by year, according to the construction plan proposed in ANNEX II, CHAPTER V.

Build-up period for full development of paddy production is assumed to be five years after implementation of each construction work. The assumed build-up period is likely to be relatively short but surely conservative, because the cultivation practices for paddy are considerably advanced in the project area. The per-ha direct benefit during the build-up period would be linearly increased to the full development stage.

While, build-up period for polowijo crops is assumed to be 10 years after their introduction in due consideration of current farming practices for polowijo crops in the project area. The per-ha direct benefit during the build-up period would be also assumed to be linearly increased to the full development stage.

Based on the presumptions above, the annual direct benefit during build-up period is calculated by each irrigation area, as shown in Table 10.1.2 and then, the economic benefit flow is summarized in Table 10.1.3 and illustrated in Fig. 10.1.1. The direct benefit at full development stage is attained at 1996 within 12 years after the commencement of the project in 1982.

10.1.2 Economic Cost Flow

The transfer payment incorporated in the financial project cost is deemed to be 10% equivalence of the direct construction cost, replacement and O/M cost, and 2% of engineering and administratin cost. The economic project cost is estimated at 1980 price level by deducting the transfer payment and price contingency. The economic project cost amounts to about US$21.7 million as shown in Table 10.1.4, comprising about US$10.0 million of foreign currency portion and about US$11.7 million equivalence of local currency portion. (See Table 10.1.5)

The engineering works for the project will commence in early 1982 fisical year and be completed by the end of 1986 fisical year; whole the project works are implemented within five years. The O/M and replacement costs for the project are financially estimated at 1980 price level as shown in ANNEX II, CHAPTER IV. The economic O/M and replacement costs are also estimated by deducting the transfer payment accroding to the assumption above. According to the construction schedule proposed in ANNEX II, CHAPTER V and the work quantities, the flow of the project cost, O/M cost and replacement cost are prepared as shown in Table 10.1.6.

10.1.3 Economic Internal Rate of Return

The project life is 50 years from 1982 to 2031 fiscal year. The construction period is five years from 1982 fiscal year including about one year for the detailed design. The project benefits will accrue in 1984 and increase year by year to attain the maximum level in 1996.

The O/M cost of the project will be initially distributed in 1984 when the partial operation will commence. The O/M cost increase linearly year by year and will reach the full amount in 1987 when the full operation will start for the whole project area of 6,400 ha. The gates and their attachments would be replaced once during the entire period of the project life and the other materials povided for the irrigation system are replaced four times during the project life.

The economic internal rate of return is calculated as given in Table 10.1.7, based on the economic benefit and cost flows prepared above. The economic IRR of 14.7% is estimated as the benefit and cost flows would be scheduled. It is verified that the project is economically feasible.

10.1.4 Sensitivity Analysis

Sensitivity analysis is also made in respect to changes in annual irrigation benefits, project costs and over-run of build-up period. The following five changes to be anticipated are tested:

Case-1: Cost is 20% increase of the total estimated one and benefit is as scheduled.

Case-2: Benefit is 20% decreases of the total anticipated ones and cost is as scheduled.

Case-3: Cost is 20% increases of the total estimated one and benefit is 20% decreases of the total anticipated one.

Case-4: Build-up period requires more two years than proposed.

Case-5: Build-up period requires more two years than proposed and, moreover, benefit is 20% decreased of the total anticipated ones.

The calculation of each case is given in Table 10.1.8 and the results can be summarized as below:

Case-1	12.7 %
Case-2	12.3 %
Case-3	10.6 %
Case-4	13.7 %
Case-5	11.5 %

The Case-3 (20% increase of cost and 20% decrease of benefit) indicates the lowest economic internal rate of return but still maintains greater than 10%. The project is still insensitive against the anticipated changes.

10.2 FINANCIAL EVALUATION

The financial project cost is estimated at 1980 price level in ANNEX II, CHAPTER IV. It amounts to about US$34.6 million including about US$10.9 million of the price contingency for five years. The annual disbursement is prepared as given in Table 10.2.1 on the basis of the implementation schedule proposed in ANNEX II, CHAPTER V. The project cost is initially disbursed for the engineering works, administration cost and the preparatory works in 1982 fiscal year and, finally, in 1986 fiscal year.

The financial evaluation is made on the cash-flow statement from the viewpoint of the project executing organization which is responsible for both the construction and the O/M of the project. To prepare the statement, the following assumptions are made:

i) Both full amount of foreign currency and about 31% of local currency portion (30% equivalence of total loan amount) would be financed by international financing agency. The loan amounts total about US$23.4 million including 3.5% of annual interest within seven years of grace period,

ii) The remaining about 69% of local currency portion would be financed by the budget allocation of the Government,

iii) The O/M cost would be disbursed from 1983 when the project is partially operated,

iv) The replacement cost would be periodically disbursed depending on durability of materials: gates and their attachments would be replaced at 25th year after installed and the other materials would be replaced every 10 years,

v) The project cost would be disbursed in accordance with the implementation schedule as proposed in ANNEX II, CHAPTER V,

vi) The repayment for the project loan would be subsidized by the Government; the project loan would be paid off within 27 years including seven years of grace period,

vii) Annual repayment amounts to about US$1.65 million,

viii) The O//M and replacement cost would be also subsidized by the budget allocation of the Government; no water charge is collected from beneficiary farmers.

The cash-flow statement of the project is given in Table 10.2.2. The statement is balanced by subsidizing the full amount of the project cost and annual costs for major project facilities. The beneficiary formes under the project only bear the O/M cost for tertiary and quaternary facilities.

Table 10.1.1 Per-Ha.Direct Benefit

		Work Division I (2,900 ha)		Work Division II (4,500 ha)		Work Division III (6,400 ha)		Total
		Direct Benefit	Unit Benefit	Direct Benefit	Unit Benefit	Direct Benefit	Unit Benefit	Direct Benefit
		($x10^6$Rp)	($x10^6$Rp/ha)	($x10^6$Rp)	($x10^6$Rp/ha)	($x10^6$Rp)	($x10^6$Rp/ha)	($x10^6$Rp)
1. Deas Non-technical Irrigation								
(2,900 ha)	Wet Season Paddy	31.61	0.010900	344.23	0.118700	26.82	0.009248	402.66
	Dry Season Paddy	199.76	0.068883	521.80	0.179931	11.28	0.003890	732.84
	Palowiji Crops	-	-	497.65	0.171603	27.74	0.009566	525.39
2. Deas Semi-technical Irrigation								
(1,400 ha)	Wet Season Paddy	-	-	250.44	0.178886	12.95	0.009250	263.39
	Dry Season Paddy	-	-	375.07	0.267907	5.44	0.003886	380.51
	Palowiji Crops	-	-	231.99	0.165707	13.39	0.009564	245.38
3. D.P.U. Semi-technical Irrigation								
(2,100 ha)	Wet Season Paddy	-	-	28.59	0.142950	315.67	0.150319	344.26
	Dry Season Paddy	-	-	61.14	0.305700	479.63	0.228395	540.77
	Palowijo Crops	-	-	35.85	0.179250	344.97	0.164271	380.82
Total		231.37	-	2,346.76	-	1,237.89	-	3,816.02

Remark: Direct Benefit; See ANNEX-I CHAPTER II

Unit Benefit = Direct Benefit ÷ Cropped Area by Each Irrigation Area

Table 10.1.2 (1) Annual Direct Benefit during Build up Period

Dewa Non-technical Irrigation
Wet Season Paddy (2,900 ha)

Unit Benefit: (x10^6 Rp/ha)
Work Division I ; 0.010900
Work Division II ; 0.118700
Work Division III; 0.009248

Year		20% Planted Area (ha)	20% Direct Benefit ($x10^6$Rp)	40% Planted Area (ha)	40% Direct Benefit ($x10^6$Rp)	60% Planted Area (ha)	60% Direct Benefit ($x10^6$Rp)	80% Planted Area (ha)	80% Direct Benefit ($x10^6$Rp)	100% Planted Area (ha)	100% Direct Benefit ($x10^6$Rp)	Annual Direct Benefit ($x10^6$Rp)
1984	Work Division I	370	0.81									
	Work Division II											
	Work Division III											0.81
1985	Work Division I	1,270	2.77	370	1.61							
	Work Division II	900	21.36									
	Work Division III											25.74
1986	Work Division I	1,260	2.75	1,270	5.54	370	2.42					
	Work Division II	2,000	47.48	900	42.73							
	Work Division III											100.92
1987	Work Division I			1,260	5.49	1,270	8.31	370	3.23			
	Work Division II			2,000	94.96	900	64.10					
	Work Division III	2,900	5.36									176.09
1988	Work Division I					1,260	8.24	1,270	11.07	370	4.03	
	Work Division II					2,000	142.44	900	85.46			
	Work Division III			2,900	10.73							261.97
1989	Work Division I							1,260	10.99	1,640	17.88	
	Work Division II							2,000	189.92	900	106.83	
	Work Division III					2,900	16.09					341.71
1990	Work Division I									2,900	31.61	
	Work Division II									2,900	344.23	
	Work Division III							2,900	21.46			397.30
1991	Work Division I									2,900	31.61	
	Work Division II									2,900	344.23	
	Work Division III									2,900	26.82	402.66
1992	Work Division I											
	Work Division II											
	Work Division III											

Table 10.1.2 (2) Annual Direct Benefit during Build up Period

Dema Non-technical Irrigation
Dry Season Paddy (2,900 ha)

Unit Benefit: ($x10^6$Rp/ha)
Work Division I : 0.068883
Work Division II : 0.179931
Work Division III: 0.003890

Year		20% Planted Area (ha)	20% Direct Benefit (x106Rp)	40% Planted Area (ha)	40% Direct Benefit (x106Rp)	60% Planted Area (ha)	60% Direct Benefit (x106Rp)	80% Planted Area (ha)	80% Direct Benefit (x106Rp)	100% Planted Area (ha)	100% Direct Benefit (x106Rp)	Annual Direct Benefit (x106Rp)
1984	Work Division I	370	5.10									
	Work Division II											5.10
	Work Division III											
1985	Work Division I	1,270	17.50	370	10.19							
	Work Division II	900	32.39									60.08
	Work Division III											
1986	Work Division I	1,260	17.36	1,270	34.99	370	15.29					
	Work Division II			900	64.78							132.42
	Work Division III											
1987	Work Division I			1,260	34.72	1,270	52.49	370	20.39			
	Work Division II	2,000	71.97			900	97.16					276.73
	Work Division III											
1988	Work Division I					1,260	52.08	1,270	69.99	370	25.49	
	Work Division II			2,000	143.94			900	129.55			423.31
	Work Division III	2,900	2.26									
1989	Work Division I							1,260	69.43	1,640	112.97	
	Work Division II					2,000	215.92			900	161.94	564.77
	Work Division III			2,900	4.51							
1990	Work Division I									2,900	199.76	
	Work Division II							2,000	287.89	900	161.94	656.36
	Work Division III					2,900	6.77					
1991	Work Division I									2,900	199.76	
	Work Division II									2,900	521.80	730.58
	Work Division III							2,900	9.02			
1992	Work Division I									2,900	199.76	
	Work Division II									2,900	521.80	732.84
	Work Division III									2,900	11.28	

Table 10.1.2 (3) Annual Direct Benefit during Build up Period

Dema Semi-technical Irrigation
Wet Season Paddy (1,400 ha)

Unit Benefit: ($x10^6$Rp/ha)
Work Division I : -
Work Division II : 0.178886
Work Division III: 0.009250

		20%		40%		60%		80%		100%		Annual Direct Benefit
		Planted Area	Direct Benefit	Planted Area	Direct Benefit	Planted Area	Direct Benefit	Planted Area	Direct Benefit	Planted Area	Direct Benefit	
		(ha)	($x10^6$Rp)	(ha)	($x10^6$Rp)	(ha)	($x10^6$Rp)	(ha)	($x10^6$Rp)	(ha)	($x10^6$Rp)	($x10^6$Rp)
1984	Work Division I											
	Work Division II											
	Work Division III											
1985	Work Division I											
	Work Division II											
	Work Division III											
1986	Work Division I											
	Work Division II											
	Work Division III											
1987	Work Division I											
	Work Division II	1,400	50.09									
	Work Division III	1,400	2.59									52.68
1988	Work Division I											
	Work Division II			1,400	100.18							
	Work Division III			1,400	5.18							105.36
1989	Work Division I											
	Work Division II					1,400	150.26					
	Work Division III					1,400	7.77					157.96
1990	Work Division I											
	Work Division II							1,400	200.35			
	Work Division III							1,400	10.36			210.71
1991	Work Division I											
	Work Division II									1,400	250.44	
	Work Division III									1,400	12.95	263.39
1992	Work Division I											
	Work Division II											
	Work Division III											

Table 10.1.2 (4) Annual Direct Benefit during Build up Period

Dasa Semi-technical Irrigation
Dry Season Paddy (1,400 ha)

Unit Benefit: (x10⁶Rp/ha) Work Division I : -
Work Division II : 0.267907
Work Division III: 0.003886

		20%		40%		60%		80%		100%		Annual Direct Benefit
		Planted Area (ha)	Direct Benefit ($x10^6$Rp)	Planted Area (ha)	Direct Benefit ($x10^6$Rp)	Planted Area (ha)	Direct Benefit ($x10^6$Rp)	Planted Area (ha)	Direct Benefit ($x10^6$Rp)	Planted Area (ha)	Direct Benefit ($x10^6$Rp)	($x10^6$Rp)
1984	Work Division I											
	Work Division II											
	Work Division III											
1985	Work Division I											
	Work Division II											
	Work Division III											
1986	Work Division I											
	Work Division II											
	Work Division III											
1987	Work Division I											
	Work Division II	1,400	75.01									75.01
	Work Division III											
1988	Work Division I			1,400	150.03							
	Work Division II											151.12
	Work Division III	1,400	1.09									
1989	Work Division I					1,400	225.04					
	Work Division II			1,400	2.18							227.22
	Work Division III											
1990	Work Division I							1,400	300.06			
	Work Division II					1,400	3.26					303.32
	Work Division III											
1991	Work Division I									1,400	375.07	
	Work Division II							1,400	4.35			379.42
	Work Division III											
1992	Work Division I									1,400	375.07	
	Work Division II									1,400	5.44	380.51
	Work Division III											

Table 10.1.2 (5) Annual Direct Benefit during Build up Period

D.P.U. Semi-technical Irrigation
Wet Season Paddy (2,100 ha)

Unit Benefit: (x10⁶Rp/ha) Work Division I : -
Work Division II : 0.142950
Work Division III: 0.150319

		20%		40%		60%		80%		100%		Annual Direct Benefit
		Planted Area	Direct Benefit	Planted Area	Direct Benefit	Planted Area	Direct Benefit	Planted Area	Direct Benefit	Planted Area	Direct Benefit	
		(ha)	($x10^6$Rp)	(ha)	($x10^6$Rp)	(ha)	($x10^6$Rp)	(ha)	($x10^6$Rp)	(ha)	($x10^6$Rp)	($x10^6$Rp)
1984	Work Division I											
	Work Division II											
	Work Division III											
1985	Work Division I											
	Work Division II											
	Work Division III											
1986	Work Division I											
	Work Division II											
	Work Division III											
1987	Work Division I											
	Work Division II	200	5.72									
	Work Division III											5.72
1988	Work Division I											
	Work Division II			200	11.44							
	Work Division III	2,100	63.13									74.57
1989	Work Division I											
	Work Division II					200	17.15					
	Work Division III			2,100	126.27							143.43
1990	Work Division I											
	Work Division II							200	22.87			
	Work Division III					2,100	189.40					212.27
1991	Work Division I											
	Work Division II									200	28.59	
	Work Division III							2,100	252.54			281.13
1992	Work Division I											
	Work Division II									200	28.59	
	Work Division III									2,100	315.67	344.26

Table 10.1.2 (6) Annual Direct Benefit during Build up Period

D.P.U. Semi-technical Irrigation
Dry Season Paddy (2,100 ha)

Unit Benefit: (x10⁶Rp/ha)
Work Division I : -
Work Division II : 0.305700
Work Division III: 0.228395

Year	Work Division	20% Planted Area (ha)	20% Direct Benefit ($x10^6$Rp)	40% Planted Area (ha)	40% Direct Benefit ($x10^6$Rp)	60% Planted Area (ha)	60% Direct Benefit ($x10^6$Rp)	80% Planted Area (ha)	80% Direct Benefit ($x10^6$Rp)	100% Planted Area (ha)	100% Direct Benefit ($x10^6$Rp)	Annual Direct Benefit ($x10^6$Rp)
1984	Work Division I											
	Work Division II											
	Work Division III											
1985	Work Division I											
	Work Division II											
	Work Division III											
1986	Work Division I											
	Work Division II											
	Work Division III											
1987	Work Division I											
	Work Division II	200	12.23									12.23
	Work Division III											
1988	Work Division I											
	Work Division II			200	24.46							120.39
	Work Division III	2,100	95.93									
1989	Work Division I											
	Work Division II					200	36.68					228.53
	Work Division III			2,100	191.85							
1990	Work Division I											
	Work Division II							200	48.91			336.69
	Work Division III					2,100	287.78					
1991	Work Division I											
	Work Division II									200	61.14	444.84
	Work Division III							2,100	383.70			
1992	Work Division I											
	Work Division II									200	61.14	540.77
	Work Division III									2,100	479.63	

Table 10.1.2 (7) Annual Direct Benefit during Build up Period

D.P.U. Semi-technical Irrigation
Polowijo Crops (2,100 ha)

Unit Benefit: (x10⁶Rp/ha) Work Division II : 0.179250
Work Division III: 0.164271

	10%		20%		30%		40%		50%		60%		70%		80%		90%		100%		Annual Direct Benefit
	P.A./1	D.B./2	P.A.	D.B.	P.A.	D.B.	P.A.	D.B.	P.A.	D.B.	P.A.	D.B.	P.A.	D.B.	P.A.	D.B.	P.A.	D.B.	P.A.	D.B.	
	(ha)	(10^6Rp)	(ha)	(10^6Rp)	(ha)	(10^6Rp)	(ha)	(10^6Rp)	(ha)	(10^6Rp)	(ha)	(10^6Rp)	(ha)	(10^6Rp)	(ha)	(10^6Rp)	(ha)	(10^6Rp)	(ha)	(10^6Rp)	(10^6Rp)
1985																					
W.D.II/3																					
W.D.III																					
1986																					
W.D.II																					
W.D.III																					
1987																					
W.D.II	200	3.58																			
W.D.III	2,100	34.50																			38.08
1988																					
W.D.II			200	7.67																	
W.D.III			2,100	68.99																	76.16
1989																					
W.D.II					200	10.76															
W.D.III					2,100	103.49															114.25
1990																					
W.D.II							200	14.34													
W.D.III							2,100	137.99													152.33
1991																					
W.D.II									200	17.93											
W.D.III									2,100	172.48											190.41
1992																					
W.D.II											200	21.51									
W.D.III											2,100	206.98									228.49
1993																					
W.D.II													200	25.10							
W.D.III													2,100	241.48							266.58
1994																					
W.D.II															200	28.68					
W.D.III															2,100	275.98					304.66
1995																					
W.D.II																	200	32.27			
W.D.III																	2,100	310.47			342.74
1996																					
W.D.II																			200	35.85	
W.D.III																			2,100	344.97	380.82

/1 : P.A.: Planted Area /2 : D.B.: Direct Benefit /3 : W.D.I, W.D.II; Work Division I, II

Table 10.1.2 (8) Annual Direct Benefit during Build up Period

Dasa Non-technical Irrigation
Polowijo Crops (2,900 ha)

Unit Benefit: Work Division II : 0.171603
($x10^6$Rp/ha) Work Division III: 0.009566

	10%		20%		30%		40%		50%		60%		70%		80%		90%		100%		Annual Direct Benefit
	P.A./1	D.B./2	P.A.	D.B.	P.A.	D.B.	P.A.	D.B.	P.A.	D.B.	P.A.	D.B.	P.A.	D.B.	P.A.	D.B.	P.A.	D.B.	P.A.	D.B.	
	(ha)	(10^6Rp)	(ha)	(10^6Rp)	(ha)	(10^6Rp)	(ha)	(10^6Rp)	(ha)	(10^6Rp)	(ha)	(10^6Rp)	(ha)	(10^6Rp)	(ha)	(10^6Rp)	(ha)	(10^6Rp)	(ha)	(10^6Rp)	(10^6Rp)
1985																					
W.D.II/3	900	13.44																			13.44
W.D.III																					
1986																					
W.D.II	2,000	34.32	900	30.89																	65.21
W.D.III																					
1987																					
W.D.II			2,000	68.64	900	46.33															117.74
W.D.III	2,900	2.77																			
1988																					
W.D.II					2,000	102.96	900	61.78													170.29
W.D.III			2,900	5.55																	
1989																					
W.D.II							2,000	137.28	900	77.22											222.82
W.D.III					2,900	8.32															
1990																					
W.D.II									2,000	171.60	900	92.67									275.37
W.D.III							2,900	11.10													
1991																					
W.D.II											2,000	205.92	900	108.11							327.90
W.D.III									2,900	13.87											
1992																					
W.D.II													2,000	240.24	900	123.55					380.43
W.D.III											2,900	16.64									
1993																					
W.D.II															2,000	274.56	900	139.00			432.98
W.D.III													2,900	19.42							
1994																					
W.D.II																	2,000	308.89	900	154.44	485.52
W.D.III															2,900	22.19					
1995																					
W.D.II																			2,900	497.65	522.62
W.D.III																	2,900	24.97			
1996																					
W.D.II																			2,900	497.65	525.39
W.D.III																			2,900	27.74	

/1 : P.A.; Planted Area /2 : D.B.; Direct Benefit /3 : W.D.I, W.D.II; Work Division I, II

Table 10.1.2 (9) Annual Direct Benefit during Build up Period

Dema Semi-technical Irrigation
Polowijo Crops (1,400 ha)

Unit Benefit: Work Division II ;
($x10^6$Rp/ha) Work Division III:

	10%		20%		30%		40%		50%		60%		70%		80%		90%		100%		Annual Direct Benefit
	P.A./1 (ha)	D.B./2 (10^6Rp)	P.A. (ha)	D.B. (10^6Rp)	P.A. (ha)	D.B. (10^6Rp)	P.A. (ha)	D.B. (10^6Rp)	P.A. (ha)	D.B. (10^6Rp)	P.A. (ha)	D.B. (10^6Rp)	P.A. (ha)	D.B. (10^6Rp)	P.A. (ha)	D.B. (10^6Rp)	P.A. (ha)	D.B. (10^6Rp)	P.A. (ha)	D.B. (10^6Rp)	(10^6Rp)
1985																					
W.D.II/3																					
W.D.III																					
1986																					
W.D.II																					
W.D.III																					
1987																					
W.D.II	1,400	23.20																			
W.D.III	1,400	1.34																			24.54
1988																					
W.D.II			1,400	46.40																	
W.D.III			1,400	2.68																	49.08
1989																					
W.D.II					1,400	69.60															
W.D.III					1,400	4.02															73.62
1990																					
W.D.II							1,400	92.80													
W.D.III							1,400	6.69													99.49
1991																					
W.D.II									1,400	116.00											
W.D.III									1,400	8.03											124.03
1992																					
W.D.II											1,400	139.20									
W.D.III											1,400	9.37									148.57
1993																					
W.D.II													1,400	162.39							
W.D.III													1,400	10.71							173.10
1994																					
W.D.II															1,400	185.59					
W.D.III															1,400	12.05					197.64
1995																					
W.D.II																	1,400	208.79			
W.D.III																	1,400	13.39			222.18
1996																					
W.D.II																			1,400	231.99	
W.D.III																			1,400	13.39	245.38

/1 : P.A.; Planted Area /2: D.B.; Direct Benefit /3 : W.D.I, W.D.II; Work Division I, II

Table 10.1.3 Economic Benefit Flow

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
A. Planted Area (ha)														
Desa non-technical irrigation area														
Wet season paddy	-	370	1,640	2,900	2,900	2,900	2,900	2,900	2,900	2,900	2,900	2,900	2,900	2,900
Dry season paddy	370	1,640	2,900	2,900	2,900	2,900	2,900	2,900	2,900	2,900	2,900	2,900	2,900	2,900
Polowijo crops	-	-	900	2,900	2,900	2,900	2,900	2,900	2,900	2,900	2,900	2,900	2,900	2,900
Desa semi-technical irrigation area														
Wet season paddy	-	-	-	-	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400
Dry season paddy	-	-	-	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400
Polowijo crops	-	-	-	-	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400
D.P.U. semi-technical irrigation area														
Wet season paddy	-		-	-	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100
Dry season paddy	-		-	200	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100
Polowijo crops	-		-	-	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100
B. Direct Benefit by Crop ($x10^6$Rp)														
Desa non-technical irrigation area														
Wet season paddy	-	0.8	25.7	100.9	176.1	262.0	341.8	397.3	402.7	402.7	402.7	402.7	402.7	402.7
Dry season paddy	-	5.1	60.1	132.4	276.7	423.3	564.8	656.4	730.6	732.8	732.8	732.8	732.8	732.8
Polowijo crops	-	-	15.4	65.2	117.7	170.3	222.9	275.4	328.0	380.4	433.0	485.5	522.6	525.4
Desa semi-technical irrigation area														
Wet season paddy	-	-	-	-	52.7	105.4	158.0	210.7	263.4	263.4	263.4	263.4	263.4	263.4
Dry season paddy	-	-	-	-	75.0	151.1	227.2	303.3	379.4	380.5	380.5	380.5	380.5	380.5
Polowijo crops	-	-	-	-	24.5	49.1	73.6	99.5	124.0	148.6	173.1	197.6	222.2	245.3
D.P.U. semi-technical irrigation area														
Wet season paddy	-	-	-	-	5.7	74.6	143.4	212.3	281.1	344.3	344.3	344.3	344.3	344.3
Dry season paddy	-	-	-	-	12.2	120.4	228.5	336.7	444.8	540.8	540.8	540.8	540.8	540.8
Polowijo crops	-	-	-	-	38.1	76.2	114.3	152.3	190.4	228.5	266.6	304.7	342.7	380.8
C. Annual Direct Benefits ($x10^6$Rp)														
Desa non-technical irrigation area	-	5.9	101.2	298.5	570.5	855.6	1,129.5	1,329.1	1,461.3	1,515.9	1,568.5	1,621.0	1,658.1	1,660.9
Desa semi-technical irrigation area	-	-	-	-	152.2	305.6	458.8	613.5	766.8	792.5	817.0	841.5	866.1	889.2
D.P.U. semi-technical irrigation area	-	-	-	-	56.0	271.2	486.2	701.3	916.3	1,113.6	1,151.7	1,189.8	1,227.8	1,265.9
Total		5.9	101.2	298.5	778.7	1,432.4	2,074.5	2,643.9	3,144.4	3,422.0	3,537.2	3,652.3	3,752.0	3,816.0

Table 10.1.4 Economic Cost of the Project

(US$)

Work Item	Local Currency	Foreign Currency	Total
I. Construction Cost (Work Division I)			
Preparation	234,000	-	234,000
Weir in Tributeries	375,000	90,000	465,000
Link Canal in NT Area	1,139,000	216,000	1,355,000
Tertiary Development	371,000	-	371,000
Land Acquisition	147,000	-	147,000
Sub-total	2,266,000	306,000	2,572,000
(Work Division II)			
Preparation	723,000	-	723,000
Langkemme Intake Weir	176,000	89,000	265,000
Langkemme Canal	1,688,000	3,268,000	4,956,000
Link Canal in ST Area	77,000	21,000	98,000
Tertiary Development	1,532,000	-	1,532,000
Land Acquisition	374,000	-	374,000
Sub-total	4,570,000	3,378,000	7,948,000
(Work Division III)			
Preparation	396,000	-	396,000
Sero Intake Weirs	97,000	23,000	120,000
Sero Diversion Canal	956,000	1,813,000	2,769,000
Link Canal in DPU Area	113,000	24,000	137,000
Tertiary Development	800,000	-	800,000
Land Acquisition	134,000	-	134,000
Sub-total	2,496,000	1,860,000	4,356,000
Total	9,332,000	5,544,000	14,876,000
II. Engineering Service	455,000	3,173,000	3,628,000
III. Administration Cost	376,000	-	376,000
IV. Physical Contingency (15%)	1,524,000	1,308,000	2,832,000
Grand Total	11,687,000	10,025,000	21,712,000

Table 10.1.5 Annual Disbursement Schedule of Economic Project Cost

(10^3 US$)

	1982	1983	1984	1985	1986	1987
Construction Cost	-	2,604	4,386	3,745	4,028	113
Engineering Service	771	1,127	669	555	459	47
Administration Cost	118	148	33	31	28	18
Sub-total	889	3,879	5,088	4,331	4,515	178
Physical Contingency (15%)	133	582	763	650	677	27
Total	1,022	4,461	5,851	4,981	5,192	205

(21,712)

Table 10.1.6 Annual Costs and Benefits Flow

(x 10^3 US$)

Year	Economic Project Cost	O & M Cost	Replacement Cost	Total Cost (A)	Benefits (B)	Balance (B) - (A)
1982	1,022	-	-	1,022	-	-1,022
1983	4,461	-	-	4,461	-	-4,461
1984	5,851	94	-	5,945	9	-5,936
1985	4,981	189	-	5,170	162	-5,008
1986	5,192	283	-	5,475	478	-4,997
1987	205	378	-	583	1,246	663
1988	-	472	-	472	2,292	1,820
1989	-	472	-	472	3,319	2,847
1990	-	472	-	472	4,230	3,758
1991	-	472	-	472	5,115	4,643
1992	-	472	138	610	5,475	4,865
1993	-	472	-	472	5,660	5,188
1994	-	472	-	472	5,844	5,372
1995	-	472	-	472	6,003	5,531
1996	-	472	-	472	6,106	5,634
.	.	.	.	.	.	.
.	.	.	.	.	.	.
2002	-	472	138	610	6,106	5,496
2003	-	472	-	472	6,106	5,634
.	.	.	.	.	.	.
.	.	.	.	.	.	.
2007	-	472	105	577	6,106	5,529
2008	-	472	-	472	6,106	5,634
.	.	.	.	.	.	.
.	.	.	.	.	.	.
2012	-	472	138	610	6,106	5,496
2013	-	472	-	472	6,106	5,634
.	.	.	.	.	.	.
.	.	.	.	.	.	.
2022	-	472	138	610	6,106	5,496
2023	-	472	-	472	6,106	5,634
.	.	.	.	.	.	.
.	.	.	.	.	.	.
2031	-	472	-	472	6,106	5,634
Total	21,712	21,712	657	44,081	259,649	215,568

Table 10.1.7 Internal Rate of Return
(on the Economic Basis)

Rate	Cost	Benefit
(%)	(10^3US$)	(10^3US$)
4.0	27,694	92,868
6.0	23,814	60,925
8.0	21,095	42,007
10.0	19,052	30,170
12.0	17,431	22,397
14.0	16,091	17,080
14.7	15,673	15,618
16.0	14,952	13,313
18.0	13,964	10,566
20.0	13,092	8,514

Table 10.1.8 Sensitivity Analysis

Rate (%)	Cost (10^3 US$)	Benefit (10^3 US$)
Case 1		
4.0	33,233	92,868
6.0	28,576	60,925
8.0	25,315	42,007
10.0	22,863	30,170
12.0	20,917	22,397
12.7	20,322	20,314
14.0	19,309	17,080
16.0	17,943	13,313
18.0	16,756	10,566
20.0	15,710	8,314
Case 2		
4.0	27,694	74,294
6.0	23,814	48,740
8.0	21,095	33,605
10.0	19,052	24,136
12.0	17,431	17,918
12.3	17,214	17,177
14.0	16,091	13,664
16.0	14,952	10,650
18.0	13,964	8,453
20.0	13,092	6,811
Case 3		
4.0	33,233	74,294
6.0	28,576	48,740
8.0	25,315	33,605
10.0	22,863	24,136
10.6	22,235	22,003
12.0	20,917	17,918
14.0	19,309	13,664
16.0	17,943	10,650
18.0	16,756	8,453
20.0	15,710	6,811
Case 4		
4.0	27,694	88,705
6.0	23,814	57,566
8.0	21,095	39,277
10.0	19,052	27,937
12.0	17,431	20,560
13.7	16,278	16,197
14.0	16,091	15,558
16.0	14,952	12,045
18.0	13,964	9,505
20.0	13,092	7,620
Case 5		
4.0	27,694	70,964
6.0	23,814	46,053
8.0	21,095	31,422
10.0	19,052	22,350
11.5	17,805	17,708
12.0	17,431	16,448
14.0	16,091	12,446
16.0	14,952	9,636
18.0	13,964	7,604
20.0	13,092	6,096

Note: Case 1; Costs, 20% increase
Benefits, scheduled

Case 2; Costs, scheduled
Benefits, 20% decrease

Case 3; Costs, 20% increase
Benefits, 20% decrease

Case 4; Build-up period delays 2 years

Case 5; As Case 4,
Benefits, 20% decrease

Table 10.2.1 Annual Disbursement Schedule of Financial Project Cost

(Unit : 10^3 US$)

	1982			1983			1984			1985			1986			1987		
	L	F	T	L	F	T	L	F	T	L	F	T	L	F	T	L	F	T
Construction Cost																		
Work Division I				844.3	68.0	912.3	937.4	146.4	1,083.8	736.3	125.6	861.9						
Work Division II				1,190.8	789.6	1,980.4	1,463.4	1,584.8	3,048.2	738.5	831.3	1,569.8	1,682.3	547.3	2,229.6			
Work Division III							642.1	97.9	740.0	639.7	1,089.5	1,729.2	1,370.4	876.4	2,246.8	121.8	3.2	125.0
Sub Total				2,035.1	857.6	2,892.7	3,042.9	1,829.1	4,872.0	2,114.5	2,046.4	4,160.9	3,052.7	1,423.7	4,476.4	121.8	3.2	125.0
Engineering Services	52.2	734.9	787.1	129.2	1,020.5	1,149.7	91.7	590.8	682.5	86.8	478.8	565.6	99.4	369.0	468.4	4.3	44.0	48.3
Administration	119.4	-	119.4	150.3	-	150.3	34.4	-	34.4	31.9	-	31.9	29.4	-	29.4	18.1	-	18.1
Sub Total	171.6	734.9	906.5	2,314.6	1,878.1	4,192.7	3,169.0	2,419.9	5,588.9	2,233.2	2,525.2	4,758.4	3,181.5	1,792.7	4,974.2	144.2	47.2	191.4
Physical Contingency (15%)	25.7	110.2	135.9	347.2	281.7	628.9	475.4	363.0	838.4	335.0	378.8	713.8	477.2	268.9	746.1	21.6	7.1	28.7
Sub Total	197.3	845.1	1,042.4	2,661.8	2,159.8	4,821.6	3,644.4	2,782.9	6,427.3	2,568.2	2,904.0	5,472.2	3,658.7	2,061.6	5,720.3	165.8	54.3	220.1
Price Contingency									1,691.4	1,567.9	-	1,567.9	2,823.1	-	2,823.1	157.3	-	157.3
Local (10%)	41.4	-	41.4	881.1	-	881.1	1,691.4	-										
Foreign (7%)	-	122.5	122.5 (163.9)	-	486.0	486.0 (1,367.1)	-	864.9	864.9 (2,556.3)	-	1,169.2	1,169.2 (2,737.1)	-	1,032.2	1,032.2 (3,855.3)	-	32.9	32.9 (190.2)
Total	238.7	967.6	1,206.3	3,542.9	2,645.8	6,188.7	5,335.8	3,647.8	8,983.6	4,136.1	4,073.2	8,209.3	6,481.8	3,093.8	9,575.6	323.1	87.2	410.3

(34,573.8)

Note: L ; Local portion
F ; Forein portion
T : Total cost

Table 10.2.2 Cash Flow Statement

(x 10^3 US$)

Year	Cash Outflow				Cash Inflow				Balance
	Project Cost	O/M Replacement Cost	Loan Repayment	Total Outflow (A)	Foreign Loan	Government Budget	Government Subsidy/1	Total Inflow (B)	(B) - (A)
1982	1,206	-	-	1,206	1,042	164	-	1,206	0
1983	6,189	-	-	6,189	3,745	2,444	-	6,189	0
1984	8,984	-	-	8,984	5,303	3,681	-	8,984	0
1985	8,210	-	-	8,210	5,356	2,854	-	8,210	0
1986	9,576	87	-	9,663	5,104	4,559	-	9,663	0
1987	410	174	-	584	187	397	-	584	0
1988		262	-	262	(23,413)/2	262	-	262	0
1989		349	1,650	1,999		349	1,650	1,999	0
1990		436	1,650	2,086		436	1,650	2,086	0
1991		523	1,650	2,173		523	1,650	2,173	0
1992		676	1,650	2,326		676	1,650	2,326	0
1993		523	1,650	2,173		523	1,650	2,173	0
1994		523	1,650	2,173		523	1,650	2,173	0
1995		523	1,650	2,173		523	1,650	2,173	0
1996		523	1,650	2,173		523	1,650	2,173	0
1997		523	1,650	2,173		523	1,650	2,173	0
1998		523	1,650	2,173		523	1,650	2,173	0
1999		523	1,650	2,173		523	1,650	2,173	0
2000		523	1,650	2,173		523	1,650	2,173	0
2001		523	1,650	2,173		523	1,650	2,173	0
2002		676	1,650	2,326		676	1,650	2,326	0
2003		523	1,650	2,173		523	1,650	2,173	0
2004		523	1,650	2,173		523	1,650	2,173	0
2005		523	1,650	2,173		523	1,650	2,173	0
2006		523	1,650	2,173		523	1,650	2,173	0
2007		640	1,650	2,290		640	1,650	2,290	0
2008		523	1,576	2,099		523	1,576	2,099	0
2009		523		523		523		523	0
2010		523		523		523		523	0

/1 : Government subsidy to be allocated for the repayment

/2 : Accumulated foreign loan including 3.5% of interest per annum within 7 years of grace period

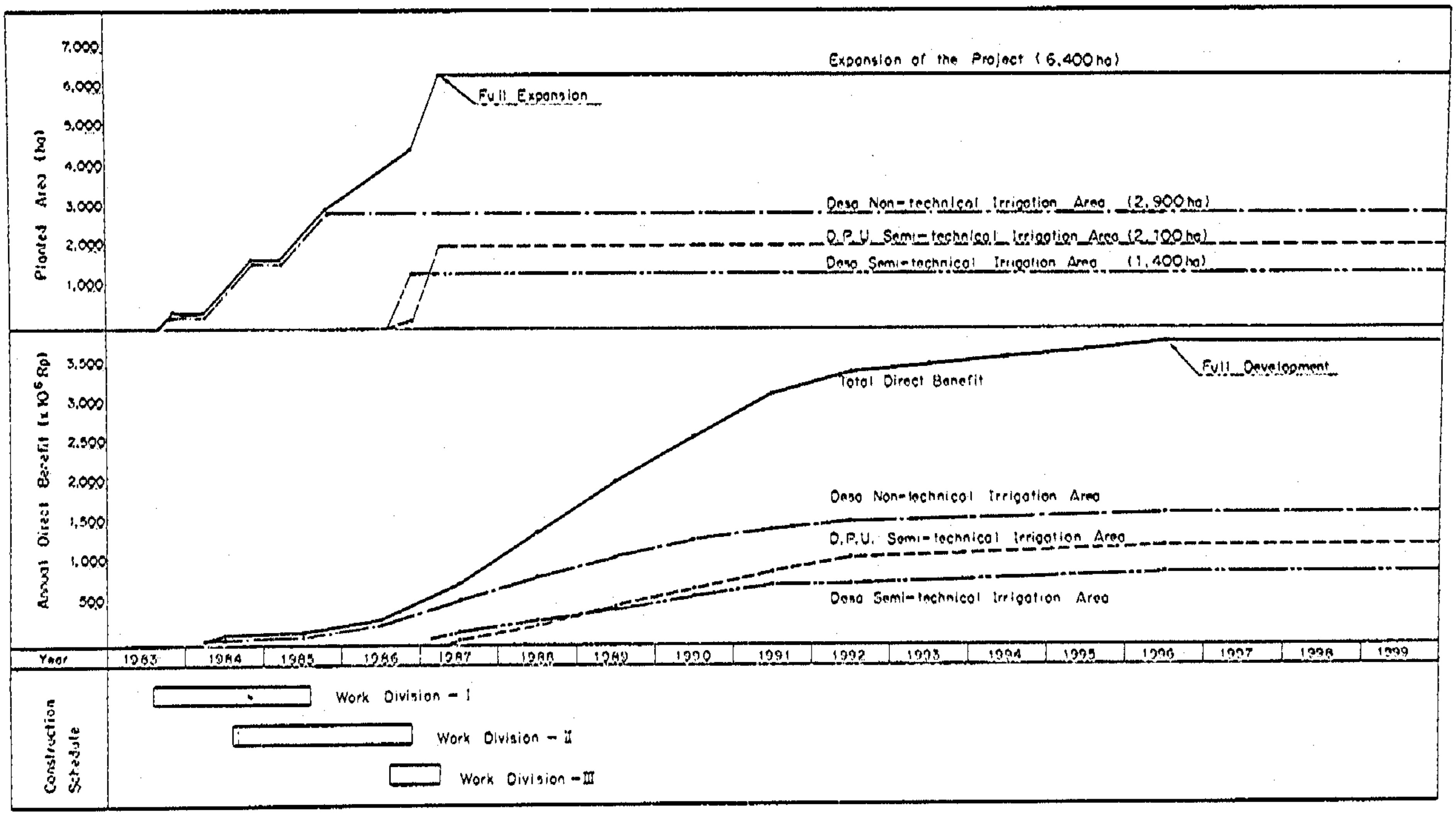


Fig. 10.1.1 PLANTED AREA AND ANNUAL DIRECT BENEFIT

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