REPUBLIC OF INDONESIA

STUDY REPORT

ON

OVERALL ULAR RIVER IMPROVEMENT PROJECT

(INCLUDING FLOOD CONTROL, RECLAMATION OF DOWNSTREAM PLAIN AND POSSIBLE IRRIGATION PROJECT)

JANUARY 1978

JAPAN INTERNATIONAL COOPERATION AGENCY

Preface

The Government of Japan, in response to the request of the Government of the Republic of Indonesia, decided to conduct a study for the Overall Ular River Improvement Project (including flood control, development of downstream plain and irrigation project), through the Japan International Cooperation Agency.

The Agency dispatched a preliminary survey team in March 1976, and organized a study team composed of experts in various fields headed by Dr. Seiichi Sato and carried out a field survey in October 1976. The report that we are submitting herewith has been compiled taking fully into account also of the questions and answeres voiced at the meetings held in Indonesia. I sincerely hope that this report would make a contribution to the development of the project.

Finally, I would like to express my deep appreciation to all the members who participated in the study for their hard work and my heartfelt gratitude to the authorities concerned in the Republic of Indonesia.

January 1978.

Shinsaku Hogen
President
Japan International
Cooperation Agency
Tokyo, Japan

LETTER OF TRANSMITTAL

Tokyo, January 1978

Mr. Shinsaku Hogen
President
Japan International Cooperation Agency
Shinjukuku Mitsui Building
Nishi-Shinjuku 2-1,
Shinjuku-ku, Tokyo, Japan

Dear Sir:

I have the pleasure to submit you the final report entitled "Republic of Indonesia, Study Report on Overall Ular River Improvement Project (Including Flood Control, Reclamation of Downstream Plain and Possible Irrigation Project)". This report has been prepared in accordance with the contracts signed on October 16, 1976 and on August 5, 1977 between the Japan International Cooperation Agency and the joint venture composed of NIKKEN Consultants, Inc. and Nippon Koei Co., Ltd.

The Team made the studies in Indonesia including data collection and necessary surveyings for about two months from October 26, 1976 to December 24, 1976 in cooperation with the Indonesian Counterpart Team organized by the Ministry of Public Works and Electric Power, the Government of Indonesia. In Japan, studies were continued for analyzing the collected data, formulating the plans and evaluating the economic feasibility thereof.

Prior to finalizing the report, final discussions were made both in Jakarta and in Medan between the Study Team and the officials concerned of the Indonesian Government as well as the Indonesian Counterpart Team. The report was completed taking account of the conclusions obtained in the above-mentioned meetings and finally approved by the Advisory Committee of the Japan International Cooperation Agency.

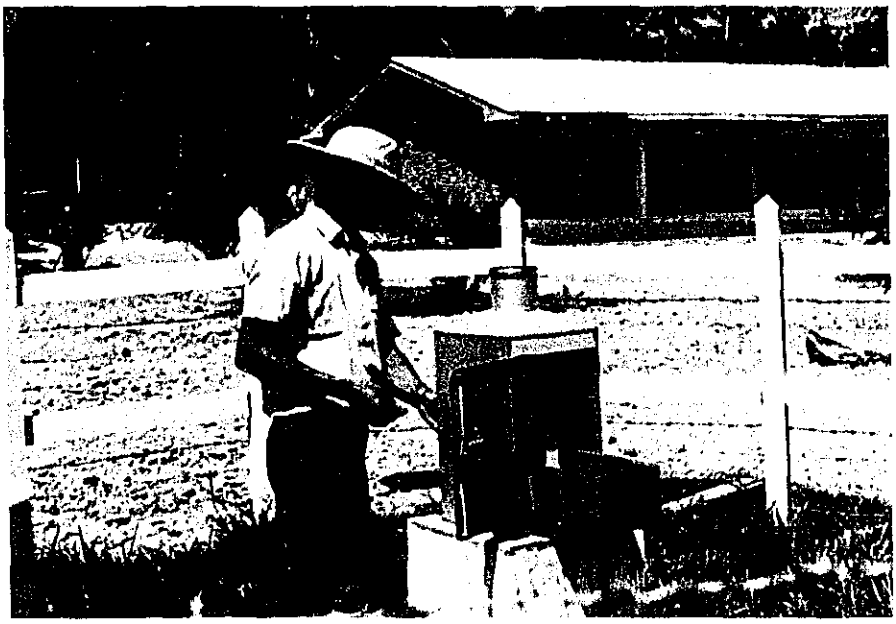
The Study Team wishes to express its sincere appreciation to the Counterpart Team and the officials of Directorate General of Water Resources Development, the Department of Public Works, North Sumatra Province and other authorites concerned in Indonesia for the hearty cooperation and support extend to the Team. Lastly, the Team wishes to acknowledge the wholehearted encouragement given to the Team by the Embassy of Japan in Jakarta, the Consulate of Japan in Medan and the Japan International Cooperation Agency during this study.

Yours faithfully,

Dr. Seiichi Sato
Leader of the Study Team
for the Overall Ular River
Improvement Project

SS/yw

Sunset on an inundation caused by breaches of a dike about 3.5 km upstream from Ular Bridge during the 1973-flood.

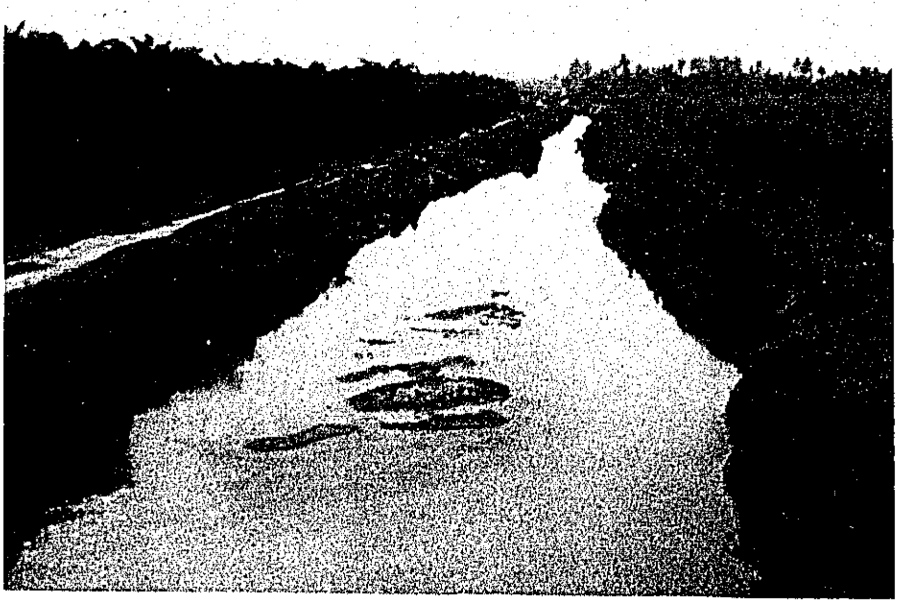


The office of Ular River Urgent Flood Control Project and a rain gage set in its premise.

The lower Ular river viewed upstream from a ferry boat at about 10 km downstream from Ular Bridge in the 1976-rainy-season.

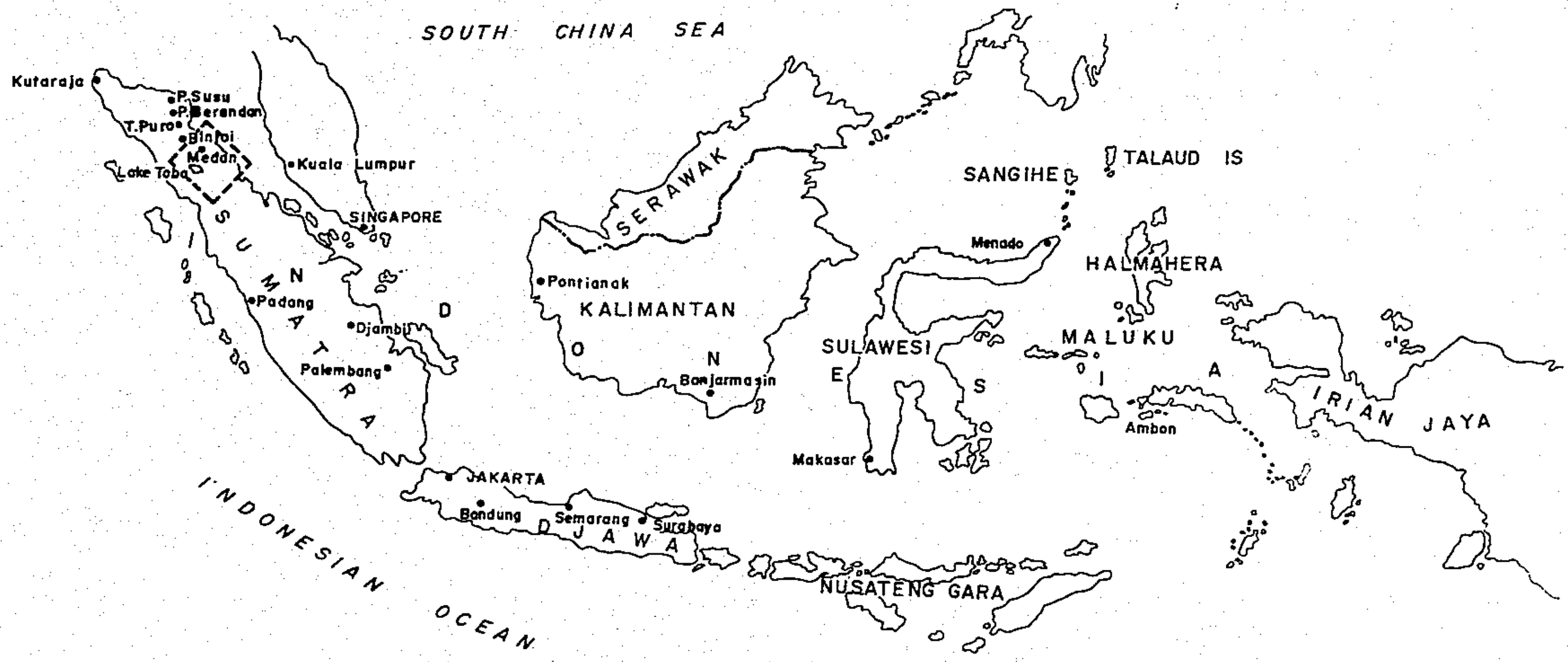
Paddy field in the project area

Sedimentation in Perbaungan irrigation canal

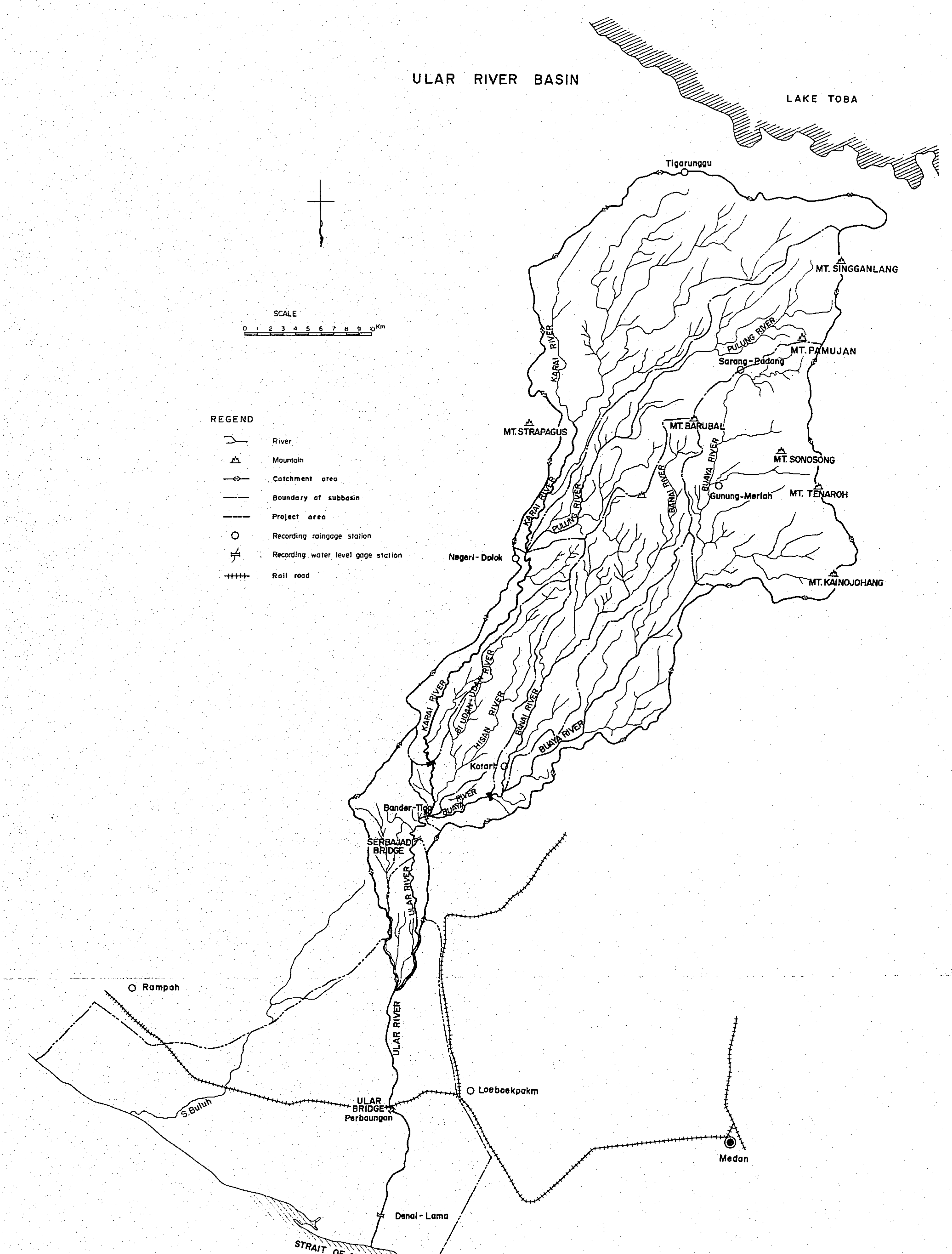


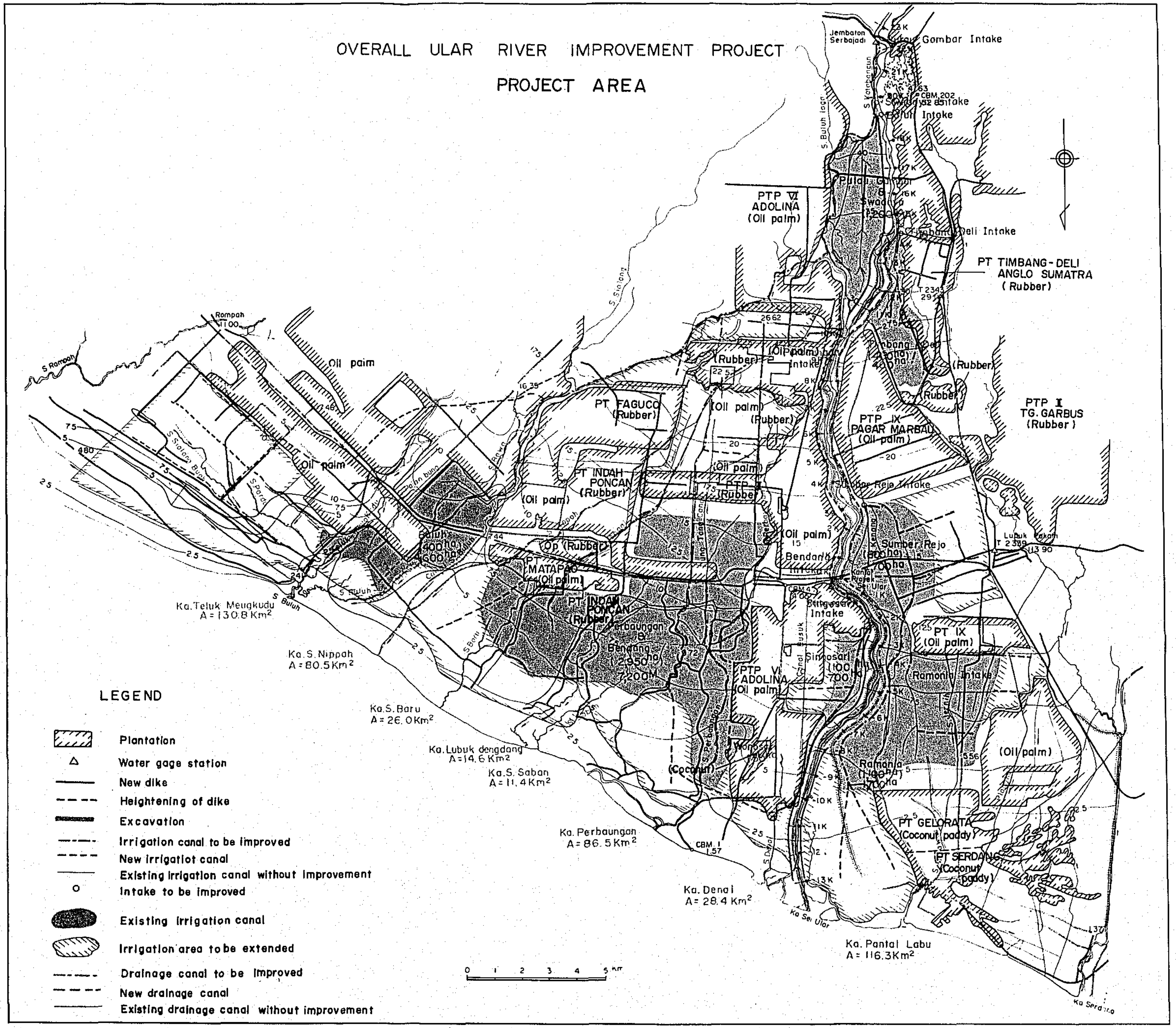
Sumber Rejo irrigation canal

Location Map



ULAR RIVER BASIN




OVERALL ULAR RIVER IMPROVEMENT PROJECT
PROJECT AREA
LEGEND
Plantation
Water gage station
New dike
Heightening of dike
Excavation
Irrigation canal to be improved
New irrigatiot canal
Existing irrigation canal without improvement
Intake to be improved
Existing irrigation canal
Irrigation area to be extended
Drainage canal to be improved
New drainage canal
Existing drainage canal without improvement
Ka. Teluk Meugkudu A = 130.8 Km2
Ka. S. Nippah A = 80.5 Km2
Ka. S. Baru A = 26.0 Km2
Ka. Lubuk dengdang A = 14.6 Km2
Ka. S. Saban A = 11.4 Km2
Ka. Perbaungan A = 86.5 Km2
Ka. Denai A = 28.4 Km2
Ka. Pantai Labu A = 116.3 Km2
Gombar Intake
Deli Intake
Sumber Rejo Intake
Ramonia Intake
PT TIMBANG-DELI ANGLO SUMATRA (Rubber)
PTP VI ADOLINA (Oil palm)
PTP X TG. GARBUS (Rubber)
PTP IX PAGAR MARBAU (Oil palm)
PT FAGUCO (Rubber)
PT INDAH PONCAN (Rubber)
PTP IX (Oil palm)
PT GELORATA (Coconut paddy)
PT SERDANG (Coconut paddy)
Oil palm
(Coconut)
Ka Sei Ular

SUMMARY AND CONCLUSIONS

SUMMARY

Originating in the somma of Lake Toba and its adjoining plateau of about 1,200 m in elevation, the Ular River flows through the center of the agricultural area of approximately 400 km^2 in the lower plain and it debouches into the Strait of Malacca at a point about 30 km east from Medan, the capital city of North Sumatra Province.

The Buaya and the Karai Rivers which have nearly the same catchment area join at a point about 40 km upstream from the estuary. The area of the basin at the confluence is about 1,000 km^2. The whole basin stretches over both Kabupaten of Simalungun and Deli-Serdang.

The total length of the river is 115 km and the slope of river channel downstream from the confluence of the aforementioned two rivers varies between 1/700 and 1/1,000.

Most of economic activities in the downstream area of the Ular River are plantation and farming by the inhabitants, except small scale commercial activities in the twon area of Lubuk Pakam and Perbaungan. In the project area, there are about 8,700 ha of palm oil plantations, about 3,500 ha of rubber plantation, 1,200 ha of coconut plantations and 18,500 ha of rice field, and the national railway and the national highway run east and west connecting Medan with the other important area.

In such a productive area, control of river water is one of the most important problems. That is to say, flooding from the Ular River which flows through this productive plain should be prevented and at the same time the water should be used effectively in order to increase the agricultural production.

It was said that overtoppings or breaks on the dikes in a stretch about 10 km upstream form the highway brdige (Ular Brdige) took place almost every year, which gave serious damages to the downstream productive area. The Feasibility Report prepared by the OTCA, JAPAN in March 1971 recommended a temporary design discharge of 600 m^3/sec which both the bridges enable to pass. Based on this report, an emergency flood control project was commenced in 1972 as Urgent Flood Control Project with an aid of Japanese Yen Loan on a stretch between Ular Bridge and a point 10.0 km upstream from the bridge. Elimination of the constriction formed by the highway and railway bridges was also recommended and the rebuilding works are now under way as independent works.

As the result of this Urgent Flood Control Project, damages to be caused by floods in the midstream area were markedly decreased, and the productivity in the downstream agricultural area was distinctly increased.

In view of the fact that the above-mentioned works are an emergent one, planning of the Overall Ular River Improvement Project which contains not only flood control measures but also improvement and development of irrigation and drainage in the downstream plain area has been required, which led to the present Overall Plan Study.

The project area for the study of Overall Plan was determined as a triangular area in the alluvial plain downstream of the Ular River with its vertex at Serbajadi Bridge. The area bounds with the Serdang River on northwest, with the Rampah River on southeast, and with the Strait of Malacca from east to west.

In studying flood control plan, four cases of peak discharges of 600 m^3/sec, 800 m^3/sec, 1,000 m^3/sec and 1,200 m^3/sec at Serbajadi Bridge were taken into consideration in view of the fact that a survey during the Urgent Project reported that there were some floods exceeding the temporary design flood discharge in the past. With regard to each of the four discharges were considered flood control measures by river channel improvement alone, dam construction alone and combination thereof. In case of dam construction, dam to be used exclusively for flood control was taken into consideration since no dam is needed for securing water requirement for irrigation as mentioned later. It was found from this study that construction cost of flood control works by channel improvement alone is the minimum. The construction works shown in Tables 3-5-2(1) to 3-5-2(4) including design works for flood control sector were planned to be carried out during five years from 1978/79 to 1982/83. The construction cost (economic cost) for flood control was estimated at Rp.2,651 million for 600 m^3/sec, Rp.3,170 million for 800 m^3/sec, Rp.4,132 million for 1,000 m^3/sec and Rp. 5,251 million for 1,200 m^3/sec at the 1976-prices.

With regard to the foodstuffs condition, the Indonesian Government still have to import about one million tons of rice annually, because of the high demand for foodstuffs due to the rapid population growth rate of 2.1% per annum together with an increase in rice consumption per capita resulting from the raised standard of living. The Second Five-Year Development Plan (PELITA-II) was launched in 1974 and aims at the attainment of self-sufficiency in foodstuffs. According to this plan, the Government directs its national effort toward an early induction of the improved irrigation farming.

The above-mentioned project area covers an area of approximately 40,000 ha which consists of 18,500 ha of rice filed, 13,400 ha of estate field. 1,100 ha of horticulture filed, 4,600 ha of houses and roads and 2,400 ha of others such as seacost. Since the project area has already been fully developed and there are no rooms for further reclamation, the objective area for irrigation plan was determined to be all rice field of 18,500 ha which comprizes the irrigated land of 7,000 ha and the rain-fed area of 11,500 ha.

Planting of paddy extends over about 100% of the whole rice field in the rainy season, while it decreases to about 25% in the dry season. The unit yield of paddy is different depending on location and harvesting year, but is estimated at 3.1 ton per on an average. Annual total production of rice amounts to about 70,000 tons in the project area.

The present irrigation and drainage systems include 13 intake facilities, main irrigation canal of about 50 km, secondary canal of about 90 km and drainage canal of about 57 km.

The main reasons for such a low planting ratio in the dry season and low crop yield are considered as follows:

(1) The amount of available water is not enough to irrigate the whole farmland in the dry season due to the shortage of irrigation facilities on farm level.

(2) The surface drainages in the project area are inhibited mainly due to the shortage of capacities of natural rivers and drainage channels, a distinctive topography of sand dune along the coastal line, tidal actions, etc. The condition of such poor drainage restricts the vigrous growth of crops.

(3) Institutional activities with emphasis on water management are not satisfactory due to the shortage of well-trained staff, the lack of mutural communication and coordination among institutions.

(4) Farm inputs are not applied properly in volume and in time.

As the discharge of this river is considerably abundant, it was concluded that irrigation water needed for the project can be supplied by free intake without building any dams on this river. However, for the purpose of smooth supply of irrigation water, 6 intake facilities as well as the main irrigation canals 42 km long will be rehabilitated. Secondary canal 74 km long will newly be constructed and that 43 km long will be rehabilitated. 23 turnouts, 14 drops, 3 aqueducts, 11 syphons, 3 conduits, 11 bridges and 5 spilways will newly be constructed or rehabilitated. Furthermore tertiary canal, farm ditch, branch road and farm road will newly be constructed at the density of 20, 40, 30 and 15m/ha, respectively. In addition, 14 km of drainage canal will newly be constructed and natural rivers 39 km long will be improved.

Upon completion of the said works, a year-round irrigation farming will become possible over the whole farm land of 18,500 ha. An intensive rice farming of double cropping of paddy per year is to be introduced. The yield of paddy will attain its maixmum of 4.5 tons of paddy per ha in the 7th year after the completion of irrigation and drainage facilities. Annual production of paddy in the project area will reach about 150,000 tons.

The construction works including the design works for irrigation sector were planned to be carried out during few years from 1978/79 to 1982/83. The construction cost (economic cost) necessary for the said works amounts to Rp.4,395 million at the 1976-prices.

Based on the aforesaid costs and considering the benefits to accrue therefrom, benefit-cost analyses were made with regard to the three cases of flood control alone, irrigation and drainage alone and combination of the two, by discharges of 600 m^3/sec, 800 m^3/sec, 1,000 m^3/sec and 1,200 m^3/sec. The results are shown in the following table.

Benefit-Cost Analyses

Kind of project	Dis-charge (m^3/s)	IRR/1 (%)	Benefit-cost ratio (B/C) 10%	12%	15%	Net present value (B-C) 10%	12%	15%
								x10^6 Rp
Flood control	600	12.7	1.25	1.05	0.84	474	88	-251
	800	20.0	1.99	1.67	1.34	2,216	1,396	638
	1,000	18.5	1.84	1.55	1.24	2,453	1,480	586
	1,200	15.4	1.52	1.28	1.02	1,941	960	76
Irrigation		21.8	2.72	2.20	1.67	5,806	3,724	1,841
Flood control & irrigation	600	20.6	2.43	1.97	1.51	7,493	4,715	2,199
	800	26.0	3.25	2.65	2.03	12,641	8,557	4,799
	1,000	26.2	3.29	2.68	2.06	14,371	9,751	5,497
	1,200	24.6	3.01	2.45	1.88	14,213	9,495	5,165

/1 : Internal rate of return.

CONCLUSIONS

The alluvial plain area governed by the Ular River had suffered from serious damages caused by floods which took place several times every year owing to breaches on the levees. In view of the fact that this area has a high productivity, an emergent work for flood control was planned and commenced in 1972. This project has brought a development effect beyond expectation as well as the expected effect to the productivity and the stabilization of the people's livelihood, which encouraged the authorities concerned to plan, as the follwoing step, an overall river improvement project partly because the project implemented so far was only an emergent one. For this purpose, an overall plan study was planned.

The first objective of the present study is to find and propose an overall plan for the Overall Ular River Improvement Project that includes both flood control and improvement of irrigation and drainage. In view of this objective, it was expected at the time of commencement of the study that the Overall Project would be composed of such individual projects as sabo project, multipurpose dam project, river-channel improvement project and irrigation/drainage improvement project.

With the progress of the study, however, it has become clear that no sabo work is needed at present, no dam is needed for the purpose of supplying irrigation water because of abundance of river water, and dam plan for flood control falls behind channel-improvement plan in the cost. Accordingly for studying the priority order as the second objective of this study, it has become unnecessary to take the above-mentioned individual projects into consideration.

In stead of the above, we decided to compare the profitableness of three kinds of projects; a flood control project by river-channel improvement alone, a project of irrigation/drainage improvement alone, and a project comprizing both of flood control by channel improvement and irrigation/drainage improvement.

Economic evaluation was made of the three kinds of projects by comparing economic costs with economic benefits in the forms of net present value, benefit-cost ratio and internal rate of return. The results are shown in the table given at the end of the SUMMARY.

As is evident in the table, the benefit, in any case of the projects, exceeds the cost when both are discounted at 12%. This means that all of the proposed projects are economically feasible. The internal rate of return exceeds 20% in the case of the design discharge of 800 m^3/s for flood control and also in the case of irrigation/drainage improvement. However, all of the combined projects further surpass the above two, and, among the four combined projects, the projects with design dishcarge of 800 m^3/s or 1,000 m^3/s are the best with no significant difference between them in the values of IRR and B/C ratio.

With regard to design discharge for flood control, the return period of 30 years is generally applied to rivers in Indonesia, while the analysis shows that the return period of 800 m^3/s is 33 years. We therefore propose that the combined project of flood control and irrigation/drainage improvement with the design discharge of 800 m^3/s should be taken as the overall plan for the Overall Ular River Improvement Project.

The Overall Plan will thus be composed of the river-channel improvement at the design discharge of 800 m^3/s over a stretch extending from the river mouth to Pulau Gambar and the agricultural development plan over an area of 18,500 ha situated in the lower region of the Ular and between the two neighboring rivers, the Serdang and the Rampah.

This objective area for agricultural plan was fixed based on the conception that the plan shall be formulated as a part of the Overall Ular River Improvement Project and the area shall not cover other area topographically connected with the two neighboring rivers. However, in the future when a regional planning which will cover a broader area than the above is made, utilization of river water of the Ular to regions beyond the present project area may have to be considered together with study of adjacent rivers including the Serdang and the Rampah.

As already mentioned, the discharge of the Ular River is considerably abundant. The record of discharge measurement at Serbajadi shows that the annual runoff of the river is 1,600 x 10^6 m^3 in 1972, 1,770 x 10^6 m^3 in 1973 and 1,680 x 10^6 m^3 in 1974, while the minimum discharge is 26.8 m^3/s in 1972, 35.0 m^3/s in 1973 and 38.6 m^3/s in 1974. Therefore, the natural discharge of the river will able to meet the water requirement for irrigation without special creation by dam. But in the last ten days of July 1972, the natural discharge of the river will be only 10.7 m^3/s after the diversion of water requirement. This means that the natural discharge of the river can just satisfy the water requirement while the remaining discharge of 10.7 m^3/s will have to be sustained as a minimum for preservation water of river.

It was found that construction of dam was uneconomical for the purpose of flood control and agricultural development. However, in connection with the study of flood control by Buaya Dam, study was made on the potentiality of exploitation of water resources represented by electric power production on the assumption that the dam planned for flood control will also be used for power production or another dam instead of the above will be built for exclusive use for power production. In both the cases, electric power production has proved to be unfeasible by reason of small storage capacity and low available head. Therefore, it is not advisable to construct dam for electric power supply. For other utilization of river water of the Ular such as for drinking water and industrial water, it is recommendable to make a study on another occasion together with a synthetic planning of regional development.

The present study on land erosion and sand control concluded that no construction of sabo facilities will be needed for the time being. It seems however to be necessary to commence a study on the mechanism of sand production in the headwaters and the quantity of production on an appropriate occasion in the future against a possible increase in sand production which may occur with the progress of time owing to such causes as development in the headwaters and/or unexpected change in rainfall. Furtheremore, it is desirable in principle from the viewpoint of control of runoff and prevention of surface erosion to cover the land with vegetation. Fortunately a reforestation and greening project is being carried out by the authorities concerned continuously since 1971. At present, reforestation of 2,450 ha and greening of 1,896 ha have already been executed. However, for the purpose of maintaining the present condition of the headwaters or improving the condition in future, the aforesaid reforestation and greening programs will desirably be further promoted together with necessary study of kind of plant which may be more suitable to the headwaters.

It is recommendable finally to study, on the comming occasion of feasibility study, whether phasing of the respective components of flood control and irrigation/drainage improvement is necessary or not and, if necessary, which is the most profitable one among practical combinations in phasing.

C O N T E N T S

LIST OF FIGURES

LIST OF TABLES

DEFINITIONS

Abbreviations

Feasibility Report	: Flood Control Projects in North Sumatra; Feasibility Study on the Ular River, Reconnaissance on the Tanah Itam Ulu Estate, the Bolon River (Siparepare, Tanjung, Gambus), and the Silau/Asahan River, prepared for Oversease Technical Cooperation Agency, Government of Japan by NIKKEN Consultants, Inc. in March 1971.
Project, Overall Project	: Overall Ular River Improvement Project
Preliminary Survey Team	: Survey Team dispatched by the JICA to Indonesia in March 1976 for making a preliminary survey for formulating a overall plan for the Overall Ular River Improvement Project.
Preliminary Survey Report	: Report prepared by the Preliminary Survey Team on the Overall Ular River Improvement Project, written in Japanese and printed in June 1976.
Scope of Work	: Scope of Work on Overall Ular River Improvement Project in the Republic of Indonesia.
Study Team	: Japanese Overall Plan Study Team for the Overall Ular River Improvement Project.
Inception Report	: Inception Report of Overall Plan (at first called Master Plan) Study for Overall Ular River Improvement Project.
Note of Understanding	: Note of Understanding on the Overall Plan (at first called Master Plan) Study for the Overall Ular River Improvement Project.
JICA Surveying Team or Surveying Team	: Aerial Photographic Surveying Team despatched by the JICA for making aerial Photographic surveying of the Ular River basin and cross-and profile leveling of the river.
Urgent Flood Control Project, Urgent Project or UFCP	: Ular River Urgent Flood Control Project commenced in 1971.

Kab.	: Kabupaten (district).
Kec.	: Kecamatan (subdistrict).
Gn.	: Gunung (mountain).
Sg.	: Sungai (river).

Datum of elevation

UP	: Ular peil; this is the refence datum of leveling for the Ular River Project. No particular gage is installed for the UP, but the Bench Mark No.T-2339 installed in Lubuk Pakam was fixed on the occasion of the overall plan study to be 13.900 m. UP in the reading.
LBM-Bandar-Tiga	: Local bench mark to be used for reading the staff gage at Bandar Tiga. 0 m,LBM-Bandar-Tiga = 21.309 m, UP.
LBM-Serbajadi	: Local bench mark to be used for reading the staff gage at Serbajadi Bridge. 0 m, LBM-Serbajadi = 39.600 m,UP.
SG-Serbajadi	: Staff gage at Serbajadi Bridge. 0 m,SG-Serbajadi = 4.843 m,LBM-Serbajadi 44.443 m, UP.
LWS	: Low water springs at Belawan Harbor and the datum level of tide at the harbor. 0 m,LWS = -2.656 m, UP.
CBM's	: The stakes that were installed by the Aerial Photographic Surveying Team, JICA for carrying out the levelings for this overall plan study. Each stake has its own level-reading in UP.

Initials and acronyms

BIMAS	: Bimbingan Masyarkat (Community Guidance Project).
BRI	: Bank Rakyat Indonesia (Indonesian People's Bank).
CRIA	: Central Research Institute of Agriculture.
DGWRD	: Directorate General of Water Resources Development, Ministry of Public Works and Electric Power.
DPMA	: Direktorat Penyelidikan Masalah Air (Directorate of Water-problem Research, in Bandung).

DPUTL	: Departemen Pekerjaan Umum dan Tenaga Listrik (Ministry of Public Works and Electric Power).
IBRD	: International Bank for Reconstruction and Development.
IDA	: International Development Association.
JICA	: Japan International Cooperation Agency (former name: OTCA).
KUD	: Koperasi Unit Desa (Village Unti Agricultural Cooperative).
OTCA	: Overseas Technical Cooperation Agency of Japan (present name: JICA).
PELITA	: Pembangunan Lima Tahun (Five-Year Development Plan).
PNP	: Perusahaan Negara Perkebunan (Government-owned Estate Enterprise).
PROSIDA	: Proyek Irigasi IDA (IDA Irrigation Project).
PTP	: Perusahaan Terbatas Perkebunan (Private Estate Enterprise).
DPU or PU	: Dinas Pekerjaan Umum Propinsi Sumatera Utara (Department of Public Works, North Sumatra Province).
RISPA	: Research Institute of the Sumatran Planters Association (former name: AVROS).
WUD	: Wilayah Unit Desa.

<u>Weights and measures</u>

ton = metric ton.

kg = kilogram.

km = kilometer.

m = meter.

mm = millimeter.

<u>Currency equivalent</u>

US$ 1 = Rp 415.

US$ 1 = ¥ 300.

CHAPTER I

INTRODUCTION

1.1. Background of Study.

The Ular River originating in the Bukit Barisan mountains that form the somma of Lake Toba runs almost to the north and pours into the Malacca Strait at a point about 30 km in the southeast of Medan, the capital of North Sumatra Province. The river has a catchment area of about 1,000 km^2 and a length of about 115 km. The river basin stretches over both Kabupaten of Deli/Serdang and Simalungun.

The flat area located on both sides of the lower reaches has well-developed plantations of oilpalm, rubber, tobacco, etc. and well-cultivated paddy field. This area is among the best agricultural production zones in Indonesia. Furthermore, the national railway and the national highway run through this area.

The climate of this area belongs to the tropical one, the mean annual rainfall is 1,500 mm to 2,500 mm in the downstream area and that in the mountainous area is 2,500 mm to 3,000 mm. Water level of the river is usually maintained high in the rainy season from September to January and large run-off discharges due to squally rainfall are frequently superposed on it. Almost in every rainy season, flooding occured repeatedly due to breaches of dikes, and caused great damages to farm land, the railway, the highway and other public facilities as well as inhabitants.

With the view to preventing these disasters emergently, a flood control project was planned over a stretch of 11 km upstream from the Ular highway bridge in view of the fact that breaches of dikes were always concentrated on this stretch. This project started in 1971 as Ular River Urgent Flood Control Project with the aid of a loan from the Overseas Economic Cooperation Fund, Japan, estimating the temporary design discharge at 600 m^3/s and is producing a remarkable effect to development beyond expectation as well as the effect of mitigation of flood damages.

However, in view of the fact that the above-mentioned works are the emergent ones, the Government of Indonesia has intended to formulate an overall plan which contains not only folld-control measures but also improvement and development of the irrigation and drainage in the downstream plain area, and requested to the Government of Japan to extend a technical aid in conducting the study for making the Overall Ular River Improvement Plan. In response to the request, the Japan International Cooperation Agency dispatched Preliminary Survey Team to Indonesia in March 1976, and it was decided to carry out the present study in cooperation with the Government of Indonesia based on the Scope of Work which was approved by the letter 4321/Set. Kab/ LN/P/9/1976 sent to the Embassy of Japan, Jakarta by the Head of the

Bureau of International Cooperation, Cabinet Secretariate, the Government of Indonesia on September 6, 1976.

1.2. Objective of Study.

The present study aims at formulation of an overall plan for the Overall Ular River Improvement Project which will be composed of both flood control and irrigation and drainage related thereto; or it will comprize a plan for flood control by means of river channel improvement and, if effective, in consideration of flood regulation by dam too and a plan for improvement of irrigation and drainage within an area located in the alluvial plain downstream of the Ular River excepting the areas topographically connected with the Serdang River on the left side and the Rampah River on the right side of the Ular River.

Further, the priority order of the individual projects to be included in the overall plan will be studied from the viewpoint of engineering and economy.

1.3. Progress of Study.

After the Japanese Study Team arrived at Jakarta on October 26, 1976, discussions were made in Jakarta and also in Medan on the Draft Inception Report prepared by the Team. It was agreed by the Government of Indonesia with the Note of Understanding.

The Study Team stayed in Indonesia up to Devember 24, 1976 and developed its field surveys of the past floods, the existing facilities for flood control, suitable sites for dams, possible area for retardation of flood discharge, land erosion in the upper basin, land use, meteorology, hydrology, the existing conditions of irrigation and drainage in the project area, soil in the same area, water requirement for irrigation, unit costs of construction works, unit prices, and such data necessary for estimation of benefits as population, general economy, general properties, agricultural products, agricultural economy, public facilities, traffic of highway and railway in the project area and damages due to floods, together with sampling and mechanical analysis of bed materials, cross-sectional surveyings at the sampling sites and dam sites, topographical surveyings for irrigation/drainage planning and estimation of benefits and borings at the dam sites, and data thereon were collected. In the course of the field surveys, meetings were held in Medan four times. At the fourth meeting held in Medan on Deceomber 18,1976, the Study Team suggested the selection of location of bench marks to be established in the area together with the specifications therefor in accordance with the Note of Understanding.

Prior to leaving Indonesia, the Study Team had the last meeting with the Government of Indonesia in Jakarta on Devember 23, 1976.

After the Study Team returned to Japan, studies were continued on return period of peak discharges, hydrographs for dam planning, sediment transportation, channel improvement, flood regulation by dam, flood control plans, land use and cropping pattern, anticipated yields and crop production, water resources, irrigation water requirement, drainage water requirement, irrigation and drainage plan, construction costs of flood control works and maintenance costs, construction costs of irrigation and drainage works, operation, maintenance and replacement costs therefor, flood control benefits, and irrigation and drainage benefits. Based on these studies, an overall plan was prepared.

During the study in Japan, a letter of suggestion for locating the additional recording rain-gage and water-level gage stations over the Ular River basin was sent to the Government of Indonesia by the Study Team in accordance with the Note of Understanding.

The Study Team visited Indonesia in March 1977 to submit the Interim Report and made discussions with the Directorate General of Water Resources Development, and the contents of the discussions were summarized by the two parties on March 23, 1977. In the course of preparing the draft of Final Report, the Study Team received additional comments on the Interim Report by a letter dated May 4, 1977.

Taking account of all the comments mentioned above, the Study Team prepared the Draft Final Report and submitted it on August 18, 1977 to the DGWRD with necessary explanations. As the result of the meetings held in Medan on August 18, 1977 and in Jakarta on August 24, 1977, it was decided to name this study "Overall Plan Study" instead of "Master Plan Study" so far called.

In the meetings held in Medan on Novermber 8, 1977 and successively held in Jakarta on November 11, 1977, discussions were made about the Draft Final Report on Overall Plan Study of Overall Ular River Improvement Project and the scheduled Feasibility Study of the Project, and the Draft Final Report of the Project was agreed by the DGWRD.

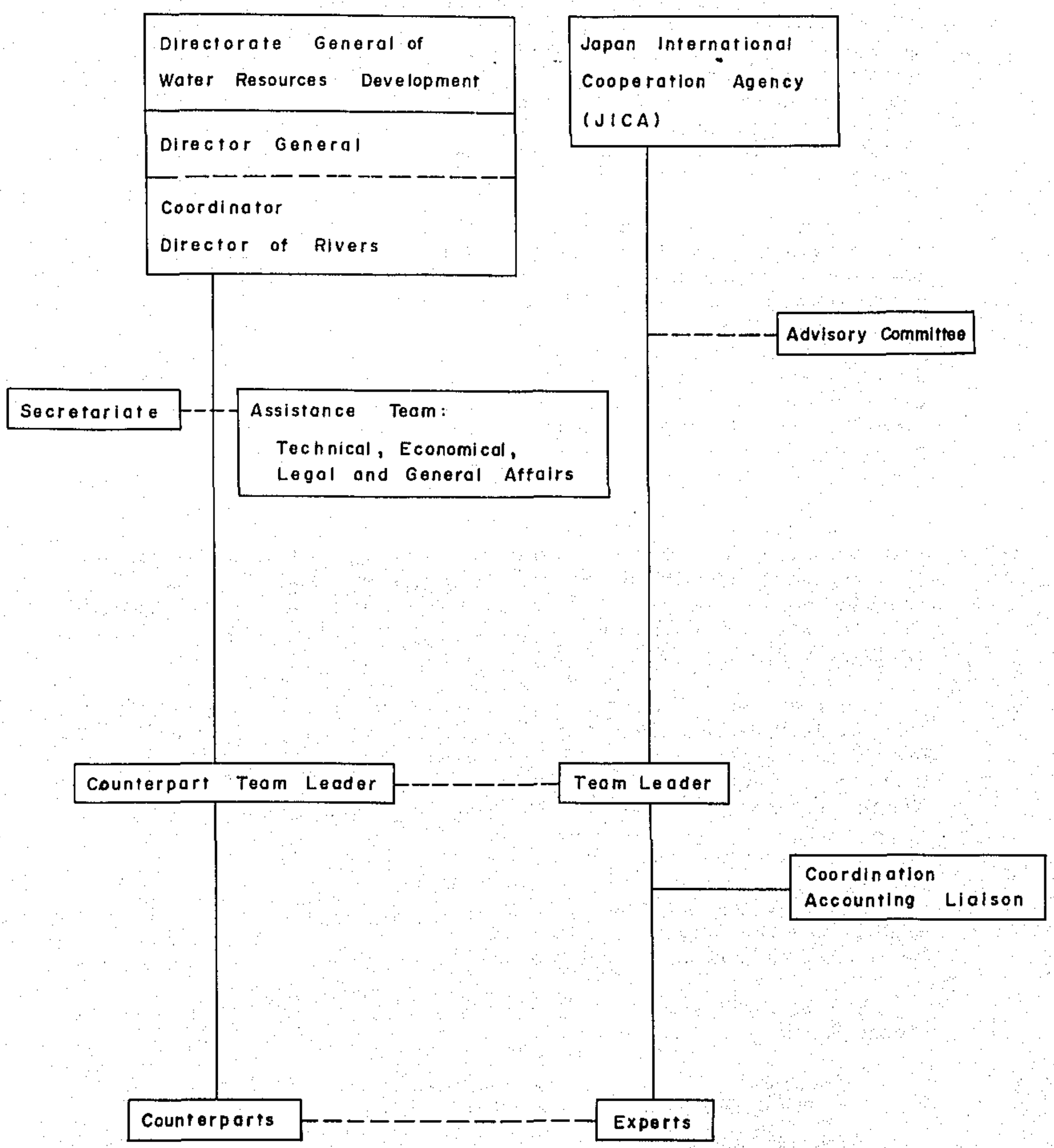
1.4. Organizations for Study.

For carrying out the study, the JICA and the Government of Indonesia established the organizations shown in Fig.1-1 in accordance with the Scope of Work agreed by the Government of Indonesia.

The Advisory Committee of the JICA consisted of the members mentioned below.

Chairman River engineer	Mr. Yukito Imanaga Ministry of Construction
Dam engineer	Mr. Katsuji Komiyama Ministry of Construction
Economist	Mr. Tetsuji Maruta Ministry of Construction

Fig. I-I Organization for Study



Sabo engineer	Mr. Michinobu Tsunematsu Ministry of Construction
Agronomist	Mr. Shikatsugu Muraoka Ministry of Agriculture and Forestry
Irrigation engineer	Mr. Kiichiro Tanaka Ministry of Agriculture and Forestry

The Study Team of the JICA consisted of the members mentioned below.

Team leader	Dr. Seiichi Sato NIKKEN Consultants, Inc.
Co-leader	Mr. Kiyomi Kasama NIKKEN Consultants, Inc.
River engineer	Mr. Shoji Kawabata NIKKEN Consultants, Inc.
Hydrologist	Mr. Noboru Jitsuhiro NIKKEN Consultants, Inc.
Sabo engineer	Mr. Masahiro Kimura NIKKEN Consultants, Inc.
Dam engineer	Mr. Jiro Shimoyama Nippon Koei Co., Ltd.
Geologist	Mr. Hisashi Sasaki Nippon Koei Co., Ltd.
Irrigation and drainage engineer	Mr. Takeshi Nomoto Nippon Koei Co., Ltd.
Agronomist	Mr. Kenjiro Onaka Nippon Koei Co., Ltd.
Agroeconomist	Mr. Masashi Shono Nippon Koei Co., Ltd.
Surveying engineer	Mr. Masaru Yonai NIKKEN Consultants, Inc.
Project economist	Dr. Kin'ichi Ohno NIKKEN Consultants, Inc.
Measurement and liaison	Mr. Yoshiaki Ishizuka NIKKEN Consultants, Inc.

The Indonesian Counterpart Team consisted of the members mentioned below.

Team leader	Ir. Machmudin Makdurah
Deputy I team leader	Ir. Kasim Siregar

Deputy II team leader, river engineer	Ir. B. Simanungkalit
Assistant river engineer	Mr. B. Tampubolon BIE
Hydrologist	Drs. Soedirman
Assistant hydrologist	Ir. Aisyah Nasution
Dam and sabo engineer	Ir. Dartawan
Geologist	Ir. Sudaryanto
Irrigation and drainage engineer	Mr. O. Lumban Goal BIE
Agronomist	Ir. N. Ginting
Agroeconomist	Ir. Sardjono Adji
Surveying engineer	Mr. Sahar BE
Project economist	Drs. Dj. Siahaan
General affairs	Mr. P. Simatupang
Measurement I	Ir. Widiyastuty D.
Measurement II	Mr. L. Pardosi BIE

In the course of the study in Japan, Ir. Sumarso, Ir. Dartawan, Mr. O. Lumban Goal BIE and Ir. Widiyastuty D. participated in the study for one month in February and March 1977.

CHAPTER II

REGIONAL ECONOMY

Sumatra Island, the second large one next to Kalimantan in Indonesia, belongs to the tropical zone, located between 6° North and 6° South Latitude and between 95° and 109° Longitude. In spite of a fertile land with the climate of high temperature and heavy rainfall, the island had not shown any notable development in the 19th century. However, with the development of the estate plantations as well as mines, the island began to have direct contact with the world economy since the beginning of the 20th century. At present, area of the plantations in Sumatra accounts for about 60 percent of total area of the plantations in Indonesia.

North Sumatra Province, where the present project is under consideration, is the most developed one among 7 provinces in Sumatra Island. North Sumatra Province consists of 6 municipalities and 11 regencies (Kabpaten). Among Kabpaten, Deli Serdang has the largest population with high density and well-developed plantations and paddy fileds (Table 2-1).

Table 2-1. Area, Population and Population Density (1975)

	Area (km^2)	Population	Population density (per km^2)
North Sumatra	72,513	7,231,259 /1	100
Kab. Deli Serdang	4,700	1,138,955	235
Kec. Galang	168	54,281	323
" Lubuk Pakam	173	118,598	686
" Perbaungan	203	75,484	372
" Pantai Cermin	63	23,157	368
" Sei Rampah	337	85,040	252
" Teluk Mengkudu	91	25,107	276

Source: Census and Statistical Office of North Sumatra and Kabpatan and Kecamatan Offices.

/1 : 1974

The Ular River, the source of which is in the highland in the east of Lake Toba, flows to the northwest through the plantation and paddy field area in the middle part of Deli Serdang, and finally pours into the Malacca Strait at about 30 km to the east of Medan.

Most of the plantations in the downstream area of the Ular River, except a few plantations owned by foreign capital and small-sized private enterprises, have been operated as national plantations called PNP (Fig.2-1). However, recently in order to expand their activities, they are going to be handed over to private hands called PTP gradually. Generally, the major agricultural products in the plantations are palm oil, rubber, tobacco, coffee and tea. The downstream area of the Ular River mainly produces palm oil and rubber. Palm oil is a very important agricultural export product, contributing greatly to the earning of foreign currencies (Table 2-2). On the other hand, some part of rubber plantations has been replaced to palm oil plantations in recent years because of instability of the rubber price in the international market and lower value compared with palm oil. In the project area, there are about 8,000 ha of oil palm plantations and about 3,500 ha of rubber plantations in the estate field of 13,400 ha and most of them belong to II, IV, VI and IX of PTP.

Table 2-2. Export of Major Agricultural Products in Indonesia

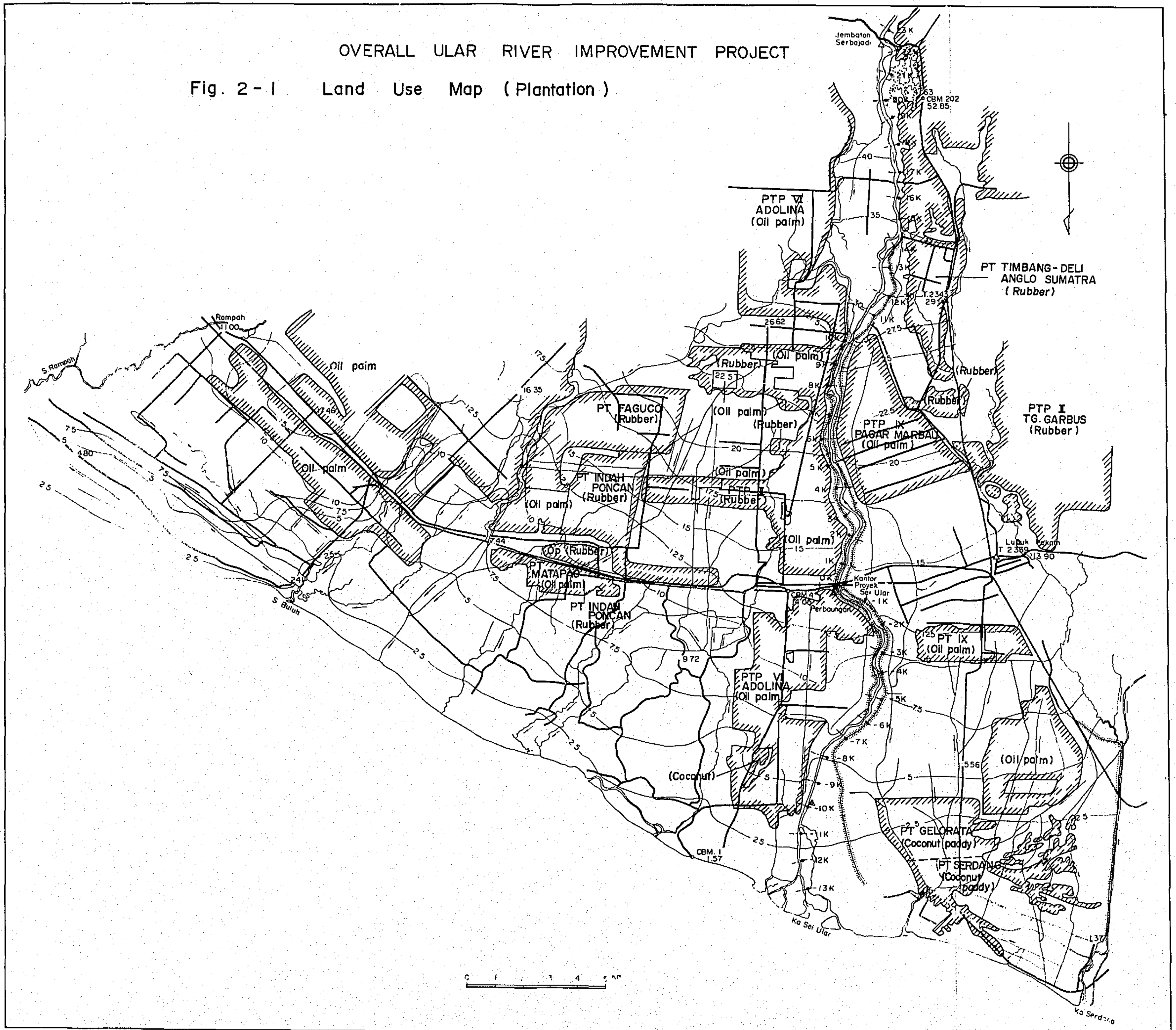
Unit: Thousand ton

Kind of Products	Year 1970	1971	1972	1973	1974	1975
Rubber	790.2	789.3	774.6	990.2	840.4	788.3
Copra	185.1	77.5	42.4	44.6	-	33.0
Coffee	104.3	74.3	107.0	100.8	111.9	128.4
Palm oil	159.2	209.0	236.5	262.7	281.2	386.6
Palm Kernel	42.4	48.6	51.4	39.2	28.5	21.0
Tobacco	11.0	18.3	26.2	33.3	28.1	19.6
Pepper	2.6	24.2	25.7	25.6	15.7	14.5
Tea	41.1	44.8	44.0	39.6	55.7	45.9

Source: Monthly Statistical Bulletin, Sept. 1976, Biro Pusat Statistik, Jakarta, Indonesia.

OVERALL ULAR RIVER IMPROVEMENT PROJECT

Fig. 2 - 1 Land Use Map (Plantation)



Besides the estate plantations mentioned above, the project area is characterized by the well developed farming by the inhabitants and various kinds of crops are produced. The major products are rice, maize, cassava, sweet potatoes and peanuts (Table 2-3). The rice field of 18,500 ha consists of technical irrigation area of 3,000 ha, semi-technical irrigation area of 1,500 ha, non-technical irrigation area of 2,500 ha and rain-fed area of 11,500 ha. Though water from the Ular River is taken into some part of the irrigated area, it does not reach fully to all the area due to the insufficient irrigation facilities. However, owing to positive investments by the government, the irrigation facilities in the project area have gradually been improved and the production of paddy, which is about 3.1 ton per ha, will be expected to become over 3.4 ton per ha in the near future.

Table 2-3. Production of Food Crops in North Sumatra

Year: 1975

Kind of Crops	Harvested area (ha)		Production (ton)	
	North Sumatra	Deli Serdang	North Sumatra	Deli Serdang
Paddy	516,702	59,972	1,382,319	129,958
Maize	35,080	3,055	62,431	5,904
Cassava	20,970	2,547	202,356	31,472
Sweet Potatoes	26,414	1,213	154,089	15,260
Peanuts	14,939	4,726	16,638	6,069
Soy Beans	9,605	1,272	7,683	1,194
Small Green Peas	2,333	515	1,958	399

Source: Statistical Year Book, 1975, Kantor Sensus & Statistik, Sumatera Utara.

In North Sumatra as a whole, however, the supply of rice cannot meet its own demand, because Medan city consumes much and population density is comparatively high and also the demand for rice per capita is increasing (Table 2-4). This shortage of rice, which is anticipated to continue for quite some period, will be supplemented by the importation from foreign countries as well as from other domestic area.

Table 2-4. Production and Consumption of Rice in North Sumatra

Unit: Ton

Item	year				
	1970	1971	1972	1973	1974
Production (paddy)	1,383,251	1,511,129	1,657,706	1,690,965	1,643,791
Consumption (")	1,538,036	1,578,203	1,783,789	1,752,232	1,804,613
Difference (")	-154,785	-67,074	-126,083	-61,267	-160,822
Difference (rice)	- 92,871	-40,244	- 75,650	-36,760	- 96,463

Source: Statistical Year Book, 1975, Kantor Sensus & Statistik, Sumatera Utara.

Excepting the above-mentioned plantation and rice farming, we can not see any noteworthy industry in the project area. Namely, most of economic activities in the project area are limited to the plantation and farming by the inhabitants, except small scale commercial activities in the twon area of Lubuk Pakam and Perbaungan. In such an agricultural land, one of the most important matters is to control water. That is to say, the flood from the Ular River which flows through this flat agricultural area should be prevented and at the same time the water should be used effectively in order to increase the production of agricultural products.

The flat area in the downstream of the Ular River suffered from the flood damages almost every year in the past. In 1970, the Government of Japan, at the request of the Government of Indonesia, had carried out the Feasibility Study of the Urgent Flood Control Project of the Ular River, and subsequently gave technical and financial aids to the Government of Indonesia for the execution of the project. As the result of this river improvement work, the damage caused by flood at the midstream markedly decreased, and the plantations by the river, which improved the drainage facilities, were able to accomplish an effective plan of increasing agricultural products.

In the project area, a national railway and a national highway run east and west connecting Medan with the area of Tubing Tinggi. The railway runs with a single track. Passanger trains make a return trip twice a day. As for freight trains, they make six return trips a day. According to the statistical records by the Railway Authority in Medan, the transport volume is about 2,000 passengers per day, and about 2,000 tons per day as to freight. Concerning the transportation on the highway, passenger cars are running about 2,400 per day, buses about 600 per day, and trucks about 1,400 per day. The transport volume is about 28,000 passengers per day, and about 10,000 tons per day as to freight.

Indonesia, which was suffered severe inflation during 1960's holds the comparatively stabilized price in 1970's. However, the rate of price increase in Indonesia is nearly 20 percent a year and is rather high compared with other countries (Table 2-5).

Table 2-5. Price Index in Medan

(Sept. 1966 = 100)

Item	Year						
	1970	1971	1972	1973	1974	1975	1976 /1
General	100	103	111	171	210	242	269
Food	100	105	116	206	245	272	296

/1: May 1976.

Source: Monthly Statistical Bulletin, Sept. 1976, Biro Pusat Statistik, Jakarta, Indonesia.

The price in the project area is affected by the price in Medan. In 1976, the price of rice in Medan was about Rp 150 per kg which is about three times compared with the price in 1970. In other words, it shows the increase of about 20 percent per year. As for other food prices, their increase rates are nearly equal to that of rice.

GDP in Indonesia in Fiscal Year 1973/74 is about US$15 Billion, or about US$120 per capita. According to Pelita II, GDP is estimated at US$22 Billion in Fiscal Year 1978/79 with the growth rate of 7.5 percent per annum on the average. As for the related agricultural sector, GDP is planned to be raised by 36% during the period of Pelita II, with annual growth rate of 4.6%. In the project area, accordingly, it is expected to increase the productions of rice, palm oil and rubber in the light of Pelita II.

CHAPTER III

FLOOD CONTROL

3.1. General.

In this chapter, the results of study for planning the flood control to be involved in the overall plan of Overall Ular River Improvement Project are mentioned according to the following items.

Topography of the basin.

General geology of the basin and geology at dam sites.

Hydrology.

Alternatives of the river-channel improvement.

Sand control measure.

Alternative plans for flood control by dam.

Alternative allocation of flood discharges.

Flood damages by discharges.

Several kinds of flood discharges and flood damages by discharges are given as data required for making economic evaluation of flood control scheme.

In the section of geology, general geology of the basin and geology at dam sites are described based on the field reconnaissance and the results of machine borings carried out at the dam sites.

In the section of hydrological study, basic data for planning of river-channel improvement, flood control by dam, discharge duration, peak discharges, flood hydrographs for dam planning, tide level and sediment transportation are described.

In the section of river improvement, study of alternative plans for river-channel improvement at each flood dishcarge is described. Retarding effect in flood discharge was also studied as a part of river-channel improvement. The basic execution schedule of the alternatives and their construction costs were estimated.

In the section of sand control, consideration was made of sand control measure based on the visual inspection and the study of aerial photographs.

In the section of dam, flood control by dam was studied with regard to several flood hydrographs prepared in the section of hydrology. Alternative plans of dam were studied corresponding to discharges allocated to the river-channel. The basic execution schedule of the alternatives was planned and the construction costs were estimated thereon.

In the section of allocation of flood discharges, studies were made with regard to six kinds of allocation to dam and river-channel, and the most economical measure for flood control was chosen by comparing the construction costs of river-channel improvement alone with those of the combination of dam construction and river-channel improvement.

In the section of flood damages, studies were made on flood damages to be mitigated by flood control works. The results were used for economic evaluation.

3.2. Topography of River Basin.

The Ular River basin is mainly composed of the basins of the Karai and Buaya Rivers. Originating in the northwestern somma of Lake Toba, the Karai River flows to the northeast gathering the water from such tributaries as the Pulung and the Si Udan-Udan and joins with the Buaya River which gathers the water from the tributary Banai.

Outline of the Ular River basin is shwon in Fig.3-2-1 together with the river system and the catchment area of each sub-basin. The Ular River has a catchment area of 1,081 km^2 in total and a length of about 115 km from the river mouth to the headwaters. Based on the topographic maps of 1/50,000, profiles of the Ular River and its tributaries were prepared and are shown in Fig.3-2-2. As is seen from Fig.3-2-1 and Fig.3-2-2, the Karai River basin is rather different from the Buaya River basin in the shape and condition of the headwater region. The Karai River basin is long and narrow and the headwater forms a plateau which has mean gradient of about 1/50, while the Buaya River basin is relatively short and wide, and the headwater forms steepsloped mountains. The difference may cause the difference in their runoff characteristics.

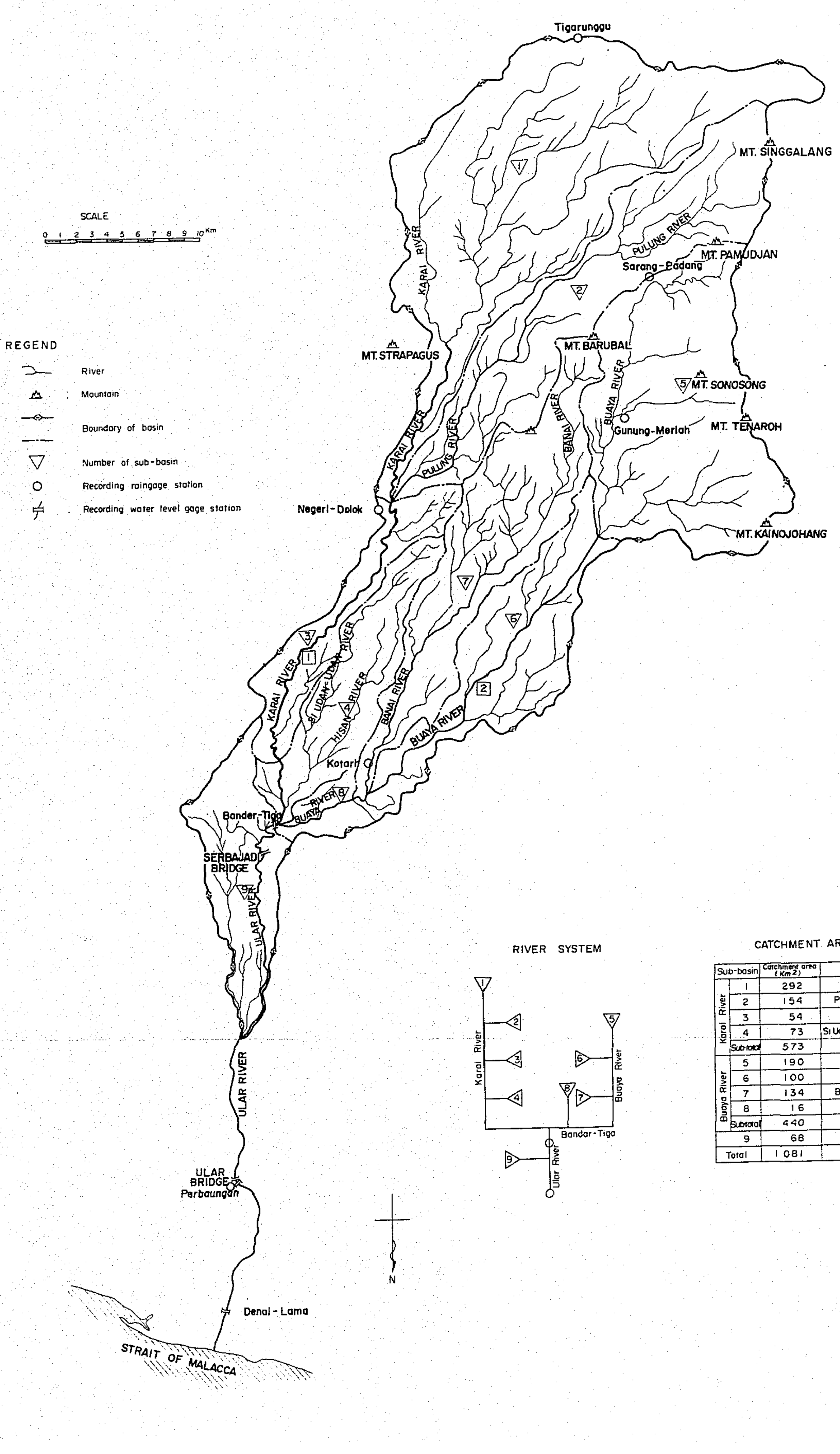
3.3 Geology.

3.3.1. General geology.

Near its source, the Ular River runs through an area covered with andesite forming the Barisan volcano range, but the basin of the river is widely covered with acidic tuff, under which dacite and dacite tuff are found exposed on the banks. Near Mabar Bridge on the upstream course of the Sg. Buaya, the andesite mass can be seen.

Acidic tuff is considered as the product of Toba eruptions, and its thickness is estimated at more than 100 meters.

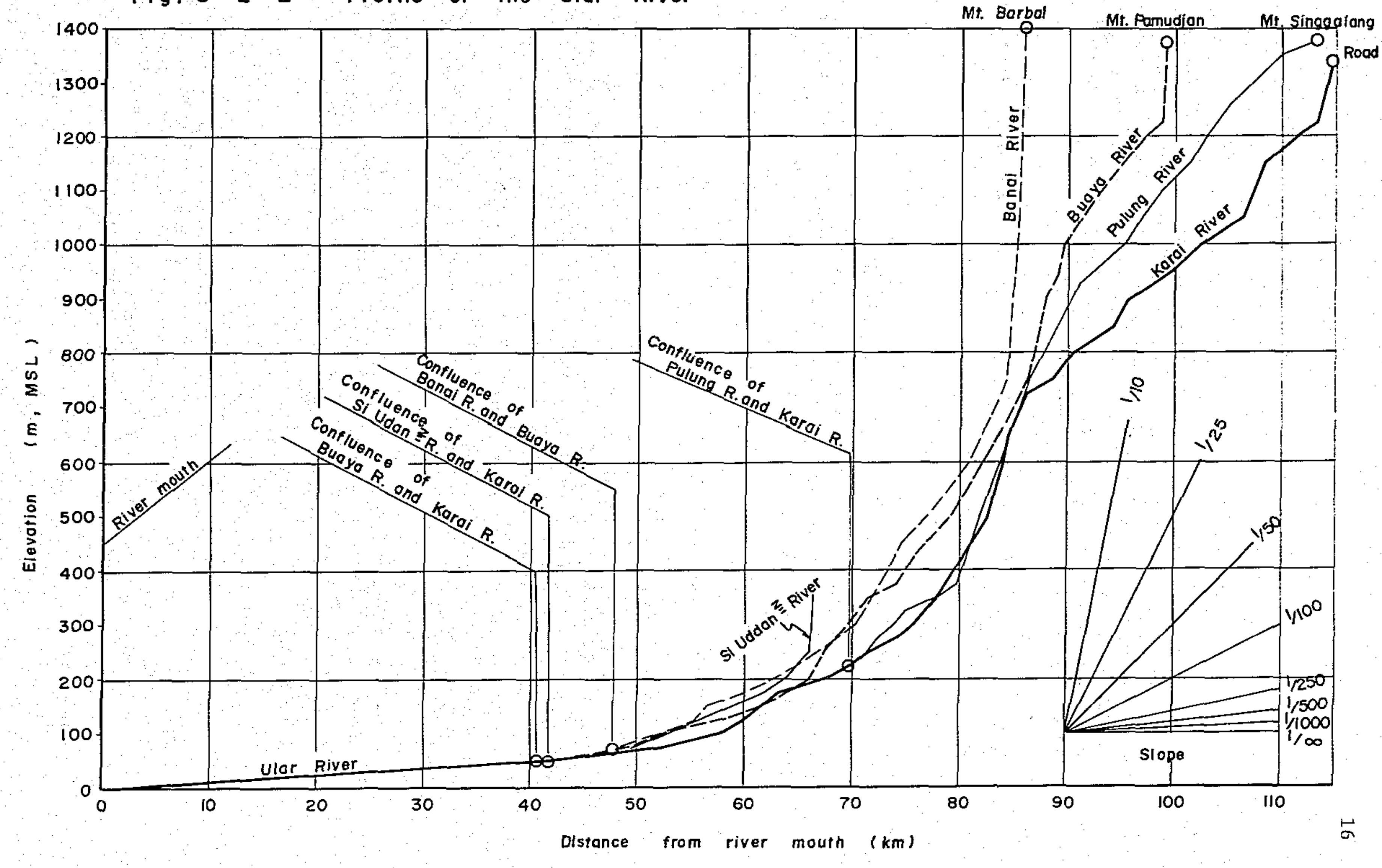
Fig. 3-2-1 Ular River Basin



CATCHMENT AREA

	Sub-basin	Catchment area (Km2)	Remarks
	1	292	
Karai River	2	154	Pulung River
	3	54	
	4	73	Si Udan-Udan River
	Sub-total	573	
	5	190	
Buaya River	6	100	
	7	134	Banai River
	8	16	
	Subtotal	440	
	9	68	
Total		1 081	

Fig. 3-2-2 Profile of the Ular River



Andesite mass seen along the upstream course of the Sg. Buaya is considered to have been produced before the volcanic activity of the Toba volcano, but it is not clear whether dacite was produced before or simultaneously with the Toba volcanic activity. The exposure of the Tertiary rocks and pre-Tertiary rocks which are considered to form base of these volcanic rocks could not be found.

The geological survey was carried out this time in the area mainly along the Sg. Buaya, Sg. Karai, and Sg. Banai because of the short period allowed for the survey.

3.3.2. Geology.

(1) Geology of the Sg. Ular.

The river course downstream from the confluence of Sg. Buaya and Sg.Karai covering a distance of about 40 km is known as the Sg. Ular. The basin of the Sg. Ular is covered with fluvial deposits and alluvial deposits mainly consisting of clay, gravel and sand. Near the seashore facing the Strait of Malacca, marine deposits are found.

(2) Geology of the Sg. Buaya.

The Sg. Buaya is about 57 km long from its source to the confluence where it joins the Sg. Ular. Slightly soft dacite tuff is found on the course between Kotari Brdige and the proposed damsite, and on the upstream from the damsite are found firm dacite rocks. Over a distance of about 2 km upstream from Mabar Bridge, andestie mass is found on the banks.

On the further upstream course of the Sg. Buaya near Gunung Meriah village, andesite tuff and agglomerate tuff are found. Agglomerate tuff contains andesite gravels, pumices, and fragments of slate of the pre-Tertiary.

On the river bed are accumulated a large quantity of gravels of andesite, and sometimes large boulders several meters in diameter are found. These change to gravels on the downstream, and gravels 30 to 20 cm in diameter are found on the course down to the portion near Kotari Bridge.

(3) Geology of the Sg. Karai.

The Sg. Karai is mostly covered with acidic tuff. This tuff is very soft and is easily eroded by flow of the river. The river bank has degraded at many places, forming cliffs. On the river bed are accumulated sands of quartz, biotite, etc. which are disturbed by the flow of river and change the flow into a muddy stream.

(4) *Geology of the Sg. Banai.*

The Sg. Banai is a tributary of the Sg. Buaya which flows from the Gn. Barubai (EL. 1,150 m) and is 36.5 km long. Hard dacite rocks are found on the river bed on the course about 10 km long upstream from the confluence. The river width gets as narrow as several meters in some places, and gorges 5 meters or more in depth are found.

3.3.3. Rocks Observed with Naked Eyes.

(1) Acidic Tuff.

Acidic tuff is distributed widely in the basin of this river. This soft tuff is the liparitic pumiceous tuff consisting of volcanic ash, pumice, quartz, biotite, feldspar and often hornblende. Sometimes pumices as large as 30 cm in diameter and highly absorbent are found. This pumiceous tuff is easily eroded, changes to a large quantity of sand and earth.

(2) Dacite and Its Tuff.

Dacite and its tuff are exposed mainly in the Sg. Banai and the Sg. Buaya consisting of quartz, feldspar, biotite, hornblende and rarely augite. The rock is very hard and partially turns to tuff. The rock looks almost similar to the so-called "ignimbrite" of the Sg. Asahan, but it is difficult to discern its welded texture with naked eye.

(3) Andesite.

Andesite is compact and hard mass with phenocrysts of feldspar, biotite, and hornblende. Typical outcrops can be seen under Mabar Bridge on the Sg. Buaya.

3.3.4. Proposed Dam sites.

(1) Sg. Buaya.

The proposed dam site on the Sg. Buaya is at a point about 5.6 km upstream from the confluence of the Sg. Karai and Sg. Buaya. Dacite and its tuff are exposed on both the abutments.

The result of the core-boring shows that the surface soil is 1.5 m thick and dacite tuff 9 m, and dacite 6 m thick is lying under them. Dacite is a lava-flow underlying thermal metamorphosed rock. This proposed dam site has a good foundation for the construction of a dam about 25 m high.

On the river bed there are many gravels which can be used as concrete aggregates. The surface soil of reddish brown clay can be used as core material.

Fig. 3·3·1 Geological Map in the Project Area

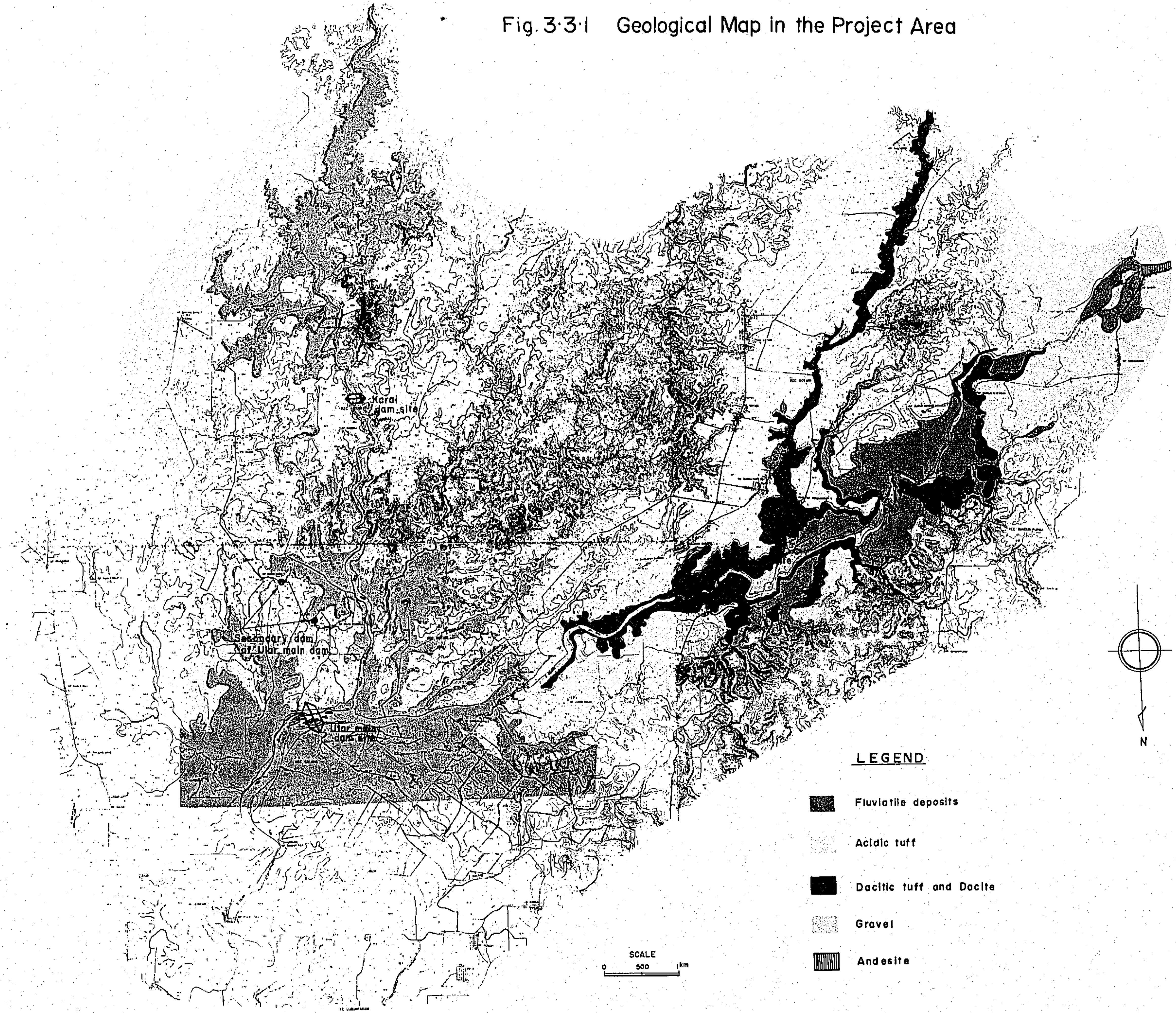
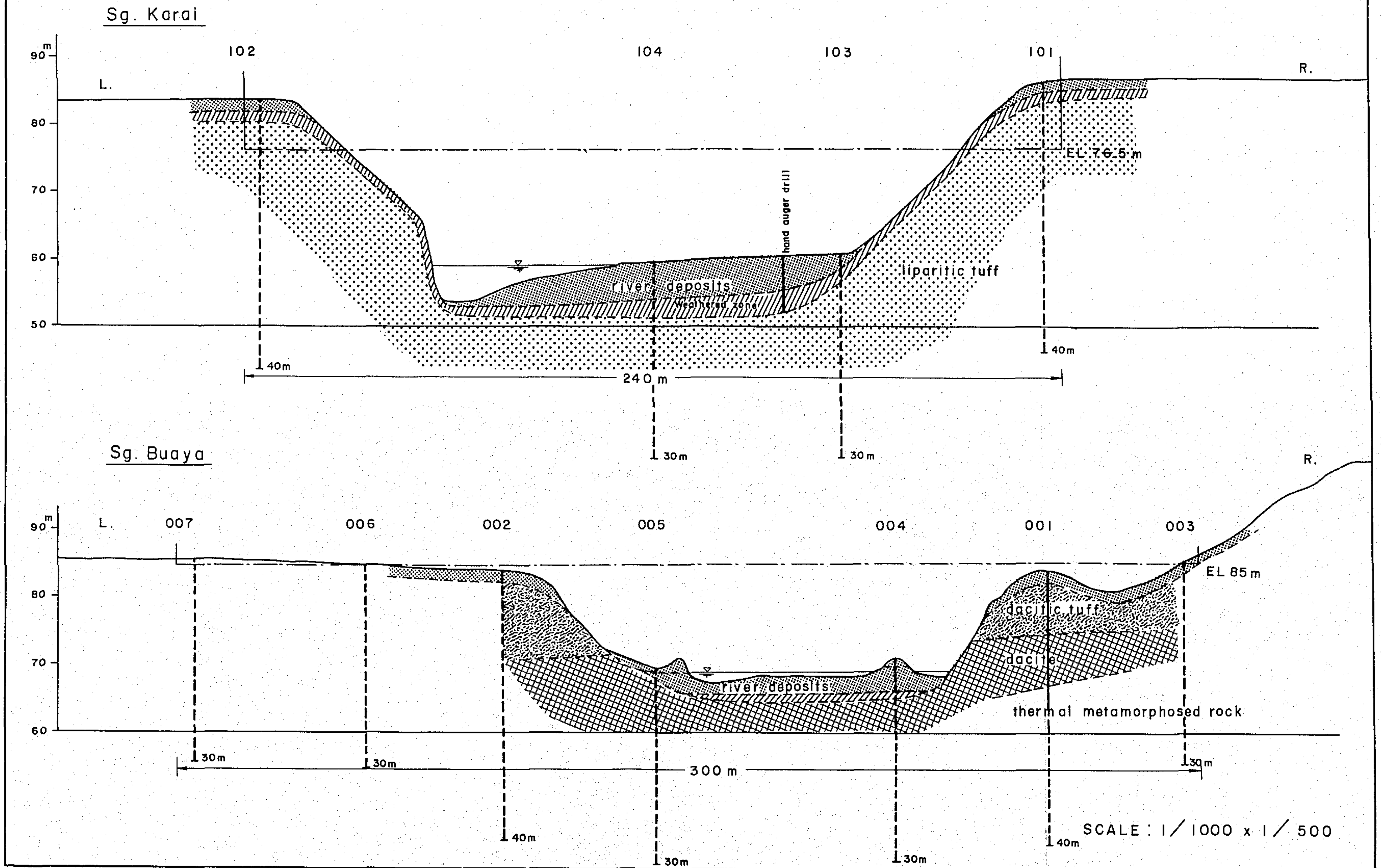


Fig.3-3-2 Geological Profile at Proposed Dam Sites



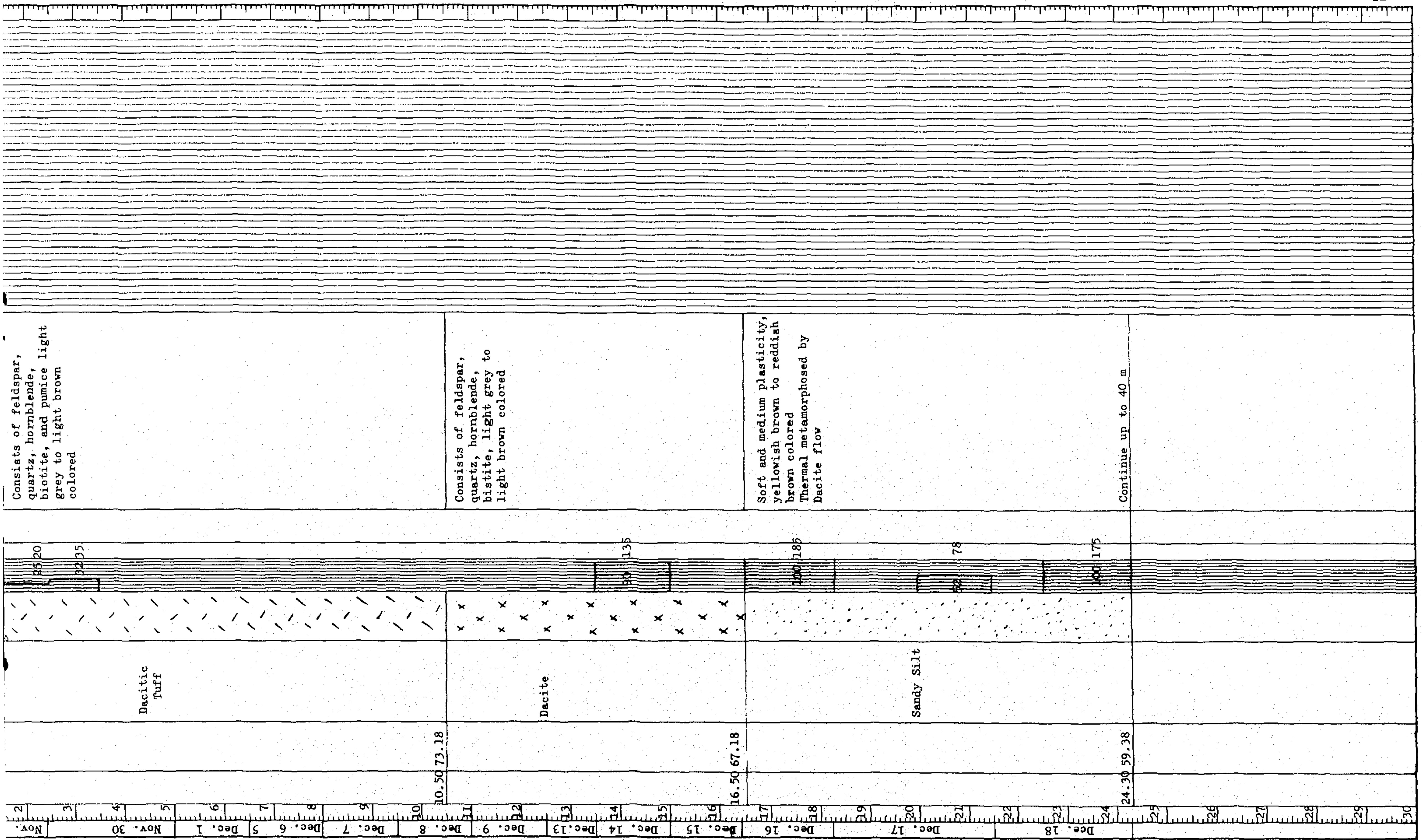
GEOLOGICAL RECORD OF BORING

HOLE No. 001

PROJECT	Sungai Ular	**LOCATION**	Right Abatment of Buaya Dam Site
ELEVATION OF GROUND SURFACE	83.68 m	**DEPTH OF HOLE**	
INCLINATION OF HOLE	Vertical		
DIAMETER OF HOLE	3 inch	**MACHINE**	TONE UD-5
DATE OF DRILLING	Nov. 26 - Dec. 18, 1976		
CORE RECOVERY		**DRILLED BY**	A. GULTOM
LOGGED BY	SOEDARYANTO HS.		

DATE	DEPTH (m)	ELEVATION (m)	ROCK TYPE	CORE RECOVERY %	CORE RECOVERY cm	BIT & DIAMETER	DESCRIPTION
26, Nov. 27	1.50	82.18	Surface Soil	100 50	50 40		Sandy Silt, light brown colored soft, moist, medium plasticity
Nov. 27, Nov. 30, Dec. 1, 5, Dec. 6, Dec. 7, Dec. 8	10.50	73.18	Dacitic Tuff	25 32	20 35		Consists of feldspar, quartz, hornblende, biotite, and pumice light grey to light brown colored
Dec. 8, Dec. 9, Dec.13, Dec. 14, Dec. 15	16.50	67.18	Dacite	90	135		Consists of feldspar, quartz, hornblende, bistite, light grey to light brown colored
Dec. 16, Dec. 17, 18			Sandy Silt	100 53	185 78		Soft and medium plasticity, yellowish brown to reddish brown colored Thermal metamorphosed by Dacite flow

DEPTH


Consists of feldspar, quartz, hornblende, biotite, and pumice light grey to light brown colored
Consists of feldspar, quartz, hornblende, bistite, light grey to light brown colored
Soft and medium plasticity, yellowish brown to reddish brown colored Thermal metamorphosed by Dacite flow
Continue up to 40 m
25 20
32 35
90 135
100 185
52 78
100 175
Dacitic Tuff
Dacite
Sandy Silt
10.50 73.18
16.50 67.18
24.30 59.38
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Nov.
Nov. 30
Dec. 1
Dec. 5
Dec. 6
Dec. 7
Dec. 8
Dec. 9
Dec. 13
Dec. 14
Dec. 15
Dec. 16
Dec. 17
Dec. 18

GEOLOGICAL RECORD OF BORING

HOLE No. 1 (Auger Drill)

PROJECT	Sungai Ular	LOCATION	Right Bank of Karai Dam Site
ELEVATION OF GROUND SURFACE	60.50 m	DEPTH OF HOLE	8.15 m
INCLINATION OF HOLE	Vertical	DIAMETER OF HOLE	10 cm
MACHINE	Hand Auger	DATE OF DRILLING	Dec. 3 - Dec. 10, 1976
CORE RECOVERY		DRILLED BY	ARMYN HARAHAP
LOGGED BY	SOEDARYANTO HS.		

DATE	DEPTH (m)	ELEVATION (m)	ROCK TYPE	BIT & DIAMETER	DESCRIPTION	
Dec. 3	0.40	60.10	Top Soil	Pit	Sandy Silt, dark brown colored, Soft, Contains Charcoal and roofs.	River Terrace Deposits
Dec. 3	1.45	59.05	Silty Sand	Pit / Spoon Auger (ϕ 10 cm)	Well sorted brown to dark brown colored, non plastic, consist of quartz grains subround to angular, medium to coarse grain. Ground water level at 1.15 m depth.	River Terrace Deposits
Dec. 3	2.95	57.55	Clayey Sand	Spoon Auger (ϕ 10 cm)	Well sorted, subround to angular, medium to coarse grain, quartz, felspar, hornblende, mica. Yellowish brown to light brown colored.	River Terrace Deposits
Dec. 4	5.05	55.45	Silty Sand	Spoon Auger (ϕ 10 cm)	Well sorted, subround to angular medium to coarse grain, quartz grains, felspar, hornblende and mica. Yellowish brown to light brown colored.	River Terrace Deposits
Dec. 5, Dec. 10	8.15	52.35	Weathered Acidic Tuff	Spoon Auger (ϕ 10 cm)	Weathered acidic tuff, feldspar, quartz, hornblende, biotite. Brownish grey colored.	
			Acidic Tuff		Acidic tuff, could not drill by hand auger.	

Date	Depth (m)	Elevation (m)	Soil	Method	Description	Geology
	1.45	59.05	Silty Sand	Spoon Auger (ϕ 10 cm)	consist of quartz grains subround to angular, medium to coarse grain. Ground water level at 1.15 m depth.	River Terrace Deposits
Dec. 3	2.95	57.55	Clayey Sand	Spoon Auger (ϕ 10 cm)	Well sorted, subround to angular, medium to coarse grain, quartz, felspar, hornblende, mica. Yellowish brown to light brown colored.	River Terrace Deposits
Dec. 4	5.05	55.45	Silty Sand	Spoon Auger (ϕ 10 cm)	Well sorted, subround to angular medium to coarse grain, quartz grains, felspar, hornblende and mica. Yellowish brown to light brown colored.	River Terrace Deposits
Dec. 5, Dec. 10	8.15	52.35	Weathered Acidic Tuff	Spoon Auger (ϕ 10 cm)	Weathered acidic tuff, feldspar, quartz, hornblende, biotite. Brownish grey colored.	
			Acidic Tuff		Acidic tuff, could not drill by hand auger.	

(2) Sg. Karai.

Acidic tuff is found extensively at the proposed dam site on the Sg. Karai which is situated 5 km upstream from the confluence. According to the results of the hand auger drilling, acidic tuff is found 8 meters below the river side. This tuff is very soft, but is comparatively compact, and its N-value is about 20. Unless the presence of hard rocks underneath the tuff is confirmed, it would be difficult to construct a dam on this foundation.

3.3.5. Quarry.

It would be possible to use as aggregates such gravels on the river bed, under the river terrace and the shoal of the Sg. Buaya extending about 10 km from Kotari Bridge toward upstream. Gravels are mostly andesite, compact and hard with 20 to 30 cm in average size.

Assuming that the average width of the river is 70 meters and the exploitation depth is 2 meters, the volume of gravels available can be calculated as follows:

$$2.00 \text{ m} \times 70 \text{ m} \times 10{,}000 \text{ m} = 1{,}400{,}000 \text{ m}^3$$

If the percentage of void is 50% and the practice ratio is 80%, the volume is:

$$1{,}400{,}000 \text{ m}^3 \times 0.5 \times 0.8 = 560{,}000 \text{ m}^3$$

There are sand deposits on the river bed downstream from the confluence of the Sg. Buaya and the Sg. Karai. Sands mainly consist of quartz sand, and the maximum grain size is about 3 mm. The area around Serbajadi Bridge is suitable for gathering aggregates.

3.4. Hydrology.

3.4.1. Rainfall.

In and around the Ular River basin, the Ular River Project Office has installed six recording rain gages, fourteen ordinary rain gages, three recroding water-level gages and one staff gage, which are shown in Fig. 3-2-1.

(1) Rain gage stations

Data are available for the period from Aug., 1972 to Jul., 1976 for recording gages and from Aug., 1975 to Oct., 1976 for ordinary gage.

Recording gage	Ordinary gage
Perbaungan	Paku
Kotari	Silinda
Gunung-Meriah	Rumah-Deleng
Sarang-Padang	Bandar-Negrei
Tiga-Runggu	Tiga-Juhar
Negeri-Dolok	Marubun-Lokung
	Negeri-Kasihan
	Bah-Bah
	Sarang-Ganjang
	Siporkas
	Pematan-Raya
	Huta-Raja
	Serib-Dolok

(2) Water level gage stations

Data are available for the period from Aug., 1972 to Jul., 1976 for recording gages and from Oct., 1971 to Sept., 1976 for staff gage.

Recording gage	Staff gage
Denai-Lama	Ular Bridge
Perbaungan	
Bandar-Tiga	

At Silinda, besides the ordinary rain-gage station installed by the said Office, the DPMA (Direktorat Penyelidikan Masalah Air) also has a climatologic station equipped with recroding rain gage, thermometer, hygrometer, anemometer, evaporimeter and actinometer. Data thereby are available at this station from February 1975 to July 1976. The DPMA also has a staff gage at Serbajadi Bridge where data are available from August 1971 to December 1974.

In addition, the PNP (Perusahaan Negara Perkebunan) has a number of ordinary rain-gage stations in the downstream area of the Ular River. Daily data are available at these stations for more than 20 years, while monthly data are available at some stations for longer period. The names and locations of the stations are shown in Fig. 3-4-1.

Fig.3-4-1 Location of Rainfall-Gauge Stations in the Downstream Area of the Ular River

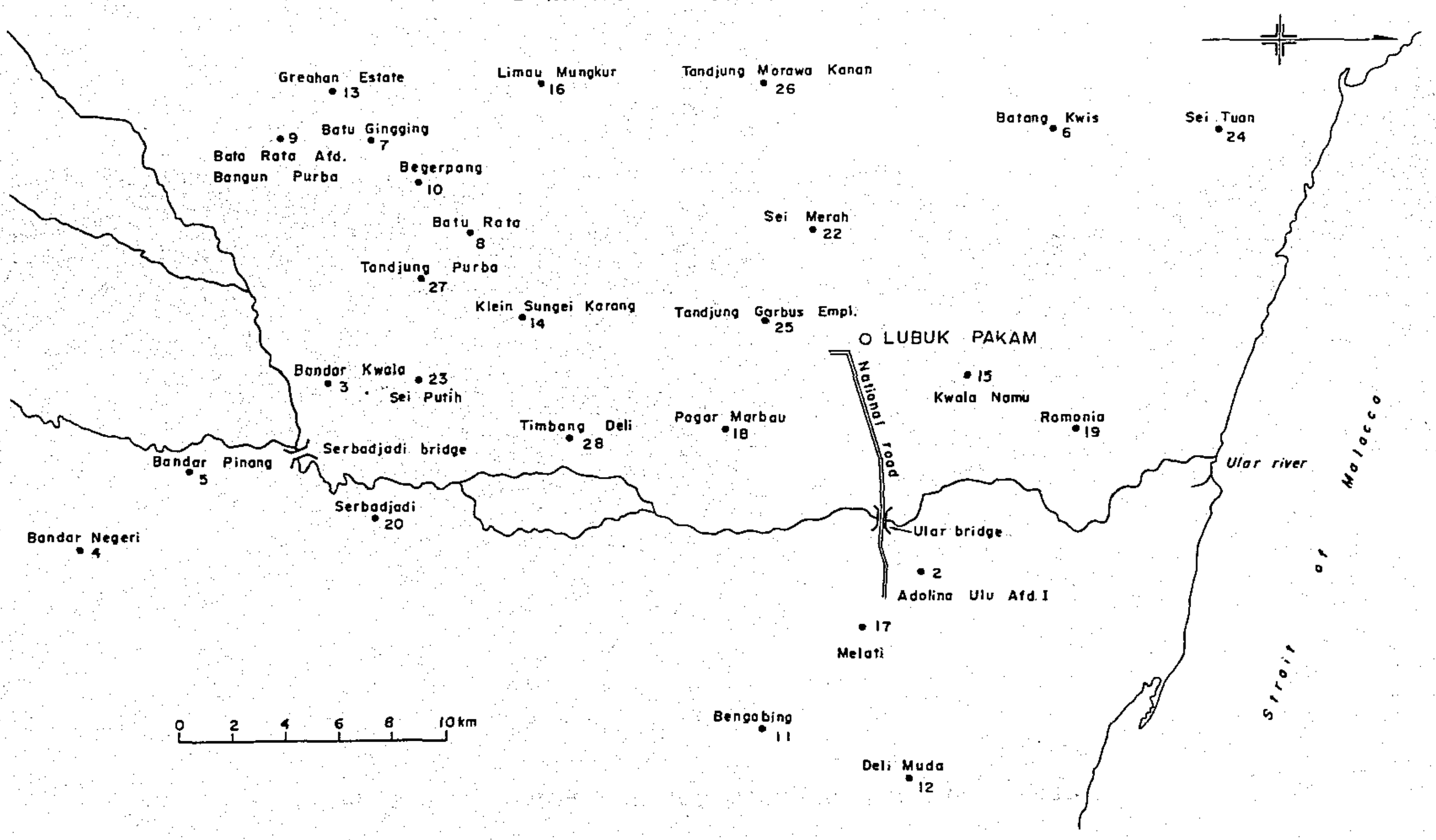
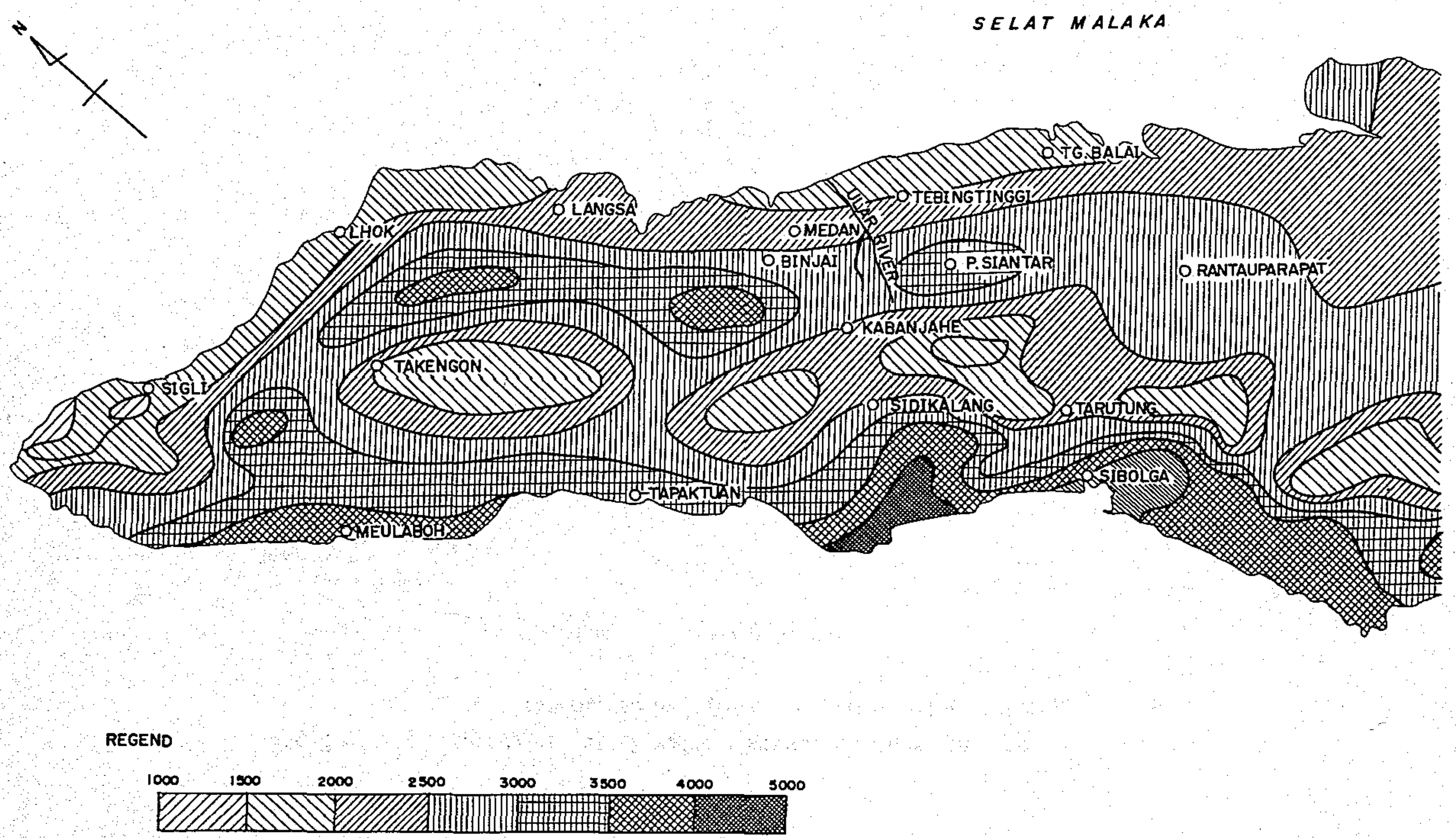


Fig. 3-4-2 Mean Annual Rainfall in the Northern Part of Sumatra



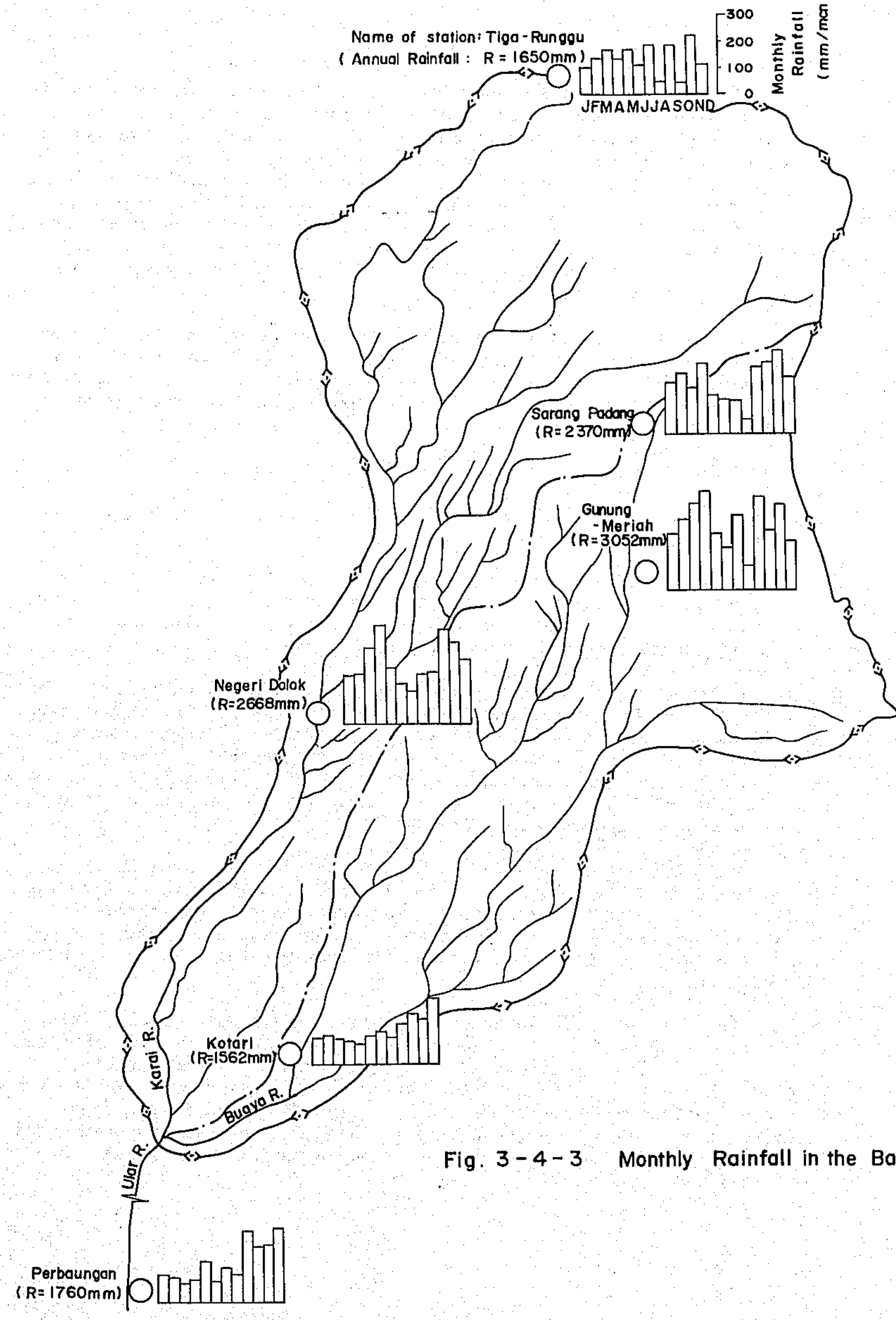


Fig. 3-4-3 Monthly Rainfall in the Basin

Meteorological and Geophysical Institute, Department of Communication prepared mean monthly and annual isohyetal maps of Sumatra Island based on the records from 1911 to 1940. The annual isohyetal map of northern part of the island is reproduced and shown in Fig.3-4-2. As is obvious from the figure, mean annual rainfall is 1,500 mm to 2,500 mm in the downstream area of the Ular River and increases toward upstream to reach the maximum 2,500 mm to 3,000 mm at the foot of hilly land. It decreases again toward further upstream to 2,000 mm to 2,500 mm in the uppermost plateau. This variation indicates a close relation between rainfall and topography.

Using the records of the recording raingage stations managed by the Ular River Project Office, mean monthly rainfall in the basin was studied. Although the periods of available data are only three or four years, the differences in rainfall features among the stations are clear as is seen in Fig.3-4-3.

From this figure, the following is disclosed.

a. The mean annual rainfall shows similar tendency as is shown in the isohyetal map (Fig.3-4-2).

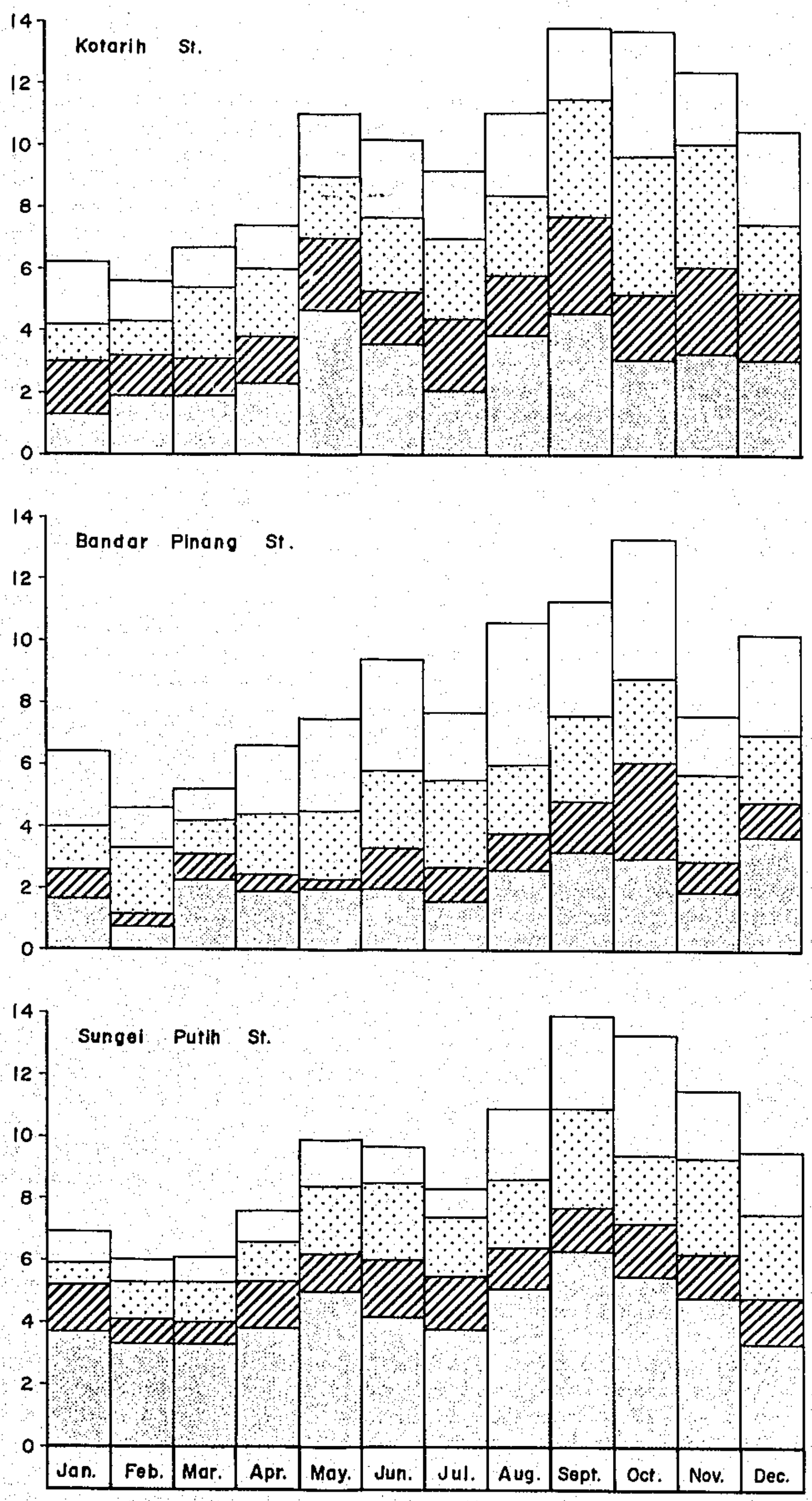
b. The rainy and dry seasons are not distinguished clearly in this region in North Sumatra. Two rainy seasons seem to exist in a year, the first rainy season which has the maximum rainfall usually in April and the second one usually in November.

c. In the lower basin of the Ular River, the first rainy season is not clear. In the middle part of the basin, the first and second rainy seasons become remarkably clear and the rainfall depth in both seasons are almost equal. In the upper basin, both the first and second rainy seasons are not distinguishable and rainfall is almost uniform through the year, but the first rainy season seems to prevail over the second one, if anything.

Correlations between two rain gage stations were studied in the Feasibility Study on the Ular River (by the OTCA in Mar., 1971) using data from the PNP. No correlation was found on daily and three-day rainfall even between stations 6 km apart in distance, while some correlation was seen on monthly rainfall. This was the same in the present study too.

For planning the construction works, studies were made of rainy days by using the data obtained by the PNP for ten years from 1966 to 1975. Rainy days were counted at three stations of Sungai Putih, Bandar Pinang and Kotarih by four kinds of rainfall depth. The Sungai Putih station was selected for the construction works in the downstream area of the river, the Bandar Pinang station for proposed Karai dam and the Kotarih station for proposed Buaya dam. The results are shown in Fig. 3-4-4.

Fig. 3-4-4 Number of Rainy Days



3.4.2. Discharge of River.

(1) Discharge Duration.

There are two gaging stations which provide discharge rating curves. One is located at Pulo-Tagor (Serbajadi Bridge) under the management of the DPMA and the other one is located at Ular Bridge under the management of the Ular River Project Office. The Pulo-Tagor station locates about 4 km downstream of the confluence of the Karai and the Buaya, and the Ular River station locates about 22.2 km downstream of the Pulo-Tagor station. The catchment area between the two stations is about 65 km^2.

Correlation of discharges between the two stations is shown in Fig.3-4-5 based on the data obtained in 1973 and 1974. Although the discharge at Pulo-Tagor may be affected by some inflow and channel storage before it reaches Ular Bridge, the increase rate of discharge at Ular Bridge seems to be too much. The greater part of this difference may be caused by observation time and the accuracy of the discharge rating curves of both stations. Anyway the discharge at the Pulo-Tagor station, which provides smaller value, is acceptable from the stand point of safety in the water utilization planning.

The discharge duration curves at the Pulo-Tagor station for the period of 1972 to 1974 were arranged based on the tables of daily discharge given in APPENDIX 3 and are shown in Fig.3-4-6. The tables show that the minimum discharges are 26.8 m^3/s on August 11, 1972, 35.0 m^3/s on February 24, 1973 and 38.6 m^3/s on July 6, 1974 and the maximum discharges are 123.0 m^3/s on November 21, 1972, 189.0 m^3/s on December 25, 1973 and 172.0 m^3/s on September 29, 1974, and annual run-off is respectively 1,600 x 10^6m^3 in 1972, 1,770 x 10^6m^3 in 1973 and 1,680 x 10^6m^3 in 1974. Monthly mean discharges at Pulo-Tagor were calculated using the data from 1972 to 1974. The result is shown in Fig.3-4-7. For the estimation of monthly discharge at candidate dam sites on the Karai and the Buaya, the discharge at Pulo-Tagor was divided proportionally to the ratio of catchment area of each dam site and that of Pulo-Tagor. The results are also shown in Fig.3-4-7.

(2) Flood Discharge.

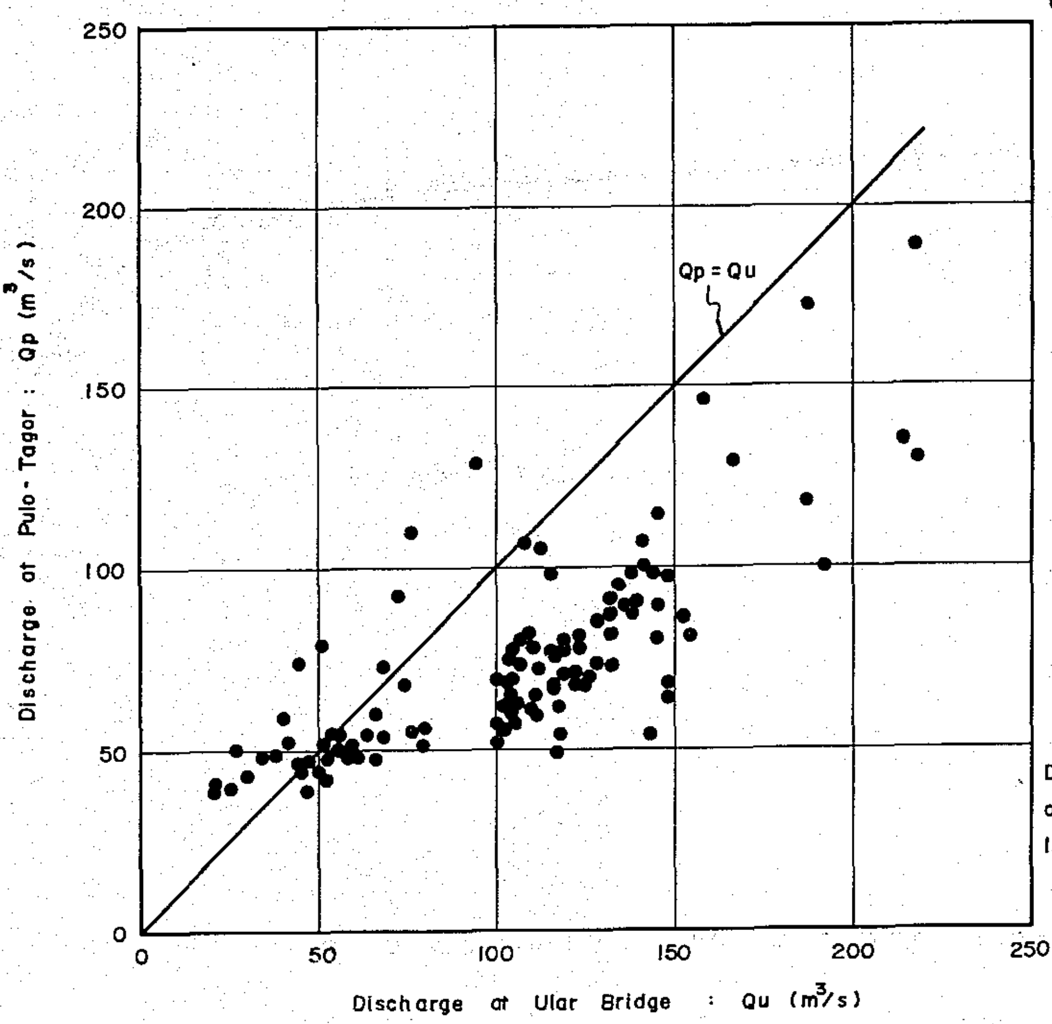
There are three recording water-level gage stations on the Ular River; Bandar-Tiga, Perbaungan and Denai-Lama. Among these, Bandar-Tiga station was selected for the study of flood discharge, for the location is suitable for runoff analysis and the datum of the gage is stable comparing with other two stations. The Bandar-Tiga station locates at 3.8 km upstream of Serbajadi Bridge and just downstream of the confluence of the Karai and the Buaya.

Discharge rating curve at the Bandar-Tiga station was prepared using the Manning formular, cross section, gradient and roughness obtained by measurements and is shown in Fig.3-4-8.

After examining and adjusting the datum of water-level gage, variation of mean water level for every 10 days as is shown in Fig. 3-4-9 was prepared. From this figure, it is also found that the flood season is not so distinguishable.

Fig. 3-4-5 Corretation of Discharge Between Serbajadi Br. and Ular Br.

(Data in 1973 & 1974)



Discharge records which are equal or more than 100m³/s and those on Ist. and 15th of each mouth are extracted

Fig. 3 - 4 - 6 Discharge Duration at Pulo - Tagor

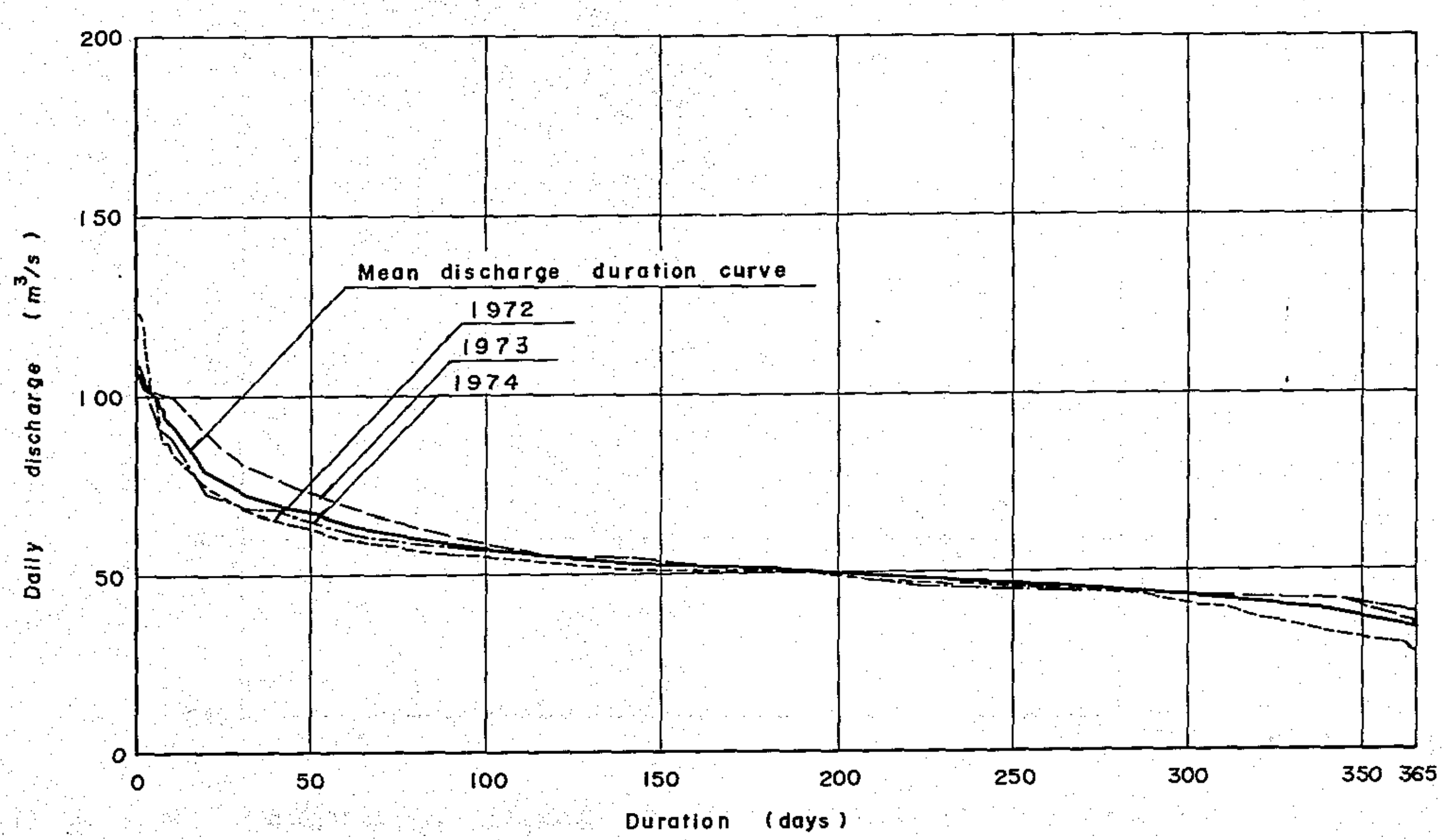
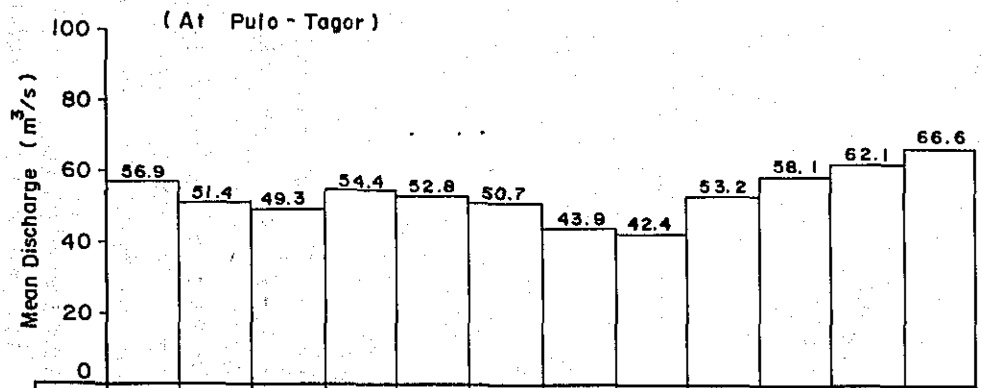
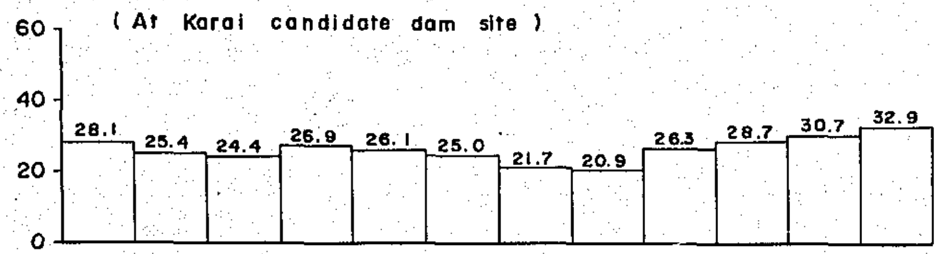


Fig. 3-4-7 Monthly Mean Discharge



Month		Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Mean Discharge (m^3/s)	1974	58.4	60.5	47.8	48.2	48.5	45.1	45.9	46.6	65.5	61.0	62.9	49.1
	1973	58.9	41.5	51.5	58.2	53.0	56.4	48.4	47.3	51.5	60.5	58.7	88.5
	1972	53.4	52.2	48.7	56.9	57.0	50.5	37.4	33.3	42.7	52.9	64.8	62.3



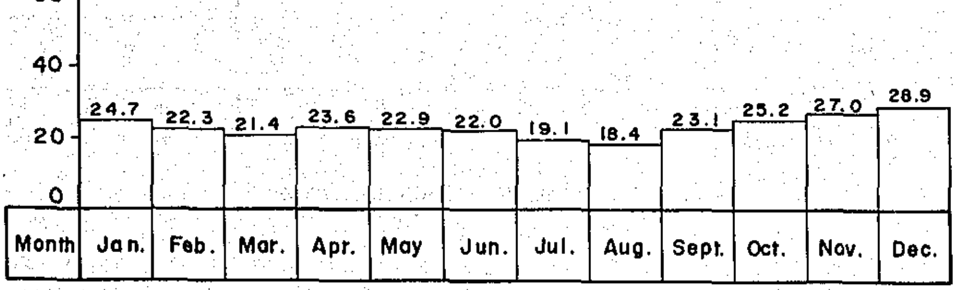


Fig. 3-4-8 Discharge Rating Curve at Bandar - Tiga

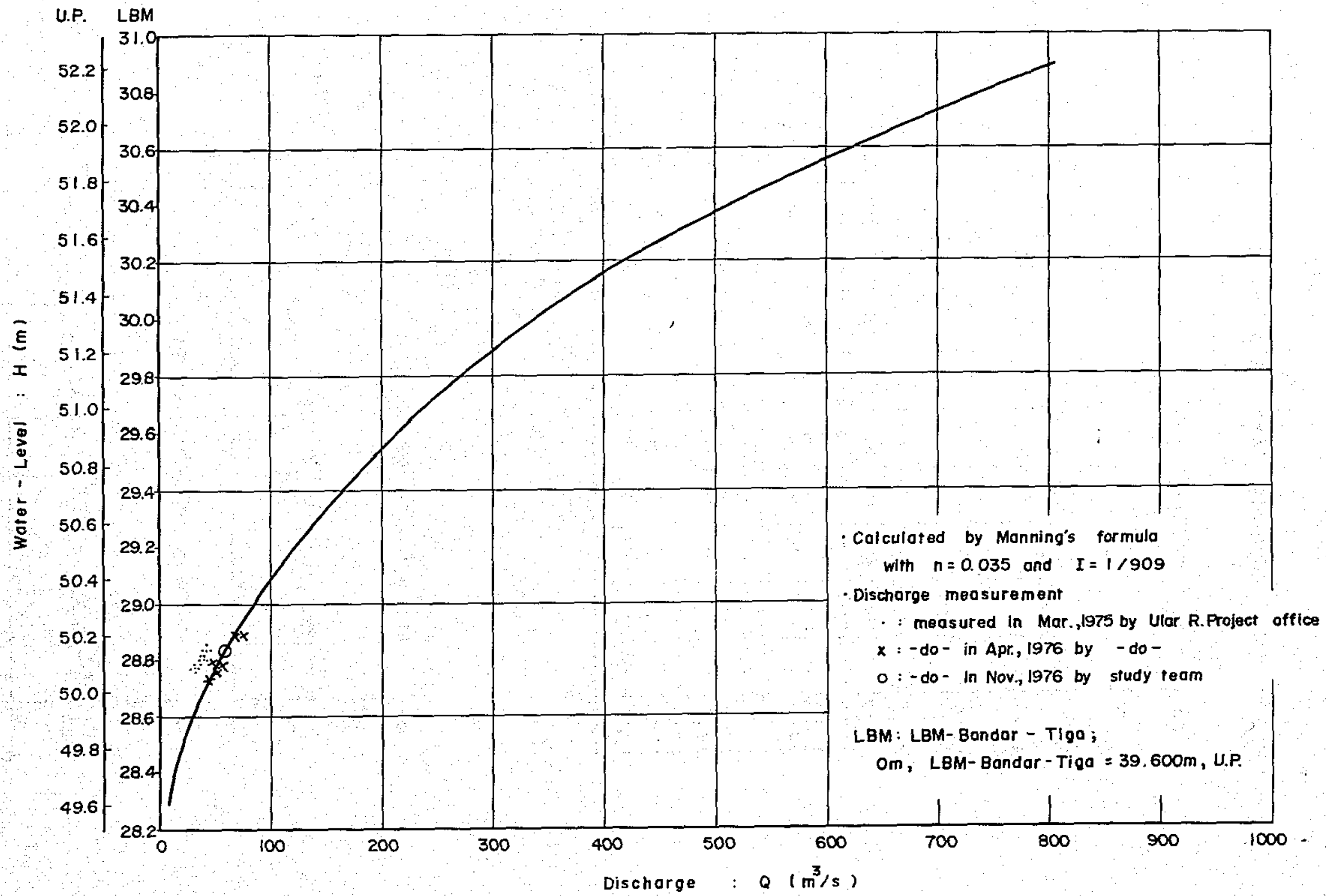
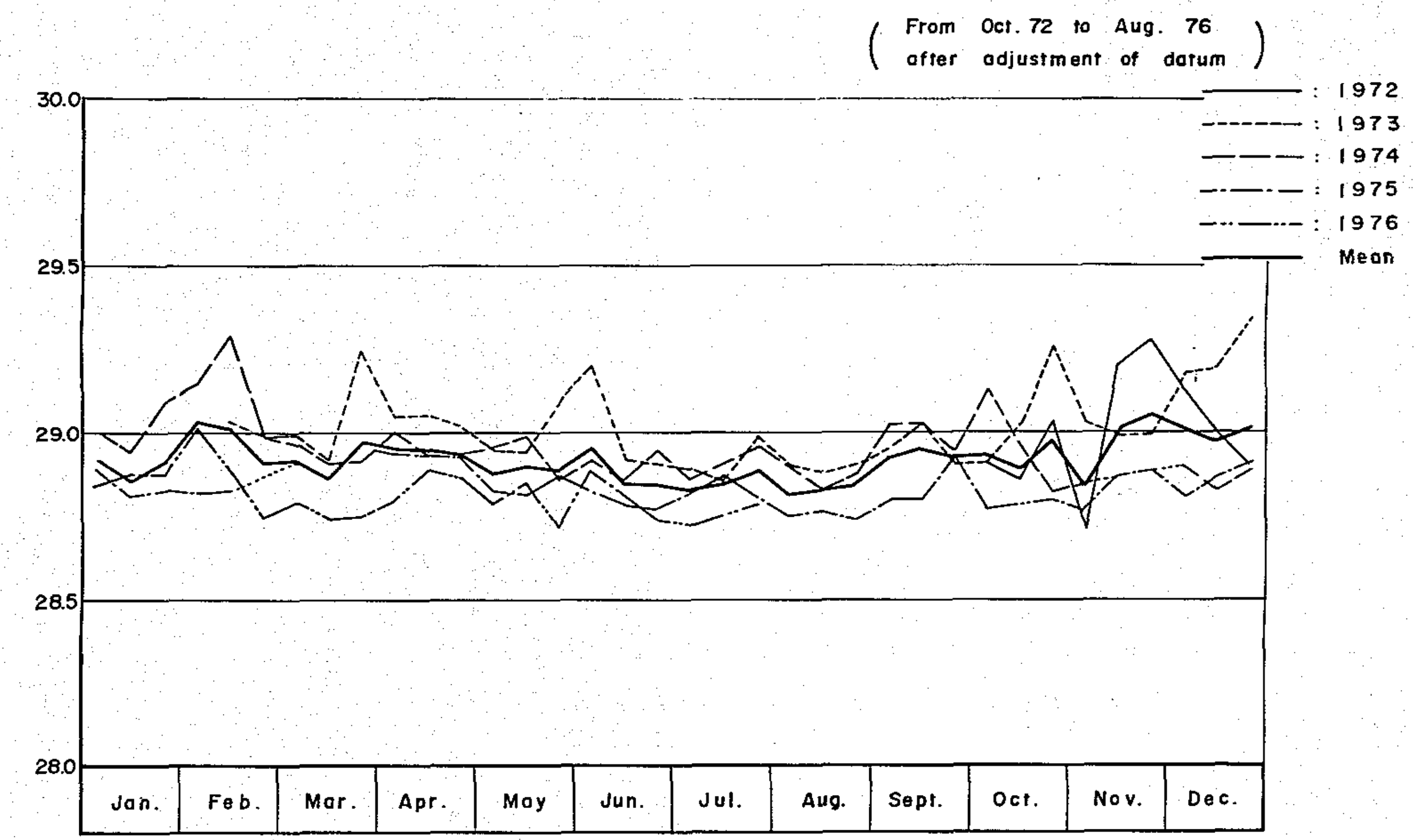


Fig. 3-4-9 Variation of Mean Water Level in a Year at Bandar-Tiga St.



Out of all the available data obtained in the period of October 1972 to August 1976, were extracted major floods of water level higher than 30.000 m, LBM-Bandar-Tiga (or 51.309 m, UP), where LBM-Bandar-Tiga is a local bench mark to be used for reading the staff-gage at Bandar Tiga. The dimensions of the major floods are shown in Table 3-4-1.

Further, study was made on the frequency of occurence of peak discharge during one day with regard to those floods whose peak water-levels are higher than 29.650 m LBM (or 50.959 m UP). The result is shown in Fig.3-4-10. As is seen in this figure, peaks of floods at Bandar-Tiga concentrate at midnight. This implies the difficulty of measurement of flood discharge.

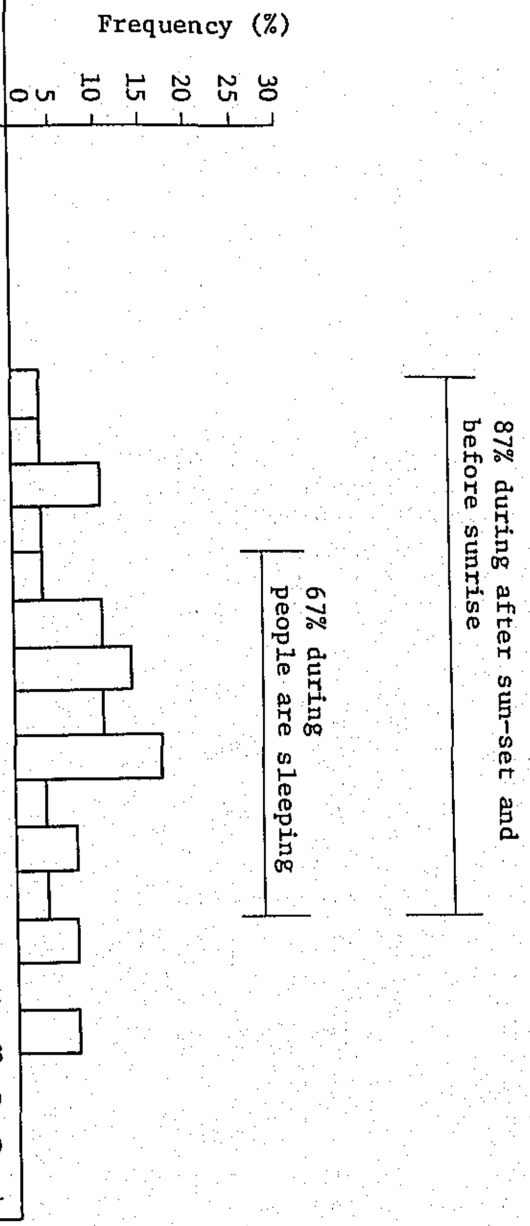
Table 3-4-1 Major Floods at Bandar-Tiga

Date	Hmax (m, LBM)*	Qpeak (m^3/s)	Rank	Remarks
Nov. 11,'72	30.075	364	7	annual max. in 1972
Jun. 5,'73	30.215	425	2	
Dec. 9,'73	30.015	344	9	
Dec. 25,'73	30.680	671	1	estimated annual max. in 1973
Dec. 26,'73	30.199	410	3	
Sept.29,'74	30.100	376	6	annual max. in 1974
Oct. 3,'74	30.070	365	8	
Apr. 15,'75	29.765	260	-	annual max. in 1975
Feb. 5,'76	30.140	393	5	
Nov. 21,'76	30.170	406	4	only the peak is known

* LBM: LBM-Bandar-Tiga.

Fig.3-4-10 Frequency of Occurence of Peak Discharge during One day

Frequency		
Times	Percent (%)	Time
0	0	12
0	0	13
0	0	14
0	0	15
0	0	16
0	0	17
1	3.3	18
1	3.3	19
3	10.0	20
1	3.3	21
1	3.3	22
3	10.0	23
4	13.3	24
3	10.0	1
5	16.7	2
1	3.3	3
2	6.7	4
1	3.3	5
2	6.7	6
0	0	7
2	6.7	8
0	0	9
0	0	10
0	0	11



3.4.3. Sediment Transportation.

Sediment discharges at Ular Bridge (a site about 350 m upstream of Ular Bridge), Bandar Tiga (water-gage station), Buaya River (a site about 2,900 m upstream of the confluence) and Karai River (a site upstream of the suspension bridge) were calculated by use of the Sato-Kikkawa-Ashida formula, the Brown formula and the Engelund-Hansen formula based on the measured properties of bed materials, and cross sections at the said sites and the monthly discharges estimated from the daily discharges obtained by the DPMA during the period from January 1972 to December 1974.

The grain size of bed materials measured by the Study Team are shown below.

Site		Ular Br.		Serbajadi Br.		Buaya R.		Karai R.	
		d_{65}	(d_{50})	d_{65}	(d_{50})	d_{65}	(d_{50})	d_{65}	(d_{50})
Right	(mm)	1.0	(0.7)	1.0	(0.8)	1.0	(0.8)	1.4	(1.0)
Center	(mm)	1.4	(1.1)	0.9	(0.7)	1.1	(0.8)	1.4	(1.0)
Left	(mm)	1.0	(0.7)	1.1	(0.9)	1.7	(1.2)	1.4	(1.0)
Mean	(mm)	1.13	(0.83)	1.00	(0.80)	1.27	(0.93)	1.40	(1.00)

On the other hand, according to the Ular River Flood Control Project Report (p. 205), the mean diameter d_m is 1.15 mm on the average on the reaches from - 13 km to + 10 km without any remarkable variation.

Based on these data, grain size to be used in the sediment discharge calculation was determined as follows.

Site	Ular Br.	Bandar-Tiga	Buaya R.	Karai R.
d_m(= d_{65}) (mm)	1.15	1.15	1.27	1.40
d_{50} (mm)	0.85	0.85	0.93	1.00

If we use the following constants,

σ = density of sediment particle = 2.65/9.8 = 0.270

ρ = density of water = 1.00/9.8

n = Manning's roughness = 0.035

g = acceleration of gravity = 9.8 m/sec^2

ψ = coefficient of the Sato-Kikkawa-Ashida formula = 0.623

the values of the following quantities are obtained for the said four sites; Ular Bridge, Bandar Tiga, Buaya River and Karai River.

Site	Ular Br.	Bandar-Tiga	Buaya R.	Karai R.
d_m	1.15×10^{-3}	1.15×10^{-3}	1.27×10^{-3}	1.40×10^{-3}
U_{*c}^2 (m^2/sec^2)	0.633×10^{-3}	0.633×10^{-3}	0.699×10^{-3}	0.770×10^{-3}
d_{50} (m)	0.85×10^{-3}	0.85×10^{-3}	0.93×10^{-3}	1.00×10^{-3}
d_m/d_{50}	1.353	1.353	1.366	1.400
I	1.525×10^{-3} (1/656)	1.100×10^{-3} (1/909)	2.065×10^{-3} (1/484)	1.770×10^{-3} (1/565)
$I^{1/2}/n$	1.116	0.948	1.298	1.202

The Sato-Kikkawa-Ashida formula is

$$\frac{q_B}{u_* d} = \psi \cdot F(\tau/\tau_c) \cdot \frac{u_*^2}{(\sigma/\rho - 1)\, gd}$$

where q_B is bed load per unit river width per unit time (m^3/s/m), u_* is friction velocity, u_{*c} is critical friction velocity, τ is tractive force of flow, τ_c is critical tractive force and $F(\tau/\tau_c)$ is a function of τ/τ_c or u_*^2/u_{*c}^2 and equal to 1.0 when $u_*^2/u_{*c}^2 > 0.80$; the Brown formula is

$$\frac{q_s}{u_* d} = 10 \left\{ \frac{u_*^2}{(\sigma/\rho - 1)\, gd} \right\}^2$$

where q_s is sediment discharge including bed load and suspended load per unit river width and per unit time (m^3/s/m) and d is mean diameter of sediment particle (m); and the Engelund-Hansen formula is

$$q_s = 0.05 \cdot \gamma s \cdot v^2 \sqrt{\frac{d_{50}}{g(\gamma s/\gamma - 1)}} \left\{ \frac{\tau}{(\gamma s - \gamma) d_{50}} \right\}^{\frac{3}{2}}$$

where q_s is sediment discharge including both bed load and suspended load per unit river width per unit time (t/s/m), v is mean velocity (m/s), d_{50} is grain size at 50% of bed material, γ_s is unit weight of bed material and γ is unit weight of water (t/m^3).

Using the values of the above-mentioned quantities, those formulas can be transformed as follows.

Sato-Kikkawa-Ashida formula:

$$Q_B = 0.03853 \cdot B \cdot F\left(\frac{u_*^2}{u_{*c}^2}\right) \cdot u_*^3$$

Brown formula:

$$Q_s = 0.03825 \cdot B \cdot \frac{u_*^5}{d}$$

Engelund-Hansen formula:

$$Q_s = 0.4165 \cdot \frac{d}{d_{50}} \cdot R^{\frac{1}{3}} \cdot Q_{s(Brown)}$$

where Q_B is bed load through the whole river width (m^3/s), Q_s is sediment discharge including both bed load and suspended load (m^3/s) through the whole river width, B is the whole river width (m) and R is hydraulic mean depth (m) in the Manning formula

$$Q = A \cdot \frac{1}{n} R^{\frac{2}{3}} \quad I^{\frac{1}{2}}$$

where A is water area (m^2), I is water surface slope or energy gradient and n is roughness.

The relationships between sediment discharge and water discharge calculated by the above-mentioned three formulas with regard to the four sites are shown in Fig.3-4-11, which indicates that the three formulas can be expressed simply as follows.

Sato-Kikkawa-Ashida formula:

$$Q_B = K_1 Q^{0.9}$$

Brown formula:

$$Q_{s(Brown)} = K_2Q^{1.4}$$

Engelund-Hansen formula:

$$Q_{s(Engelund\text{-}Hansen)} = K_3Q^{1.6}$$

We assumed that monthly mean discharge obtained from daily discharges measured at the Pulo-Tagor station during the period from 1972 to 1974 are applicable to the sites of Ular Bridge and Bandar-Tiga, and that the monthly mean discharges at the sites of Buaya River and Karai River can be obtained by dividing the discharge at Pulo-Tagor at the ratio of the two catchment areas at the sites of Buaya River and Karai River.

Based on the above monthly mean discharges and $Q - Q_B$ or $Q - Q_s$ curves given in Fig.3-4-11 were calculated monthly sediment discharges and annual total sediment discharges at the said four sites. The results are shown in Table 3-4-2. In this table are also shown the annual sediment discharges expressed by volume including void assuming that the void ratio λ is 0.3.

As the above calculations were made based on the monthly mean discharges, error was examined against the calculation based on the daily discharges. For this purpose were used the data on daily discharges obtained at Bandar-Tiga in December 1973 when a big flood occured. The study showed that the sediment discharges calculated by the Brown formula based on the daily discharges were larger than those from the monthly discharges only by 3%. It can easily be seen that the error of the bed load will become far less.

3.4.4. Tide Level.

Observation was made on tide level of the Ular River mouth by the Aerial Photographic Surveying Team of the JICA at Pantai Cermin CBM-1 for three days of September 6, 7 and 8 of 1976. CBM-1 is a provisional bench mark installed for observing tide at a point on the seacoast about 5 km east of the river mouth. 0 m CBM-1 is 1.57 m, UP.

The observed tide curve is shown in Fig.3-4-12. On the other hand, the record of tide level at Belawan Harbor for the same three days was collected by the Study Team in cooperation with the authorities concerned. This tide level is also given in the same figure.

Fig. 3-4-11 Relationship Between Sediment Discharge and Water Discharge

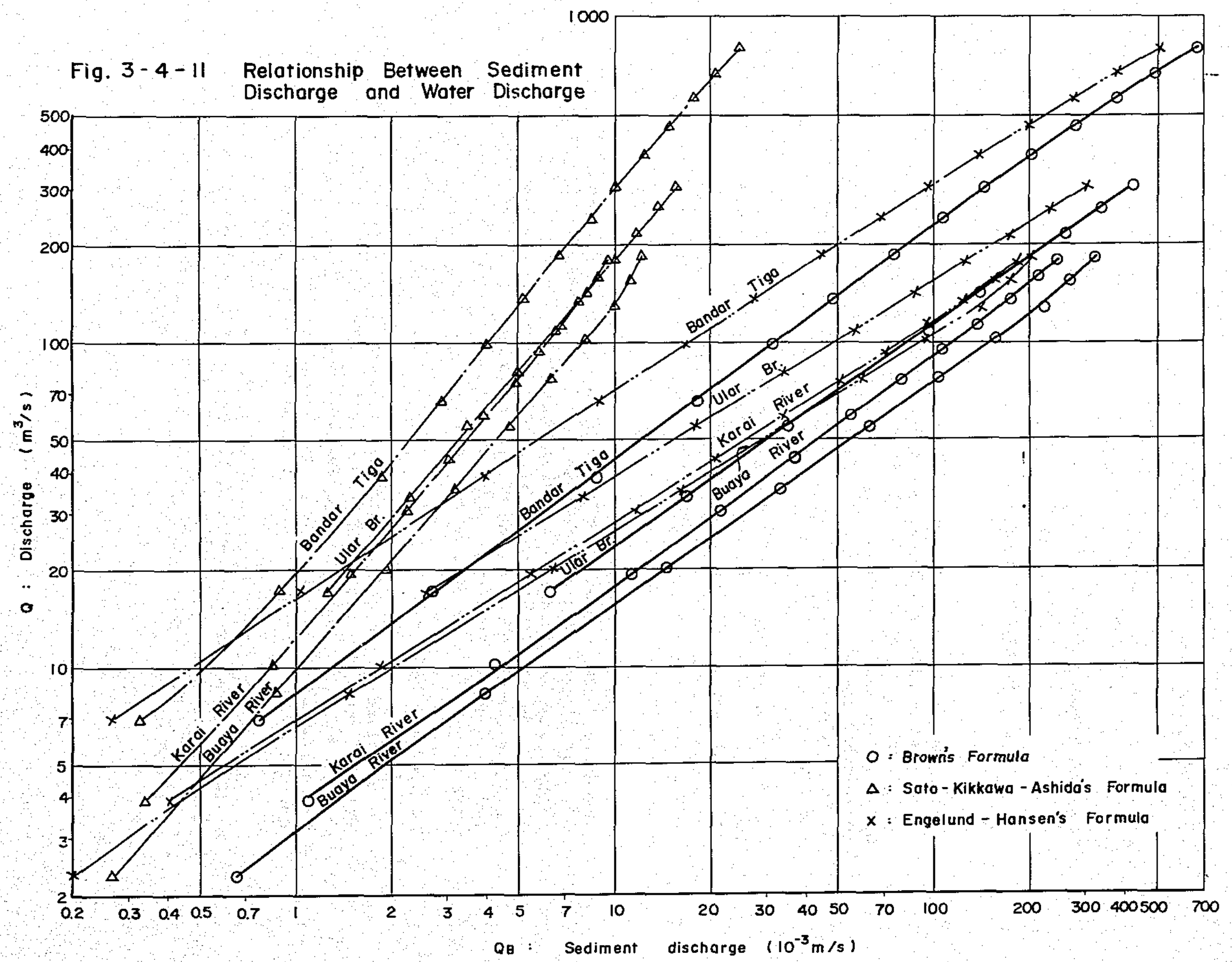


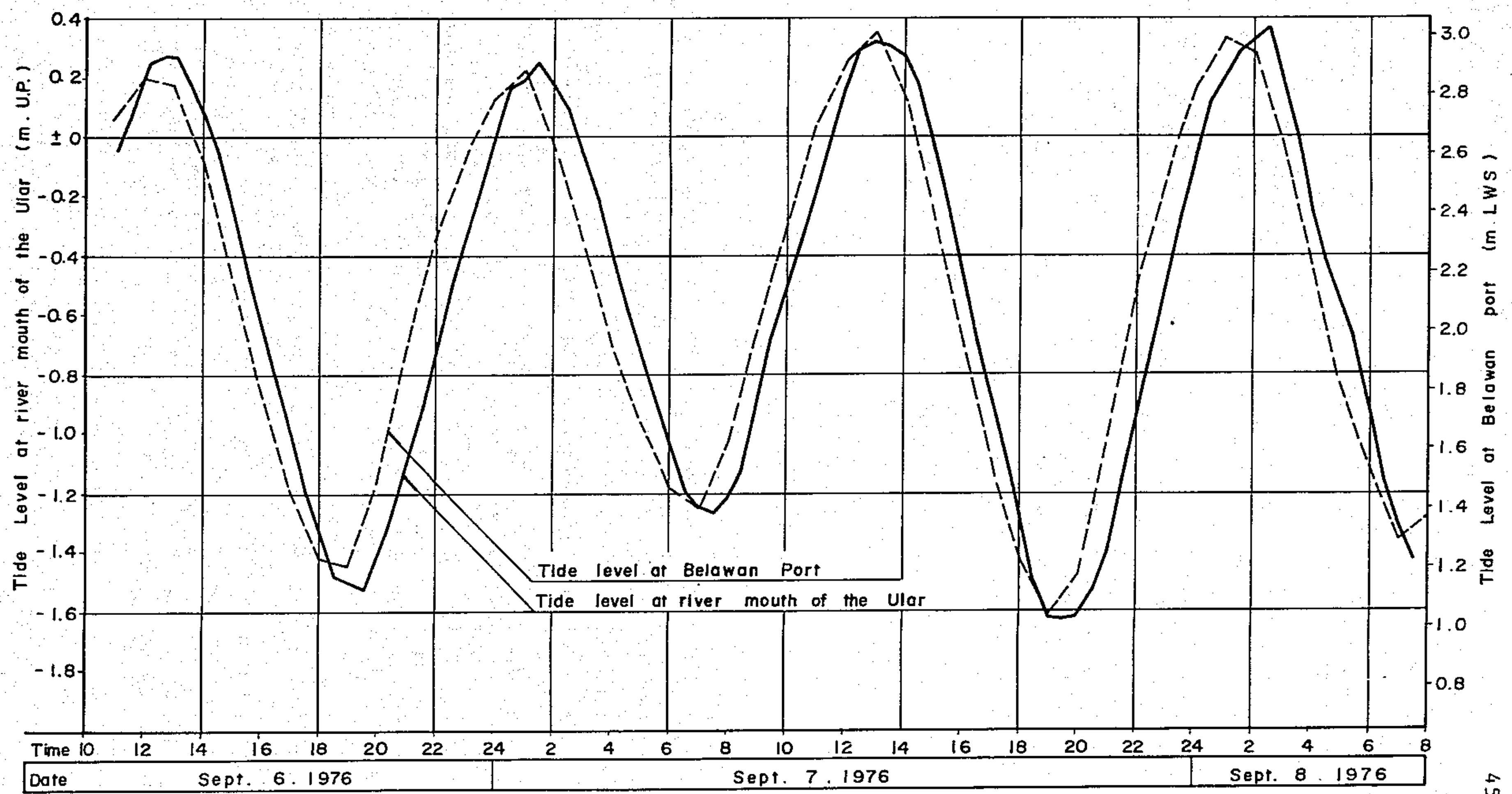
Table 3-4-2(1) Sediment Discharge

Month	Ular Bridge				Bandar-Tiga			
	Q (m^3/s)	$Q_{B(SKA)}$ ($10^{-3}m^3/s$)	$Q_{s(Br)}$ ($10^{-3}m^3/s$)	$Q_{s(EH)}$ ($10^{-3}m^3/s$)	Q (m^3/s)	$Q_{B(SKA)}$ ($10^{-3}m^3/s$)	$Q_{s(Br)}$ ($10^{-3}m^3/s$)	$Q_{s(EH)}$ ($10^{-3}m^3/s$)
Jan.	56.9	3.63	36.8	19.3	56.9	2.54	14.5	7.1
Feb.	51.4	3.32	31.4	16.2	51.4	2.34	12.6	6.0
Mar.	49.3	3.20	29.9	15.1	49.3	2.27	12.0	5.6
Apr.	54.4	3.50	34.2	18.0	54.4	2.46	13.8	6.7
May	52.8	3.40	33.0	17.0	52.8	2.40	13.1	6.4
Jun.	50.7	3.29	31.0	16.0	50.7	2.32	12.4	7.1
Jul.	43.9	2.87	25.0	12.4	43.9	2.04	10.0	5.7
Aug.	42.4	2.80	24.0	11.7	42.4	2.00	9.7	5.5
Sep.	52.2	3.53	35.1	18.1	55.2	2.47	14.0	6.8
Oct.	58.5	3.74	38.0	20.2	58.5	2.62	15.2	7.5
Nov.	62.1	3.92	41.5	22.1	62.1	2.75	16.6	8.2
Dec.	66.6	4.20	46.6	25.0	66.6	2.90	18.2	9.2
(Mean)	(53.7)	(3.45)	(33.9)	(17.6)	(53.7)	(2.43)	(13.5)	(6.82)
Annual total Q_s (10^3m^3)	-	108.8	1,069	555	-	76.6	426	215
Q_s at $\lambda = 0.3$ (10^3m^3)	-	155.4	1,527	792	-	109.4	609	307
Catchment area: A(km^2)	-	1,081	1,081	1,081	-	1,013	1,013	1,013
Q_s/A: ($m^3/km^2/yr$)	-	144	1,410	733	-	108	600	303
(mm/yr.)	-	0.144	1,410	0.733	-	0.108	0.600	0.303

Table 3-4-2(2) Sediment Discharges

Month	Buaya River				Karai River			
	Q (m^3/s)	Q_s(SKA) ($10^{-3}m^3/s$)	Q_s(Br) ($10^{-3}m^3/s$)	Q_B(EH) ($10^{-3}m^3/s$)	Q (m^3/s)	Q_s(SKA) ($10^{-3}m^3/s$)	Q_s(Br) ($10^{-3}m^3/s$)	Q_B(EH) ($10^{-3}m^3/s$)
Jan.	24.7	2.27	19.5	9.0	28.1	2.09	19.6	10.1
Feb.	22.3	2.08	17.0	7.6	25.4	1.90	17.0	8.6
Mar.	21.4	1.99	16.1	7.2	24.4	1.83	16.0	8.0
Apr.	23.6	2.18	18.6	8.3	26.9	2.00	18.1	9.3
May	22.9	2.10	17.5	8.0	26.1	1.95	17.6	9.0
Jun.	22.0	2.05	16.5	7.4	25.0	1.86	16.5	8.3
Jul.	19.1	1.80	13.6	6.0	21.7	1.66	13.5	6.6
Aug.	18.4	1.73	12.9	5.6	20.9	1.94	12.7	6.2
Sep.	24.0	2.21	19.0	8.6	27.3	2.02	18.9	9.6
Oct.	25.4	2.33	20.5	9.5	28.9	2.11	20.0	10.3
Nov.	27.0	2.45	22.3	10.5	30.7	2.25	22.0	11.6
Dec.	28.9	2.60	24.6	11.7	32.9	2.37	25.0	13.0
(Mean)	(23.3)	(2.15)	(18.2)	(8.28)	(26.5)	(2.00)	(18.1)	(9.22)
Annual total Q_s (10^3m^3)	-	67.8	574	261	-	63.1	571	291
Q_s at λ = 0.3(10^3m^3)	-	96.9	820	373	-	90.1	816	416
Catchment area: A(km^2)	-	440	440	440	-	500	500	500
Q_s/A: ($m^3/km^2/yr.$)	-	220	1,860	933	-	180	1,630	832
Q_s/A: (mm/yr.)	-	0.220	1.860	0.933	-	0.180	1.630	0.832

Fig. 3-4-12 Comporison of Tide Levels at Belawan Harbor and River Mouth of Ular River



Comparing the two tide curves, we will find the following relation.

2.111 meters, LWS = - 0.545 meter, UP

Time lag between the two = 43 minutes.

In the above relation, LWS means the low water springs at Belawan Harbor and is the datum level of tide at the harbor, UP means the reference datum of leveling for the Ular River project, - 0.545 m is the mean water level of the tide observed at Pantai Cermin for the said 3 days and 2.111 m is the mean water level of the tide observed at Belawan Harbor for the same days. For reference, the significant tide levels at Belawan Harbor are as follows.

HHWS = + 3.40 m

HWS = + 3.00 m

MLS = + 1.50 m

LWS = + 0 m

LLWS = - 0.20 m

3.4.5. Return Period of Peak Discharge.

To estimate the return period of peak discharge, there are two approaches; estimation by discharge records in the past and that by rainfall records through runoff analysis. In the case of the Ular River, the latter approach is almost impossible at present by the following reasons.

a. Rainfall records for a period long enough for the analysis are not available in the upper and middle regions of the basin.

b. As the rainfall occurs in spots, the correlation of daily rainfall depth does not exist between the existing stations.

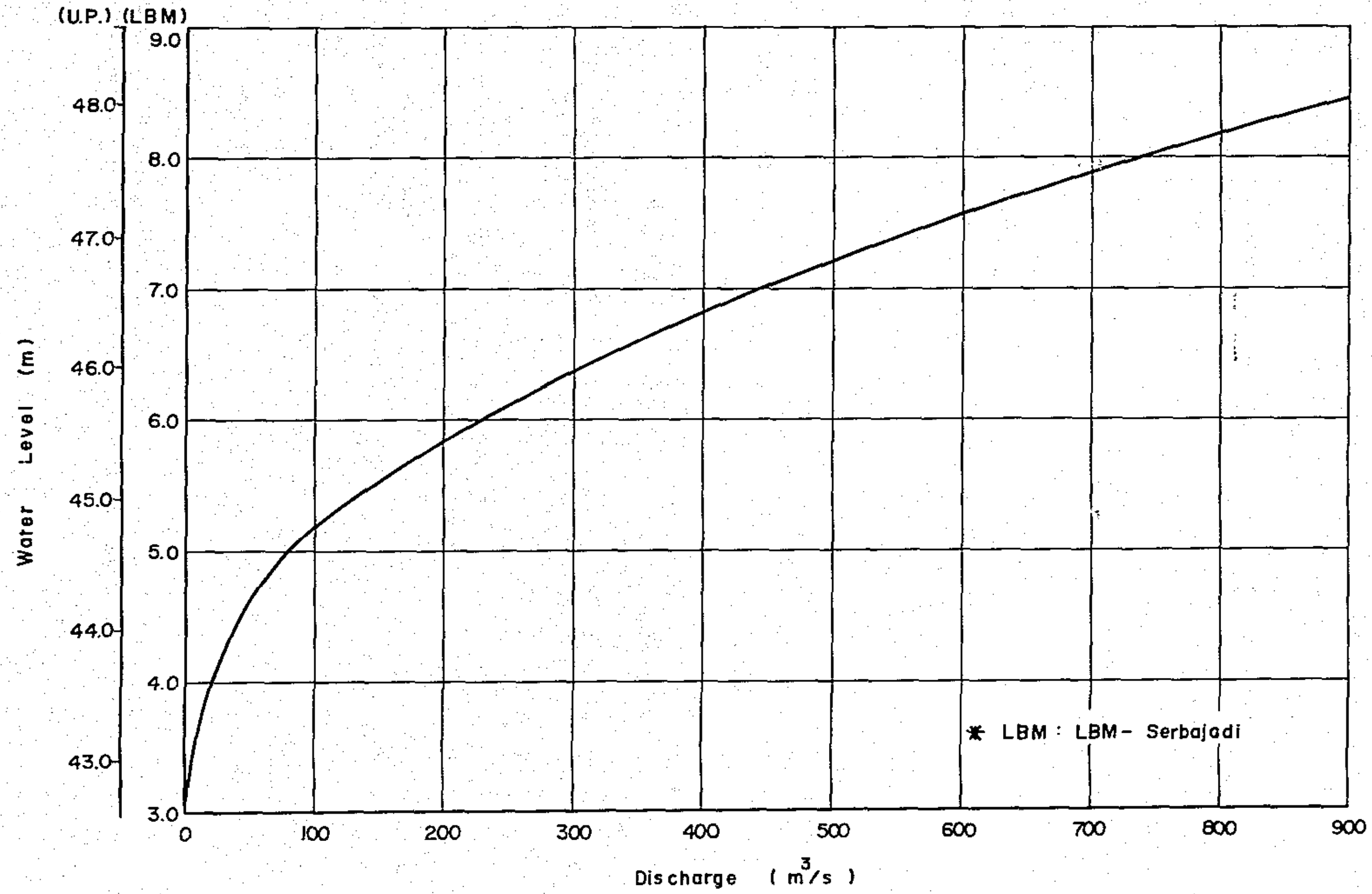
c. Most of the characteristics of rainfall and runoff mechanism necessary for the runoff analysis are not known yet. Some runoff analyses by the rational formula and the storage function method were tried provisionally. But the results were not successful.

Therefore, the estimation of return period by discharge records in the past was adopted in the present study. The base point for design discharge was taken at Serbajadi Bridge where scarce influence of flooding and irrigation are found.

The discharge rating curve at Serbajadi Bridge is shown in Fig.3-4-13 after the Final Report on the Ular River Urgent Flood Control Project (Aug., 1973; DPUTL).

(1) Record of peak discharges in the past.

Fig. 3 - 4 - 13 Discharge Rating Curve at Serbajadi Bridge



Intervaiews and surveys on flood marks around Serbajadi and examination of old drawings disclosed the followings.

a. The biggest flood as far as in memory occured on Dec. 10, 1954.

b. The second biggest flood since the 1954-flood occured on Dec. 25, 1973 and the third one in Oct. 1969.

c. The dimensions of these floods are as follows.

Year	Max. water level			Discharge	Remarks
	(m, LBM)	(m, SG)	(m, UP)	(m^3/s)	
1954	8.36	3.52	47.96	865	by drawings 47.97 m UP by interview
1969	7.36	2.52	46.96	540	by interview
1973	7.60	2.76	47.20	610	by interview

In this table, LBM means LBM-Serbajadi that is a local bench mark to be used for reading the staff-gage at Serbajadi Bridge, SG means SG-Serbajadi that is a staff-gage installed at Serbajadi Bridge, and UP means Ular peil which is the reference datum of leveling for the Ular River project. The relation among them at Serbajadi Bridge is as follows.

0 m, SG = 4.843 m, LBM = 44.443 m, UP

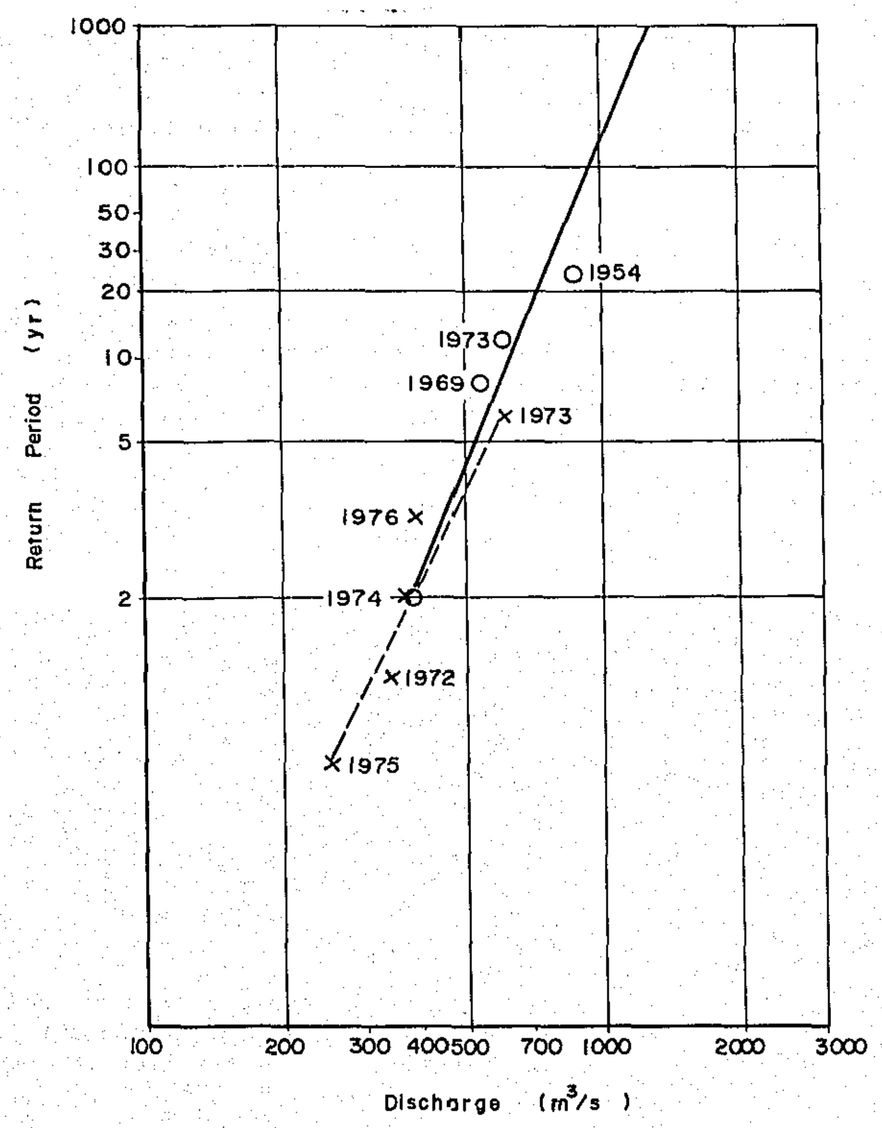
The above data indicate that the 1954-flood is of the first rank during 23 years from 1954 to 1976, the 1973-flood is of the second rank and the 1969-flood is of the third rank.

Applying the Thomas method, their return periods were obtained as below. These are plotted in Fig.3-4-14.

Flood	Peak discharge	Rank	Return period
1954-flood	865 m^3/s	1	24 yr.
1973-flood	610 "	2	12 yr.
1969-flood	540 "	3	8 yr.

On the other hand, the annual maximum discharges at Bandar Tiga during these five years from 1972 to 1976 are as follows (refer to Table 3-4-1).

Fig. 3-4-14 Return Period of Discharge at Serbajadi Bridge



Year	1972	1973	1974	1975	1976
Peak discharge (m^3/s)	364	671	376	260	406

Among these, the peak discharges in 1972 and 1976 are not confirmed exactly to be the annual maximum, but are probably maximum or close to it.

The peak discharges at Serbajadi Bridge can be estimated with regard to the floods mentioned above except the 1973-flood by means of flood routing considering discharge hydrograph and channel storage. As a result, the annual maximum discharges at Serbajadi Bridge are

Year	1972	1973	1974	1975	1976
Peak discharge (m^3/s)	340	610	372	255	392

Sample size n = 5 is too small to extrapolate such return period as 20-year, 50-year and 100-year, but it may be possible to interpolate return period of 2-year. Return periods of these discharges were estimated by the Thomas method and are plotted in Fig.3-4-14.

Making use of 1st, 2nd and 3rd biggest discharges during 23 years and 2-year discharge obtained from annual maximum discharges in these five years, the return period of discharge at Serbajadi Bridge was estimated as follows.

Return period (yr.)	10	20	50	100
Discharge (m^3/s)	630	730	860	960

or

Discharge (m^3/s)	600	800	1,000	1,200
Return period (yr.)	8	33	133	500

3.4.6. Hydrographs for Dam Planning.

Two dams were proposed; one on the Karai River and the other on the Buaya River. Karai dam site and Buaya dam site locate at about 5.0 km upstream and 5.6 km upstream respectively from the confluence of the Karai and the Buaya.

As the discharge estimation from rainfall is not applicable as was mentioned previously, an expediential means was introduced for the estimation of discharge hydrographs for dam planning based on the records at the Bandar-Tiga station.

The discharge hydrographs for studying the storage capacity of the dams were assumed according to the following process.

(1) Peak Discharge at Bandar-Tiga.

Four kinds of discharges, 600 m^3/s, 800 m^3/s, 1,000 m^3/s and 1,200 m^3/s, were taken as the peak discharges at Bandar-Tiga.

(2) Discharge Hydrographs at Bandar-Tiga.

Actual record of discharge hydrograph at Bandar-Tiga was divided into two parts, base flow and storm runoff. Then storm runoff was enlarged proportionally until the total of storm runoff and base flow at peak reaches respective peak discharge of 600 m^3/s, 800 m^3/s, 1,000 m^3/s and 1,200 m^3/s. From among the major flood records mentioned in Table 3-4-1, the discharge hydrograph of Dec. 25, 1973 was selected and applied to the study considering the following reasons.

a. The rate of proportional enlargement should be as small as possible. If the enlargement rate get larger, the reliability of occurence of those enlarged hydrographs will get more doubtful. From this view-point, the 1973-flood is preferable by far.

b. The shape of the 1973-flood hydrograph is not sharp compared with others, which means that the 1973-flood has large volume of water than the others at the same peak discharge. In addition, the 1973-flood happened to be a double-peaked hydrograph.

(3) Base Flow Discharge at Flood Time.

The discharge at the beginning point of rising curve of the major flood-discharge hydrographs are as follows.

Date and time	Discharge (m^3/s)
Nov. 10, '72 at 21:00	71
Jun. 15, '73 at 20:00	95
Dec. 9, '73 at 17:00	90
Dec. 24, '73 at 17:00	106
Sep. 28, '74 at 24:00	60
Oct. 2, '74 at 18:00	87
Feb. 5, '76 at 19:00	79
Mean	84

Considering the above data, the base flow discharge (Q_0) was assumed at $Q_0 = 85\ m^3/s$.

(4) Discharge at Dam Site.

The catchment areas at the dam sites are as follows.

Site	Catchment area (km^2)	Ratio of area
Bandar-Tiga	1,013	1.000
Lower end of Karai R.	573	0.566
Karai dam site	500	0.494
Lower end of Buaya R.	440	0.434
Buaya dam site	424	0.419

The Thissen ratios of the recording rain gage stations under the management of the Ular River Project Office are as follows.

Station	with G. Meriah st.		without G. Meriah st.	
	Karai R.	Buaya R.	Karai R.	Buaya R.
Kotarih	0.138	0.232	0.138	0.232
Gunung Meriah	0.063	0.484	-	-
Sarang Padang	0.341	0.113	0.380	0.468
Tiga Runggu	0.283	0	0.283	0
Negeri Dolok	0.175	0.171	0.199	0.300

Average rainfalls which caused the major floods over the Karai River basin and the Buaya River basin were calculated using the Thiessen ratios mentioned above. These are shown in Fig.3-4-15. From this figure, the following facts are found.

a. The big floods at Bandar-Tiga were caused by the rainfalls that fell more in the Buaya River basin than in the Karai River basin.

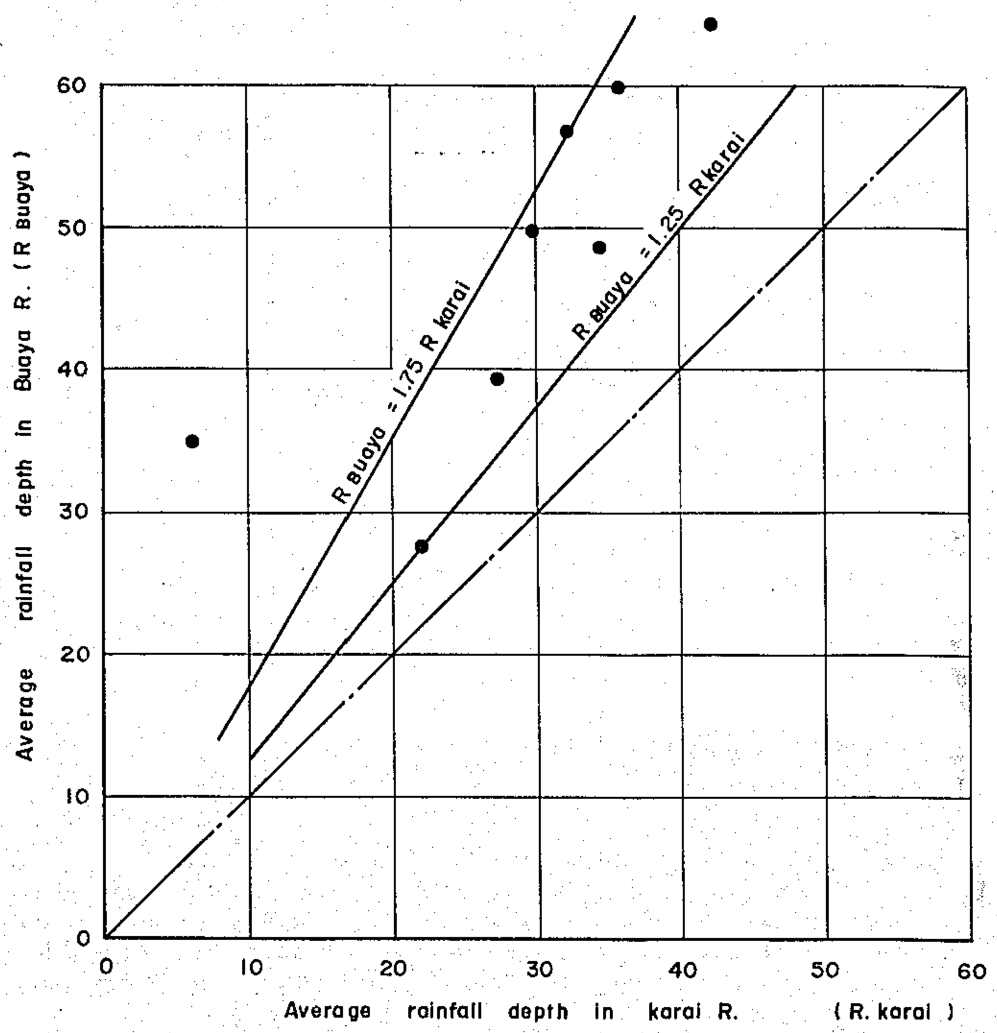
b. The plotted points other than the flood of Feb. 5, 1976 are distributed between the two lines.

$$R_{Buaya} = 1.25\ R_{Karai} \text{ and } R_{Buaya} = 1.75\ R_{Karai}$$

The former line can be interpreted to indicate the upper limit of eccentricity of rainfall distribution and the latter one the lower limit. From the viewpoint of safety of planning, the former line should be taken for assuming the design hydrograph for the Karai dam and the latter line should be taken for the Buaya dam.

To estimate the discharge hydrograph at dam site, the base flow discharge at Bandar-Tiga was divided proportionally to the rate of catchment areas and the storm runoff at Bandar-Tiga was divided proportionally to the ratio of catchment areas and the ratio of average

Fig. 3-4-15 Relation of Average Rainfalls



Major Floods at Bandar - Tiga Station (Aug.'72 ~ Aug.'76)
(Water-levels more than 3.0m, TBM are picked up)

Date	Water-level		Average rainfall (mm)	
	Rank	Hmax (m.TBM)	Karai R.	Buaya R.
Nov. 11 '72	6	30.075	22.0	27.6
Jun 5 '73	2	30.215	29.8	49.8
Dec. 9 '73	8	30.015	27.2	39.4
Dec. 25 '73	1	(30.680)	42.1	64.3
Dec. 26 '73	3	30.180	34.5	48.6
Sept. 29 '74	5	30.100	35.8	59.9
Oct. 3 '74	7	30.070	32.2	56.8
Feb. 5 '76	4	30.140	6.3	34.9

rainfalls, as shown below.

i. Discharge at the lower end of the Karai R. (Q_{KR}):

$$Q_{KR} = 0.566 \times (1/1.25)(Q_{BT} - Q_o) + 0.566\ Q_o$$

ii. Discharge at Karai dam site (Q_{KD}):

$$Q_{KD} = 0.494 \times (1/1.25)(Q_{BT} - Q_o) + 0.494\ Q_o$$

iii. Discharge at the lower end of the Buaya R. (Q_{BR}):

$$Q_{BR} = 0.434 \times 1.75\ (Q_{BT} - Q_o) + 0.434\ Q_o$$

iv. Discharge at Buaya dam site (Q_{BD}):

$$Q_{BD} = 0.419 \times 1.75\ (Q_{BT} - Q_o) + 0.419\ Q_o$$

where

Q_{BT} : discharge at Bandar-Tiga

Q_o : base flow discharge at Bandar-Tiga.

Fig.3-4-16 shows respective discharge hydrographs for planning the Karai and the Buaya dams corresponding to the four hydrographs with peak discharges 600 m^3/s, 800 m^3/s, 1,000 m^3/s and 1,200 m^3/s at Bandar-Tiga.

3.5. Improvement of River Channel.

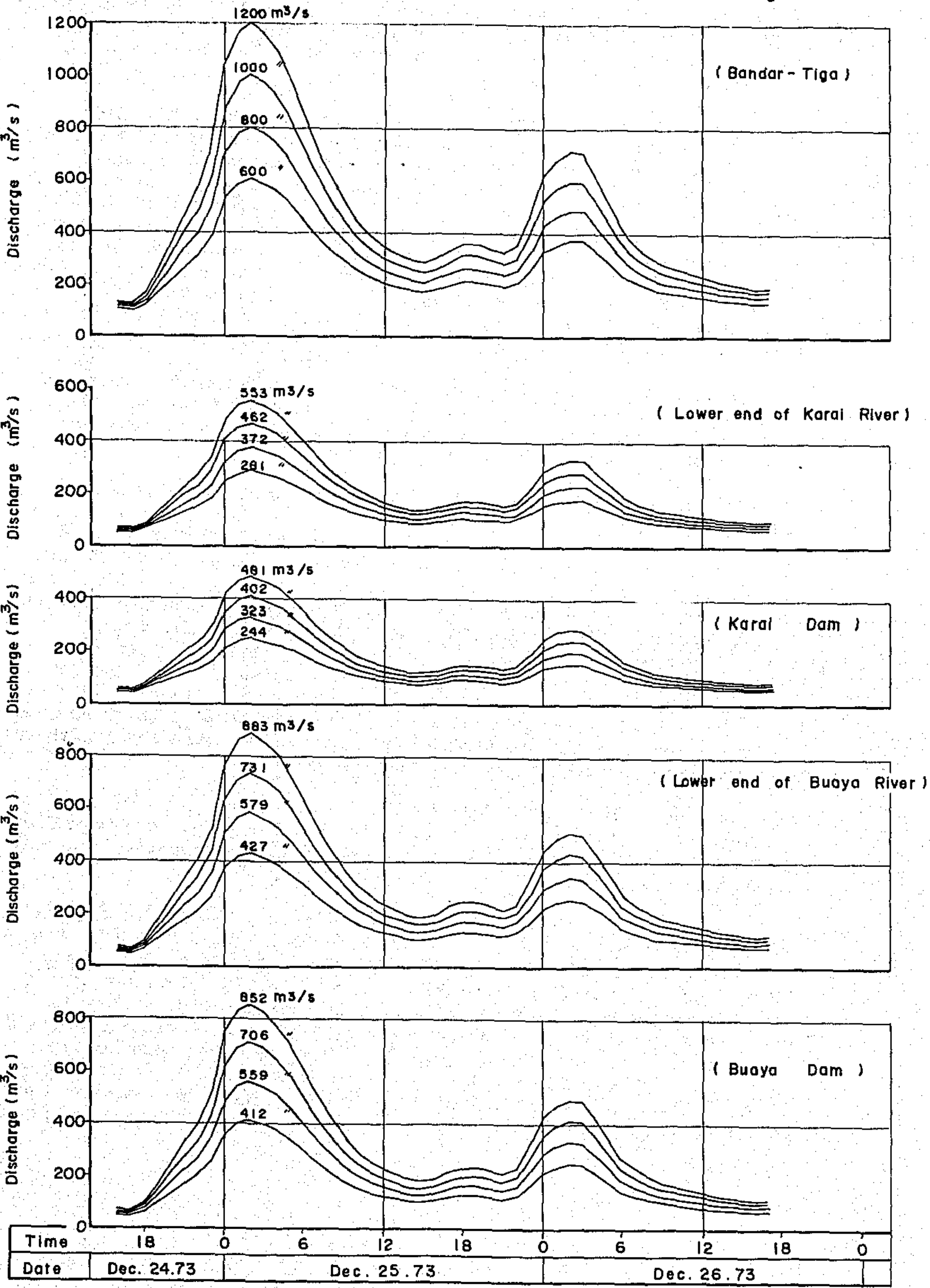
3.5.1. Present Condition of River.

After joining of the Buaya River with the Karai River at a point about 26 km upstream of Ular Bridge, the Ular River runs down through hilly land, and at the distance-mark No.19 km begins the right-side plain area and at the distance-mark No.15 km begins the left-side plain area. Serbajadi Bridge is located at the distance-mark No. 22.5 km in the hilly land.

On the right side between No.19 km and No.10 km there exists only a small levee 1 m to 1.5 m in height. It is uncertain whether it was caused by the 1954-flood or the 1969-flood, but a levee breach occured at No.13 km recently and a new channel which returns to the original river at No.10 km was formed and continues its condition up to present. On the left side between No.15 km and No.10 km there exists a larger levee which was built by the Seksi, P.U. and is maintained comparatively well by the Seksi.

Between No.10 km and No.0 km, such works as levee construction, arrangement of major beds and widening of low-water channel were

Fig. 3-4-16 Discharge Hydrographs for Dam Planning



commenced in 1972 as Urgent Flood Control Project at a design discharge of 600 m^3/s with the aid of Yen Loan and completed in 1976 leaving a part of the works related to the construction of Ular Highway Bridge and Railway Bridge behind.

Near No.0 km, there are Ular Highway Bridge and Railway Bridge. These bridges, which are short in total span and constricted the river channel remarkably, were planned to be rebuilt at the same time as the river improvement. Those plans, as shown in Fig.3-5-7, have the total spans longer than the old ones by 94.72 m in the highway bridge and by 50.68 m in the railway bridge. The bridges are being built by the Directorate General of Highway and the Perusahaan Jawatan Kereta Api and scheduled to be completed by August 1977. The constrictions formed by the old bridges are to be mitigated by the rebuilding but still there remain some constrictions. However, they have plans to elongate the total spans further.

Between No.0 km and No.-3 km, river improvement works are going on the scale of design discharge 600 m^3/s. Levees of the same scale as the upstream reaches have been almost completed and reformation works of major and minor beds are under way.

On the left side between No.-3 km and Ramonia Intake at No.-4.8 km, a levee is completed on the same scale as in the Urgent Flood Control Project. Downwards from here, a levee under the control of the Prefectural Government continues up to No.-8 km. This levee is of small scale compared with the upstream one but maintained comparatively well. Downstream from No.-8 km, as is seen in Fig.3-5-1, a levee is located in a direction different from the river channel. Judging from the 1/50,000 topographic map revised in 1940, this levee is presumed to have been constructed along the old Ular. Local people say that the river course shifted to the present one owing to the flood of 1942 or 1943. Consequently the present river channel is in a state of no levees on both sides. On the right side between No.-3 km and No.-7 km, there is a small-scale levee constructed by the PNP.

Judging from the 1/50,000 topographic map drawn in 1919, the distance-mark No.-13 km was the shoreline at that time. Landward from the old shoreline, there are crop fields and inhabitants live, but the seaward land is still soft and forms swampy area.

The Ular River is reportedly rising in its bed owing to a quantity of sediment load. On the other hand, Fig.3-5-2(1) and 3-5-2(2) show changes in river beds at Serbajadi Bridge located at No.22.5 km and Ular Bridge. It is seen from these figures that the river bed at Ular Bridge seems to have no rise while the river bed at Serbajadi Bridge has scarce change since 1955 or rather has a tendency of slight lowering. We can interpret, therefore, that there has been no change in river bed on the whole but severe local changes have occured. Before the urgent flood control works were executed, levee breaches had been repeated several times every year. Once a levee breach took place,

Fig. 3-5-1 Ular River Improvement Project (Case of 800m³/s)

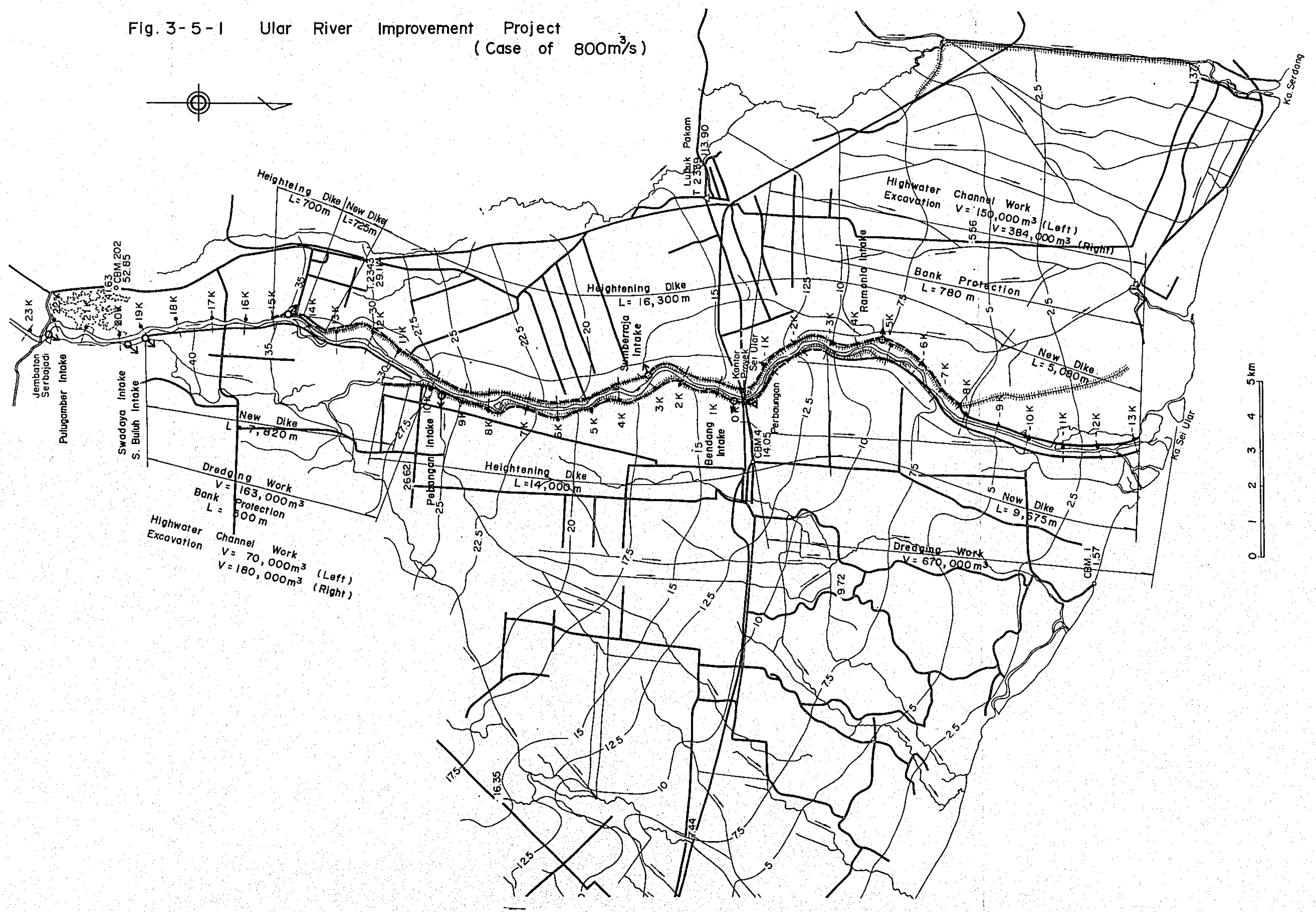


Fig. 3-5-2 (1) Cross Section at Serbajadi Bridge

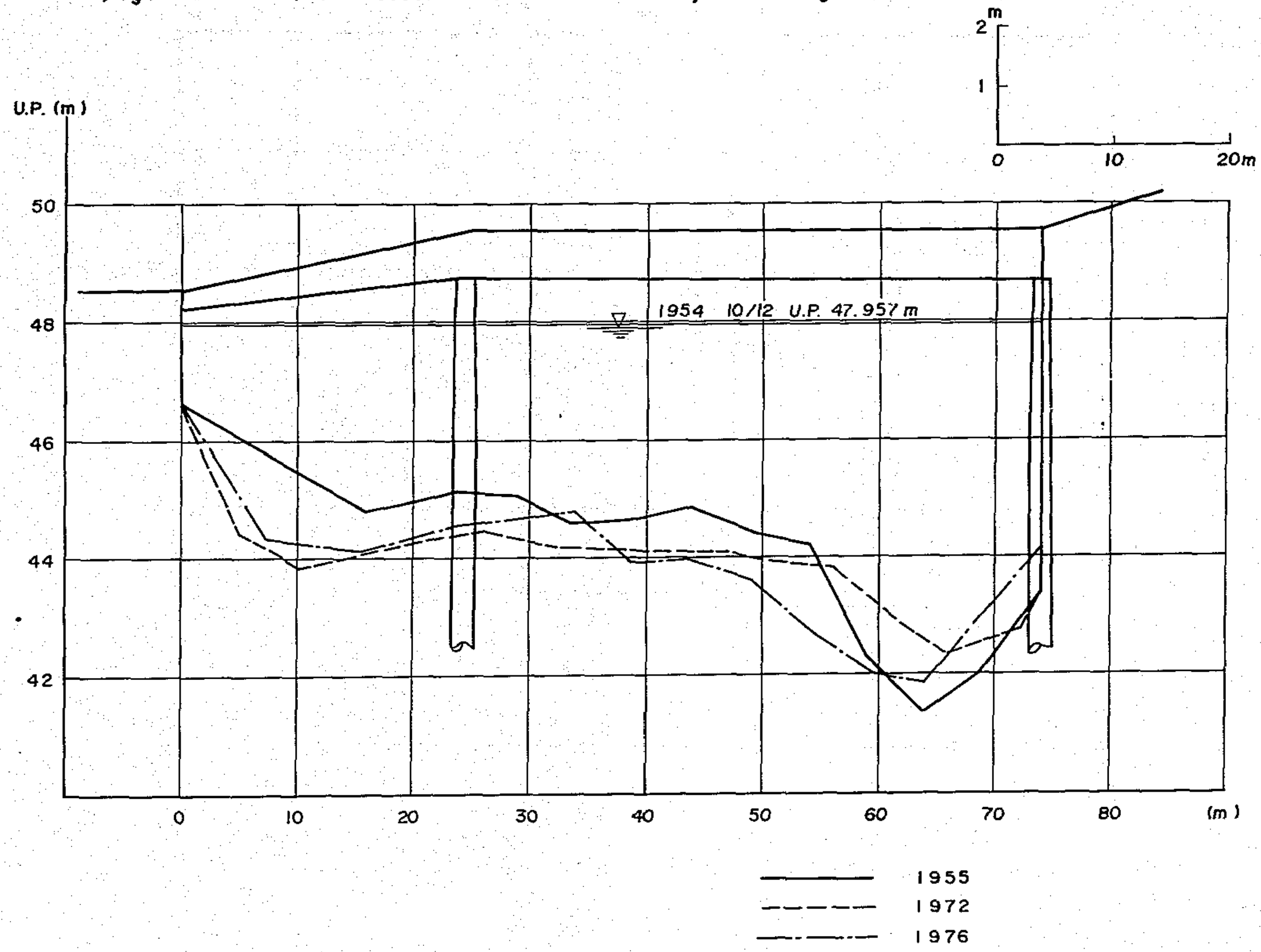
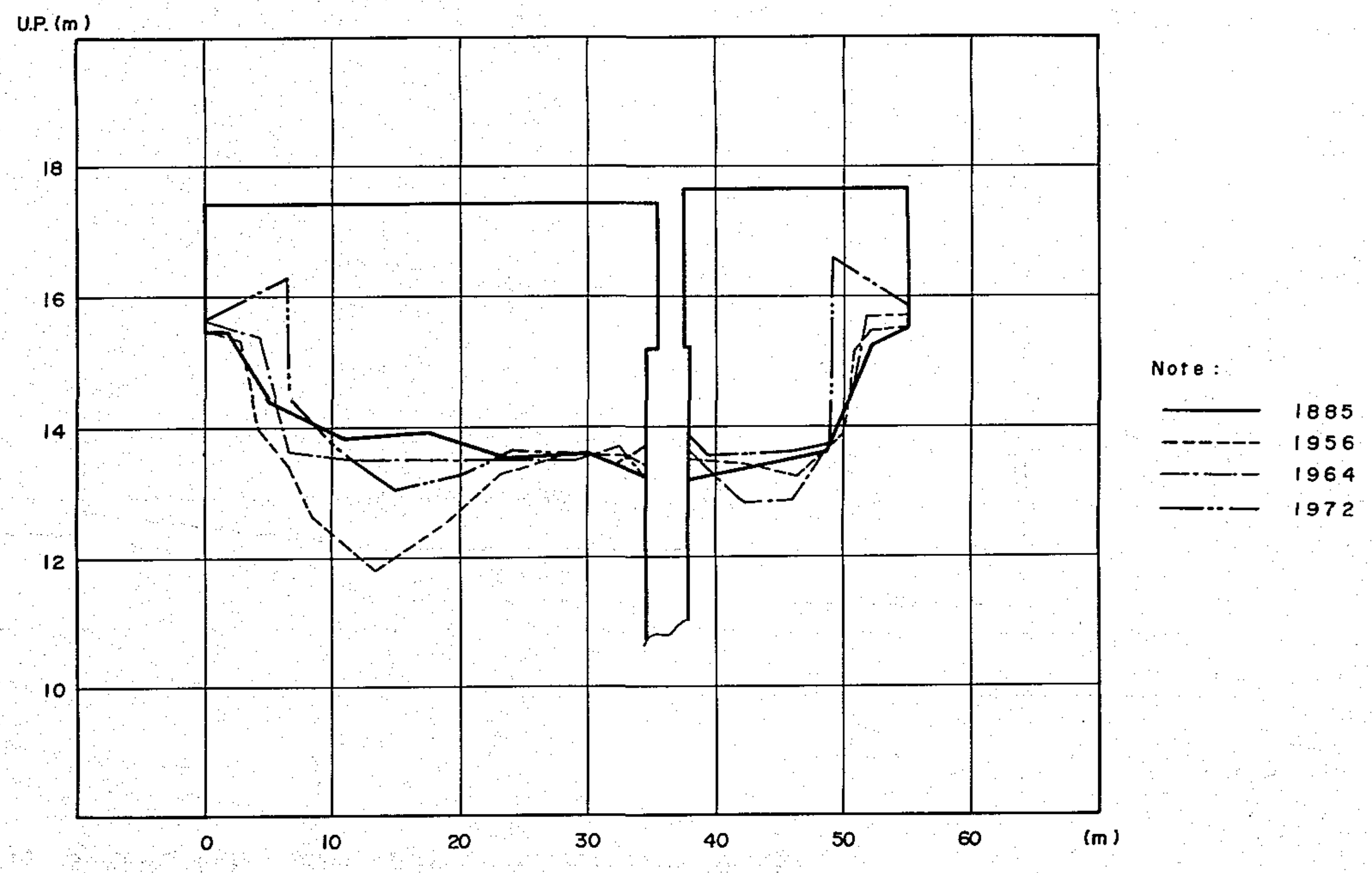


Fig. 3-5-2 (2) Cross Section at Ular Railway Bridge



owing to the fineness of sediment grain size and its movability too, sedimentation occured on the downstream of the breach by losing tractive force and scouring occured on the upstream by an ephemeral increase of velocity. It seems therefore that those local changes in river beds occured everywhere and the changes caused breaches of levees in a vicious cycle. This leads to a judgement that floodings by repeated breaches of levees were not caused by sedimentation but rather by weakness of the levees.

3.5.2. Carrying Capacity of Existing River Channel and Retardation Effect.

(1) Carrying Capacity.

For examining the carrying capacity of the existing river channel, non-uniform flow calculation was made on the reaches between the distance-mark No.-13 km and No.26 km. The conditions for calculation are as follows.

a. Cross-sections of river channel.

The JICA Surveying Team conducted cross-sectional levellings at intervals of 1 km in September 1976. The cross-sections drawn by the Surveying Team were used for the calculation. For convenience of calculation, four supplementary cross-sections were interpolated at intervals of 200 m and more cross-sections were interpolated in an extremely constricted reach such as at Ular Bridge. On a reach where the calculated water levels exceed the height of levee, assumption was made that there is a vertical wall at the levee.

b. Coefficient of Roughness.

Coefficients of roughness were assumed at n = 0.033 for the low-water channel and n = 0.18 for the high-water channel after the study in the detail design for the Urgent Flood Control Works. For the reaches between No.0 km and No.10 km where the river improvement works have been finished, the design roughness n = 0.028 was adopted for the low-water channel and n = 0.04 for the high-water channel.

c. Water Stage at Lower End of River.

The lower end of the river channel for the calculation was set at the distance-mark No.-13 km. The relationship between stage and discharge at this point was obtained by uniform flow calculation.

d. Discharges for Calculation.

Calculations were made with regard to five cases of 100 m^3/s, 400 m^3/s, 600 m^3/s, 800 m^3/s and 1,000 m^3/s.

The results of calculations are shown in Fig.3-5-3, which indicates the following. The carrying capacity is only 100 to 200 m^3/s on the reaches from the lower end to No.-8 km and about 400 m^3/s on the reaches from No.-8 km to No.-4 km. On the reaches upstream from No.-4 km, the water level is raised owing to the extreme constriction at No.-4 km. This constriction affects up to No.3 km and severely reduces the carrying capacity of this reach. Hence the carrying capacity on the reaches of No.-3 km and No.-2 km decreases to less than 400 m^3/s. On the reaches between No.0 km and No.10 km where the urgent works were executed, the carrying capacity of 600 m^3/s is secured except the reach affected by the constriction. On the right side between No.10 km and No.19 km, no levee exists. Hence the carrying capacity on the reaches around No.12 km, No.13 km and No.14 km is less than 400 m^3/s. On the reaches upstream from No.15 km, river banks become high and the carrying capacity exceeds 400 m^3/s. On the upstream from No.19 km, we have hilly land, which has no fear of inundation due to carrying capacity.

(2) Effect of Retardation.

The lower part of the Pulau Gambar area was selected as a retarding basin and the retarding effect was studied by planning an open levee near the distance-mark No.10.2 km. For this study were adopted the hydrographs studied in paragraph 3.4.6. Fig.3-5-4 shows the results of the study. It is found from this figure that reduction in the peak discharges are only 2.5 m^3/s in case of the original peak discharge 600 m^3/s, 2.8 m^3/s in case of 800 m^3/s, 4.1 m^3/s in case of 1,000 m^3/s and 4.5 m^3/s in case of 1,200 m^3/s. The retarding effect is very scarce. In our judgement, this is caused by the fact that the land slope of this area is so steep (about 1/600) that the storage capacity is spent by initial storage.

3.5.3. Channel Improvement Plan.

(1) Project Stretch of Channel Improvement.

A stretch between the river mouth and the distance-mark No.19 km of the starting point of plain area was taken in planning channel improvement.

(2) Design High-Water Discharge.

For the purpose of studying the design high-water discharge which shall be determined later, four kinds of discharges of 600 m^3/s, 800 m^3/s, 1,000 m^3/s and 1,200 m^3/s were taken at Serbajadi Bridge as design discharges for channel improvement. In this study, the effects of channel storage and retarding effect at Pulau Gambar were neglected. Hence one discharge was used for channel improvement plan on the whole stretch.

Fig. 3-5-3 Longitudinal Profile of the Ular River

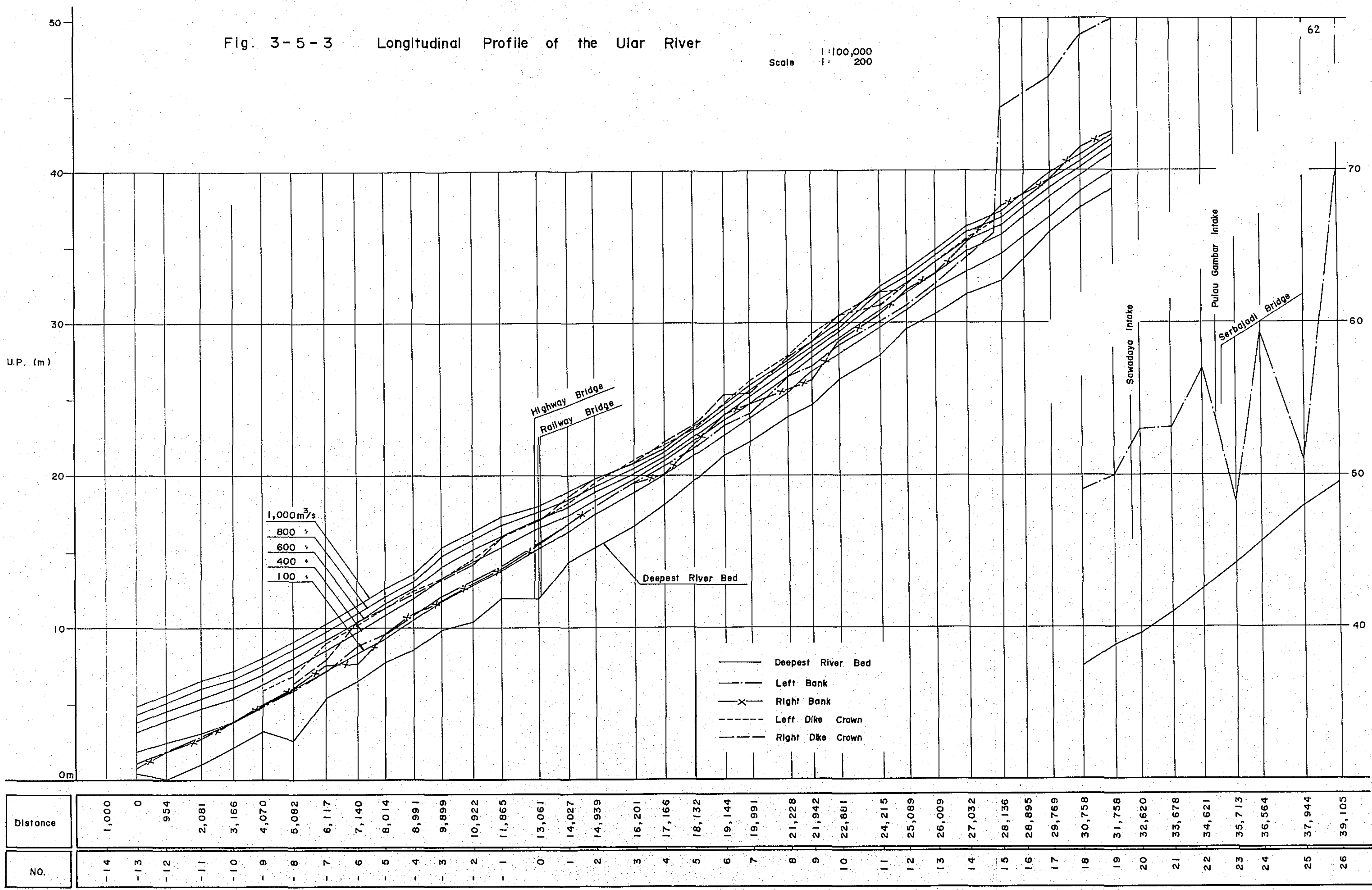
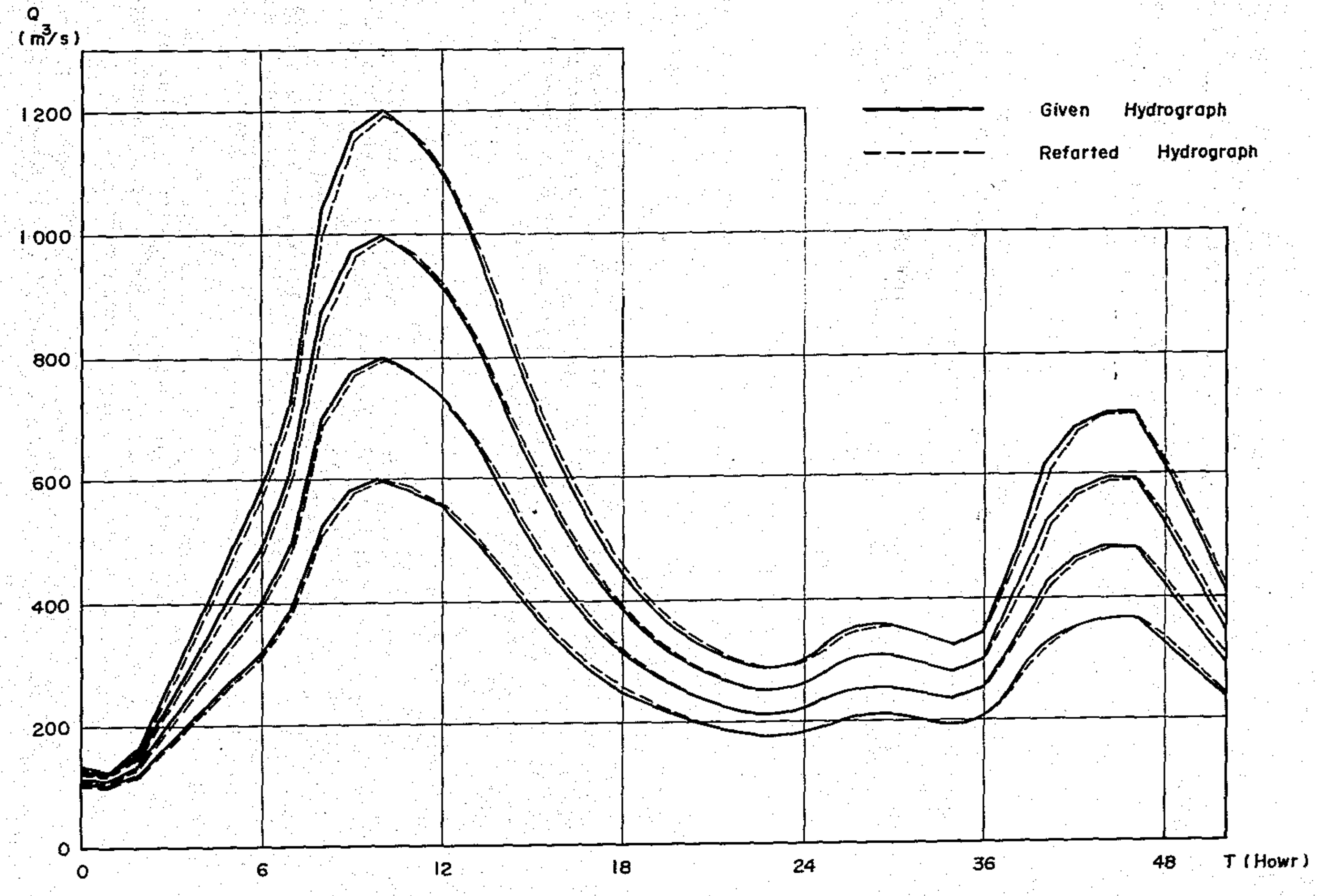


Fig. 3-5-4 Effect of Retarding Area



(3) Design River-Bed Slope.

The design river-bed slope was determined by paying attention to the existing river-bed slope which has been formed over a long period of time. In determining the design river-bed slope, we took aim at the mean height of the existing minor bed, paid attention not so as to change remarkably the existing low-water level and avoided to the utmost the influence to water intake. The designed profile are shown in Figs.3-5-5(1) and 3-5-5(2).

(4) Standard Cross-Section of River Channel.

Double section system with river width of 250 m was adopted after the principle in the Urgent Flood Control Project. The cross-sections were designed by giving minor-bed roughness n = 0.028 and major-bed roughness n = 0.040 to the stretch downstream from No.10 km and minor-bed roughness n = 0.030 and major-bed roughness n = 0.040 to the stretch upstream from No.10 km. Hydraulic quantities for the standard design cross-sections are given in Table 3-5-1, and some of the designed cross-sections are shown in Fig.3-5-6(1) and 3-5-6(2).

(5) Reformation of Low-Water and High-Water Channels.

Alignment of the low-water channel was designed so as to secure necessary water area and to be as smooth as possible by reforming extreme bends and severe closeness to levees. High-water channel, which has remarkable unequalness in height, was designed so as to be evened as much as possible by cutting at high ground and filling at low ground. Low-water channel work was planned to be executed by dredger, whose spoil would be used for filling depressions on the high-water channel. Earth to be obtained by cutting high ground on the high-water channel was planned to be used for embankment of levees as well as for filling depressions.

(6) Alignment of Levee.

On the right side between No.19 km and No.10 km will be built a new levee, which will not only protect the Pulau Gambar area but also prevent flooding outside from the area. On the left side will be heightened and strengthened the existing levee and joined to a hill at No.15 km. But the existing levee 725 m in length between No.13.4 km and No.14.1 km has remarkable bend and is too close to the low-water channel, hence a new levee was planned by removing the existing one.

On the right side between No.10 km and No.11 km, an open levee was planned by reason that small river joins with the Ular at a point closely upstream of No.10 km. The retarding effect by this open levee was not taken into planning as mentioned previously.

The stretch between No.10 km and No.0 km is the one for the Urgent Flood Control Project and the alignment of the levees has already been

Fig. 3-5-5 (1) Longitudinal Profile of the Ular River

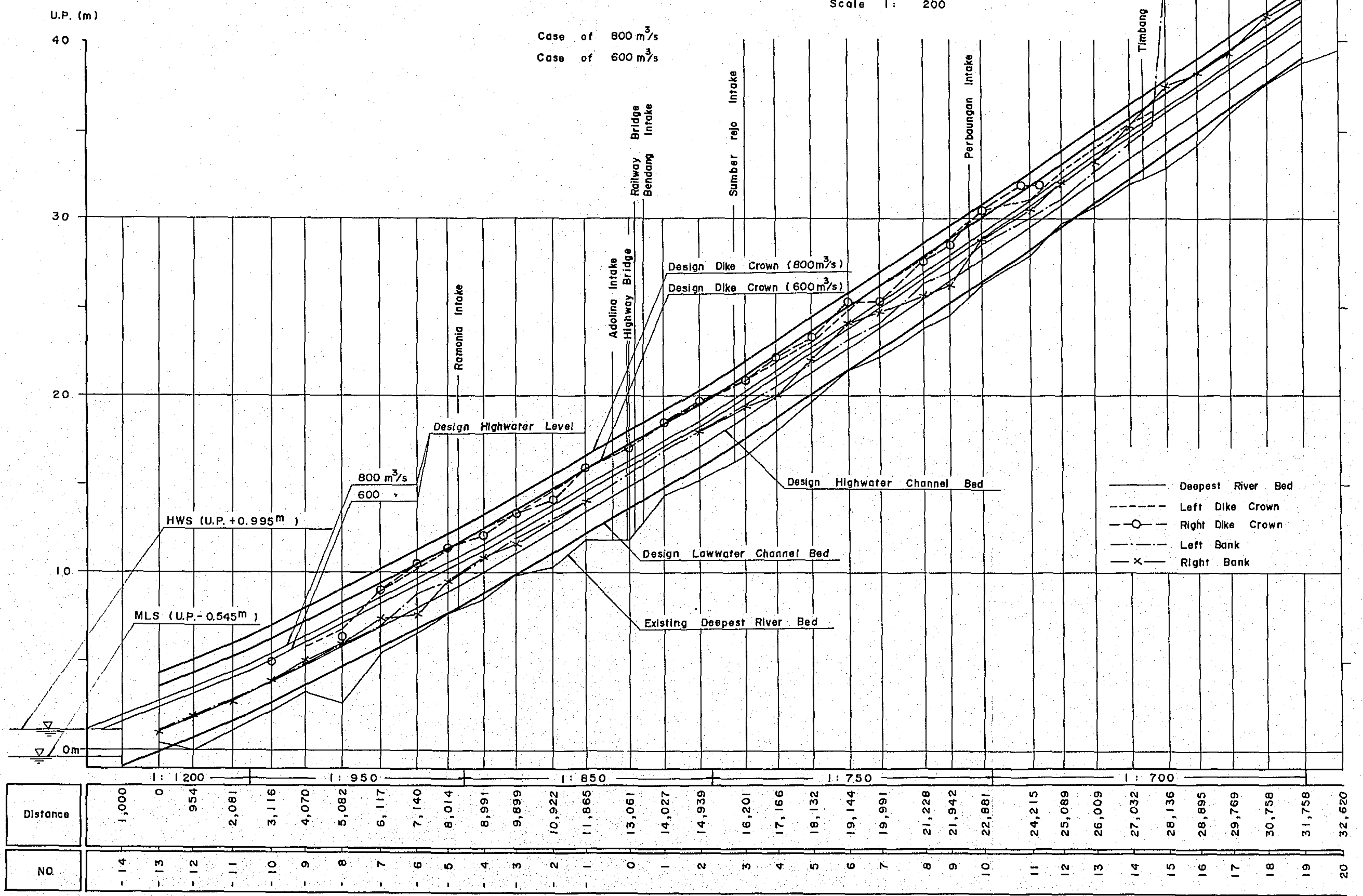


Fig. 3-5-5 (2) Longitudinal Profile of the Ular River

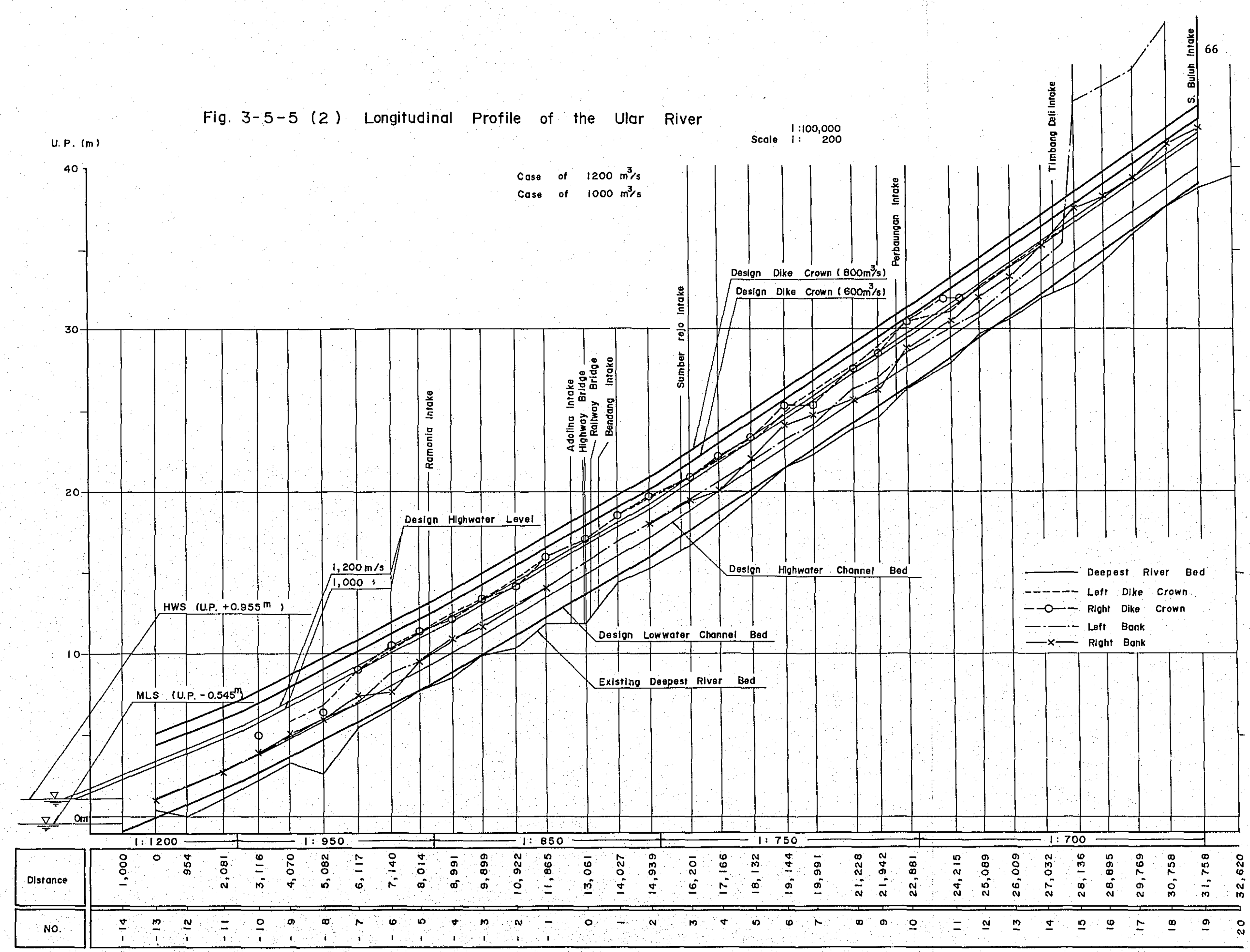
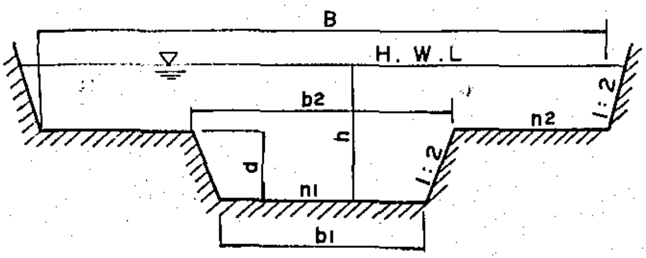


Table 3-5-1 Hydraulic Elements of Standard Cross Section of River



n1 : 0.028

n2 : 0.040

d = 1.20 m

Part	Q	T	h (m)	b1 (m)	b2 (m)	B (m)	V1 (m/s)	Vm (m/s)	Q1 (m³/s)
No. -13	600		2.51				1.87	1.38	415
	800	1/1200	2.87	85.5	90.3	250	2.05	1.52	525
	1,000		3.20				2.21	1.64	635
No. -11	1,200		3.50				2.36	1.76	735
No. -12	600		2.44				2.08	1.47	400
	800	1/ 950	2.80	76.0	80.8	250	2.27	1.63	508
	1,000		3.10				2.42	1.76	638
No. - 5	1,200		3.38				2.57	1.88	700
No. - 4	600		2.44				2.18	1.52	386
	800	1/ 850	2.78	69.2	74.0	250	2.38	1.68	483
	1,000		3.07				2.54	1.80	572
No. - 2	1,200		3.34				2.70	1.92	660
No. - 3	600		2.40				2.30	1.58	380
	800	1/ 750	2.72	65.2	70.0	250	2.51	1.74	470
	1,000		3.02				2.68	1.88	560
No. -10	1,200		3.28				2.84	2.00	645
No. -11	600		2.38				2.72	1.58	385
	800	1/ 700	2.69	70.0	74.8	250	2.41	1.74	475
	1,000		2.98				2.58	1.88	565
No. -19	1,200		3.25				2.73	2.01	655

I : Slope of River Bed.

Q : Design Discharge.

Q_1 : Discharge of Low-water Channel Section.

V_1 : Mean Velocity of Low-water Channel Section.

V_m : Mean Velocity of the Whole Channel Section.

Fig. 3-5-6 (1) Planned Cross Sections

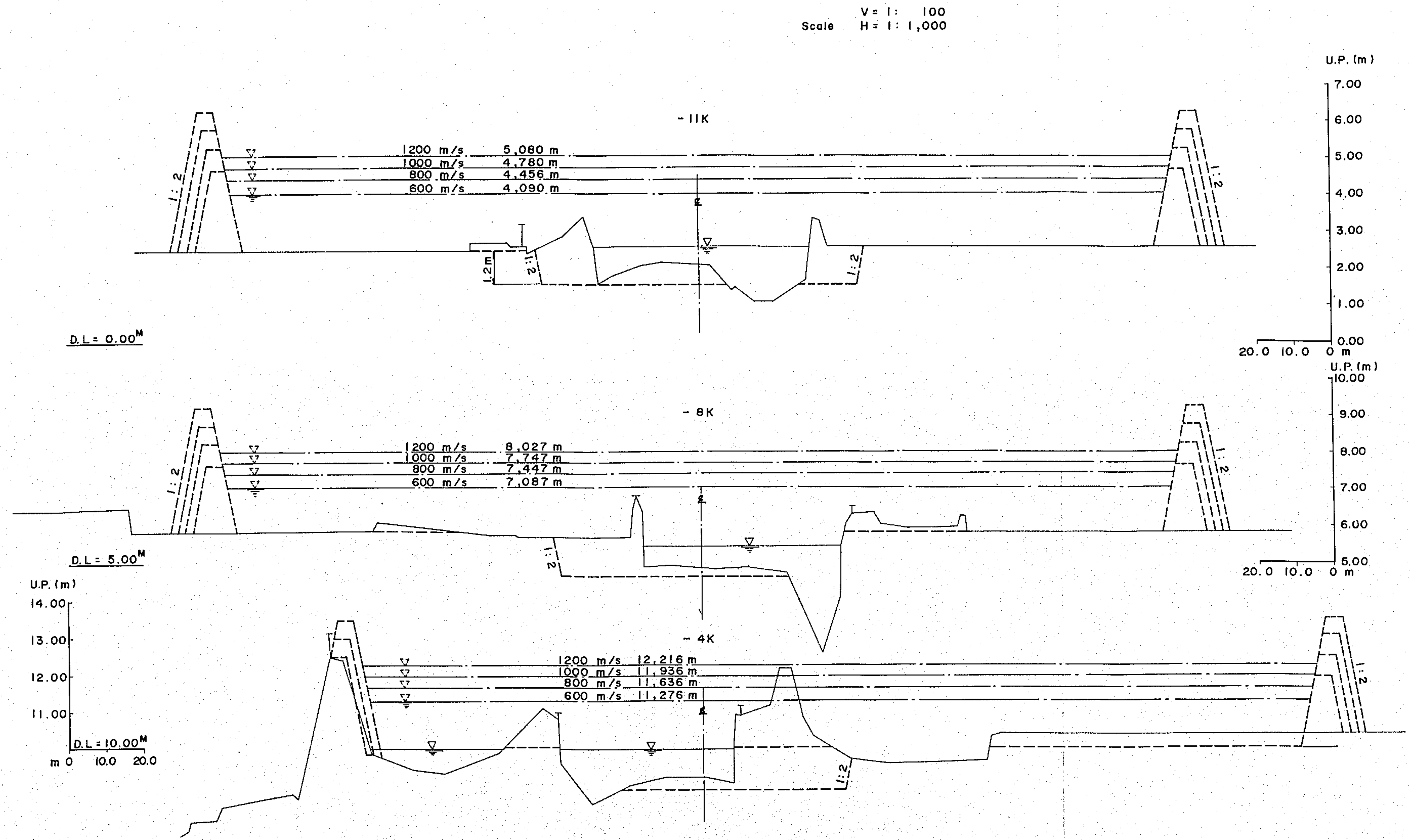
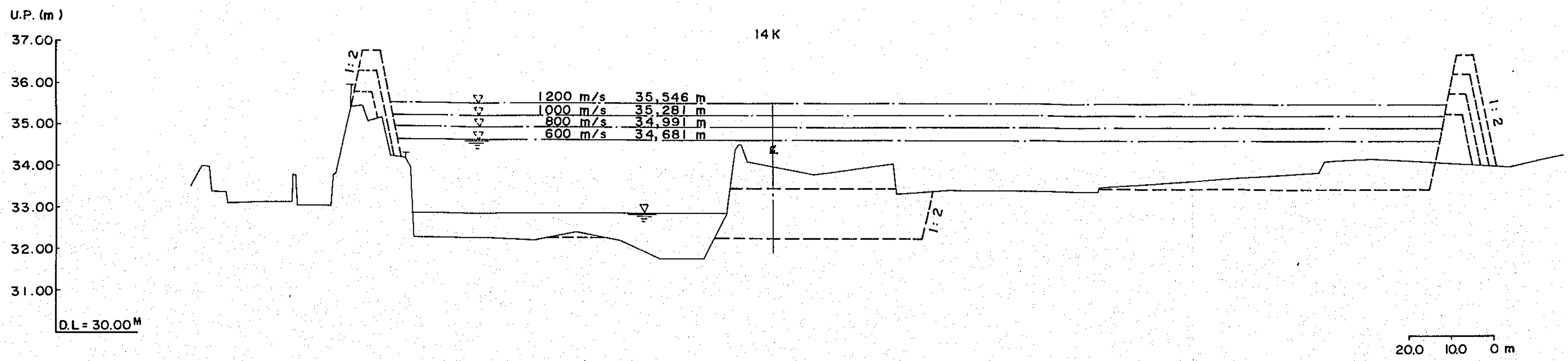


Fig. 3-5-6 (2) Planned Cross Sections

Scale V = 1 : 100
H = 1 : 1,000



reformed. Therefore leaving the alignment as it is, only heightening of levees was planned to cope with increase of discharges. As a matter of course, there can be no improvement work in case of a design discharge 600 m^3/s.

At the points of Ular Highway Bridge and Railway Bridge, works are going on for increasing the carrying capacity by expanding each total span. The present works, however, are only the first step of the plan to span the whole river width, hence the constrictions as shown in Fig.3-5-7 will be left behind even when the works have been completed. The results of calculation of water level at these constrictions are shown in Fig.3-5-8. The full lines indicate the water profiles for four kinds of discharges in case constrictions remain and the broken lines indicate the water profiles in case the constrictions have been removed completely. It is seen from this figure that backwater heights at a point 150 m upstream from the railway bridge is as follows.

0.16 m in case of 600 m^3/s

0.22 m in case of 800 m^3/s

0.32 m in case of 1,000 m^3/s

0.36 m in case of 1,200 m^3/s

Against the constrictions which will still remain, it was planned to widen the low-water channel as shown in Fig.3-5-7 and to protect the right low-water bank with a revetment 372 m in length and the left low-water bank with a revetment 252 m in length.

As is seen from Fig.3-5-8, overhead clearances of the highway and railway bridges are as follows.

Discharge (m^3/s)	Overhead clearance (m)	
	Highway bridge	Railway bridge
600	3.04 (3.00)	1.32 (1.40)
800	2.45 (2.40)	0.97 (1.13)
1,000	2.70 (2.65)	0.70 (0.95)
1,200	2.10 (2.10)	0.40 (0.80)

Note: ( ) means a case with constriction left.

The above table indicates that the highway bridge has overhead clearance sufficient for every discharge but the railway bridge has no sufficient overhead clearance. Hence in case of 1,200 m^3/s, it was planned to raise the railway bridge by one meter.

Fig. 3-5-7 Plan of New Bridges Sites

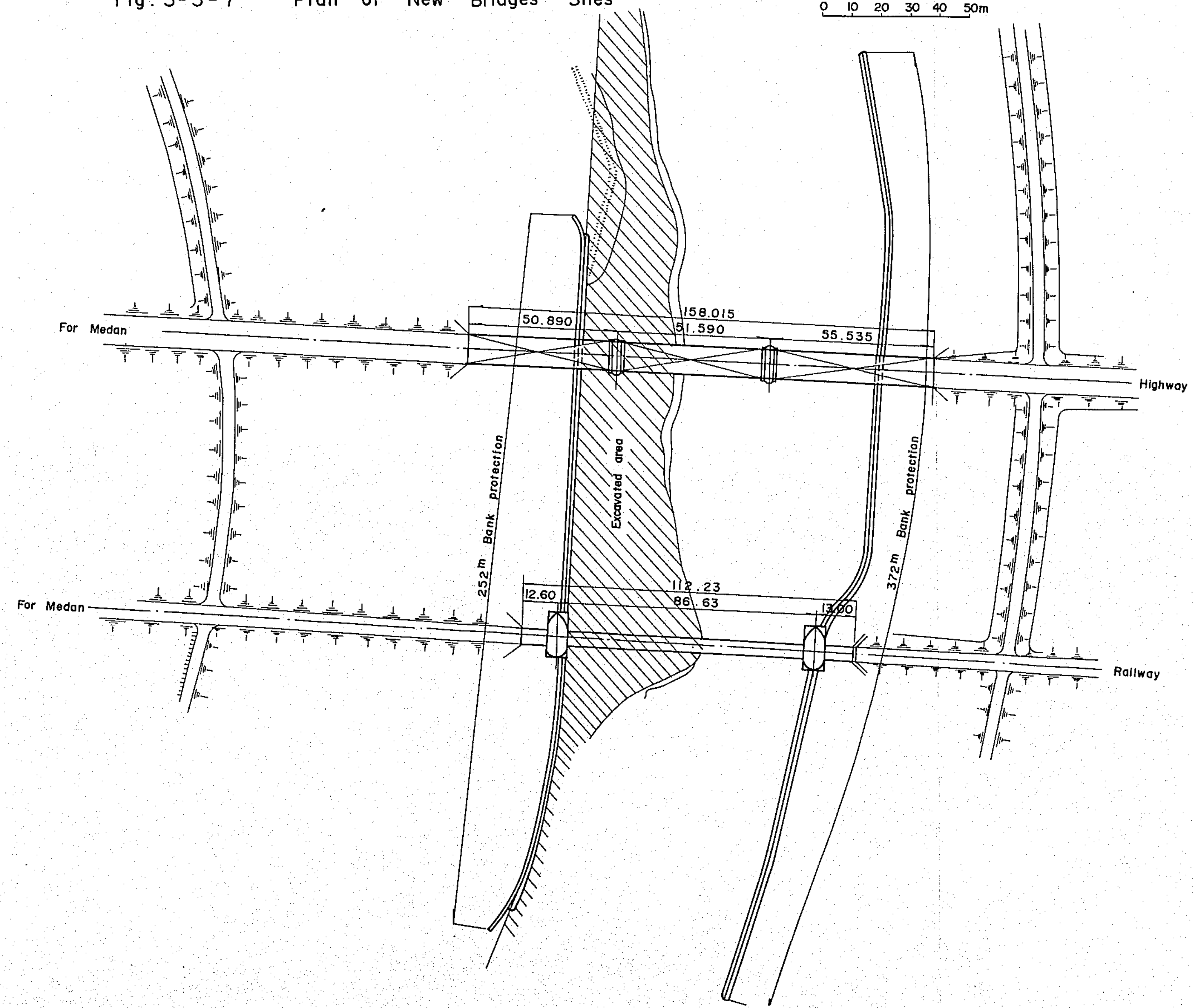
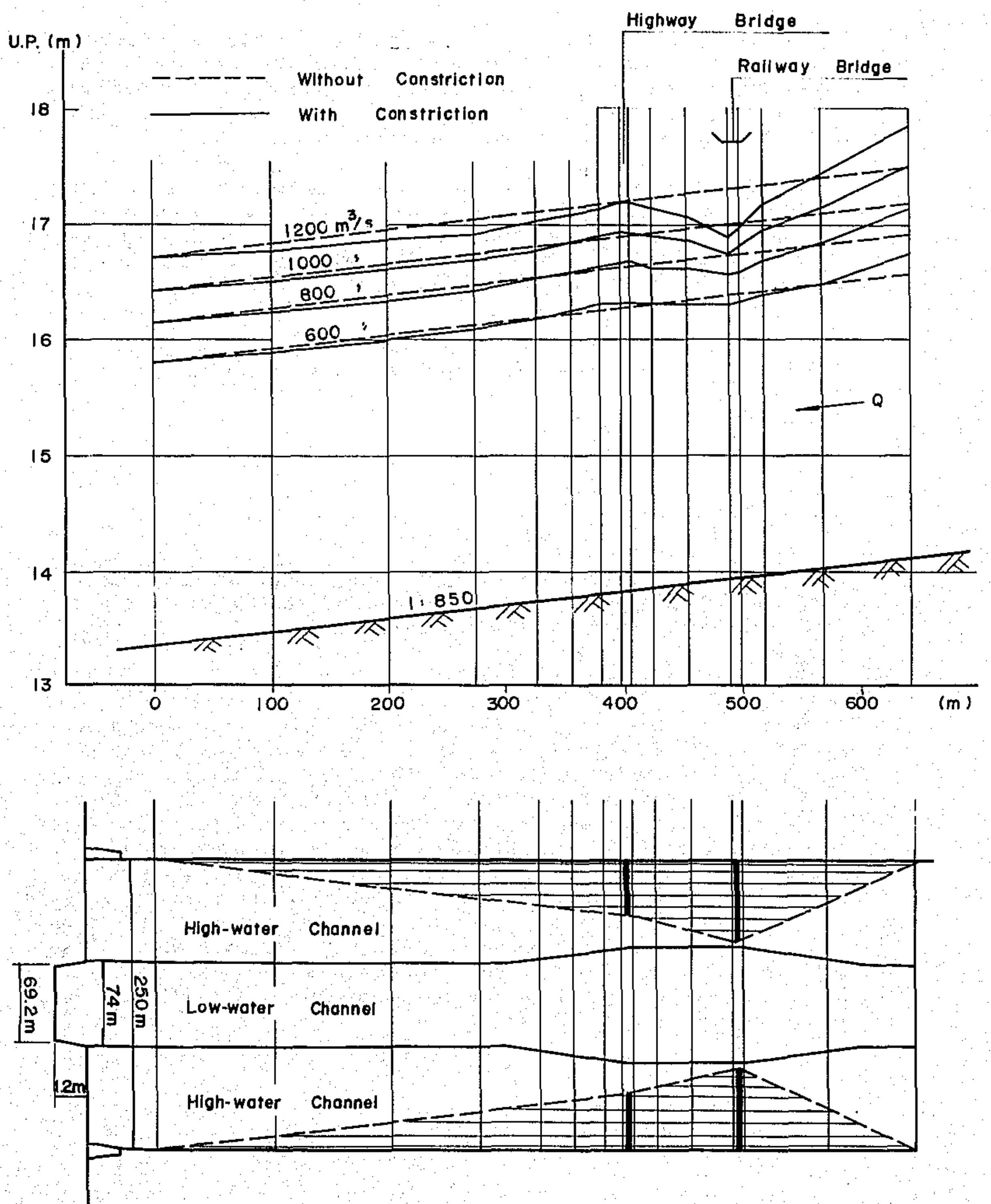


Fig. 3-5-8 Profile of Flow Through Constriction



On the stretch between No.0 km and No.-3 km, following the Urgent Flood Control Project, the levees on both sides of the river are completed on the same scale as the urgent works by displacing the right levee and heightening the left levee. For this stretch, therefore, no levee work was planned for 600 m^3/s but the heightening of levees was planned on both sides for the other cases.

On the left side between No.-3 km and No.-7.8 km, heightening of the existing levee was planned and on the right side between No.-3 km and No.-5 km, it was planned to displace the existing levee and build a new levee as the existing levee is poor and too close to the low-water channel causing lack of necessary river width.

The stretch downstream from No.-7.8 km on the left side and from No.-5.0 km on the right side has no levee. Hence new levees were planned up to No.-13 km along the low-water channel. The total length of new levees and the total length of the levees to be heightened downstream from No.-3 km are as follows respectively.

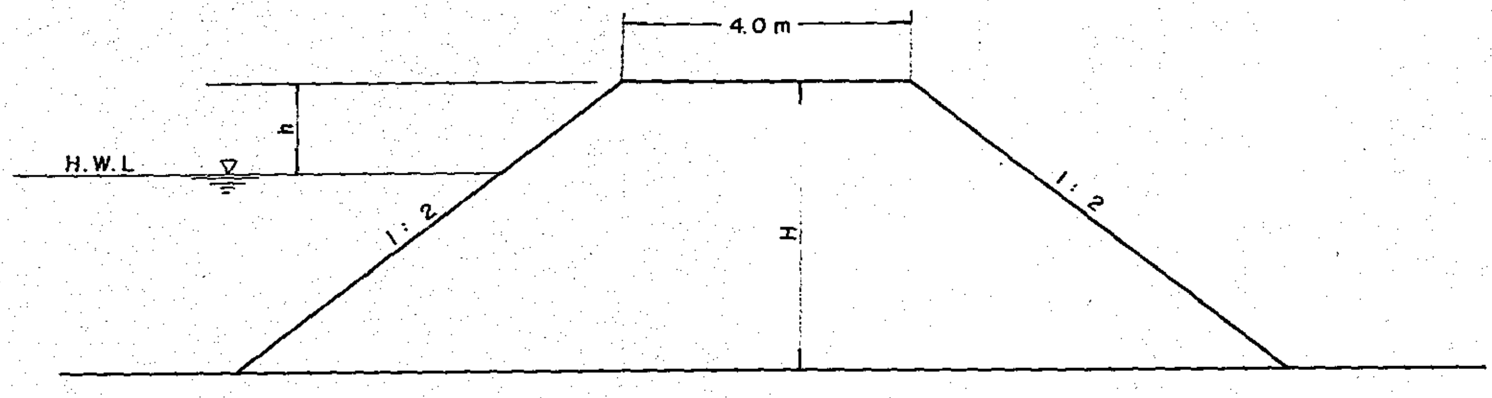
	New levee (m)	Levee to be heightened (m)
Right bank	9,675	0
Left bank	5,080	5,900
Total	14,755	5,900

The standard cross-section of levee was planned to have a crown width of 4 m and a gradient of 1 : 2 on both slopes following the Urgent Flood Control Project as shown in Fig.3-5-9.

(7) Planning near River Mouth.

As mentioned previously, the line at No.-13 km was an old shoreline. The seaward land from this line is a comparatively new land produced by sedimentation accompanied with charge in river course of the Ular, hence it forms swampy land of very soft soil. Since there is no inhabitant and no crop field to be protected and it is too early to develop new crop field, the planning of levee improvement was stopped at No.-13 km. There is a branch river at No.-12.4 km on the right side and further many branch rivers appear downstream of the said branch, which is weakening the power of flow to the sea. Hence it was planned to improve the discharge of flood to the sea by closing these branches and unifying river channel with dredging work, which will surely contribute to improving drainage condition on the adjacent area and promoting development of land.

Fig. 3-5-9 Standard Cross Section of Dike



h : Free board

1,200 m^3/s	h = 1.20 m
1,000 〃	h = 1.00 〃
800 〃	h = 0.80 〃
600 〃	h = 0.60 〃

(8) Revetment.

The revetment works on the stretch of the Urgent Flood Control Project have already been completed. On the other stretches, revetment works were planned at the same rate in length of levee as was designed in the Urgent Project, and almost the same structure as the Urgent Project was taken in this plan, since the revetment in the Urgent Project is achieving success.

(9) Intake.

As seen in Fig.3-5-1, the stretch for improvement has 7 intakes, 5 of which are planned to be improved in the irrigation project, hence the river improvement plan will need simple improvement of the two other intakes (Bendang Intake and Ramonia Intake) following the heightening of levees. But there is no need in case of 600 m^3/s since the improvement has already been completed.

(10) Quantity of Works.

Quantity of the works are given in Table 3-5-2.

3.5.4. Construction Costs.

(1) Method of Execution of Works.

a. Embankment.

Excavated earth on the high ground of the high-water channel, dredged earth and earth to be produced by excavation of canals on the land-side of the river will be used for embankment of levees, for which bull-dozers, dump-trucks, dozer-shovels and draglines will be used. Backhoes will be used for drainage at borrow pits.

b. Reformation of Major Beds.

For reformation of major beds will be used bulldozers. One half of volume of earth to be excavated on the major beds was assumed to be used for emabankment of levees, and the remaining half was assumed to be used for filling depressions on the major beds.

c. Excavation of Low-Water Channel.

For excavation of low-water channel will be used amphibious dredgers, and cooperated work with amphibious clamshells was planned for removal of flowing trees, etc. The reason for using amphibious type is as follows.

(a) Since the water depth of the Ular River is shallow in general and

Table 3-5-2(1) Construction Cost of River Improvement Work
(Case of 600 m^3/s)

Item	Quantity	Unit Cost (Rp)	Amount (10^3 Rp)
1. Main Civil Work			1,654,000
1) Preparation work	L.S		117,000
2) Embankment work			492,300
No.-13 km --- No.-3 km			
Left	163,000 m^3	900	146,700
Right	208,000 m^3	900	187,200
No.-3 km --- No.0 km			
Left	77,000	900	69,300
Right	-		-
No.0 km --- No.10 km			
Left	-		-
Right	-		-
No.10 km --- No.19 km			
Left	19,000 m^3	900	17,100
Right	80,000 m^3	900	72,000
3) Excavation of high-water channel			98,000
No.-13 km --- No.-3 km			
Left	122,000 $m^3 \times \frac{1}{2}$	250	15,250
Right	204,000 $m^3 \times \frac{1}{2}$	250	25,500
No.-3 km --- No.0 km			
Left	28,000 $m^3 \times \frac{1}{2}$	250	3,500
Right	180,000 $m^3 \times \frac{1}{2}$	250	22,500
No.10 km --- No.19 km			
Left	70,000 $m^3 \times \frac{1}{2}$	250	8,750
Right	180,000 $m^3 \times \frac{1}{2}$	250	22,500
(Other $\frac{1}{2}$ of excavated earth of high-water channel is included in the above Embankment work together with its cost)			
4) Dredging low-water channel			708,050
Estuary --- No.-3 km	500,000 m^3	850	425,000
No.-3 km --- No.0 km	170,000 m^3	850	144,500
No.10 km --- No.19 km	163,000 m^3	850	138,550

		(Rp)	(x10[3] Rp)
5) Bank protection work			94,720
No.-13 km --- No.-3 km	600 m	74,000	44,400
No.-3 km --- No.0 km	180 m	74,000	13,320
No.10 km --- No.19 km	500 m	74,000	37,000
6) Bridge protection work			67,382
Bank protection	543 m	74,000	40,182
Dredging	32,000 m^3	850	27,200
Heightening of bridge	-		-
7) Miscellaneous	L.S.		76,548
2. Land acquisition			187,100
No.-13 km --- No.-3 km			
Dike	60 ha	500,000	30,000
High-water channel	242 ha	300,000	72,600
No.-3 km --- No.0 km			
Dike	-		-
High-water channel	-		-
No.0 km --- No.10 km			
Dike	-		-
High-water channel	-		-
No.10 km --- No.19 km			
Dike	27 ha	500,000	13,500
High-water channel	142 ha	500,000	71,000
3. Eng. & administration	20% above (1. + 2.)		368,000
4. Contingency	20% above (1.+2.+ 3.)		442,000
Total			2,651,000

Table 3-5-2(2) Construction Cost of River Improvement Work
(Case of 800 m^3/s)

Item	Quantity	Unit Cost(Rp)	Amount(x10^3 Rp)
1. Main Civil Work			2,012,000
1) Preparation work	L.S.		142,000
2) Embankment work			803,700
No.-13 km --- No.-3 km			
Left	237,000 m^3	900	213,300
Right	300,000 m^3	900	270,000
No.-3 km --- No.0 km			
Left	12,000 m^3	900	10,800
Right	93,000 m^3	900	83,700
No.0 km --- No.10 km			
Left	26,000 m^3	900	23,400
Right	44,000 m^3	900	39,600
No.10 km --- No.19 km			
Left	45,000 m^3	900	40,500
Right	136,000 m^3	900	122,400
3) Excavation high-water channel			98,000
No.-13 km --- No.-3 km			
Left	122,000 $m^3 \times \frac{1}{2}$	250	15,250
Right	204,000 $m^3 \times \frac{1}{2}$	250	25,500
No.-3 km --- No.0 km			
Left	28,000 $m^3 \times \frac{1}{2}$	250	3,500
Right	180,000 $m^3 \times \frac{1}{2}$	250	22,500
No.10 km --- No.19 km			
Left	70,000 $m^3 \times \frac{1}{2}$	250	8,750
Right	180,000 $m^3 \times \frac{1}{2}$	250	22,500
(other $\frac{1}{2}$ of excavated earth of high-water channel is included in the above Embankment work together with its cost)			
4) Dredging of low-water channel			708,050
Eastuary --- No.-3 km	500,000 m^3	850	425,000
No.-3 km --- No.0 km	170,000 m^3	850	144,500
No.10 km --- No.19 km	163,000 m^3	850	138,550

		(Rp)	($x10^3$ Rp)
5) Bank protection work			94,720
No.-13 km --- No.-3 km	600 m	74,000	44,400
No.-3 km --- No.0 km	180 m	74,000	13,320
No.10 km --- No.19 km	500 m	74,000	37,000
6) Bridge protection work			67,382
Bank protection	543 m	74,000	40,182
Dredging	32,000 m^3	850	27,200
Heightening of bridge	-		-
7) Miscellaneous	L.S.		99,148
2. Land acquistion			189,100
No.-13 km --- No.-3 km			
Dike	62 ha	500,000	31,000
Highwater channel	242 ha	300,000	72,600
No.-3 km --- No.0 km	-		-
Dike	-		-
Highwater channel	-		-
No.0 km --- No.10 km			
Dike	-		-
Highwater channel	-		-
No 10 km --- 19 km			
Dike	29 ha	500,000	14,500
Highwater channel	142 ha	500,000	71,000
3. Eng. & administration	20% above (1.+2.)		44,000
4. Contingency	20% above (1.+2.+3.)		527,900
Total			3,170,000

Table 3-5-2(3) Construction Cost of River Improvement Work
(Case of 1,000 m^3/s)

Item	Quantity	Unit Cost (Rp)	Amount ($x10^3$ Rp)
1. Main Civil Work			2,671,400
1) Preparation work	L.S.		188,000
2) Embankment work			1,310,400
No.-13 km --- No.-3 km			
Left	322,000 m^3	900	289,800
Right	405,000 m^3	900	364,500
No.-3 km --- No.0 km			
Left	57,000 m^3	900	51,300
Right	128,000 m^3	900	115,200
No.0 km --- No.10 km			
Left	105,000 m^3	900	94,500
Right	131,000 m^3	900	117,900
No.10 km --- No.19 km			
Left	91,000 m^3	900	81,900
Right	217,000 m^3	900	195,300
3) Excavating of high-water channel			132,750
No.-13 km --- No.-3 km			
Left	122,000 m^3 x $\frac{1}{2}$	250	15,250
Right	204,000 m^3 x $\frac{1}{2}$	250	25,500
No.-3 km --- No.0 km			
Left	28,000 m^3 x $\frac{1}{2}$	250	3,500
Right	180,000 m^3 x $\frac{1}{2}$	250	22,500
No.10 km --- No.19 km			
Left	180,000 m^3 x $\frac{1}{2}$	250	22,500
Right	348,000 m^3 x $\frac{1}{2}$	250	43,500
(other $\frac{1}{2}$ of excavated earth of high-water channel is included in the above Embankment work together with its cost)			
4) Dredging low-water channel			744,600
Estuary --- No.-3 km	500,000 m^3	850	425,000
No.-3 km --- No.0 km	170,000 m^3	850	144,500
No.10 km --- No.19 km	206,000 m^3	850	175,100

		(Rp)	($x10^3$ Rp)
5) Bank protection work			94,720
No.-13 km --- No.-3 km	600 m	74,000	44,400
No.-3 km --- No.0 km	180 m	74,000	13,320
No.10 km --- No.19 km	500 m	74,000	37,000
6) Bridge protection work			
Bank protection	543 m	74,000	40,182
Dredging	32,000 m^3	850	27,200
Heightening of bridge	-		-
7) Miscellaneous	L.S.		133,548
2. Land acquisition			197,600
No.-13 km --- No.-3 km			
Dike	65 ha	500,000	32,500
Highwater channel	242 ha	300,000	72,600
No.-3 km --- No.0 km			
Dike	3 ha	500,000	1,500
Highwater channel	-		-
No.0 km --- No.10 km			
Dike	8 ha	500,000	4,000
Highwater channel	-		-
No.10 km --- No.19 km			
Dike	32 ha	500,000	16,000
Highwater channel	142 ha	500,000	71,000
3. Eng. & administration	20 %	above (1.+2.)	574,000
4. Contingency	20 %	above (1.+2.+3.)	689,000
Total			4,132,000

Table 3-5-2(4) Construction Cost of River Improvement Work (Case of 1,200 m^3/s)

Item	Quantity	Unit Cost(Rp)	Amount($x10^3$Rp)
1. Main Civil Work			3,442,900
1) Preparation work	-L.S.-		242,000
2) Embankment work			1,833,300
No.-13 km --- No.-3 km			
Left	410,000 m^3	900	369,000
Right	457,000 m^3	900	411,300
No.-3 km --- No.0 km			
Left	107,000 m^3	900	96,300
Right	217,000 m^3	900	195,300
No.0 km --- No.10 km			
Left	185,000 m^3	900	166,500
Right	239,000 m^3	900	215,100
No.10 km --- No.19 km			
Left	133,000 m^3	900	119,700
Right	289,000 m^3	900	260,100
3) Excavation of high-water channel			
No.-13 km --- No.-3 km			
Left	122,000 $m^3 \times \frac{1}{2}$	250	15,250
Right	204,000 $m^3 \times \frac{1}{2}$	250	25,500
No.-3 km --- No.0 km			
Left	28,000 $m^3 \times \frac{1}{2}$	250	3,500
Right	180,000 $m^3 \times \frac{1}{2}$	250	22,500
No.10 km --- No.19 km			
Left	180,000 $m^3 \times \frac{1}{2}$	250	22,550
Right	348,000 $m^3 \times \frac{1}{2}$	250	43,500
(other $\frac{1}{2}$ excavated earth of high-water channel is included in the above Embankment work together with its cost)			
4) Dredging of low-water channel			744,600
Estuary --- No.-3 km	500,000 m^3	850	425,000
No.-3 km --- No.0 km	170,000 m^3	850	144,500
No.10 km --- No.19 km	206,000 m^3	850	175,100

		(Rp)	($x10^3$Rp)
5) Bank protection work			
No.-13 km --- No.-3 km	600 m	74,000	44,400
No.-3 km --- No.0 km	180 m	74,000	13,320
No.10 km --- No.19 km	500	74,000	37,000
6) Bridge protection work	·		217,382
Bank protection	543 m	74,000	40,182
Dredging	32,000 m^3	850	27,200
Heightening of bridge	L.S.		150,000
7) Miscellaneous	L.S.		178,000
2. Land acquisition			204,100
No.-13 km --- No.-3 km			
Dike	69 ha	500,000	34,500
Highwater channel	242 ha	300,000	72,600
No.-3 km --- No.0 km			
Dike	5 ha	500,000	2,500
Highwater channel	-		-
No.0 km --- No.10 km			
Dike	14 ha	500,000	7,000
Highwater channel	-		-
No.10 km --- No.19 km			
Dike	33 ha	500,000	16,500
Highwater channel	142 ha	500,000	71,000
3. Eng. & administration	20%	above (1.+2.)	729,000
4. Contingency	20%	above (1.+2.+3.)	875,000
Total			5,251,000

flooding occurs frequently, ordinary dredger is apt to get a ground. A dredger must easily take shelter because the ship is endangered by such high velocity as 2 m/s which usually occurs locally in the low-water channel on the occasion of flood.

(b) Since the working place will be long, the dredger must move very frequently in such a shallow channel as 40 cm or 50 cm. The ship must have a function to move in this shallow water in a short time.

It was planned to dump dredged spoil in the depressions on the major beds. The dredged spoil will also be used for embankment of levees at need.

(2) Estimate of Construction Costs.

According to the above-mentioned principles of works and based on the following assumptions and conditions, the construction costs were estimated.

a. Cost estimation is made by multiplying work quantities by unit construction costs on 1976-price.

b. Such construction materials as mentioned below are procurable in local markets:

Cement.

Reinforcing bars,

Wooden materials,

Fuel, oil,

Ordinary steel materials,

Repair of construction equipment.

c. Wages of laborers and unit prices of fuel and oil are as shown below at the 1976-prices.

Foreman	Rp 1,000
Laborer	500
Operator (A)	1,500
Operator (B)	1,250
Operator (C)	1,000
Mechanic (A)	1,500
Mechanic (B)	1,000
Diesel oil	35
Engine oil	650
Gear oil	1,000

Hydraulic oil	1,000
Grease	900
Gasoline	75

d. Construction equipment, spareparts therefor and special construction materials are pruchased from abroad. The equipment costs are estimated by depreciation costs therefor.

e. The construction works are carried out with the assistance of consulting engineers in design and supervision.

The construction costs are shown in Tables 3-5-2(1) to 3-5-2(4) by design discharges.

(3) Construction Costs by Years.

Based on the work shedule shown in Fig.3-5-10, the construction costs were estimated by years as shown in Table 3-5-3.

Table 3-5-3 Yearly Construction Cost (1976 Prices)

Unit: x 10^6Rp

Case	1978/79	1979/80	1980/81	1981/82	1982/83	Total
600 m^3/s	73	240	850	782	706	2,651
800 m^3/s	88	268	1,009	942	863	3,170
1,000 m^3/s	115	330	1,302	1,232	1,153	4,132
1,200 m^3/s	146	403	1,759	1,513	1,430	5,251

Table 3-5-4 gives the annual construction cost spent in the Urgent Flood Control Project by converting them into 1976-costs by use of price indices. Among the price indices, the item of Medan of "Indikator Ekonomi" published by Biro Pusat Statistik Jakarta, Indonesia was used for Rp and the item of excavator of "Monthly Journal of Price Indices" published by the Bureau of Statistics of the Bank of Japan was used for Yen.

3.6. Land erosion and sand control.

3.6.1. Topography and vegetation.

Topography and vegetation of the basin are summarized as follows based on reconnaissance which was made during the site inspection of the study by use of aerial photographs and mosaics of aerial photographs which were prepared by the JICA. Geology of the basin was described in paragraph 3.3.

Fig. 3-5-10 Construction Schedule of River Improvement Work

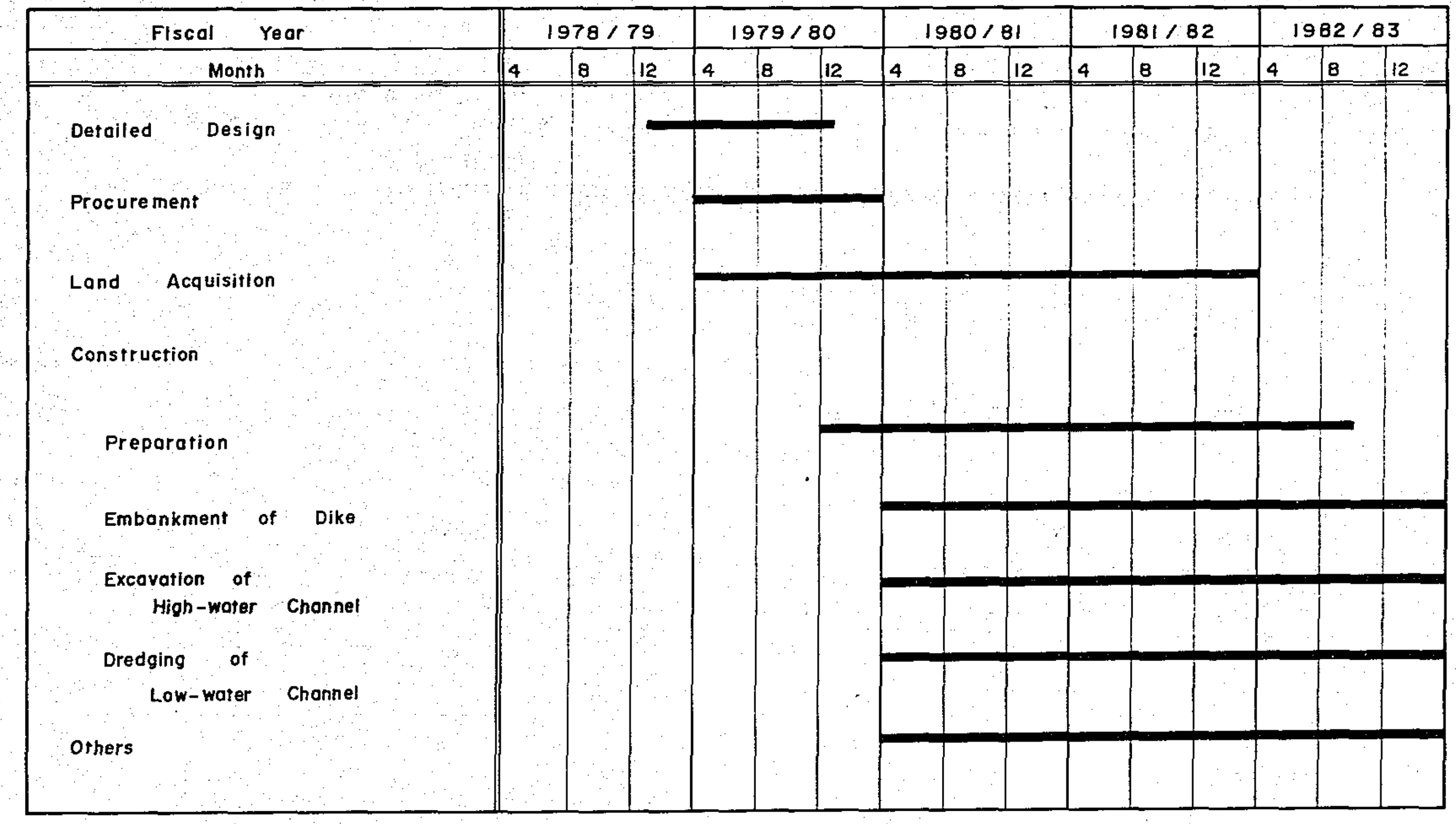


Table 3-5-4 Annual Costs Invested in the Urgent Flood Control Project

Unit: ¥ 1 million
: Rp 1 million

Year	Invested Cost		Converted Cost				
	Rupiah portion	Yen portion	Price index (Rp)	Price index (¥)	Converted to 1976-cost(Rp)	Converted to 1976-cost(¥)	Total 1976-cost(Rp)
1972/73	125		111		304		304
1973/74	137	241	171	116.1	218	296	627
1974/75	451	28	210	133.1	580	30	622
1975/76	496	182	242	142.9	554	182	805
1976/77	285		270	142.5	285		285
Total	1,494	422			1,491	508	2,643

Rp 415 = ¥ 300 = US$ 1

Price index (Rp) : Price index of MEDAN in the "INDIKATOR EKONOMI", BIRO PUSAT STATISTIK JAKARTA, INDONESIA

Price index (¥) : Price index of excavator in "Monthly Journal of Price Indeces", the Bank of Japan.

(1) The area located over 1,000 meters above the sea level is a plateau which streches over an area of 200 km^2 and is almost covered by alang-alang grass or bush. There are many ravines in this area.

(2) The area located between 1,000 meters and about 500 meters (near Gunung Meriah) above the sea level shows about 1/25 of surface-slope and is covered by a primeval forest.

(3) The lower reaches located between the above-mentioned area and the confluence of the Buaya and Karai rivers show about 1/150 of surface-slope and plantations of rubber and oil-palm have been developed in this area.

(4) The area located between the confluence and the estuary of the Ular River shows about 1/800 of surface-slope and is an alluvial plain where paddy field has been developed.

In this section, the basin is divided into the following three zones for explanation.

Upper reaches---- In the Buaya and the Karai, an upper area from a point about 70 km upstream from the river mouth.

Middle reaches--- In the Buaya and the Karai, an area located between the confluence of both the rivers and the point about 70 km upstream from the river mouth.

Lower reaches---- In the Buaya and the Karai, an area located in the lower part from the confluence of both the rivers.

3.6.2. Present State of Erosion.

(1) Upper Reaches.

Since this area is mostly covered with vegetation consisting of alang-alang grass and bush as mentioned previously, sand-product due to surface erosion by rainfall seems to be of small scale. However, also in this area, many ravines are developed in a mixed state with and without vegetable coverage.

In some of the stripped ravines, sandy soil weathered from dacite tuff (stretched in the Buaya River basin) and acidic tuff (stretched in the Karai River basin) was seen exposed forming a slope of 50° to 70° with thickness of 10 to 20 m. In these places, some production of sand may occur if those slopes are collapsed by rainfall.

In some places, paddy fields were seen developed in a small flat area surrounded by the slopes and the area of paddy field seems to be being increased by collapses of the slopes. In this case, some ditches excavated at the toes of the slopes were seen to increase the collapses.

No occurence of land sliding or sliding with collapse was seen in this area.

(2) Middle Reaches.

In this area, plantations of rubber and oil-palm have been developed. The surface of the planted land is well covered with underbrush. Therefore surface erosion will be of small quantity. However, reading of aerial photographs and geological survey suggest occurence of some collapses of slopes and erosion of ravine-head as well as lateral erosion of ravines. But also in this area, no occurence of land sliding or sliding with collapse was seen.

(3) Lower Reaches.

In the area downstream from the confluence of the Buaya and the Karai up to the river mouth of the Ular River, river-bank erosion was seen near Serbajadi Bridge. However the length of this erosion is very small compared with the total length of the lower reaches.

It is generally thought that the production of sand in the Buaya River basin is smaller than the Karai River basin. This may result from the fact that the Buaya River basin has long-exposed rock along the river channels compared with the Karai River.

3.6.3. Sediment Transportation.

Comparing the 1/50,000 topographic maps prepared from the aerial photographs made in 1915 and a mosaic of aerial photographs taken by the JICA Aerial Photographic Surveying Team in 1976, it was found that the seacoast line had been shifted remarkably seawards during a long period of time. The comparison indicated that a new land of 7.236 km^2, about 10.8 km in length and about 0.67 km in width, was formed near the river mouth of the Ular during 61 years from 1915 to 1976. Reading the depth on the sea chart, the volume of deposition was estimated at 27,190,000 m^3. If we add a volume flown away offshore or to other places, sediment far exceeding 450,000 m^3 is presumed to have been discharged to the sea every year.

On the other hand, the study made in paragraph 3.4.3 indicates that annual sediment discharge at the confluence of the Buaya and the Karai is estimated at about 800,000 m^3. Further, the study made in Section 3.5 indicates that the sediment load at the confluence is discharged to the sea without any deposition in the river channel. It can be said therefore that the sediment transported from the Buaya and the Karai rivers passes through the river channel without harmful deposition and annual quantity of sediment to be discharged to the sea will reach about 800,000 m^3.

3.6.4. Sabo Facilities and Afforestation.

From the field inspection and consideration mentioned in the previous paragraphs, the following will be concluded.

a. There is no land sliding nor sliding with collapse in the mountaneous region of the basin.

b. The surface erosion is scarce.

c. Some of the ravine-heads have erosion in form of steep slope, which has a potenticality to produce sand. The size of this sand is fine in general. Owing to the fineness of sand, sufficient effect of sabo dam cannot be expected.

d. The produced sand does not give unfavorable influence to the river channel of the Ular after its passing the confluence of the two tributaries.

Judging from the above consideration, construction of sabo facilities will not be needed for the time being. However, it seems to be necessary to commence a study on the mechanism of sand production in the headwaters and the quantity of its production on an appropriate ocassion in the future against a possible increase in sand production which may occur in the future owing to such causes as development in the headwaters and unexpected change in rainfall.

In principle, it is desirable from the viewpoint of control of runoff and prevention of surface erosion to cover the land with vegetation. Fortunately a reforestation project and a greening project are being carried out by the authorities concerned continuously since 1971. At present, reforestation of 2,450 ha and greening of 1,896 ha have already been executed as Fig.3-6-1 shows. However, for the purpose of maintaining the present condition of the headwaters or further improving the condition, the aforesaid reforestation programs will desirably be promoted together with a further study of kind of plant which may be more suitable to the headwaters.

LUAS TANAMAN REBOISASI & PENGHIJAUAN DI DAS ULAR

SELAMA PELTITA I s/d II TH 1976/1977

REBOISASI

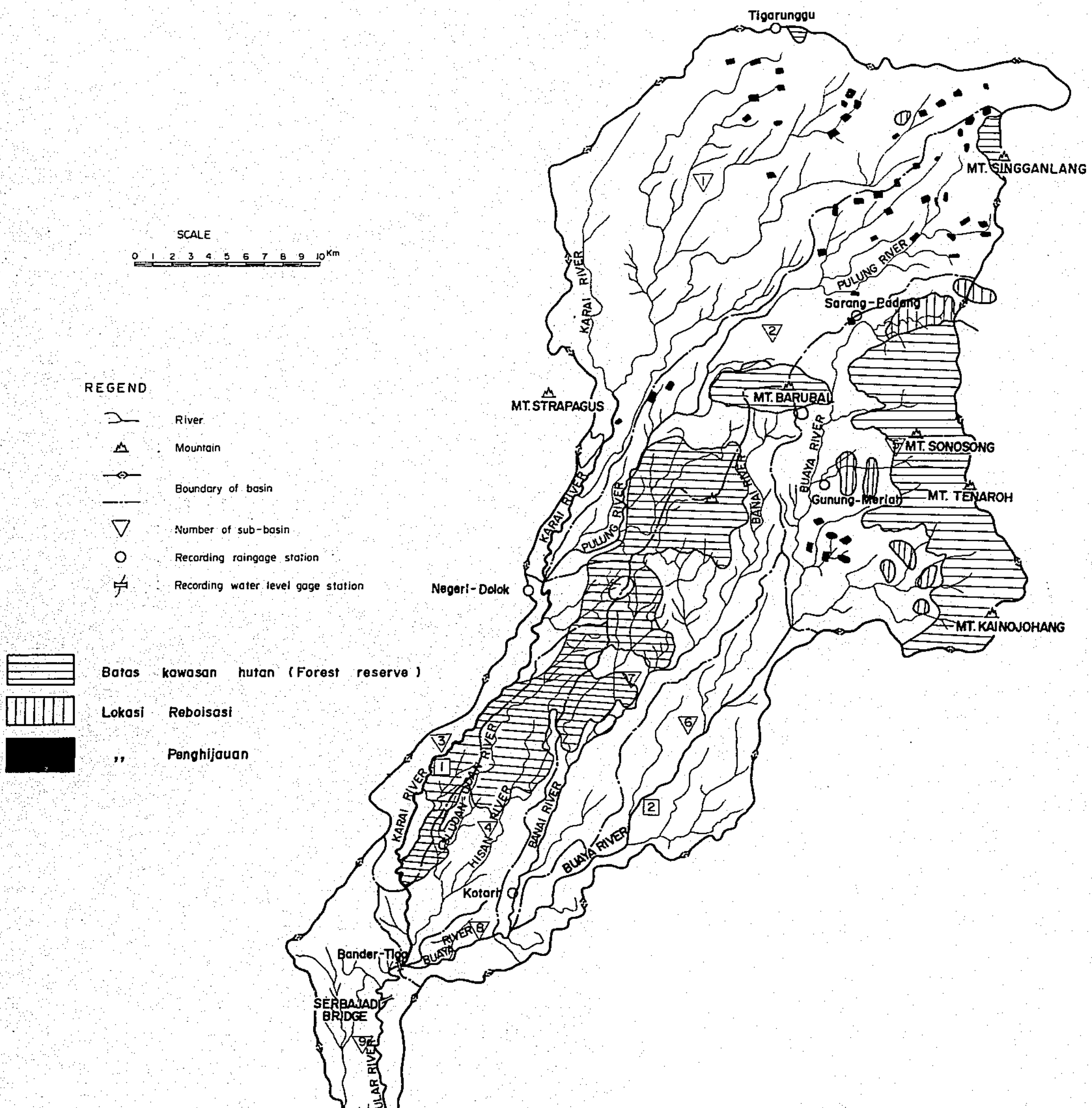
K.P.H./BKPH.	Lokasi	Th. Tanam	Joins	Luas.
SUM.TIMUR I				
Serdang	Silinda	1971/72	Pinus/Mahoni	100 ha
	Marubei I	1971/72	Pinus	50 "
	Simacik I	1970/70	"	100 "

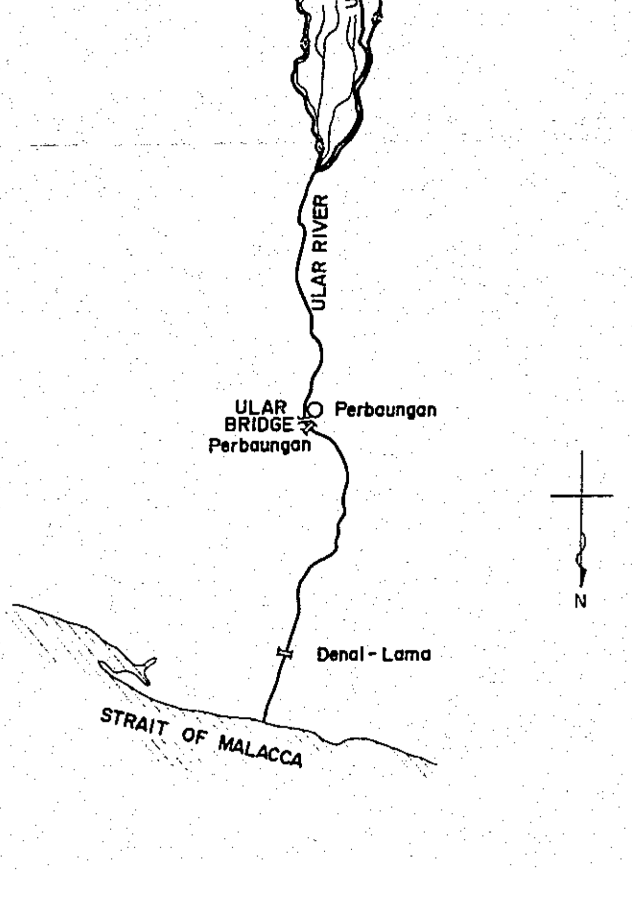
K.P.H./BKPH.	Lokasi	Th. Tanam	Joins	Luas.	
		1971/72	Pinus	130	ha
		1972/73	"	165.50	"
		1973/74	"	70	"
		1974/75	"	150	"
		1975/76	"	200	"
		1976/77	"	50	"
AEK NA ULI					
Seribu Dolok Simacik II		1973/74	Pinus	205	ha
		1974/75	"	669	"
		1975/76	"	60	"
	Perluasan Simacik	1974/75	"	383	"
	Marubei II	1974/75	"	33	"
		1975/76	"	100	"
	Gaja Pokki	1976/77	"	34.80	"
J u m l a h R e b o i s a s i				2,450.30	ha

PEN GHIJAUAN

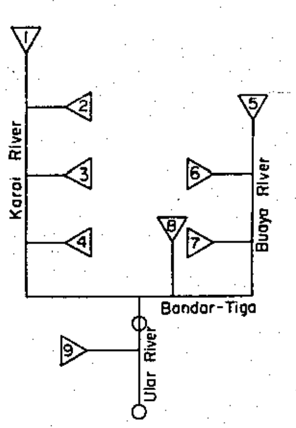
KECAMATAN	Th. Tanam	Luas.	
SUM.TIMUR I			
Kec. G. Meriah	1971/72	50	ha
"	1974/75	45.50	"
	1975/76	65	"
AEK NA ULI			
Kec.Silima Kuta	1971/72	50	"
	1972/73	386.25	"
	1973/74	30	"
	1974/75	189	"
	1975/76	300	"
Kec.Dolok Pardamean	1972/73	150	"

Fig. 3-6-1





RIVER SYSTEM



CATCHMENT AREA

	Sub-basin	Catchment area (Km2)	Remarks
Karai River	1	292	
	2	154	Pulung River
	3	54	
	4	73	Si Udan-Udan River
	Subtotal	573	
Buaya River	5	190	
	6	100	
	7	134	Banai River
	8	16	
	Subtotal	440	
	9	68	
	Total	1 081	

KECAMATAN	Th. Tanam	Luas
Kec.Dolok Silau	1973/73	220 ha
	1974/75	111 "
	1975/76	300 "
Jumlah Penghijauan		1,896.75 ha

3.7. Dam

3.7.1. Selection of Dam Site.

Selection of dam site was made based on our pre-study using topographic maps with the scale of 1/10,000 and our field investigations. As a dam site, it is preferable to select a dam site in the area around the confluence of the Buaya and the Karai rivers for the purpose of flood control.

(1) Downstream Dam Site.

We could not find out any promising dam site in the downstream area from the confluence of the Buaya and the Karai rivers since both the topographic and geological conditions are considered to be inadequate for dam construction.

Speaking of the topographic condition, even the highest portion of the Ular River banks, the top elevation reaches only 65 m at the place about 2 km downstream from the confluence, and the adjoining area thereto (right bank area) is being formed of low land with an elevation of 50 m to 60 m, UP.

While, these areas are composed of fluvial deposit with a considerable depth, therefore, the costs for removal of permeable layers and foundation treatments would be expensive.

Considered from both the technical and economical view point, the selection of dam site in the downstream area was compelled to give up consequently.

(2) Buaya Dam Site.

(i) Main dam site.

Dam site is proposed at the place about 5.60 km upstream from the confluence of the Buaya and the Karai rivers taking account of the topographic and geological conditions and also the reservoir capacity to be created by a new dam.

Both banks of the proposed dam site are covered mostly with trees and bushes, and the slope gradient of both banks is comparatively gentle. The elevation at the lowest portion of riverbed is 67.50 m, UP and the elevations of the highest portion on the right and the left abutments are 100 m and 86 m respectively. Width and gradient of the Buaya River where the dam is proposed are 80 m and 1/200 respectively.

(ii) Secondary dam site.

Considering from the topographic conditions, the reservoir water to be created by a new dam will be evacuated at the time of higher reservoir water level through the depression portion (gouge shaped portion) being located on the northern part of the main dam site with a direct distance of 1.50 km since the elevation of said portion is lower than the expected reservoir high water level.

In this light, a secondary dam will be required at the abovementioned place. Both banks of the proposed secondary dam site are covered mostly with trees and bushes, and the slope gradient of both banks is relatively steep, and the elevations of the highest portion on the west and the east abutments are 95 m and 100 m respectively.

(3) Karai Dam Site.

(i) Main dam site.

Dam site is proposed at the place about 5 km upstream from the confluence of the Buaya and the Karai rivers taking account of the topographic and geological conditions and also the reservoir capacity to be created by a new dam.

Both banks of the proposed dam site are covered partly with trees and bushes, and the slope gradient of the left bank is partially steep and that of the right bank is rather gentle. The elevation at the lowest portion of river bed is 54 m, and the elevations of the highest portion on the right and the left abutments are 86 m and 83 m respectively. Width and gradient of the Karai River where the dam is proposed are 60 m and 1/800 respectively.

(ii) Secondary dam site.

As will be seen in the topographic map with the scale of 1/10,000, the reservoir water to be created by a new dam will be evacuated at the time of higher reservoir water level through depression portions of hill ridge being located on the eastern part of the main dam site.

Among these depression portions scattered in this slender hill ridge, 2 or 3 portions shall be provided with secondary dam and/or be protected with side embankment judging from the field investigations.

The area of the said hill ridge is mostly covered with bushes and partly with trees, and the highest elevation thereon is approximately 95 m.

3.7.2. Geology of Dam Site.

(1) Buaya Dam Site.

The foundation rock at the proposed dam site area consists of dacitic tuff and dacite, and they are exposed in part at both the abutments. The result of core-boring (right abutment) shows that the area is covered with 1.50 m thick top soil, and beneath therefrom, the rock formation consists of dacitic tuff (upper layer) and dacite (lower layer), and their thicknesses are 9 m and 6 m respectively. Even though the thermal deteriorated clayey material was observed beneath the dacite layer of 6 m thick, however, the said dacite is very hard and durable, accordingly, it is judged that the proposed dam site will be durable, accordingly, it is judged that the proposed dam site will be adequate for the construction of low dam (20 - 30 m class in height).

(2) Karai Dam Site.

Proposed dam site area is widely covered with acidic tuff (liparitic tuff). Resulting from the hand auger drilling (right abutment), the layer up to the depth of 8 m from the ground surface consists of liparitic tuff. This tuff is very soft and their N-value is estimated to be about 20 since the tuff layer is compacted relatively well. However, the foundation of the proposed dam site seems to be questionable for dam construction in case of the competent hard rock could not find out just beneath the above soft tuff layer.

3.7.3. Reconnaissance of Borrow Area.

(1) Buaya Dam Area.

(i) Concrete aggregate.

Many sand and gravel bars and river terraces are observed in the Buaya River course (between dam site and 10 km upstream portion). Especially, the upstream area from Kotari Bridge abounds in gravelly material. Gravel and boulder in the above areas are andestic rock, and the quality of gravelly material is suitable as a concrete aggregate since they are very hard and durable. However, small size gravel seems to be insufficient in quantity, in this respect, an appropriate crushing plant will be required so as to enable to produce pea gravels. Sandy deposits are observed in the downstream area from the confluence of the Buaya and the Karai rivers, and these sands are mainly consists of quartz sand having the maximum grain size of 3mm. As for the quality of sandy material, it is requested to take material samples aimed at checking their characteristics.

(ii) Core material.

The brown coloured clayed soil observed on the right bank in the dam site area is expected to be available for the core zone of fill-type dam. However, the laboratory tests for soil samples shall be made, and if the characteristics of clayey material were found to be available after the laboratory tests, then, the obtainable quantity of these materials deposited in the borrow area shall be confirmed by test pits or trenches.

(iii) Shell material.

Gravelly materials including boulders deposited in the sand and gravel bars and river terraces mentioned above will be available as a shell material of fill-type dam.

(2) Karai Dam Area.

(i) Concrete aggregate.

There are no gravelly materials but quartz sand in the Karai River course. Accordingly, the gravelly materials shall be obtained from the Buaya River basin.

(ii) Core material.

The brown coloured clayey soil observed on the right bank in the dam site area is expected to be available for the core zone of fill-type dam. The said material is being covered with thin volcanic ash layer.

Aimed at checking the material quality, the laboratory tests for soil samples shall be made, and if the characteristics of clayey material were found to be available after the laboratory test, then, the obtainable quantity of these materials deposited in the borrow area shall be confirmed.

(iii) Shell material.

We could not find out any competent gravelly deposits in the Karai river course.

Considering from the matters mentioned above, the construction of concrete dam or fill-type dam in the Karai River course will be given up unavoidably from the standpoint of dam material.

3.7.4. Planning of Dam and Appurtenant Works by Hydrographs.

(1) General.

Judging from the monthly and daily river discharges during the period of 3 years observed in 1972 - 1974, the Ular River discharges are expected to be sufficient in quantity for the water requirement of irrigation side. Accordingly, the planning of dam will be focussed on the purpose of flood control.

Regarding to the proposed dams - Buaya Dam and Karai Dam - the planning of dam is made only for the case of Buaya dam since the Karai dam involves many disadvantageous factors as described below.

Disadvantageous points of Karai Dam compared with Buaya Dam are:

a. Foundation rock is not dependable.

b. Shortage of dam material.

c. Accessibility to the dam site is very difficult.

d. Construction cost is estimated to be expensive.

As for the dam type for Buaya dam site, the construction cost of fill-type dam, diversion tunnel and spillway is estimated to be 20% higher than that of the concrete dam with an overflow section, thus, the Buaya Dam is planned as a concrete gravity-type dam with an overflow section and a temporary diversion channel through dam body.

(2) Reservoir Capacity.

The maximum elevation of dam top is restricted to be as high as 85 m from the topographical conditions. Maximum H.W.L. of Buaya reservoir is planned to be EL. 83.50 m with a freeboard of 1.50 m on the one hand, L.W.L. of Buaya reservoir is settled to be EL. 73.00 m (elevation of center line of outlet pipe) on the other.

Resulting from the grain-size sieve analysis of material samples obtained from the riverbed, it is found that the 65% diameter of sediment particles is approximately 1.2 mm.

Considered from such distribution of grain-size, it is supposed that bed load deriving from upper reaches will be mostly flushed out through the large size (ϕ 3 m) outlet pipes to be equipped in the dam body.

As will be seen in the Fig.3-7-2, the gross reservoir capacity and the net reservoir capacity corresponding to H.W.L. of 83.50 m and L.W.L. of 73.00 mm are 27.50 x 10^6 m^3 and 21 x 10^6 m^3 respectively. Besides, this capacity curve was made using topographic map with the scale of 1/10,000.

(3) Flood Control Effect.

Evacuation of reservoir water is made by 2 outlet pipes (3 mϕ) and the spillway located on the central part of Buaya Dam and their capacities of evacuation are shown in the Fig.3-7-4.

Flood routing computation was made for 6 cases as described hereunder.

Case	Design flood	Peak discharge at Buaya Dam site	Peak discharge of Karai River	Combined outflow /1
	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)
I-A	1,200	852	348	632
I-B	1,200	647	553	671
II-A	1,000	706	294	539
II-B	1,000	538	462	573
III-A	800	559	241	358
III-B	800	428	372	473

Note: /1 Combined outflow = Outflow from Buaya reservoir + discharge of Karai River.

Flood control effects are shown in the Fig.3-7-6, Fig.3-7-7 and Fig.3-7-8 respectively.

Considering the discharge allocation for the various design floods, the required reservoir capacities corresponding to the design capacities of river channel were pursued and their results are as follows.

Combined case						
	Design flood (m^3/s)	Design discharge of river channel (m^3/s)	Outflow from reservoir plus discharge of Karai River (m^3/s)	Reservoir high water level (m)	Required reservoir capacity (10^6 m^3)	Remarks
(1)	800	600	590	80.50	12.50	
(2)	1,000	600	590	83.20	20.40	
(3)	1,000	800	790	81.00	14.00	
(4)	1,200	600	671>600	83.50	21.00	Beyond the reservoir control
(5)	1,200	800	790	82.60	18.50	
(6)	1,200	1,000	990	81.20	14.50	

(4) Appurtenant Works.

(i) Spillway and outlet pipe.

Design flood for spillway and outlet pipes is indicated in the following table.

Place	Flood (m^3/s)	Design flood (m^3/s)	Remarks
Bandar-Tiga	1,200 (100%)	1,600	design flood of Bandar-Tiga = past maximum flood x 2 = 800 x 2 = 1,600 m^3/s
Buaya dam site	852 (71%)	1,136	design flood at Buaya dam site = 1,600 x 0.71 = 1,136 m^3/s

Reservoir high-water levels corresponding to various floods are as follows:

Flood peak at dam site (m^3/s)	Reservoir high water level (m)
559	82.55
706	83.35
852	83.50
1,136	83.80

Should the flood peak is continued abnormally for long time, then, the reservoir water level would be EL. 84.20 m, in this case, the capacity check is made as follows: (see Fig.3-7-4)

evacuation from outlet pipes Q_1 = 435 m^3/s

evacuation from spillway Q_2 = 740 m^3/s

$Q = Q_1 + Q_2$ = 1,175 m^3/s > 1,136 m^3/s O.K.

(ii) Temporary diversion channel.

Design flood for temporary diversion channel during dam construction works is estimated based on the past maximum flood of 800 m^3/s, and thus, the design flood at the Buaya dam site is calculated as follows:

800 m^3/s = 700 m^3/s + 100 m^3/s

where,

800 m^3/s: past maximum flood of Ular River

700 m^3/s: flood discharge

100 m^3/s: basic discharge

then, the design flood at Buaya dam site is

$$Q = 700\ m^3/s \times 43.4\% \times 1.50 + 100\ m^3/s \times 43.4\%$$
$$= 455.70 + 43.40$$
$$= 499.10$$
$$\fallingdotseq 500\ m^3/s$$

Capacity check for diversion channel is as follows.

Semi-circle section with the diameter of 8 m is given.

$$Q = A \cdot V = A \cdot R^{2/3} \cdot \frac{1}{n} \cdot I^{1/2}$$

where,

$Q = 500\ m^3/s$

$A = 0.8715\ D^2$

$n = 0.015$

$I = 1/150$

here,

$$\frac{1}{n} \cdot I^{1/2} = 5.442$$

$R^{2/3} = 0.4352\ D^{2/3} = 0.4352 \times 4 = 1.74$

$A = 0.8715\ D^2 = 0.8715 \times 64 = 55.78$

then, $Q = 55.78 \times 1.74 \times 5.442 = 528\ m^3/s > 500\ m^3/s$ O.K.

3.7.5. General Plan.

Regarding to the general plan, we are intending herewith to explain on the maximum scale of dam as an instance since serveral heights of dam can be considered for the purpose of flood control.

(1) Main Dam.

Main dam is planned to dam up the Buaya river at the site locating about 5.60 km upstream from the confluence of the Buaya and Karai rivers with a catchment area of 44 km^2 and to create a reservoir with a gross capacity of 27,500,000 m^3.

Concrete gravity-type dam with a maximum height of 22.50 m and a volume of 52,000 m^3 is planned at the proposed site. The dam is divided into 3 parts - left side non-overflow section of 40 m, overflow section 200 m at the central part and right side non-overflow section of 10 m - and the crest length is as long as 250 m (see Fig.3-7-9).

(2) Secondary Dam.

Fill-type dam with a maximum height of 15 m and a volume of

60,000 m^3 is planned at the gouge shaped portion locating on the northern part of the main dam site with a direct distance of 1.50 km (see Fig.3-7-9).

(3) Spillway.

Spillway with a creast length of 200 m is provided at the central part of dam so as to enable to evacuate a reservoir water during the flood season. The crest of spillway consists of 2 parts - lower crest of EL. 82.50 m on both sides and higher crest of EL. 83.00 m at the center -, and a spilled out water is evacuated toward the downstream through a plunge pool provided at the dam toe (see Fig.3-7-9).

(4) Outlet Pipe.

2 outlet pipes with a diameter of 3 m are provided at the elevation of 73.00 m in the dam body. The outlet pipes are planned as a preventive measures so as to maintain a reservoir capacity as much as possible, in other words, an inflow at the Buaya dam can be evacuated to some extent through outlet pipes during the initial stage of flood, thus, the reservoir water level can be withheld, and as a result, the reservoir will be maintained with a competent capacity for the flood peak (see Fig.3-7-9).

(5) Temporary Diversion Channel.

For the purpose of reducing the construction cost, a diversion channel is provided temporarily in the dam body (Block No.10). The diversion channel with a diameter of 8 m - semi-circle section - will be plugged finally after it served the purpose. Prior to the plugging work, the river flow shall be shut with a stoplog to be equipped at the inlet portion.

3.7.6. Estimation of Construction Cost.

(1) Construction Cost.

Construction Costs for 6 cases are indicated in table 3-7-1.

Table 3-7-1 (1) Construction Cost

Case	Design flood	Design discharge of river channel	Over flow reservoir + discharge of Karai river	Reservoir high water level	Required reservoir capacity	Elevation of dam top	Construction cost	Remarks

	(m^3/s)	(m^3/s)	(m^3/s)	(m)	(10^6m^3)	(m)	(10^6Rp)
1	800	600	590	80.50	12.50	82.00	2,327
2	1,000	600	590	83.20	20.00	84.70	2,695
3	1,000	800	790	81.00	14.00	82.50	2,410
4	1,200	600	671	83.50	21.00	85.00	2,712
5	1,200	800	790	82.60	18.50	84.10	2,631
6	1,200	1,000	990	81.20	14.50	82.70	2,445

Among the above construction costs, the costs of (1), (4) and (5) were calculated in detail as indicated in the following tables, and the costs of (2), (3) and (6) were gotten from height-cost curve.

Table 3-7-1 (2) Estimated Construction Cost (dam top: EL 82 m) Case 1

Currency Equivalent : US$=415Rp

Item	Description	Cost (10^3Rp)	Foreign currency (SU$)	Local currency (10^3Rp)	Remarks
I. Direct					
(1)Land and Right		38,000	0	38,000	
(2)Dam	civil work	1,027,000	148,000	965,580	/1
(3)Construction equipment		452,000	1,062,000	11,270	/2
Sub-total		1,517,000	1,210,000	1,014,850	
II. Indirect Cost					
(1)Engineering & Administration	20 %	303,400	220,000	212,100	
(2)Construction Facilities		118,400	10,800	113,918	
Sub-total		421,800	230,800	326,018	
III. Contingencies					
(1)For Direct Cost	20 %	303,400	242,000	202,970	
(2)For Indirect Cost	20 %	84,360	46,160	65,203	
Sub-total		387,760	288,160	268,173	
IV. Construction Cost (I + II + III)		2,326,560	1,728,960	1,609,041	

/1 : Table 3-7-1 (5)

/2 : Depreciation and inland transportation cost

Reference:

Annual Cost = Amortization of initial investment + Maintenance and Administration
$= 108,082 \times 10^3 + 5,135 \times 10^3$
$= 113,217 \times 10^3$ Rp

/1: Table 3-7-2 (5).

/2: Depreciation and inland transportation cost.

Reference: Estimated Annual Cost (dam top: EL 82 m) Case 1.

(1) Amortization of initial investment.

Item	Initial investment (Rp)	f_{cr} */	Amortization (Rp)
Foreign currency	717,518,400	0.0634	45,490,666
Local currency	1,609,041,600	0.0389	62,591,718
Total	2,326,560,000		108,082,384

*/ : f_{cr} = capital recovery factor $= \frac{i\,(1+i)^n}{(1+i)^n - 1}$

where i : interest rate for F.C. = 6 %
interest rate for L.C. = 3 %
n : service life of dam = 50 years

then

for Foreign Currency $f_{cr} = \frac{1.10496}{17.416} = 0.0634$

for Local Currency $f_{cr} = \frac{0.13512}{3.384} = 0.0389$

(2) Maintenance and Administration cost.

= Construction Cost of dam x 0.5 %
= 1,027,000,000 Rp x 0.005
= 5,135,000 Rp

Annual Cost = (1) + (2) = $113,217 \times 10^3$ Rp

Table 3-7-1 (3) Estimated Construction Cost (dam top: EL 85 m) Case 4

Currency Equivalent : US$ = 415 Rp

Item	Description	Cost (10^3Rp)	Foreign currency (US$)	Local currency (10^3Rp)	Remarks
I. Direct Cost					
(1) Land and Right		45,000	0	45,000	
(2) Dam	Civil work	1,227,000	148,000	1,165,580	/1
(3) Construction equipment		501,735	1,179,000	12,450	/2
Sub-total		1,773,735	1,327,000	1,223,030	
II. Indirect Cost					
(1) Engineering & Administration	20 %	354,745	256,400	248,339	
(2) Construction Facilities		131,565	10,800	127,083	/3
Sub-total		486,310	267,200	375,422	
III. Contingencies					
(1) For direct cost	20 %	354,747	265,400	244,606	
(2) For indirect cost	20 %	97,262	53,440	75,084	
Sub-total		452,009	318,840	319,690	
IV. Construction Cost (I + II + III)		2,712,054	1,913,040	1,918,142	

Reference:

Annual Cost = Amortization of initial investment + Maintenance and Administration cost
$= 124,950 \times 10^3 + 6,135 \times 10^3$
$= 131,085 \times 10^3$ Rp

/1 : Table 3-7-1 (6)

/2 : Depreciation and inland transportation cost, Table 3-7-1 (7)

/3 : Table 3-7-1 (8)

Reference: Estimated Annual Cost (dam top: EL 85 m) Case 4.

Annual cost = Amortization of initial investment + Maintenance and Administration cost

(1) Amortization of initial investment.

Item	Initial investment (Rp)	f_{cr} */	Annual cost (Rp)	Remarks
Foreign currency	793,911,600	0.0634	50,333,995	US$-415Rp
Local currency	1,918,142,400	0.0389	74,615,739	
Total	2,712,054,000		124,949,734	

*/ : f_{cr} = capital recovery factor = $\frac{i\ (1+i)^n}{(1+i)^n - 1}$

where,

i : interest rate for F.C. = 6 %

interest rate for L.C. = 3 %

n : service life of dam = 50 years

then, for foreign currency $f_{cr} = \frac{1.10496}{17.416} = 0.0634$

for local currency $f_{cr} = \frac{0.13152}{3.384} = 0.0389$

(2) Maintenance and Administration cost

= Construction cost of dam x 0.5 %

= 1,227,000,000 x 0.005

= 6,135,000 Rp

Annual cost = (1) + (2)

= $124,950 \times 10^3 + 6,135 \times 10^3$

= $\underline{131,085 \times 10^3}$ Rp

Table 3-7-1 (4) Estimated Construction Cost (dam top: EL 84 m) Case 5

Currency Equivalent US$=415 Rp

Item	Descrip-tion	Cost (10^3Rp)	Foreign currency (US$)	Local currency (10^3Rp)	Remarks
I. Direct Cost					
(1) Land and Right		45,000	0	45,000	
(2) Dam	civil works	1,171,000	148,000	1,109,580	/1
(3) Construction equipment		501,735	1,179,000	12,450	/2
Sub-total		1,717,735	1,327,000	1,167,030	
II. Indirect Cost					
(1) Engineering & Administration	20 %	343,500	280,400	240,414	
(2) Construction Facilities		131,565	10,800	127,083	/3
Sub-total		475,065	259,200	367,497	
III. Contingencies					
(1) For direct cost	20 %	343,547	265,400	233,406	
(2) For indirect cost	20 %	95,013	51,840	73,499	
Sub-total		438,560	317,240	306,905	
IV. Construction Cost					
(I + II + III)		2,631,360	1,903,440	1,841,432	

Reference:

Annual Cost = Amortization of initial investment + Maintenance and Administration Cost

= $121,713 \times 10^3 + 5,855 \times 10^3$

= $127,568 \times 10^3$ Rp

/1: Table 3-7-1 (9)

/2: Table 3-7-1 (7)

/3: Table 3-7-1 (8)

Table 3-7-1 (5) Dam (dam top: EL 82 m) Case 1

Currency Equivalent US$=415Rp

Work Item	Unit	Quantity	Unit cost (Rp)	Cost (10^3Rp)	Foreign currency (US$)	Local currency (10^3Rp)
Clearing and stripping	m^2	60,000	20	1,200	0	1,200
Excavation open, common	m^3	138,500	400	55,400	0	55,400
Excavation open, rock	m^3	9,500	1,500	14,250	0	14,250
Embankment, 2ndary dam	m^3	47,000	750	35,250	0	35,250
Embankment, coffer dam	m^3	70,000	580	40,600	0	40,600
Grouting dam foundation	m	5,000	12,000	60,000	0	60,000
Concrete	m^3	42,600	14,000	596,400	0	596,400
Reinforcement bar	ton	170	180,000	30,600	0	30,600
Outlet pipe	ton	20	913,000	18,260	40,000	1,660
Stop-log	ton	40	1,245,000	49,800	108,000	4,980
Misc work	L.S.			83,240	0	83,240
Construction facilities	L.S.			42,000	0	42,000
Total				1,027,000	148,000	965,580

Table 3-7-1 (6) Dam (dam top: EL 85 m) Case 4

Currency Equivalent US$-415Rp

Work Item	Unit	Quantity	Unit cost (Rp)	Cost (10^3Rp)	Foreign currency (US$)	Local currency (10^3Rp)
Clearing and stripping	m^2	60,000	20	1,200	0	1,200
Excavation open, common	m^3	170,000	400	68,000	0	68,000
Excavation open, rock	m^3	12,000	1,500	18,000	0	18,000
Embankment, secondary dam	m^3	60,000	750	45,000	0	45,000
Embankment, coffer dam	m^3	70,000	580	40,600	0	40,600
Grouting dam foundation	m	6,000	12,000	72,000	0	72,000
Concrete	m^3	52,000	14,000	728,000	0	728,000
Reinforcement bar	ton	200	180,000	36,000	0	36,000
Outlet pipe	ton	20	913,000	18,260	40,000	1,660
Stop-log	ton	40	1,245,000	49,800	108,000	4,980
Misc. work	L.S.			100,140	0	100,140
Construction facilities	L.S.			50,000	0	50,000
Total				1,227,000	148,000	1,165,580

Table 3-7-1 (7) Estimated Construction Machinery and Equipment

Item	Capacity	Quantity	Unit price (US$)	Amount (US$)	Remarks
1. Gravel plant	50ton/hr	L.S.		500,000	
2. Batching plant	$1m^3$mixer 3sets	L.S.		150,000	
3. Cable crane	4.50 ton	2	230,000	460,000	
4. Diesel generator	60 KVA	10	12,000	120,000	
5. Compressor	125 KW	4	18,000	72,000	
6. Bulldozer	D7 class	6	80,000	480,000	
7. Power shovel	2 m^3	2	200,000	400,000	
8. Tractor shovel	2 m^3	4	50,000	200,000	
9. Dump truck	15 ton	10	46,000	460,000	
10. Dump truck	10 ton	15	23,000	345,000	
11. Truck	6 ton	10	12,000	120,000	
12. Truck crane	20 ton	1	100,000	100,000	
13. Grader	8 ton	1	30,000	30,000	
14. Trailer	30 ton	1	60,000	60,000	
15. Boring machine	15 P.S	3	12,000	36,000	
16. Grout mixer with pump	10 P.S	2	10,000	20,000	
17. Concrete pump	30 m^3/hr	1	57,000	57,000	
18. Truck mixer	3 m^3	3	20,000	60,000	
19. Road roller	10 ton	1	22,000	22,000	
20. Portable air compressor	110 P.S	1	15,000	15,000	
21. Fuel truck & grense car		2	18,000	36,000	
22. Other equipment				187,000	5%
Total				3,930,000	CIF

Yearly depreciation of equipment during 2 years construction period

(service life is 6 years) $= \dfrac{3,930,000 - 393,000 \text{ (residual)}}{6} \times 2$

$= 1,179,000$ US$

Inland transportation cost = 30 US$ x 1,000 ton

= 30,000 US$

= 12,450 x 10^3Rp

Table 3-7-1 (8) Estimated Construction Facilities

Currency Equivalent US$=415Rp

Item	Unit	Quantity	Unit cost (Rp)	Amount (10^3Rp)	Foreign currency (US$)	Local currency (10^3Rp)
1. Installation of gravel plant	L.S.			20,750	0	20,750
2. Installation of batching plant	L.S.			6,225	0	6,225
3. Installation of cable crane	L.S.			19,090	0	19,090
4. Permanent access road	m	1,000	20,000	20,000	0	20,000
5. Improvement of existing road	L.S.			30,000	0	30,000
6. Field office	m^2	500	15,000	7,500	0	7,500
7. Service facilities	L.S.			3,000	0	3,000
8. Engineering equipment	L.S.			5,000	10,800	518
9. Vehicle				20,000	0	20,000
Total				131,565	10,800	127,083

Table 3-7-1 (9) Dam (dam top: EL 84 m) Case 5

Currency Equivalent US$-415Rp

Work Item	Unit	Quantity	Unit cost (Rp)	Cost (10^3Rp)	Foreign currency (US$)	Local currency (10^3Rp)
1. Clearing and stripping	m^2	60,000	20	1,200	0	1,200
2. Excavation open, common	m^3	164,000	400	65,840	0	65,840
3. Excavation open, rock	m^3	11,400	1,500	17,100	0	17,100
4. Embankment, secondary dam	m^3	60,000	750	45,000	0	45,000
5. Embankment, coffer dams	m^3	70,000	580	40,600	0	40,600
6. Grouting dam foundation	m	6,000	12,000	72,000	0	72,000
7. Concrete	m^3	48,700	14,000	681,800	0	681,800
8. Reinforcement bar	ton	200	180,000	36,000	0	36,000

9. Outlet pipe	ton	20	913,000	18,260	40,000	1,660
10. Step-leg	ton	40	1,245,000	49,800	108,000	4,980
11. Misc. work	L.S.			95,900	0	95,900
12. Construction facilities	L.S.			47,500	0	47,500
Total				1,171,000	148,000	1,109,580

(2) Construction Plan.

(i) Preparation works.

Prior to the start of main construction works the existing road between Lubuk-Pakam and Sungai Karai shall be improved to some extent so as to facilitate the transportation of construction equipment and materials, and the existing bridge located neary Lembah Sari shall be reinforced by an appropriate means.

At access road from Sungai Karai to the right abutment of Buaya dam site shall be constructed newly, and the length of this acces road is estimated to be as long as 1 km.

Right bank area of the dam site is forming a wide flat land, accordingly, this area is expected to be a site proposed for base camps.

Installation of diesel plant, gravel plant, batching plant and cable crane shall be carried out in advance of the main construction works.

These preparation works will require some 6 months, therefore, the preparation works shall be started from September of the first year so as to enable to start a coffering work from the beginning of dry season (March of the 2nd year).

(ii) Main construction works.

a. Main dam.

First stage coffering - one-half of the river course - will be executed in the right-side area, and after completion of excavation and foundation grouting works therein, the placing of dam concrete will firstly be carried out up to the elevation of 78 m on the lowest block.

Following to the above construction works, the second stage coffering - left side of the river course - will be executed and from this stage, the river discharge is diverted into the temporary diversion channel provided through dam body. Thus, the execavation, foundation grouting and concrete works will be carried out in the left side area. In this area, the placing of dam concrete will be carried out up to the elevation of 78 m on the lowest block, and from that time, the concrete placing will finally be performed up to the final lift covering all blocks.

After completion of all concrete works and of clearing the reservoir area, the inlet of temporary diversion channel will be shut with stop-log, and then, the portion of diversion channel which belongs to dam body will be plugged with concrete.

Drilling work for the consolidation grouting will be made with wagon-type drilling machine, and for the curtain grouting, the drilling shall be made with boring machine. As for the work sequence, the consolidation grouting is made in advance of the curtain grouting.

Regarding to the concrete placing the preferable height of one lift and cycle time are 1.50 m and 4 days respectively, and the concrete placing shall be carried out in principle with cable crane.

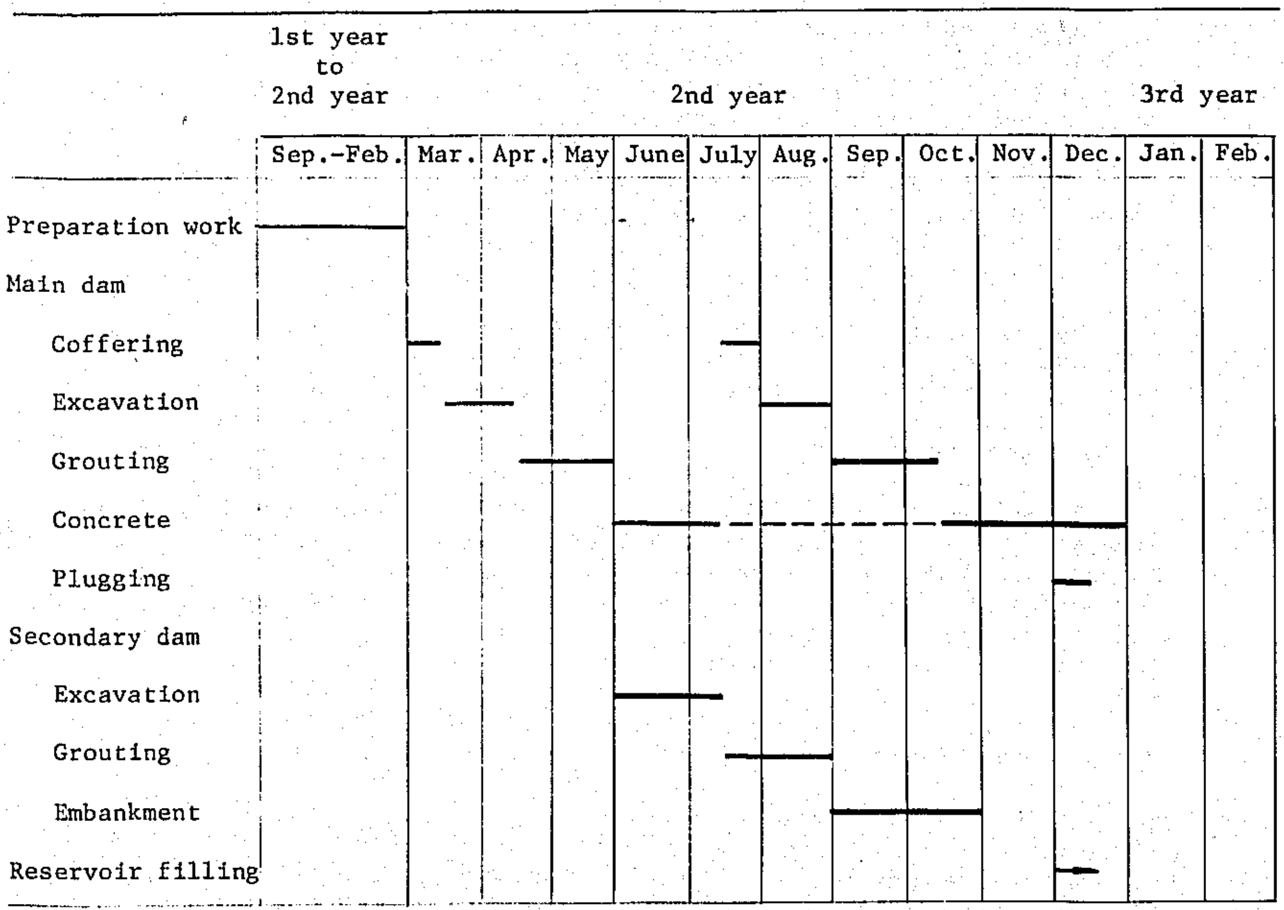
b. Secondary dam.

Fill-type which involves core zone, filter zone and shell zone is proposed for the secondary dam. The embankment of secondary dam shall be executed during the dry season. After completion of excavation and foundation grouting works, the embankment work shall be made maintaining the core zone in higher elevation than other zones so as to protect the core zone from muddy condition due to rainfall.

Besides, the brown coloured clayey soil observed on both banks of the secondary dam site is expected to be available for the core zone.

(3) Construction Program.

After the preparation works, the expected construction program for the main construction works will be as follows;



As will be seen in the above time schedule, the required construction period for the Buaya dam will be 17 months including the preparation works. And the construction costs for each fiscal year are estimated as below.

Case	Construction Cost (10^6 Rp)	Cost for 1st year (10^6 Rp)	Cost for 2nd year (10^6 Rp)
(1)	2,327	746	1,581
(2)	2,695	835	1,860
(3)	2,410	771	1,639
(4)	2,712	840	1,872
(5)	2,631	816	1,815
(6)	2,445	782	1,663

3.7.7. Potentiality of Exploitation of Water Resources by Dam.

In connection with the study of flood control by Buaya Dam, another study was made on the potentiality of exploitation of water resources by the dam represented by electric power production. Because, on other utility of water such as drinking water and industrial water, it is recommendable to make a study on another occasion together with a synthetic planning of regional development.

The present study on electric power production was made with regard to two cases. One is a case that electric power will be produced by use of the dam mentioned in the previous paragraphs, and the other one is a case that another dam for exclusive use for electric power production is planned at the same site as the former one.

(1) Potentiality of Electric Power Production by Buaya Dam Planned in the Previous Paragraphs.

Calculation of power production was made based on the monthly discharges at Buaya Dam site converted from those at Pulo-Tagor observed for three years from January 1972 to December 1974. The results are shown in Table 3-7-2, which gives only 6,500,000 kwh of annual power production with an installed capacity of 1,500 kw due to small reservoir capacity and low head. Accordingly, this dam seems to be unfeasible for producing electric power.

(2) Potentiality of Electric Power Production by an Exclusive Dam.

A dam to be used exclusively for electric power production was assumed at the same site as Buaya Dam mentioned previously and calculation was made of annual electric power production, construction cost and energy cost. The result gives 43 mills/kwh for annual average energy and 81 mills/kwh for annual firm energy, which seem to be too high from the economical viewpoint.

(i) Layout of dam, spillway and power station.

Resulted from the construction cost comparison made on two dam-types-concrete dam and fill-type dam - the concrete dam with overflow section was justified to be superior to the fill-type dam, thus, the Buaya power station was planned to have a concrete dam. (See: Fig.3-7-7, Buaya Dam and Power Station)

Buaya dam will be designed as a gravity type concrete dam with an effective storage capacity of 21 x 10^6 m^3 and a top height of EL 85 m. For the purpose of reducing the constructin cost, a diversion channel is provided temporarily in the dam body and after the diversion channel served the purpose, the upper half section of the channel is utilized as a headrace.

Three (3) spillways - left side spillway, gated spillway at the central part and right side spillway - are planned to evacuate a flood discharge of 1136 m^3/s at the reservoir water level of 84.30 m and the location of power house is proposed at the downstream side dam toe.

Table 3-7-2 Annual Electric Power Production

		(1)	(2)	(3)	(4)	
Year	Month	Hours	Discharge (m^3)	Net head (m)	Load factor	Monthly k.w.h. = 8.46x(1)x(2)x(3)x(4)
1972	1	744	23.2	5.30	0.70	541,758
	2	696	22.7	5.30	0.70	495,883
	3	744	21.1	5.20	0.70	483,423
	4	720	24.7	5.40	0.70	568,711
	5	744	24.7	5.40	0.70	587,668
	6	720	21.9	5.25	0.70	490,235
	7	744	16.2	5.10	0.70	364,021
	8	744	14.5	5.00	0.70	319,433
	9	720	18.5	5.15	0.70	406,237
	10	744	23.4	5.30	0.70	546,428
	11	720	28.1	5.40	0.70	646,955
	12	744	27.0	5.40	0.70	642,390
(Sub-total)						(6,093,182)
	1	744	25.6	5.35	0.70	603,441
	2	672	18.0	5.15	0.70	368,907
	3	744	22.4	5.30	0.70	523,077
	4	720	25.3	5.35	0.70	577,132
	5	744	23.0	5.30	0.70	537,087
	6	720	24.5	5.40	0.70	564,106
	7	744	21.0	5.20	0.70	481,132
	8	744	20.5	5.20	0.70	469,676
	9	720	22.4	5.30	0.70	506,203
	10	744	26.3	5.35	0.70	619,942
	11	720	25.5	5.35	0.70	581,694
	12	744	30.0	5.70	0.70	753,421
(Sub-total						(6,585,818)

Year	Month	(1) Hours	(2) Discharge (m^3)	(3) Net head (m)	(4) Load factor	Monthly k.w.h. = 8.46x(1)x(2)x(3)x(4)
1974	1	744	30.0	5.55	0.70	733,594
	2	672	30.0	5.50	0.70	656,631
	3	744	20.7	5.20	0.70	474,258
	4	720	20.9	5.20	0.70	463,394
	5	744	21.0	5.20	0.70	481,132
	6	720	19.6	5.20	0.70	434,571
	7	744	19.9	5.20	0.70	455,930
	8	744	20.2	5.20	0.70	462,803
	9	720	28.4	5.40	0.70	653,903
	10	744	26.5	5.35	0.70	642,656
	11	720	27.3	5.40	0.70	628,575
	12	744	21.3	5.20	0.70	488,005
(Sub-total)						(6,577,452)

Mean annual electric power production $= \frac{19,236,452}{3} = 6,412,151$

$\fallingdotseq$ 6,400,000 kwh/year

Installed capacity (kw) = 9.8 Q·H·y

where Q: discharge (m^3)

H: net head (m)

y: Combined efficiency of turbine and generator

Q, H and y are estimated to be 30 m , 5.50 m and 0.86 respectively, then

Installed capacity = 9,8 x 30 x 5.50 x 0.86
= 1,390
$\fallingdotseq$ 1,400 kw (1 unit x 1,400 kw)

(ii) Power station and electric power production.

The power station will be designed for normal effective head of 12 m, available reservoir draw down of 10.50 m and maximum power discharge of 30 m^3/s. One vertical shaft Kaplan turbine of 3,000 kw and one generator of 3,300 KVA will be installed in the power house.

Reservoir operation rule of Buaya dam was made based on the monthly discharges at Buaya damsite converted from the monthly discharges at Pulo-Tagor observed during 3 years (Jan. 1972 - Dec. 1974) as figured on the Fig.3-7-8.

Annual average energy and firm energy to be produced at the power station will be 14.50 Gwh and 7.70 Gwh respectively as will be seen in the Table 3-7-3.

(iii) Construction cost and energy cost.

Table 3-7-4 shows the estimated construction cost and annual energy cost of Buaya power station and Tables 3-7-5, 3-7-6 and 3-7-7 show the itemized costs for dam, power station and permanent equipment. Overall work outlays, exclusive of transmission lines, are estimated to reach 3,700 million Rp as shown in Table 3-7-4.

As for the annual cost, a service life is 50 years and an annual interest rat e is assumed as 10%, then, the ratio of the annual expense to the construction cost is estimated 7%, thus, the energy costs are calculated as follows:

$$\text{Energy Cost for Annual Average} = \frac{624,000\ \text{US\$}}{14,465,000\ \text{kwh}} = 43$$

$$\text{Energy Cost for Annual Firm} = \frac{624,000\ \text{US\$}}{7,689,000\ \text{kwh}} = 81$$

(iv) Conclusion.

In consequence of the studies mentioned as above, it is not advisable to construct the Buaya dam for the purpose of electric power supoly since the proposed dam has small storage capacity and an available head is very low.

Table 3-7-3 Annual Electric Power Production

Year	Month	(1) Hours	(2) Discharge (m^3)	(3) Net head (m)	(4) Load factor	k.w.h. = 8.46 x(1)x(2)x(3)x(4)
1972	1	744	23.2	14.8	0.7	8.46 x 178,822 = 1,513,000
	2	696	23.2	14.4	0.7	8.46 x 162,764 = 1,377,000
	3	744	23.2	12.4	0.7	8.46 x 149,824 = 1,268,000
	4	720	23.2	13.8	0.7	8.46 x 161,361 = 1,365,000
	5	744	23.2	15.1	0.7	8.46 x 182,447 = 1,544,000
	6	720	23.2	14.2	0.7	8.46 x 166,038 = 1,405,000
	7	744	18.0	12.4	0.8	8.46 x 132,849 = 1,124,000
	8	744	18.0	7.2	0.8	8.46 x 77,138 = 653,000
	9	720	18.0	8.3	0.8	8.46 x 86,054 = 728,000
	10	744	23.2	8.6	0.8	8.46 x 118,754 = 1,005,000
	11	720	25.0	12.4	0.7	8.46 x 156,240 = 1,322,000
	12	744	25.0	14.4	0.7	8.46 x 187,488 = 1,586,000
(Sub-total)						(14,890,000)
1973	1	744	25.0	14.8	0.7	8.46 x 192,696 = 1,630,000
	2	672	23.2	10.0	0.8	8.46 x 124,723 = 1,055,000
	3	744	23.2	8.7	0.8	8.46 x 120,723 = 1,016,000
	4	720	23.2	11.4	0.7	8.46 x 133,298 = 1,128,000
	5	744	23.2	11.1	0.7	8.46 x 134,116 = 1,135,000
	6	720	23.2	12.7	0.7	8.46 x 148,499 = 1,256,000
	7	744	22.0	11.4	0.7	8.46 x 130,617 = 1,105,000
	8	744	23.2	7.8	0.8	8.46 x 107,707 = 911,000
	9	720	23.2	6.0	0.8	8.46 x 80,179 = 678,000
	10	744	23.2	11.1	0.7	8.46 x 134,116 = 1,135,000
	11	720	29.0	5.1	0.8	8.46 x 85,190 = 721,000
	12	744	31.0	15.1	0.6	8.46 x 208,960 = 1,768,000
(Sub-total)						(13,538,000)

Year	Month	(1) Hours	(2) Discharge (m^3)	(3) Net head (m)	(4) Load factor	k.w.h. = 8.46 x(1)x(2)x(3)x(4)
1974	1	744	31.0	8.7	0.7	8.46 x 140,460 = 1,188,000
	2	672	23.2	12.4	0.7	8.46 x 135,325 = 1,145,000
	3	744	20.0	13.1	0.7	8.46 x 136,450 = 1,154,000
	4	720	20.0	13.9	0.7	8.46 x 140,112 = 1,185,000
	5	744	20.0	14.8	0.7	8.46 x 154,157 = 1,304,000
	6	720	20.0	14.4	0.7	8.46 x 145,152 = 1,228,000
	7	744	20.0	14.4	0.7	8.46 x 149,990 = 1,269,000
	8	744	23.2	11.4	0.7	8.46 x 137,741 = 1,165,000
	9	720	28.0	11.9	0.7	8.46 x 167,933 = 1,421,000
	10	744	28.0	10.0	0.7	8.46 x 145,824 = 1,234,000
	11	720	23.2	14.2	0.7	8.46 x 166,038 = 1,405,000
	12	744	23.2	12.4	0.7	8.46 x 149,824 = 1,268,000
(Sub-total)						(14,966,000)

Annual Average Energy = 43,394,000/3 = 14,465,000 kwh

Annual Firm Energy = 653,000/31 x 365 = 7,689,000 kwh

Installed Capacity(kw)= 9.8 Q.H.y

= 9.8 x 30 x 12 x 0.86

= 3,000 kw

Table 3-7-4 Construction Cost and Energy Cost
(Buaya Power Station)

Currency Equivalent: US$1 = Rp 415

Item	Description	Cost (10^3 Rp)	Foreign currency (U.S.$)	Local currency (10^3 Rp)	Remarks
I. Direct Cost					
(1) Land and Right		45,000	0	45,000	
(2) Dam	Civilwork	1,252,600	64,800	1,225,708	see Table 3-7-4
(3) Power house	Civilwork	125,100	0	125,100	" 3-7-5
(4) Permanent Equipment		484,764	1,051,000	48,599	" 3-7-6
(5) Construction Equipment		551,540	1,296,000	13,700	depreciation and inland transportation
Sub-total		2,459,004	2,411,800	1,458,107	
II. Indirect Cost					
(1) Engineering & Administr-ation	20 %	491,800	355,400	344,309	
(2) Construction Facilities		131,565	10,800	127,083	
Sub-total		623,365	366,200	471,392	
III. Contingencies					
(1) For Direct Cost	20 %	491,800	482,400	291,604	
(2) For Indirect Cost	20 %	124,600	73,200	94,222	
Sub-total		616,400	555,600	385,826	
IV. Construction Cost		3,698,769	3,333,600	2,315,325	

Annual Cost = Amortization of initial investment + Maintenance and Operation + Administration
= Construction Cost x 7%
= 3,698,796 x 0.07
= 258.900 x 10^3 Rp or 624 x 10^3 US$

Energy Cost for Annual Average $= \frac{624,000 \text{ US\$}}{14,465,000 \text{ kwh}} = 43$ mills US$/kwh

Energy Cost for Annual Farm $= \frac{624,000 \text{ US\$}}{7,689,000 \text{ kwh}} = 81$ mills US$/kwh

Table 3-7-5 Dam (dam top; EL. 85 m)

Currency Equivalent: US$1 = Rp 415

Work Item	Unit	Quantity	Unit Cost (Rp)	Amount (10^3 Rp)	Foreign currency (U.S.$)	Local currency (10^3 Rp)
Clearing and stripping	m^2	60,000	20	1,200	0	1,200
Excavation open, common	m^3	170,000	400	68,000	0	68,000
Excavation open, rock	m^3	12,000	1,500	18,000	0	18,000
Embankment, 2ndary dam	m^3	60,000	750	45,000	0	45,000
Embankment, Coffer dams	m^3	70,000	580	40,600	0	40,000
Grounting dam foundation	m	6,000	12,000	72,000	0	72,000
Concrete	m^3	55,000	14,000	770,000	0	770,000
Reinforcement bar	ton	250	180,000	45,000	0	45,000
Stop-log	ton	24	1,245,000	29,880	64,800	2,988
Misc, work	L.S.			108,920	0	108,920
Construction facilities	L.S.			54,000	0	54,000
Total				1,252,600	64,000	1,225,708

Table 3-7-6 Power Station (Installed Capacity: 3,000 kw)

Currency Equivalent: US$1 = Rp 415

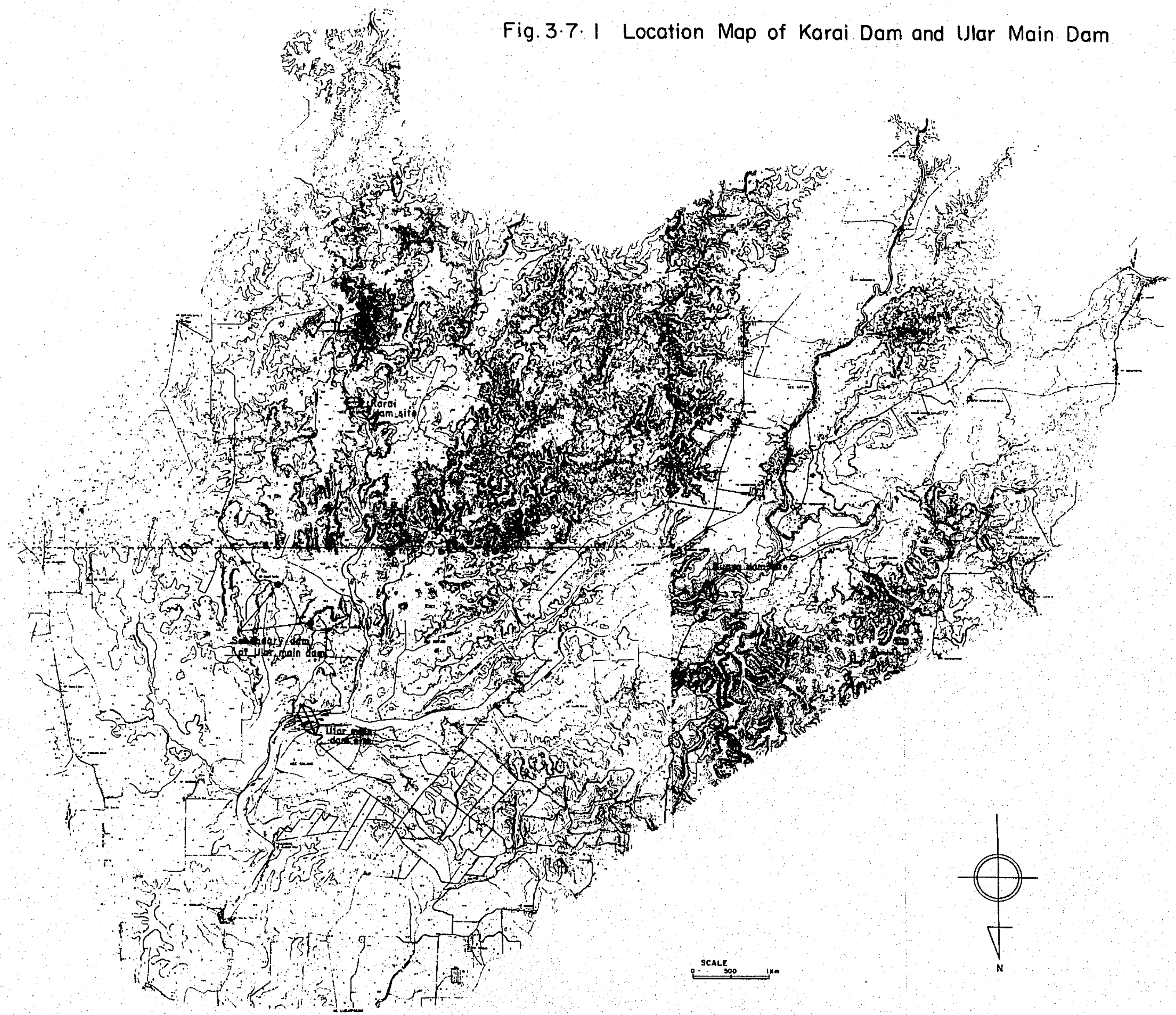
Work Item	Unit	Quantity	Unit Cost (Rp)	Amount (10^3 Rp)	Foreign currency (U.S.$)	Local currency (10^3 Rp)
Excavation open, common	m^3	8,100	400	3,240	0	3,240
Excavation open, rock	m^3	900	1,500	1,350	0	1,350
Banking	m^3	3,100	200	620	0	620
Concrete	m^3	5,000	14,000	70,000	0	70,000
Reinforcement bar	ton	150	180,000	27,000	0	27,000
Architechtural work	L.S.			7,000	0	7,000
Misc. work	L.S.			10,890	0	10,890
Construction facilities	L.S.			5,000	0	5,000
Total				125,100	0	125,100

Table 3-7-7 Permanent Equipment

Currency Equivalent: US$ = Rp 415

Item	Unit	Quantity	Unit Cost (Rp)	Amount (10^3 Rp)	Foreign currency (U.S.$)	Local currency (10^3 Rp)
Spillway gate (roller gate 9mx13m)	ton	110	1,826,000	200,860	435,600	20,086
Intake gate Sluice gate 4mx4.50m)	ton	12	1,826,000	21,912	47,400	2,241
Tailrace gate Sluice gate 4mx3m)	ton	8	1,826,000	14,608	31,600	1,494
Penstock (¢4m-¢2m, 40m)	ton	18	913,000	16,434	35,600	1,660
Steel grating	ton	10	685,000	6,850	14,800	807
Electrical equipment (including switchyard)	L.S.			224,100	486,000	22,410
Total				484,764	1,051,000	48,599

Fig. 3·7·1 Location Map of Karai Dam and Ular Main Dam



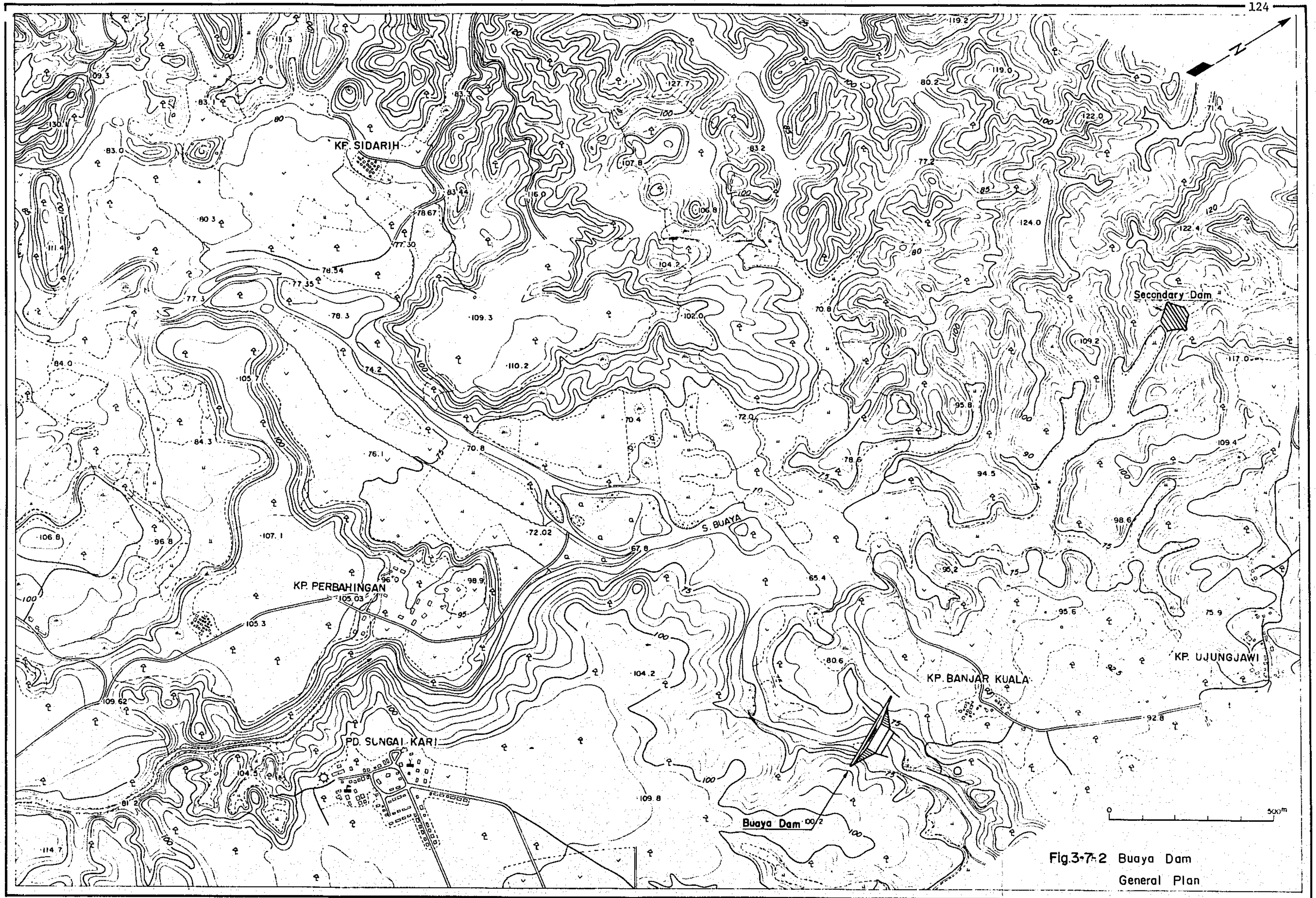


Fig.3-7-2 Buaya Dam General Plan

Fig. 3-7-3 Karai Dam General Plan

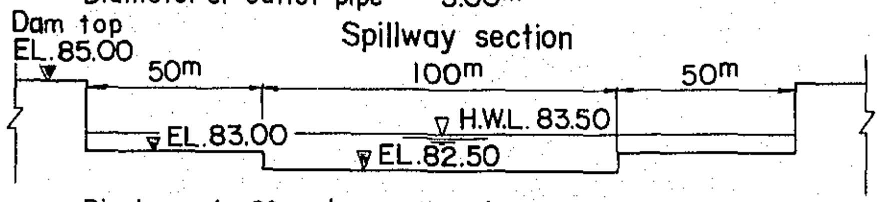
Fig. 3-7-4 Discharge Curve of Outlet Pipe and Spillway

Formula

for spillway $Q_2 = CBH^{3/2}$

for outlet pipe $Q_1 = \frac{A}{1.2}\sqrt{2gh}$ in the case of pipe flow

Elevation of outlet pipe at the center line = 73.00m
Number of outlet pipe = 2 nos
Diameter of outlet pipe = 3.00m



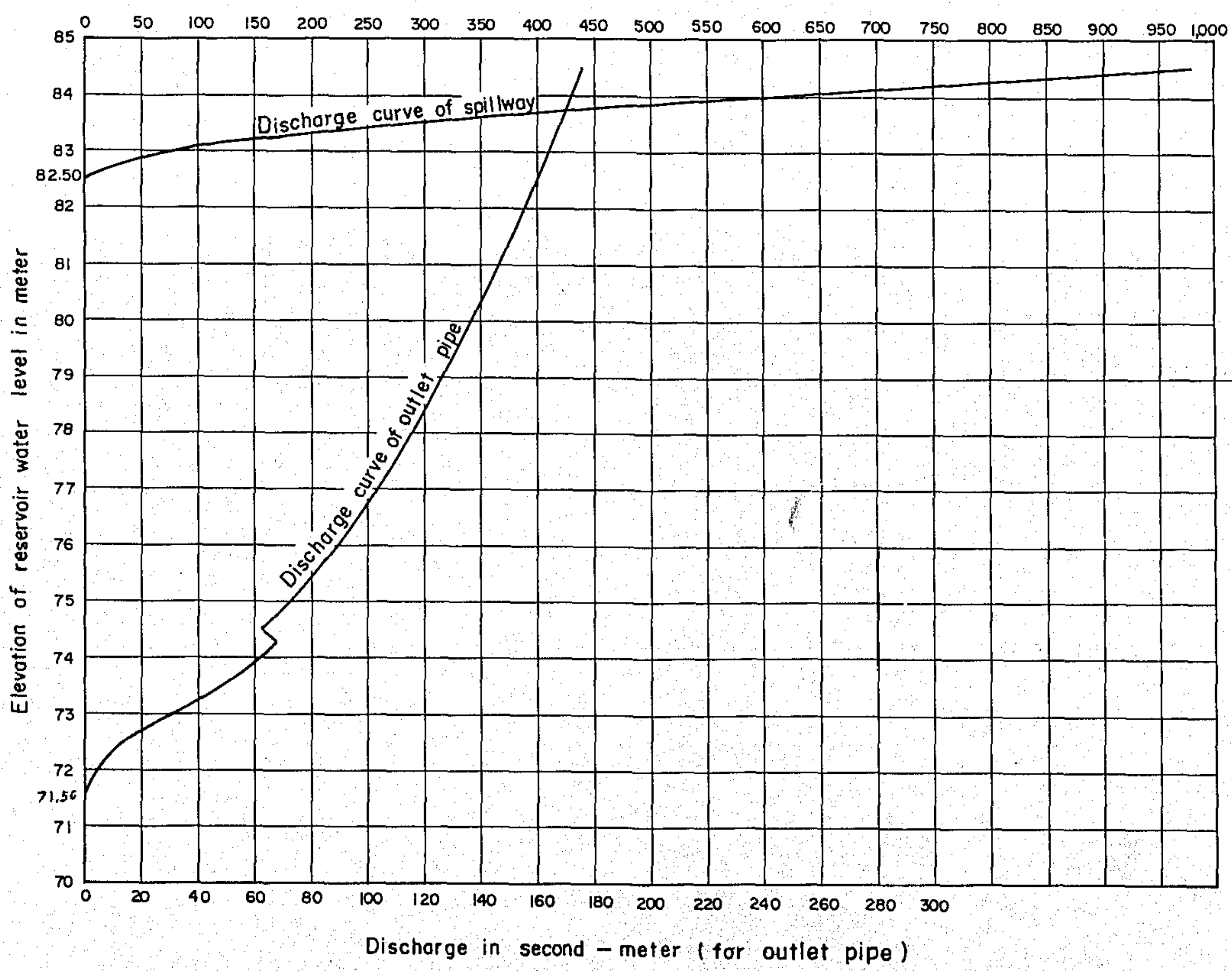


Fig. 3-7-5 Capacity Curve of Buaya Reservoir

H.W.L. = EL. 83.50m
L.W.L. = EL. 73.00m
Reservoir capacity = 21 x $10^6 m^3$

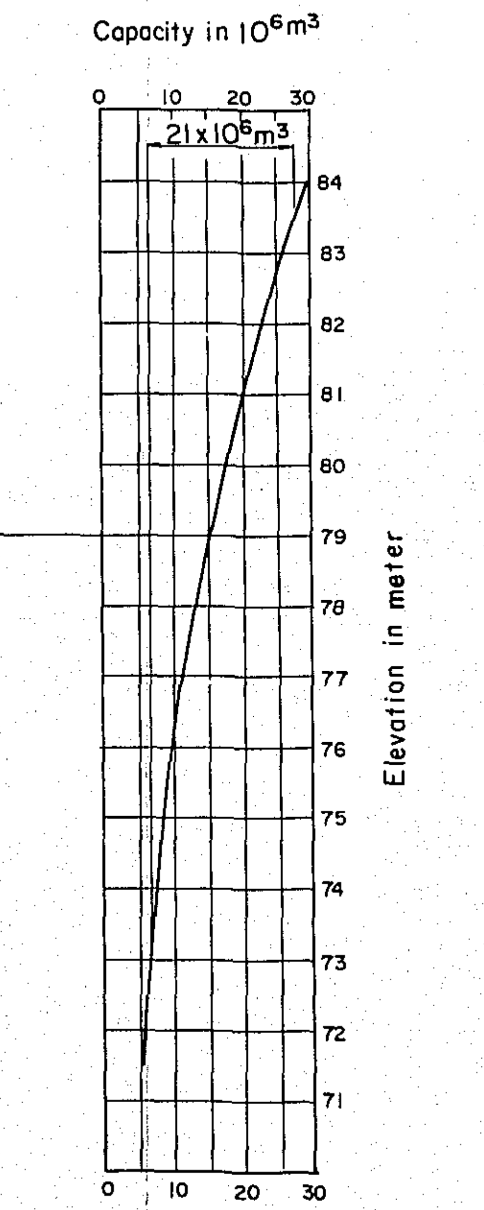
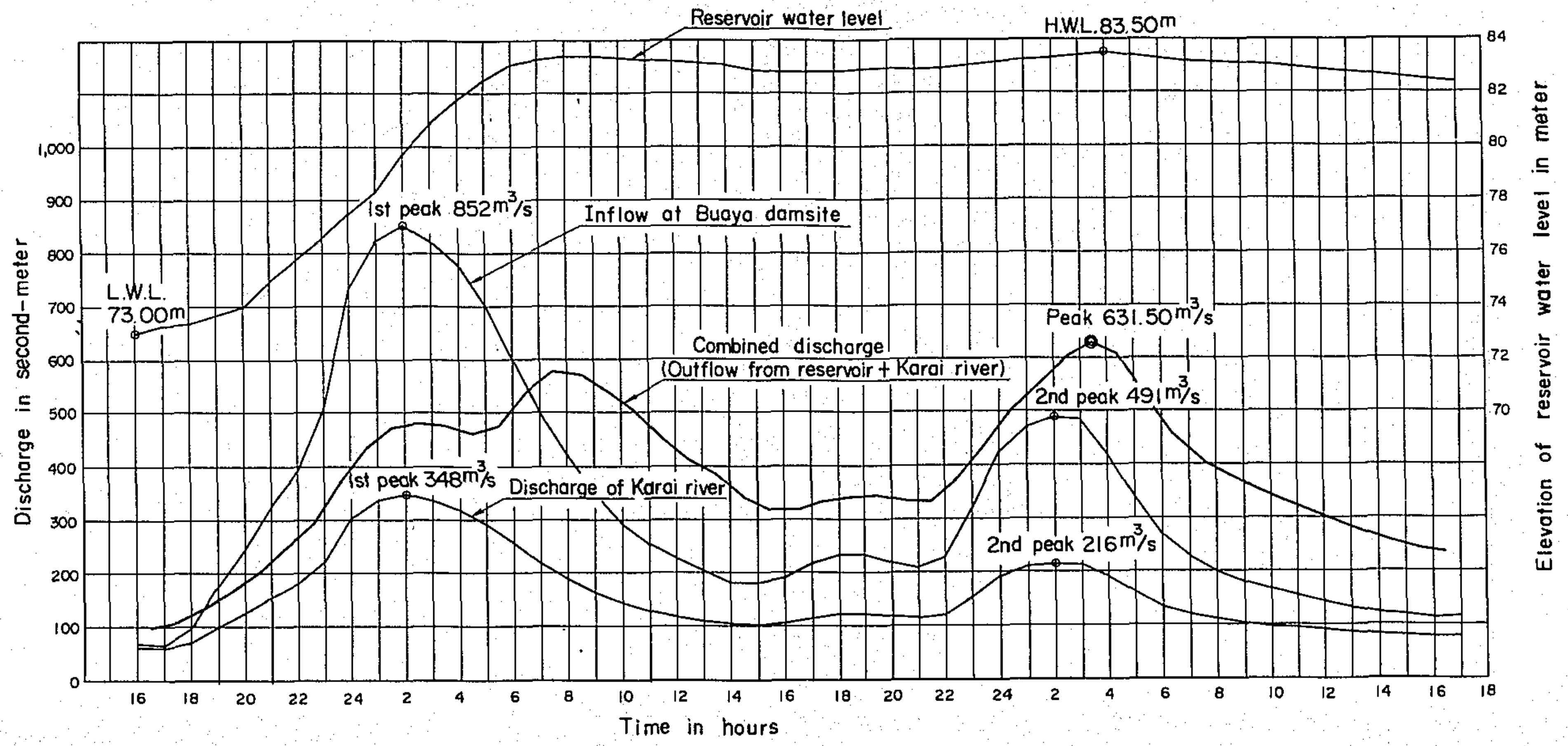


Fig.3-7-6 Flood Control by Buaya Dam



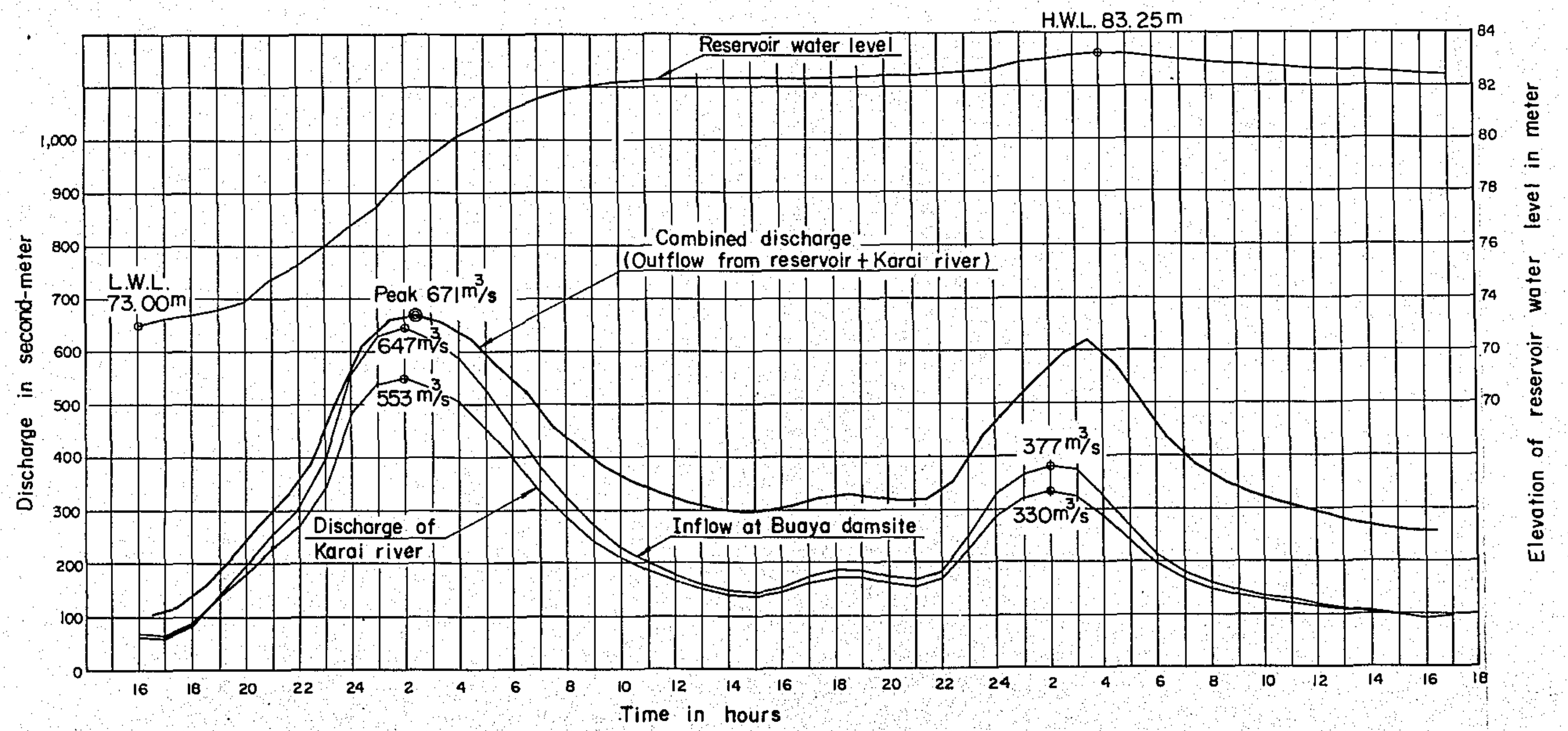
Case I - A

Design flood = 1,200 m³/s

Peak discharge
at Buaya damsite = 852 m³/s

Peak discharge
of Karai river = 348 m³/s

H.W.L. = EL.83.50m
L.W.L. = EL.73.00m
Reservoir capacity = 21 x 10^6 m³



Case I - B

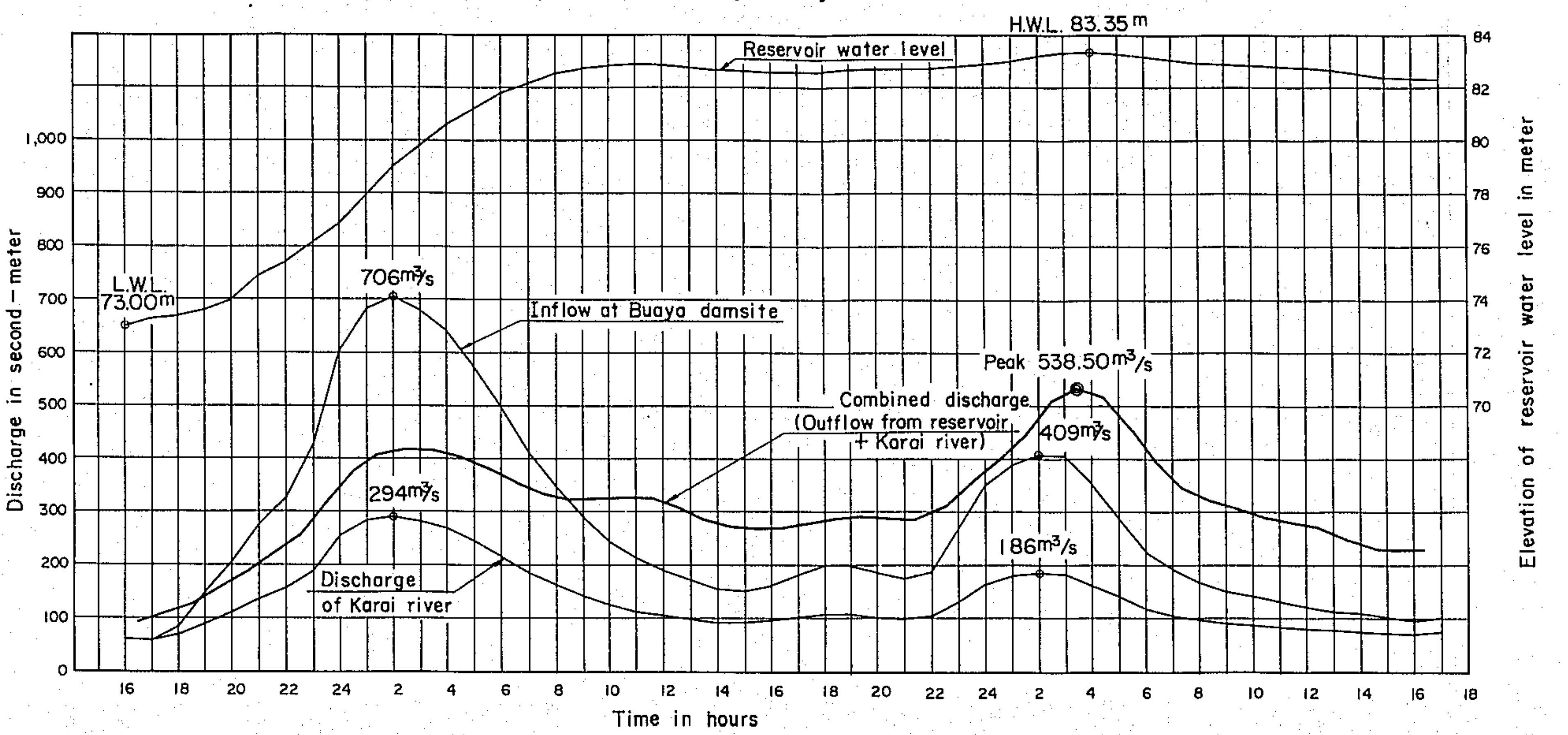
Design flood = 1,200 m³/s

Peak discharge
at Buaya damsite = 647 m³/s

Peak discharge
of Karai river = 553 m³/s

H.W.L. = EL.83.25m
L.W.L. = EL.73.00m
Reservoir capacity = 19.90 x 10^6 m³

Fig.3-7-7 Flood Control by Buaya Dam



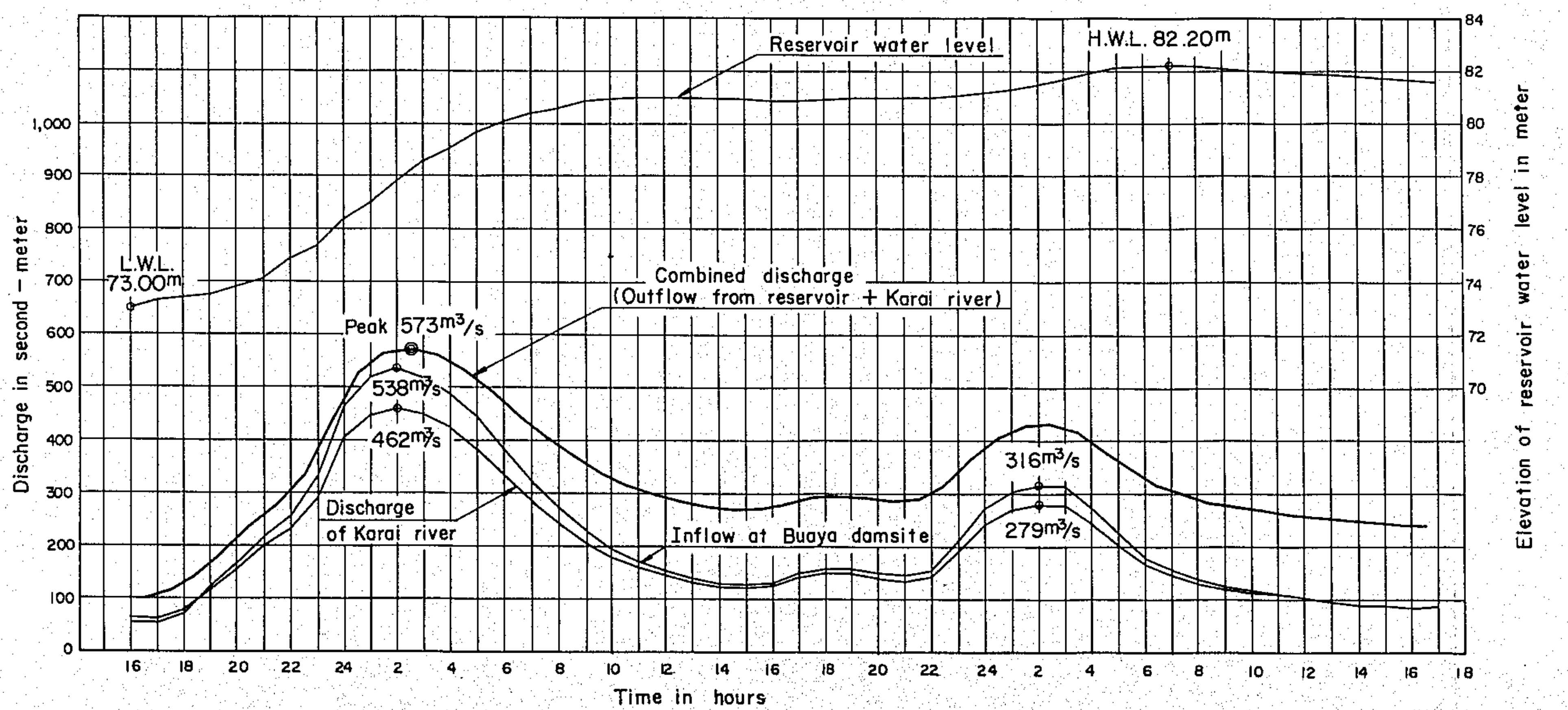
Case II - A

Design flood = 1,000m³/s

Peak discharge at Buaya damsite = 706m³/s

Peak discharge of Karai river = 294m³/s

H.W.L = EL. 83.35m /s
L.W.L. = EL. 73.00m
Reservoir capacity = 20[10] x 10⁶m³



Case II - B

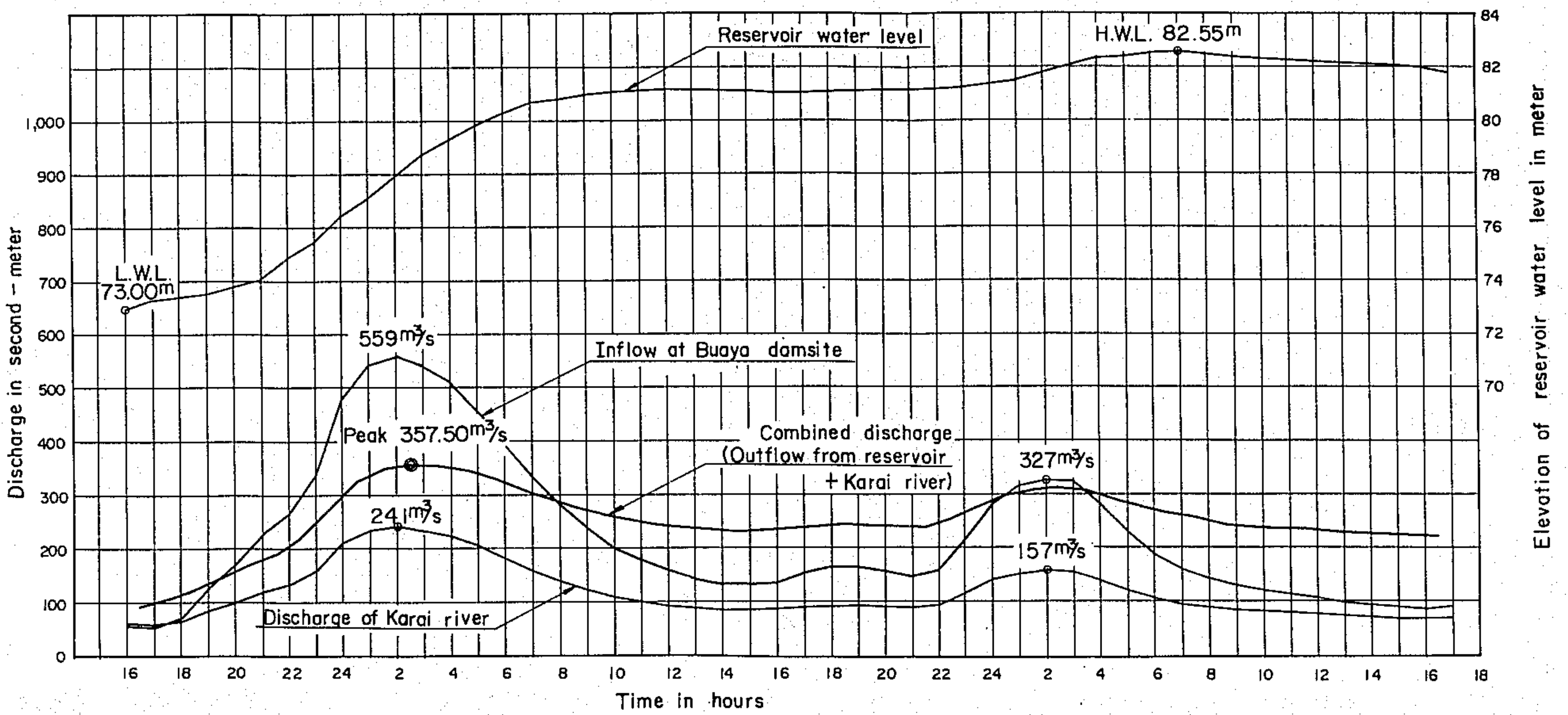
Design flood = 1,000m³/s

Peak discharge at Buaya damsite = 538m³/s

Peak discharge of Karai river = 462m³/s

H.W.L. = EL. 82.20m
L.W.L. = EL. 73.00m
Reservoir capacity = 16[90] x 10⁶m³

Fig.3-7-8 Flood Control by Buaya Dam



Case Ⅲ - A

Design flood = $800 m^3/s$

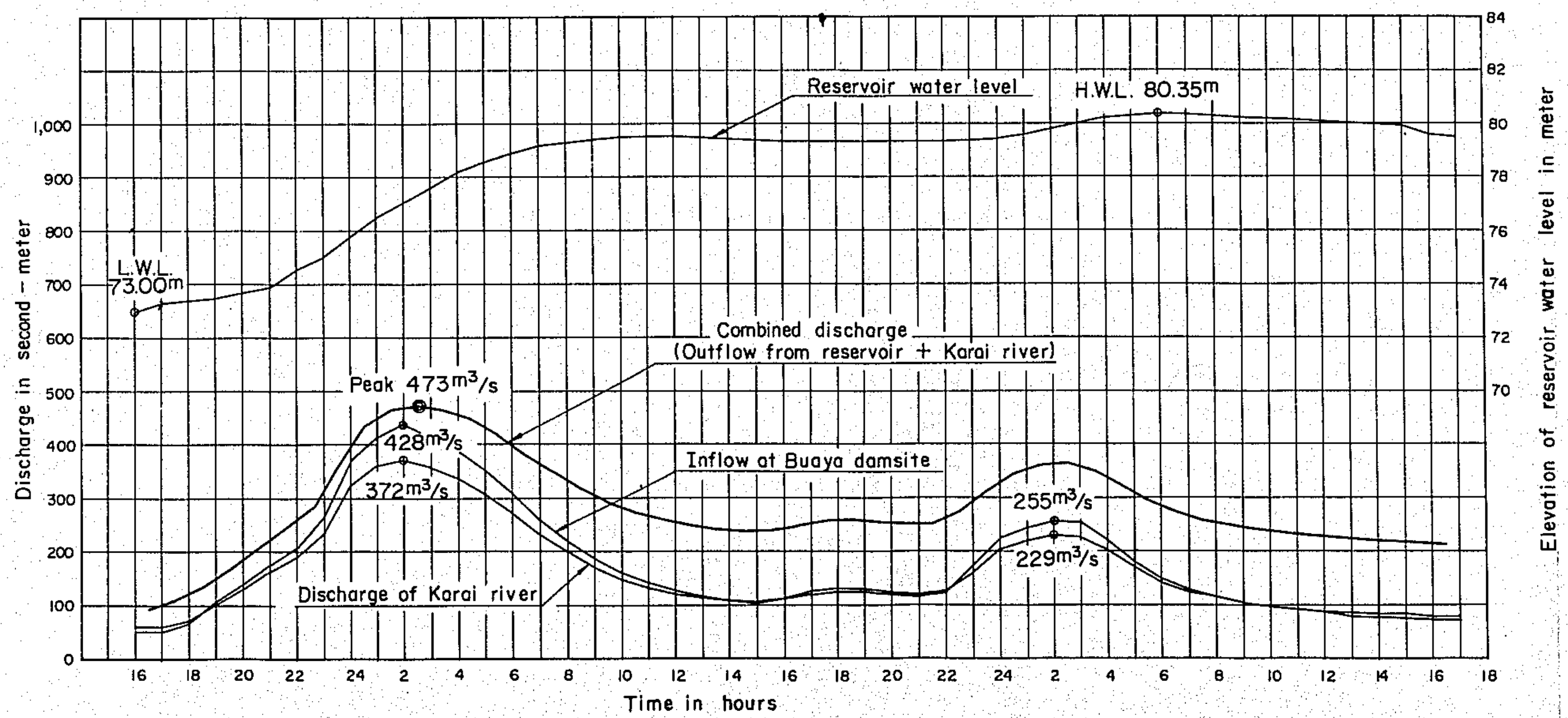
Peak discharge at Buaya damsite = $559 m^3/s$

Peak discharge of Karai river = $241 m^3/s$

H.W.L.= EL. 82.55m

L.W.L.= EL. 73.00m

Reservoir capacity = $17^{90} \times 10^6 m^3$



Case Ⅲ - B

Design flood = $800 m^3/s$

Peak discharge at Buaya damsite = $428 m^3/s$

Peak discharge of Karai river = $372 m^3/s$

H.W.L.= EL. 80.35m

L.W.L.= EL. 73.00m

Reservoir capacity = $12^{20} \times 10^6 m^3$

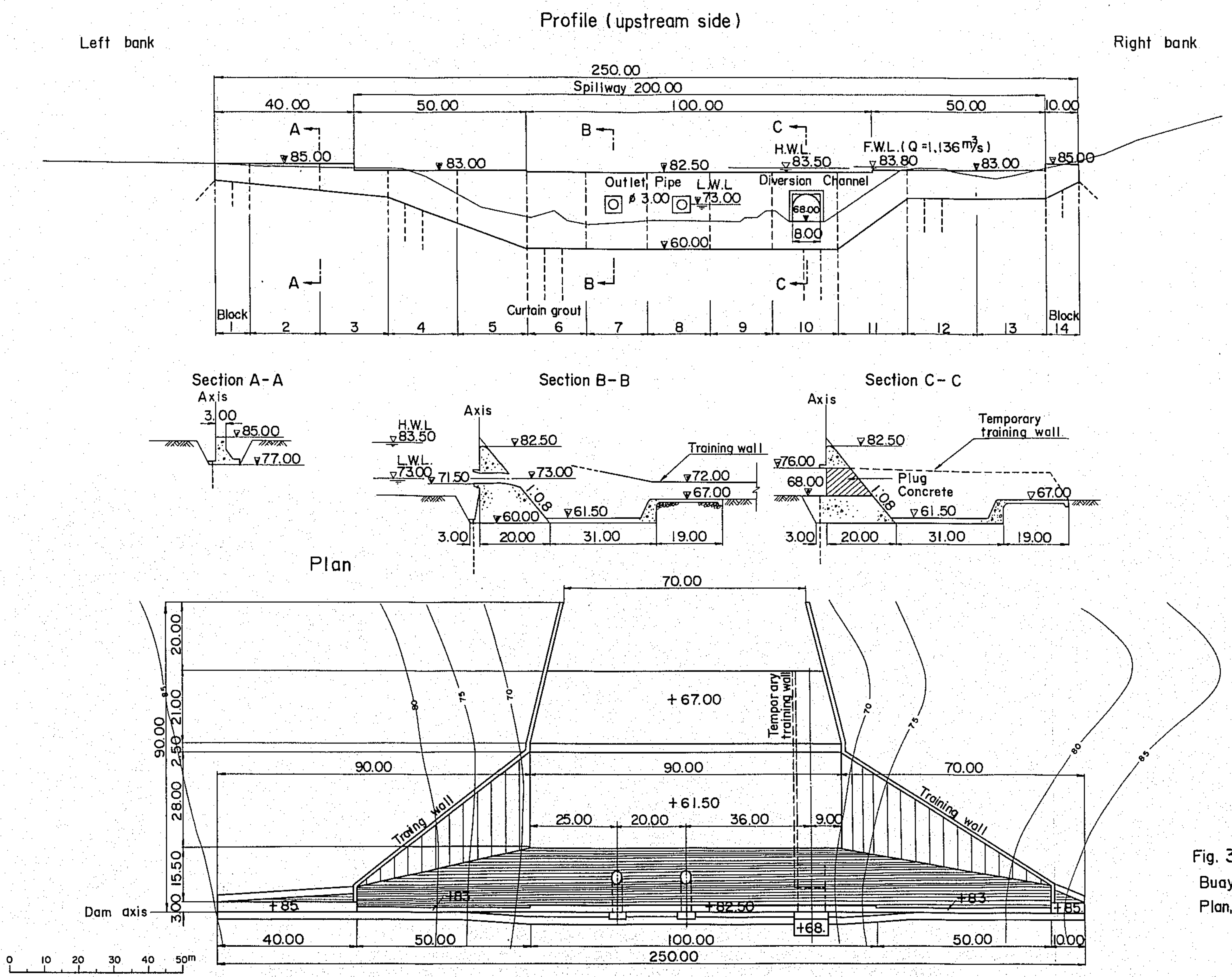


Fig. 3-7-9
Buaya Dam
Plan, Profile & Section

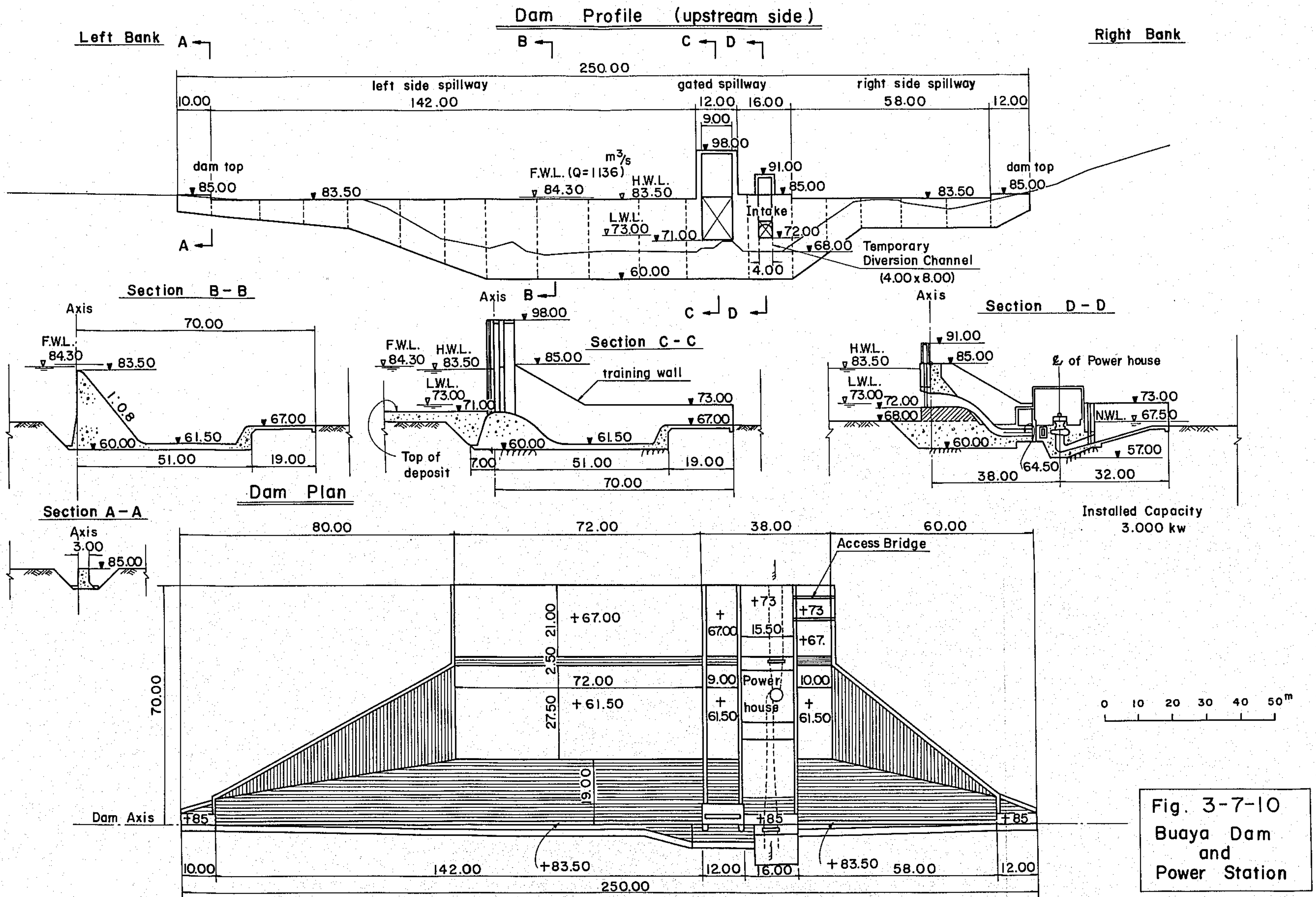
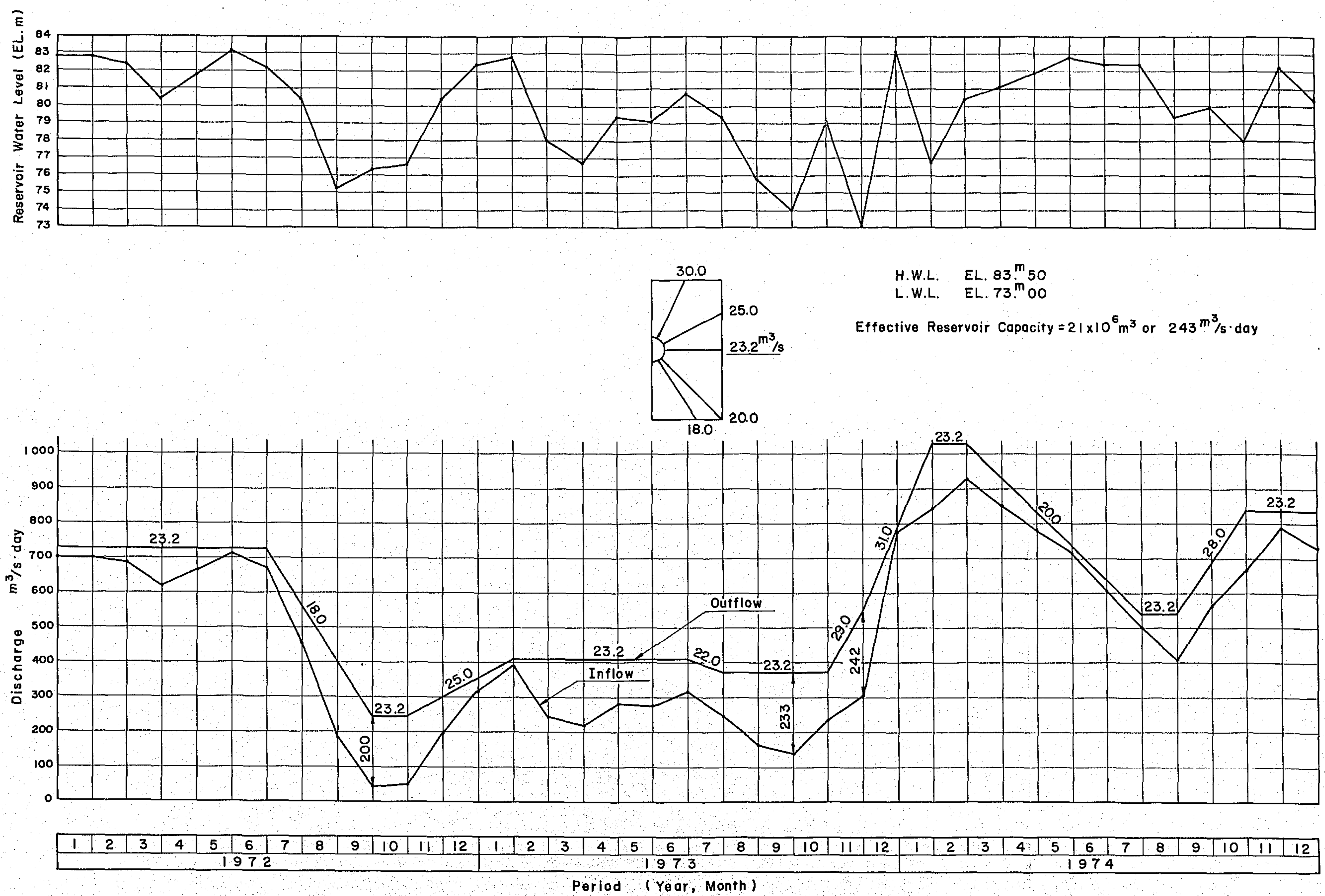


Fig. 3-7-10 Buaya Dam and Power Station

Fig. 3-7-11 Mass Curve of Buaya Reservoir



3.8. Allocation of Flood Discharge.

Three kinds of measures can be taken for flood control; the first one is river-channel improvement so as to enable to carry the flood discharge without construction of dam, the second one is construction of dam so as to enable to regulate the flood discharge without any improvement of river-channel, and the third one is combination of the above two. Among them, the second measure has no meaning in the present study because start has already been made with the improvement work of the lower reaches downstream from Ular Bridge at the design discharge of 600 m^3/s following the Urgent Flood Control Project and accordingly this work must be continued as the lowest level of river-channel improvement. Therefore, it is necessary to study the two measures for flood control, that is, flood control by river-channel improvement alone with regard to flood discharges larger than 600 m^3/s and flood control by the combination of flood regulation by dam and river-channel improvement for discharges larger than 600 m^3/s.

For improvement of river channel were assumed four kinds of discharges; 600 m^3/s, 800 m^3/s, 1,000 m^3/s and 1,200 m^3/s. As was mentioned previously in Section 3.5, construction costs were estimated for each case of the four discharges. This is shown in Table 3-8-1, in which, however, the invested costs for the Urgent Project, Rp 2,643 million at the 1976-prices, are not included.

Table 3-8-1 Construction Costs of River-channel Improvement

Basic flood discharge	Allocation	Cost at 1976-prices (unit: million Rp)
600 m^3/sec	R: 600 m^3/sec	2,651
700 m^3/sec	R: 700 m^3/sec	2,910
800 m^3/sec	R: 800 m^3/sec	3,170
1,000 m^3/sec	R: 1,000 m^3/sec	4,132
1,200 m^3/sec	R: 1,200 m^3/sec	5,251

Note: R means river channel. Cost for 700 m^3/s was estimated by averaging 600 m^3/s and 800 m^3/s.

For flood control by the combination of dam and river-channel improvement were assumed such allocation of discharges to dam and river-channel as given in Table 3-8-2, in which the basic flood discharge means the peak discharge of a basic hydrograph to be considered at the base point, Serbajadi Bridge, without regulation by dam, and the item of allocation means the discharges to be allocated to river-channel and dam respectively. Six kinds of allocation of flood discharges are thus considered as shown in the table.

The combined construction costs of dam and river-channel improvement were calculated based on the estimation of construction costs of dams as was described previously in Section 3.7 and the construction costs of river-channel improvement works as was given in Table 3-8-1. These are given in Table 3-8-2.

Table 3-8-2 Combined Construction Costs of Dam and River Improvement

Basic flood discharge	Allocation	Cost at 1976-prices (unit: million Rp)	Total
800 m^3/sec	R:600 m^3/sec D:200 "	R:2,651 D:2,327	4,978
1,000 "	R:600 " D:400 "	R:2,651 D:2,695	5,346
1,000 "	R:800 " D:200 "	R:3,170 D:2,410	5,580
1,200 "	R:600 " D:Beyond the control by one reservoir.		
1,200 "	R:700 " D:500 "	R:2,910 D:2,712	5,622
1,200 "	R:800 " D:400 "	R:3,170 D:2,631	5,801
1,200 "	R:1,000 " D: 200 "	R:4,132 D:2,445	6,577

Note: R means river channel and D means dam.

Comparing the construction costs given in Table 3-8-1 with those given in Table 3-8-2, it is found that the costs of flood control are cheaper by river-channel improvement alone than by combination of dam and river-channel improvement in any case of the four kinds of flood discharges. Therefore, without any allocation of flood discharge to dam, river-channel improvement must be taken as the most economical measure for flood control. Table 3-8-3 shows the decided allocation of flood discharges together with the construction costs of flood control by basic flood discharges.

Table 3-8-3 Discharge Allocation and Construction Costs for Flood Control by Basic Flood Discharges

Basic flood discharge	Discharge allocation		Cost at 1976-prices (unit:million Rp)		
	R	D	R	D	Total
600 m^3/se	600	0	2,651	0	2,651
800 "	800	0	3,170	0	3,170
1,000 "	1,000	0	4,132	0	4,132
1,200 "	1,200	0	5,251	0	5,251

Note: R means river channel and D means dam.

Which basic flood discharge shall be selected for the overall plan from amont the above four kinds of flood discharges is the next problem. It will be studed later from the standpoint of economic benefits. The yearly construction costs of the flood control works will be allotted as already shown in Table 3-5-3 of the paragraph 3-5-4. In this table too, no invested costs of the Urgent Project are included.

3.9. Flood Damages.

3.9.1. General.

The basin of the Ular River stretches over both Deli Serdang and Simalungun Kabupaten in North Sumatra Province, and the Ular River has been supplying water to irrigate the paddy field situated in the downstream from Galang, while the plain area in the downstream has suffered from seasonal floods of the Ular River every year.

Among damages caused by such floods, damages to public facilities are recorded on main floods, which occurred in September 1954, December 1973, October 1969 and January 1973. However, as no data were available on the damages to houses, household effects, agricultural products, etc., field survey was carried out concerning properties of houses and household effects and railway and road transportations by hearing from people, in addition to data on inundation depth and its duration time which were surveyed in the Feasibility Study of the Urgent Flood Control Project, 1971 (hereinafter referred to as the UFCP in this Section).

The items of flood damages to be estimated in the present study consist of public facilities, properties of houses and household effects, agricultural crops, estate facilities of oil palm and rubber, passenger and cargo transportations and suspension of business. The agricultural crops include paddy, oil palm, rubber and such upland crops as maize, cassava, sweet potatos, peanuts and soya beans.

At first, the damages caused by the four floods mentioned above were estimated, and then flood damages to be caused by four discharges of 600 m^3/s, 800 m^3/s, 1,000 m^3/s and 1,200 m^3/s respectively were estimated based on the said four kinds of flood damages. These amounts of damages will be given as benefits to be accrued from the river improvement works when they were executed.

3.9.2. Flood Damages in the Past.

The flood record of the PU informs that there occured frequent floods by the Ular River almost every year causing huge damages to inhabitants in the middle and lower areas of the Ular. From among these floods, the four big floods mentioned in the previous paragraph were chosen and the damages caused by them were estimated for the economic analysis.

Inundated area and depth of the three flood except the 1973-Jan-flood were estimated after the study in the Feasibility Study Study Report of the UFCP and using the data obtained in this field survey. The results are shown in Table 3-9-1. As the flooded area and depth caused by the 1973-Jan-Flood could not be estimated owing to lack of data, total damage of the flood was estimated by use of the relationship between the two damages of total and public facilities obtained from the above-mentioned three floods.

Table 3-9-1 Inundated Area

Unit: ha

(A) Flood in Oct. 1969

Land use \ Inundation depth	0.00 — 0.49	0.50 — 0.99	1.00 — 1.49	1.50 — 1.99	over — 2.00	Total
Oil palm	740	500	200	430	140	2,010
Rubber	260	350	10	0	0	620
Paddy	1,920	1,340	870	980	500	5,610
Upland crops	290	160	30	0	0	480
Others	1,500	540	560	360	670	3,630
Total	4,710	2,890	1,670	1,770	1,310	12,550

(B) Flood in Dec. 1973

Unit: ha

Land use \ Inundation depth	0.00 — 0.49	0.50 — 0.99	1.00 — 1.49	1.50 — 1.99	over — 2.00	Total
Oil palm	1,160	1,290	380	670	440	3,940
Rubber	60	90	10	0	0	160
Paddy	2,010	1,190	770	1,090	560	5,620
Upland crops	330	60	30	0	0	420
Others	1,260	530	300	310	480	2,880
Total	4,820	3,160	1,490	2,070	1,480	13,020

(C) Flood in Sept. 1954

Land use \ Inundation depth	0.00 — 0.49	0.50 — 0.99	1.00 — 1.49	1.50 — 1.99	over — 2.00	Total
Oil palm	1,650	1,480	1,080	1,310	550	6,070
Rubber	280	450	190	100	0	1,020
Paddy	2,670	3,250	2,310	2,150	1,760	12,140
Upland crops	470	220	100	100	0	890
Others	1,550	1,750	1,780	1,300	1,070	7,450
Total	6,620	7,150	5,460	4,960	3,380	27,570

(1) Damages to Public Facilities.

The damages to public facilities are recorded by the PU on four floods as shown in Table 3-9-2.

Table 3-9-2 Flood Damages to Public Facilities

Unit: 10^3 Rp

Item	Sept. 1954		Dec. 1973		Oct. 1969		Jan. 1973	
	Quantity	Amount	Quantity	Amount	Quantity	Amount	Quantity	Amount
National road	km 15.6	84,200	km 0.5	2,700	km 13.2	71,300	km 0.5	1,000
Provincial roads	km 7.5	20,200	km 3.5	9,500	km 2.6	7,000	km 5.0	5,000
Canal	km 13.0	35,100	km 3.0	8,100	km 2.0	5,400	km -	-
Intakes	5	27,000	3	16,200	3	16,200	1	25,000
Dikes	km 5.4	32,400	km 0.3	4,100	km 6.2	29,700	km 0.6	17,000
Bridges	4	32,400	4	32,400	4	32,400	1	8,100
Total		231,300		73,000		162,000		56,100

Amounts in the table are given at the 1976-prices.

(2) Damages to Houses and Household Effects.

a. Conditions in Estimating Damages to Houses.

In calculating flood damages to houses, conditions of appraisement of house, rate of damage per house and number of inundated houses must be assumed. Appraised values of houses are given in Table 3-9-3 on the average of four kecamatan (Galang, Perbaungan, Lubuk Pakam and Pantai Cermin). These were applied to the estimation of house damages.

Table 3-9-3 Appraisements of Houses and Household Effects or Stored Goods

Unit: 10^3 Rp

Kind of house	Rate of house distribution in the project area (%)	Appraisements		
		Houses	Household effects or stored goods	Total
Farm	65.1	250	175	425
Residence	29.2	250	290	540
Shop	2.4	930	1,370	2,300
School	0.3	5,270	1,000	6,270
Office/1	0.1	9,300	8,570	17,870
Hospital	0.1	3,680	1,300	4,980
Factory	0.2	3,640	2,760	6,400
Mosque & Church	0.5	2,560	490	3,050
Kiosk	2.1	100	30	130
Total	100.0			

/1: Public office, meeting hall, post office, bank and scouting house.

As for the rate of damage per house, the following rates that are usually used in Japan for economic study of flood control were applied.

Water level above floor (m)	Rate of damage
0 - 0.49	0.037
0.50 - 0.99	0.064
1.00 - 1.49	0.099
1.50 - 1.99	0.137
2.00 - 2.49	0.179

Source: Ministry of Construction, Japan.

The average number of houses in the area of the above-mentioned four Kecamatan in 1975 worked out at 0.829 houses per ha with the rate of house distribution as shown in the second column of Table 3-9-3.

b. Conditions in Estimating the Damages of Household Effects.

Conditions to be required in estimating the flood damages to household effects or stored goods were set as follows:

Amounts shown in the fourth column of Table 3-9-3 were assumed as the appraisement of household effects or stored goods and estimated based on the results of property survey in the project area during the period from November to December 1976. And a distribution of properties by heights above floor level of house was assumed on the basis of the survey mentioned above (Table 3-9-4).

Table 3-9-4 Appraisal of Household Effects Classified by Height above Floor Level

Unit: %

Kind of house	Height above floor level						
	0-0.5	0-1.0	0-1.5	0-2.0	0-2.5	0-3.0	over 3.0
Farm house	65	90	95	98	100	100	100
Residence	56	79	89	94	99	100	100
Shop	38	63	77	88	96	99	100
Office, etc./1	54	87	97	99	100	100	100

/1: Office, school, hospital, factory, mosque, church and kiosk.

As for the rates of damages to household effects and stored goods, the following rates that are usually used in Japan for economic study of flood control were applied.

Kind of property	Rate of damage to submerged goods
(A) Household effects of residence and farm house	0.690
(B) Stored goods of shop and factory	0.597
(C) Properties of office, school, hospital, mosque, church and kiosk	0.632

By giving the appraisements of household effects and stored goods, the damage rate of submerged goods and number of houses per ha, the amounts of damages to the household effects or stored goods can be calculated.

Based on the conditions mentioned above, the total amount of damages to the houses and household effects or stored goods by inundation depths are given as follows:

Inundation depth (m)	Damages to houses and household effects and stored goods per ha (10^3 Rp)
0.0 - 0.49	95.5
0.50 - 0.99	139.7
1.00 - 1.49	160.5
1.50 - 1.99	177.6
2-00 - 2.49	193.7

The damages caused by the four past floods to such properties as houses, household effects and stored goods were estimated as follows:

Flood	Damages to properties (10^6 Rp)
Sep. 1954	4,043
Dec. 1973	1,795
Oct. 1969	1,690
Jan. 1973	319

(3) Damage to Paddy.

In estimating the flood damage to paddy, the rate of decrease in yield of paddy by inundation must be given together with the price and yield of paddy and the inundated area. The price and yield of paddy were assumed at Rp65 per kg and 3.4 ton per ha at present respectively. The inundated area was already given by floods in the past (Table 3-9-1). The rate of damage of paddy due to the inundation was estimated on the basis of data shown in Fig.3-9-1 and Table 3-9-5, which were made based on the results of field survey in the present study and the Feasibility Study of the Kali Surabaya River Improvement Project.

Based on the conditions mentioned above, the rate of decrease in yield of paddy per ha was assumed as shown below taking into account cropping patterns in the present paddy field.

Inundation depth (m)	Amount of damage per ha (Rp)
0.0 - 0.49	19,200
0.50 - 0.99	54,300

Fig. 3-9-1 Relation Between Plant Height and Period of Growth of Paddy

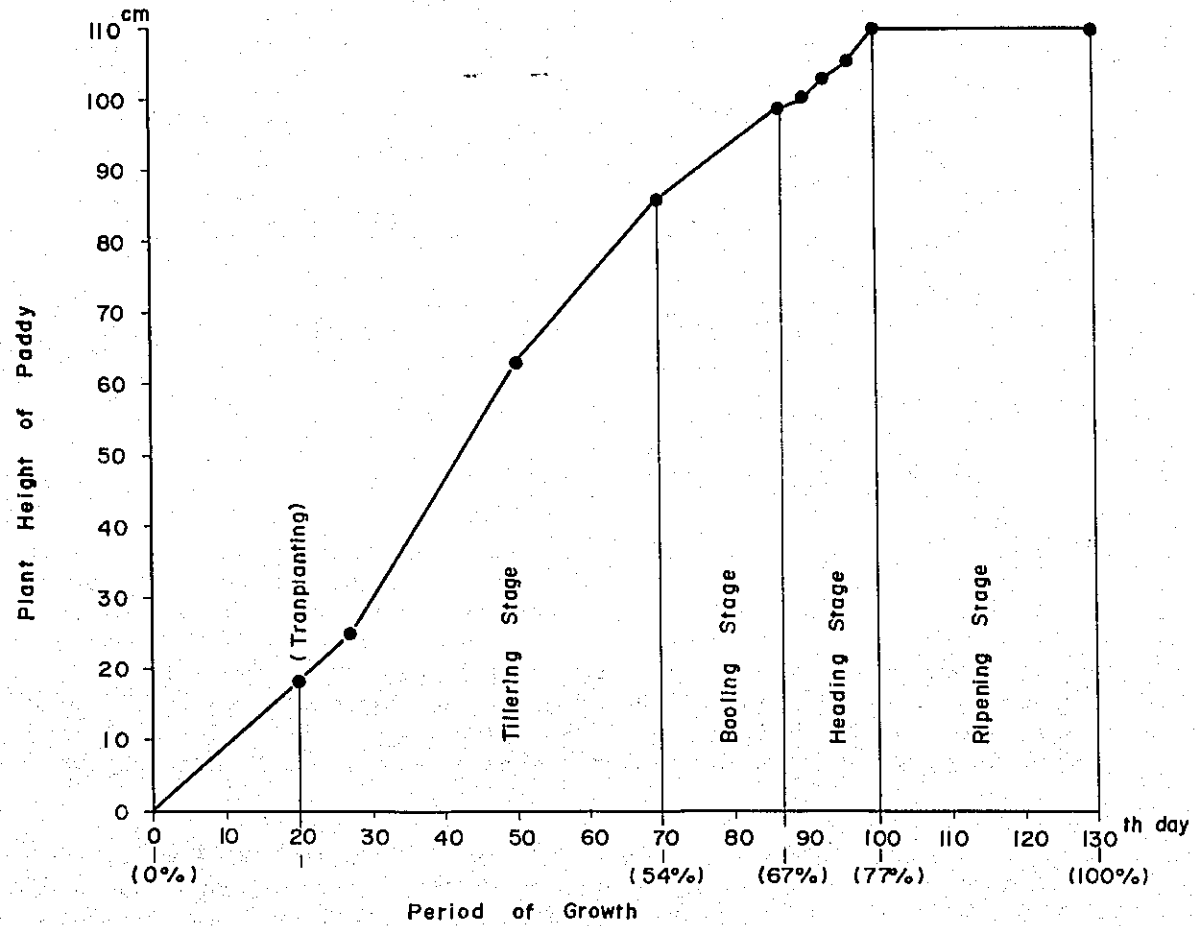


Table 3-9-5 Rate of decrease in Yield of Paddy due to Submergence (%)

Submergence Depth	Duration (days)	Tillering Stage 0 ~ 70 th day (0 ~ 54 %)	Booling St. 71 ~ 87 th (55 ~ 67%)	Heading St. 88 ~ 100 (68 ~ 77%)	Ripening Stage 101 ~ 130 th (78 ~ 100%)
Case (1) Over Plant Height	1 to 2	10 %	70 %	30%	5 %
	3 to 4	20	80	80	20
	5 to 6	30	85	90	30
	Over 7	35	95	100	30
Case (2) 75% of Plant Height	1 to 2	6	40	10	4
	3 to 4	9	46	23	15
	5 to 6	14	49	26	23
	Over 7	16	55	30	23
Case (3) 50% of Plant Height	1 to 2	4	37	8	2
	3 to 4	9	42	22	4
	5 to 6	13	45	25	6
	Over 7	15	50	28	6

(m)	per ha (Rp)
1.00 - 1.49	71,400
1.50 - 1.99	72,700
over 2.00	72,700

The damages to paddy by floods were estimated as follows:

Floods	Damage to paddy (10^6 Rp)
Sep. 1954	676
Dec. 1973	278
Oct. 1969	279
Jan. 1973	52

(4) Damages to Palm Oil and Rubber.

Drainage facilities of the plantations in the project area were remarkably improved after the UFCP was executed. Therefore, though roots of oil palm are not so strong against water, they will scarcely be damaged due to submergence in the present conditions. However, it is supposed that yields of palm oil and rubber will decrease because production activities will be suspended during flood and for a period required for rehabilitation of production facilities after the flood subsided. Flood damages to the oil palm and rubber plantations were thus assumed.

Assuming that the period to be required for rehabilitating the production facilities will nearly be equal to the period of the flood and the productions will be made uniformaly every day, the period of suspension of production and the rates of decrease in yields per ha of palm oil and rubber due to suspension of production were estimated by inundation depths as shown below:

Inundation depth (m)	Suspended period of production (days)	Rate of decrease in yield (Rp/ha)	
		Palm oil	Rubber
0.0 - 0.49	10	9,400	5,200
0.50 - 0.99	26	24,000	13,400
1.00 - 1.49	45	42,200	23,200
1.50 - 1.99	64	60,000	33,000
2.00 - 2.49	80	75,000	41,200

In the above table, prices per kg and yields per ha of palm oil, palm kernel and rubber were assumed as below in the economic costs:

Kind of crops	Unit price (Rp/kg)	Yield (kg/ha)
Palm oil	120	2,400
Palm kernel	90	600
Rubber	188	1,000

Accordingly, the damages caused by the four past floods to palm oil (including palm kernel) and rubber were estimated as follows:

Floods	Amount of damages (10^6 Rp)	
	Palm oil	Rubber
Sep. 1954	217	15
Dec. 1973	132	2
Oct. 1969	64	6
Jan. 1973	18	1

(5) Damage to Facilities in the Plantations.

Assuming that the rates of damage per ha caused by flood to such facilities as small-size roads (except national and provincial roads), canals and bridges are uniform in the inundated area, the damages to facilities in the oil palm and rubber plantations by making use of the inundated area and the damages to public facilities were estimated as shown in Table 3-9-1 and 3-9-2 respectively. The results are as follows:

Floods	Damages to facilities in the plantations (10^6 Rp)
Sep. 1954	30
Dec. 1973	23
Oct. 1969	12
Jan. 1973	5

(6) Damages to Upland Crops.

In this section, the damages are estimated with regard to such major upland crops as maize, cassava, sweat potatoes, peanuts, soya beans and small green peas. The following table shows harvested area, production and unit prices of the above-mentioned crops in Deli Serdang District.

Kind of crops	Harvest area/1 (ha)	(%)	Production/2 (ton)	Unit price/3 (Rp/kg)
Maize	3,055	23	5,904	70
Cassava	2,547	19	31,472	20
Sweet potatoes	1,213	9	15,260	25
Peanuts	4,726	35	6,069	250
Soya beans	1,272	10	1,194	200
Small green peas	515	4	399	200
Total	13,328	100		

/1, /2: 1975-data by North Sumatra Statistical Year Book, Kantor Sensus & Statistik Propinsi Sumatera Utara.

/3: Commercial Office, North Sumatra.

The damage rates of submerged crops in the field were assumed on the basis of the rates of damages which are usually used in Japan for economic study of flood control. On the conditions mentioned above, we estimated amount of damages per ha of crops. The results are shown in the following table:

Inundation depth (m)	Rate of damage
0.0 - 0.49	0.35
0.50 - 0.99	0.69
1.00 - 1.49	0.85
1.50 - 1.99	0.95
2.00 - 2.49	0.99

Accordingly, amounts of damages by the past floods were estimated as shown below:

Floods	Damages to crops (10^6 Rp)
Sep. 1954	115
Dec. 1973	43
Oct. 1969	55
Jan. 1973	9

(7) Losses due to Suspension of Business Activities.

All or a part of business activities of persons and corporations in the inundated area will be suspended during the period of inundation. However, it is very hard to grasp exactly the losses that will arise from such suspension of business. In Japan, the losses are about 6 percent of flood damages to houses and household effects according to the statistical records or floods. In the present study, the losses due to suspension of business were estimated by applying the rate of damage in Japan mentioned above because of the lack of available data in Indonesia. The results are as follows:

Floods	Losses due to suspension of business (10^6 Rp)
Sep. 1954	243
Dec. 1973	108
Oct. 1969	101
Jan. 1973	19

(8) Loss due to Interruption of Traffic.

In the project area, the national railway and a national highway run east and west connecting Medan with the area of Tebing Tinggi. Traffic and transport volumes on the railway and highway were estimated as shown in the following table based on statistical data of the offices of Railway Authority and Highway Department in Medan and the transportation survey carried out on the highway on December 13 and 14, 1976.

Mode of transport	Passenger car (car/day)	Passenger (person/day)	Freight car or truck (car/day)	Freight (ton/day)
Railway	24	2,100	40	1,900
Highway	3,000/1	28,000/2	1,400	9,800

/1: Includes buses of 600.

/2: Includes passengers of 14,000 by buses.

In this study, loss due to interruption of trafic consists of 1) decrease in income of passengers, 2) accumulation of freight and 3) losses due to suspension of buses, trucks and railway business.

1) Decrease in income of passengers.

To estimate the decrease in income of passengers due to interruption of traffic, two matters were assumed as follows:

i. Income of passengers: Rp 500 per day

ii. Ratio of working persons to entire passengers: 80 percent

By making use of these assumptions and number of passengers shown in the previous table, decrease in income of passengers was estimated at 12.04 million Rupiah per day as shown below:

a. For railway passengers: Rp500 x 2,100 persons x 0.8
= 0.84 million Rupiah

b. For highway passengers: Rp500 x 28,000 persons x 0.8
= 11.20 million Rupiah

c. Total = 12.04 million Rupiah

2) Loss due to accumulation of freight.

As the freight under transport is capital, the accumulation of freight due to interruption of traffic means suspension of working of capital, and this loss can be measured by the interest to the capital.

Price of transport goods is regarded as about Rp100,000 per ton on the average based on railway transport record of goods in the past and result of transport survey of freight on the highway. And by assuming the interest rate at 10 percent per annum, the loss due to accumulation of freight was estimated at 0.32 million Rupiah per day as shown below:

Rp 100,000 x (1,900 + 9,800) ton x 0.1 ÷ 365
= 0.32 million Rpiah

3) Losses due to suspension of buses, trucks and railway business.

Losses due to suspension of business activities of persons and corporations in the inundated area were estimated in Section (7). Such losses will also arise in other area than the inundated area, though it is difficult generally to estimate the losses. Therefore, in the present study, estimation of losses due to suspension of business activities in uninundated area was limited to such transport business as buses, trucks and railway transportations whose losses are relatively easy to estimate.

To calculate such losses, the following matters were assumed on the basis of the railway transport record and the result of transport survey on the highway mentioned above:

Item	Unit	Railway	Highway
1. Average fare per passenger	Rp	500	250
2. Average transportation range of freight	km	200	150
3. Transportation charge of freight per ton·km	Rp	8	100
4. Ratio of business truck to entire truck	%	-	40
5. Ratio of profit to transportation fare or charge	%	20	20

The losses due to suspension of the business amount to about 13.28 million Rupiah per day as calculated below:

a. For railway business for passengers:

Rp500 x 2,100 persons x 0.2 = 0.21 million Rupiah

b. For railway business for freight:

Rp8 x 1,900 ton x 200 km x 0.2 = 0.16 million Rupiah

c. For bus business on the highway:

Rp250 x 14,000 persons x 0.2 = 0.70 million Rupiah

d. For truck business on the highway:

Rp100 x 9,800 ton x 150 km x 0.4 x 0.2 = 11.76 million Rupiah

As a result, the loss due to the interruption of traffic was estimated at roughly 25 million Rupiah per day by summarizing the losses calculated in the above 1), 2) and 3).

According to records of floods in the past, periods of interruption of traffic on the above-mentioned railway and highway were estimated at three days in case of the flood in September 1954, two days in case of the floods in December 1973 and October 1969, and one day in case of January 1973.

Accordingly, the losses due to interruption of traffic are given by floods as follows:

Floods	Loss due to interruption of traffic (10^6 Rp)
Sep. 1954	75
Dec. 1973	50
Oct. 1969	50
Jan. 1973	25

3.9.3. Flood Damages by Discharges.

The total amounts of damages caused by the past floods are summarized in Table 3-9-6.

Table 3-9-6 Estimates of Damages caused by the Past Floods

Unit: Million Rp

Item	Floods			
	Sep.1954	Dec.1973	Oct.1969	Jan. 1973
1. Public facilities	231	73	162	56
2. Houses and household effects	4,043	1,795	1,690	319
3. Paddy	676	278	279	52
4. Palm oil and rubber	232	134	70	19
5. Facilities in plantation	30	23	12	5
6. Upland crops	115	43	55	9
7. Suspension of business activities	243	108	101	19
8. Interruption of traffic	75	50	50	25
Total	5,636	2,504	2,419	504

In section 3.4, the peak discharges at Serbajadi Bridge of the 1954-flood, the 1973 (Dec.)-flood, the 1969-flood and the 1973 (Jan.)-flood were estimated at 865 m^3/s, 610 m^3/s, 540 m^3/s and 430 m^3/s respectively, and also return periods of 600 m^3/s, 800 m^3/s, 1,000 m^3/s and 1,200 m^3/s were estimated at 8, 33, 133 and 500 years respectively. Based on these conditions, we estimated flood damages by discharges of 600 m^3/s, 800 m^3/s, 1,000 m^3/s and 1,200 m^3/s using the past flood damages shown in Table 3-9-6. In this estimation, however, the following assumption was made. That is, the flood damages shown in Table 3-9-6 exclude an effect due to the Urgent Flood Control Work which was executed in the middle stream of the Ular River since 1971. In the present situation, such an effect should be taken into consideration, even though it is very hard to estimate exactly the effect to flood damages. As an easier method, we assumed here that the effect is in proportion to the ratio of the construction cost of the Urgent Flood Control Work to the total construction cost of the Ular River Improvement Work.

The Urgent Flood Control Work was executed considering a peak discharge of 600 m^3/s at Serbajadi Bridge. As described in Section 3.5, in case of peak discharge of 600 m^3/s, the construction cost of the Urgent Flood Control Work is about 50 percent of the total construction cost of the Ular River Improvement Work. Therefore, the effect will also come to about 50 percent of the entire effect.

Considering the above, flood damages were estimated for each discharge as shown in Table 3-9-7.

Table 3-9-7 Flood Damages by Discharges

Discharge (m^3/s)	Return period (year)	Flood damage (10^6 Rp)
400	2	175
600	8	1,400
800	33	5,050
1,000	133	6,620
1,200	500	7,680

CHAPTER IV

AGRICULTURE

4.1. Agricultural Background.

Agriculture is the mainstay of the Indonesian economy which accounts for about 40% of the Gross Domestic Product (GDP). Agricultural sector in GDP has increased at an annual rate of 4% during the period of the PELITA-I. With the exception of 1972 which was the droughtiest year, rice production increased at a high annual growth rate of 3.5% due to the improved unit yield and the expansion of the planted area. The total rice production obtained the level of 15.4 million tons in 1974.

In spite of such high level of rice production, the Indonesian Government still had to import about one million tons of rice annually, because of the high demand for foodstuffs due to the rapid population growth rate of 2.1% per annum together with an increase in rice consumption per capita resulting from the raised standard of living.

Following the PELITA-I, the current PELITA-II was launched in 1974/75 fiscal year. This plan also gave the highest priority to agriculture with laying special emphasis on increased rice production for domestic consumption, under the rice intensification program, marketing program and rapid expansion of irrigation facilities. The annual overall growth rate of GDP under this plan is projected at an increase of 44% at an annual rate of 7.5% in a fiscal year. For agricultural sector, agricultural GDP is projected at an increase of 36% with the annual growth rate of 4.6% in a fiscal year.

Along with this plan, rice production in North Sumatra Province has been mainly increased by crop intensification and expansion of irrigation facilities. Total production of rice reached the level of 1.69 million tons in 1973 and 1.38 million tons in 1976. The decline in 1975 was mainly due to the damages caused by leaf hopper.

The population of North Sumatra Province is increasing rapidly each year at an annual growth rate of 2.9%. It finally reached the level of 7.5 million in 1975. The shortage of rice occurs annually and about 0.12 million tons of rice are either imported or shifted from other provinces. In 2000, if the population increases at 2.9% annually, nearly 15.3 million people will need nearly 2.3 million tons of rice per year to maintain their diet. It is estimated on the basis of the current increasing trend of rice production that about 1.9 million tons can be expected in 2000. Consequently, shortage of rice is estimated at 0.4 million tons in 2000.

The project area which administratively belongs to Deli Serdang District situated in the central part of North Sumatra Province is one of the important rice producing areas supplying rice mainly to Medan city, the capital of North Sumatra Province. However, the irrigated paddy field in the project area occupies less than 40% of total paddy field in spite of adequate temperature, good soils and relatively long sunshine hours and the cropping ratio of paddy during the dry season is restricted to about 25%.

The key to rapid increase in rice production is the control of water under proper farm management in the project area and the introduction of the year-round cropping of paddy in the entire project area.

Provision of irrigation and drainage facilities in the project area will play an important role in increased rice production for the growth of regional economy as well as the national economy.

4.2. Project Area.

4.2.1. Location.

The project area is a triangular area in the lower Ular with its vertex at Serbajadi Bridge. It is surrounded by the Serdang River on northwest, the Rampah River on northeast, and the Strait of Malacca from east to west.

National Highway connecting Medan and Tebing Tinggi extends east and west of the central part of the project area. This national highway, and the railway running almost parallel to this highway together form the important routes for the supply of foodstuffs to Medan City.

The project area administratively belongs to Kabupaten (District) Deli Serdang and it covers a part or the whole of seven Kecamatan (Sub-District) namely, Lubuk Pakam, Pantai Cermin, Perbaungan, Galang, Tg. Beringin, S. Rampah, and Teluk Mengkudu.

4.2.2. Population and Religion.

The population of the Project area is estimated at 159,800 in 1975. The population density is about 600 persons per km^2, which is very high compared with the average density of 100 persons per km^2 in the whole North Sumatra Province.

There are no major cities in the project area, although there are a number of large towns, of which Lubuk Pakam and Perbaungan are the largest.

Most of the inhabitants live in villages and hamlets which are scattered all over the project area. They are mostly engaged in agriculture and the related activities based on cultivation of rice. The major towns are usually kecamantan capitals, and they serve as commercial centers for the surrounding agricultural areas.

Ethnically, the majority of the people in the project area are Batak clan who Christians or Moslems. The major exceptions are the moslem Javanese, Chinese and the Merau (animist) groups. Religious doctrines provide a comprehensive moral system to sustain the people's way of life and continue to affect the people's relationships, agriculture, rituals and arts. These factors should not impede the effective use of irrigation and adoption of innovations and development technics. The proper ceremonial propitiation will be needed for the construction and the use of facilities to distribute irrigation water without adverse reaction resulting from the spiritual deities believed in by the villagers.

4.2.3. Topography and Soils.

The project area is the alluvial fan plain of the Ular River. Elevations range from about 2 meters near the sea to a maximum of about 50 meters near the Serbajadi intake. It forms a flat topography with a gradient of 1/600, sloping south to north. Undulations occur correspendingly with the natural drainage channels or hydromorphic depressions.

In spite of the relatively steep gradient, numerous minor elevations and depressions have been formed by the sea and river actions. Especially marine action has produced a distinctive topography of several sand dunes along the coastal line which inhibits surface drainage into the sea combined with the tidal action. The area enclosed between sand dunes turns to swampy land during the rainy season. In addition roads and railways also inhibits surface drainage.

These topographical features are closely related to soil formations. Most of the soils in the project area have been influenced by hydromorphic soil formation and are classified as gray hydromorphic soils in great soil group level. The soils have moderate pH value ranging from 5.1 to 6.8 for water. Cation exchange capacities are 10 to 30 me/100 g. Base saturation degree shows a relatively high value. The soils generally have deep to moderately deep effective soil depths. As regards soil particle distribution, the soils on the right side of the Buluh River consist of light to heavy clay. On the other hand, soils in the area extending over the left side of the Buluh have been affected by the sediments from the Ular River and the Serdang River, and the soil texture is different depending on the location. Generally the soils in such area are medium to fine in texture which are composed of intermittent layers. The soils in the project area have low permeability in general.

Consequently, paddy is adaptable to a wide variety of soil characteristics and a highly productive crop in the project area if proper fertilization, drainage improvement and strict irrigation water control can be essentially provided.

Soil profile descriptions and the results of soil analysis are shown in Tables 4-1 and 4-2.

4.2.4. Climate and Hydrology.

(1) Climate.

The Project area is surrounded by six meteorological stations, namely, Sampali, Polonia, RISPA, Marihat, Tg. Morawa and Sei Dadap. They have the records covering considerably long periods. In addition, there are many rainfall stations mainly managed by the PNP in and around the area. Fig.4-1 shows the locations of the above meteorological stations and the rainfall stations located at thirty-one places which have the monthly rainfall records for more than 20 years. Table 4-3 shows the mean monthly meteorological data of the representative Sampali station and the monthly averages of rainfall and number of rainy days recorded at each station.

According to the records, the mean yearly rainfall and rainy days at each station roughly range from 1,700 to 2,400 mm and from 100 to 130 days respectively. However it is difficult to say that these ranges are directly proportionate to the distance from the coast. Further, the Area has considerable rainfall and rainy days throughout the year, even in the dry months. Although the dry season generally is from February to July and the wet season is from August to January, there is no definite distinction between the two.

One of the problems encountered in this area concerning paddy cultivation is that the rainfall is occurred on a short duration and is very irregular notwithstanding the considerably large mean rainfall. For this reason, soil moisture is not kept on available condition, and the vigorous growth of paddy is not expected. It is indispensable to control water properly for the successful paddy cultivation.

The records also show that the Area has high air temperature and humidity with little annual changes and almost no seasonal fluctuations peculiar to the tropical wet climate zone. The yearly averages of the air temperature and humidity at Sampali station are about 26°C and 87% respectively. The Area is affected by the N and NE winds almost all the year around. No strong wind or typhoon occurs in the Area with the exception of the seasonal wind which is incidental to the tropical climate.

Further, the records show lower sunshine duration, solar radiation and evaporation compared with those in Jawa. This is due to the considerably large amount of rainfall and many rainy days in the Area throughout the year.

(2) Hydrology.

Although small amount of drainage water inflowing into dual-purpose canals is used for irrigation, almost all water resources for irrigation in the Area depend on the Ular River.

Table 4-1 SOIL PROFILE

SOIL PROFILE NO.1

LOCATION	Pagar Marbau II
LAND USE	Rainfed Paddy Field
Horizon	**Description**
I(A)(0-30 cm)	Dark brown, Sandy clay, Few, fine to medium mottles, Weak, fine to medium sub-angular blocky, Slightly plastic, Sticky
II(IIB)(30-40 cm)	Yellowish gray, Loamy clay, Few, fine to medium mottles, Weak fine to medium sub-angular blocky, Plastic, Sticky
III(IIIC)(40-50 cm)	Yellowish gray, Loamy sand, Few, medium to coarse mottles, Very weak sub-angular blocky, Non plastic, Non sticky
IV(IVC)(50-55 cm)	Yellowish gray, Clay loam to loamy clay, Few mottles, Medium to fine blocky, Plastic, Sticky
V(VC)(55-90 cm)	Yellowish gray, Clay loam to loamy clay, Prominent, fine to medium mottles, Medium to fine blocky, Plastic, Sticky
VI(VIG)(90 cm +)	Grayish blue, Loamy sand, Non mottles (G horizon), Very weak blocky

SOIL PROFILE NO.2

LOCATION	5 km north from Lubuk Pakam
LAND USE	Oil palm plantation
Horizon	**Description**
I(A)(0-15 cm)	Dark brown, Loamy clay, Medium to fine subangular blocky, Plastic, Sticky
II(B)(15-55 cm)	Grayish brown, Sandy clay to loam, Coarse sand spottly existed, Few, fine mottles, Medium sub-angular blocky, Plastic, Sticky
III(Bg)(55-100 cm)	Light gray, Loamy clay to Light clay, Fine to medium mottles, Weak, medium blocky, Plastic, Sticky,
IV(G)(100 cm +)	Bluish gray, Coarse sand

SOIL PROFILE NO.3

LOCATION	Kampung Sayur
LAND USE	Paddy field (Rainfed)
Horizon	**Description**
I(A)(0-15 cm)	Dark brown, Clay loam, Weak fine to medium sub-angular blocky, Slightly plastic, Slightly sticky
II(B)(15-25 cm)	Grayish brown, Clay loam, Many fine mottles, Medium sub-angular blocky, Slightly plastic, Slightly sticky, Mica
III(IIC)(25-75 cm)	Grayish brown, Coarse sand, Medium to coarse blocky, Non plastic, Non sticky, Mica
IV(IIIC)(75-85 cm)	Yellowish brown, Loamy sand, Prominent coarse mottles, structureless, Non plastic, Non sticky
V(G)(85 cm +)	Bluish gray, Coarse sand

SOIL PROFILE NO.4

LOCATION	Pantai Labu
LAND USE	Paddy Field (Rainfed) with Chilly cultivation
Horizon	**Description**
I(AG)(0-20 cm)	Dark brown, Heavy clay, Massive, Very plastic, Very sticky
II(G)(20-25 cm)	Yellowish gray, Heavy clay, Massive, Very Plastic, Very sticky,
II(G)(25-100 cm)	Grayish blue, Heavy clay, Massive, Very plastic, Very sticky

SOIL PROFILE NO.5

LOCATION	Pematang Biara
LAND USE	Paddy field (Rainfed)
Horizon	**Description**
I(AG)(0-20 cm)	Dark brown, Heavy clay, Massive, Very plastic, Very sticky
II(G)(60-90 cm)	Yellowish gray, Heavy clay, Massive, Very plastic, Very sticky
III(G)(90 cm +)	Bluish gray, Coarse sand (Coastal sand), Structureless

SOIL PROFILE NO.6

LOCATION	Pasar I Sidoardjo
LAND USE	Paddy Field
Horizon	**Description**
I(A)(0-30 cm)	Dark gray, Loam Clay, Weak sub-angular blocky, Plastic, Sticky
II(B)(30-55 cm)	Brownish gray, Loamy sand, Prominent, coarse mottles, Structureless, Non plastic, Non sticky
III(IICG)(55-100 cm)	Yellowish gray, Loam, Few mottles, Weak sub-angular blocky, Non plastic, Slightly sticky

SOIL PROFILE NO.7

LOCATION	Deli Tua
LAND USE	Upland (Sweet potatoes)
Horizon	**Description**
I(A)(0-15 cm)	Dark brown, Loam, Granular, Mica, Slightly plastic, Slightly sticky
II(B)(15-35 cm)	Yellowish brown, Loamy clay, Weak sub-angular blocky, Many fine mottles spotty gley mottles, Mica, Plastic, Sticky
III(Cg)(35-80 cm)	Yellowish brown, Loamy clay, Many fine mottles, Medium sub-angular blocky, Spotty gley mottles, Very plastic, Very sticky
IV(IICg)(80 cm +)	Yellowish brown, Coarse sand, Coarse prominent mottles, Structureless

SOIL PROFILE NO.8

LOCATION	Kota Pari
LAND USE	Paddy Field (Rainfed)
Horizon	**Description**
I(A)(0-20 cm)	Dark brown, Loamy clay
II(IIC)(20-50 cm)	Yellowish brown, Coarse sand to loamy sand, Structureless, Non Plastic, Non sticky
III(IIIC)(50-70 cm)	Grayish brown, Heavy clay, Few to many fine mottles, Massive, Very plastic, Very sticky
IV(IVC)(70-90 cm)	Grayish brown, Loam, Many medium mottles, Weak medium sub-angular blocky, Slightly plastic, Slightly sticky
V(VC)(90 cm -)	Yellowish gray, Heavy clay, Massive Very plastic, Very sticky

SOIL PROFILE NO.9

LOCATION	Kota Pari
LAND USE	Cassava Field
Horizon	**Description**
I(A)(0-35 cm)	Dark brown, Sandy clay, granular, Slightly plastic Slightly sticky
II(C)(35-100 cm)	Yellowish brown, Loamy sand (coastal sand), Structureless

(continue)

SOIL PROFILE NO.10

LOCATION: Sialang Bush
LAND USE: Paddy field (Swampy area)

Horizon	Description
I(AG)(0-30 cm)	Dark brown, Sandy clay, Weak subangular blocky Slightly plastic, Slightly sticky
II(G1)(30-60 cm)	Grayish blue, Heavy clay, Massive (marine deposited clay), Very plastic, Very sticky
III(IIG1)(60 cm +)	Grayish blue, Coarse sand, Structureless

SOIL PROFILE NO.11

LOCATION: Firdaus
LAND USE: Oil palm plantation

Horizon	Description
I(A)(0-15 cm)	Dark brown, Sandy clay, Weak sub-angular blocky, Slightly plastic, Slightly sticky
II(B)(15-45 cm)	Yellowish brown, Sandy clay, (clay content increases with depth), Weak sub-angular blocky, Slightly plastic, Sticky
III(Bg)(45-110 cm)	Reddish brown, Light clay, Weak angular blocky, Very plastic, Very sticky, Coarse prominent mottles

SOIL PROFILE NO.12

LOCATION: Teluk Menghudu
LAND USE: Paddy field (Rainfed)

Horizon	Description
I(AG)(0-30 cm)	Dark brown, Heavy clay, Massive, Very plastic, Very sticky
II(G)(30-85 cm)	Bluish gray, Heavy clay, Massive, Very plastic Very sticky

SOIL PROFILE NO.13

LOCATION: Parit 12
LAND USE: Paddy field

Horizon	Description
I(AG)(0-20 cm)	Dark brown, Heavy clay, Massive, Very plastic Very sticky
II(G)(20-50 cm)	Bluish gray, Heavy clay, Massive, Very plastic, Very sticky

SOIL PROFILE NO.14

LOCATION: Tanah Merah
LAND USE: Paddy field

Horizon	Description
I(AG)(0-15 cm)	Dark brown, Sandy loam to loam, Weak sub-angular blocky, plastic, Sticky
II(G1)(15-30 cm)	Yellowish gray, Loamy clay to loam, Few fine mottle, Weak sub-angular blocky, Plastic, Sticky
III(IIG1)(30-65 cm)	Yellowish gray, Loamy sand, Very weak sub-angular blocky, plastic, sticky
IV(IIIG1)(65 cm -)	Yellowish gray, Loamy clay, Wead sub-angular blocky, Very plastic, Very stick

SOIL PROFILE NO.15

LOCATION: Kampong Baru
LAND USE: Paddy field

Horizon	Description
I(AG)(0-15 cm)	Dark brown, Sandy clay to loamy sand, Weak sub-angular blocky, Slightly plastic, Sticky
II(G1)(15-50 cm)	Yellowish gray, Sandy clay to loam, Weak sub-angular blocky, Slightly plastic, Sticky
III(G2)(50 cm +)	Grayish blue, Loamy sand, structureless, Non plastic, Non sticky

SOIL PROFILE NO.16

LOCATION: Pematang Sijenam
LAND USE: Paddy field

Horizon	Description
I(AG)(0-15 cm)	Dark brown, Loamy clay, Weak sub-angular blocky, Very plastic, Very sticky
II(B)(15-65 cm)	Yellowish brown, Loamy clay, Medium sub-angular blocky, Very plastic, Very sticky
III(B)(65-80 cm)	Yellow grayish brown, Sandy loam, Weak sub-angular blocky, Medium fine mottles, Slightly plastic, Slightly sticky
IV(G)(80 cm -)	Gray, Sandy loam, Structureless, Non plastic, Non sticky

Table 4-2 Results of Soil Analysis

Analysis items / No. of Soil samples	pH (H_2O)	pH (Kcℓ)	Total carbon (%)	Total nitrogen (%)	C/N	Cation exchange capacity (me/100g)	Exchage cation (me/100g) Ca	Mg	K	Na	Total	Base saturation degree (%)
4 - II	7.5	5.8	0.61	0.07	9.3	36.5	10.0	20.8	0.84	2.62	34.3	94.0
4 - III	7.7	7.0	2.56	0.20	12.8	34.1	19.3	19.3	1.18	4.54	44.3	130.0
7 - II	6.8	4.9	0.67	0.07	9.1	19.0	7.73	1.84	0.16	1.68	11.4	60.1
7 - III	6.7	5.0	0.78	0.10	8	31.3	7.95	3.24	0.55	1.94	13.7	43.8
9 - I	6.3	4.8	0.83	0.09	9	12.9	5.21	1.23	0.33	1.03	7.8	60.5
9 - II	6.5	4.6	0.37	0.04	9	11.6	4.22	0.98	0.27	1.41	6.9	59.5
10 - I	6.4	5.1	0.74	0.06	12.2	8.38	4.18	3.36	0.06	0.61	8.2	98.0
10 - II	6.6	4.8	0.65	0.05	13	12.2	4.69	5.94	0.10	1.63	12.4	104.1
10 - III	6.8	4.9	0.59	0.04	14.3	18.2	6.22	9.95	0.20	2.50	18.9	103.8
11 - I	5.4	4.3	0.87	0.09	9.4	7.24	3.28	0.32	0.08	0.41	4.1	56.5
11 - II	5.5	4.3	0.63	0.07	8.7	8.55	2.84	0.32	0.08	0.10	3.3	39.1
11 - III	5.6	4.0	0.44	0.04	10	23.3	2.53	0.68	0.06	0.66	3.9	16.9
12 - I	6.5	4.05	1.76	0.20	8.9	32.7	9.11	9.61	0.21	2.86	21.8	66.7
12 - II	5.1	3.6	0.72	0.07	10.7	42.6	7.28	15.9	0.29	4.75	28.2	66.2
14 - I	5.5	4.0	1.36	0.14	10.1	15.6	4.78	1.64	0.20	1.46	8.1	51.8
14 - II	6.1	4.3	0.32	0.04	7.8	11.1	4.31	1.40	0.14	2.08	7.9	71.4
14 - III	5.8	3.9	0.34	0.04	8	19.6	4.83	1.84	0.20	2.73	9.6	49.0
16 - I	6.3	5.0	1.16	0.14	8.1	12.9	5.21	1.17	0.53	1.03	7.9	61.6
16 - II	6.1	3.9	0.41	0.05	8.0	12.5	6.22	1.04	0.53	2.08	9.9	79.0
16 - III	5.9	3.6	0.36	0.04	8.5	19.8	2.93	4.02	1.08	5.09	13.1	66.2

Table 4-2 (continued)

Analysis items / No. of Soil samples	Available P_2O_5 (mg/100g)	Available K_2O (mg/100g)	Free iron (Me_2O_3%)	Sulfide (Smg/100g)	Cℓ (mg/100g)	Soil texture	Soil particle distribution: Coarse sand (%)	Fine sand (%)	Silt (%)	Clay (%)
4 - II	-	-	-	0.5	35.6	HC	2.5	7.7	34.6	55.2
4 - III	-	-	-	8.8	97.1	HC	1.2	9.1	38.1	51.6
7 - II	-	-	-	-	-	LiC	3.0	44.8	25.5	26.7
7 - III	-	-	-	-	-	LiC	2.4	14.0	40.6	43.0
9 - I	0.54	79.1	0.39	-	3.0	SCL	16.2	42.4	17.9	23.5
9 - II	-	-	-	-	4.1	SL	8.7	66.2	10.6	14.5
10 - I	0.83	9.7	0.09	0.5	3.1	SCL	77.3	1.6	1.6	19.5
10 - II	-	-	-	0.8	1.8	SCL	68.0	1.9	5.3	24.8
10 - III	-	-	-	2.0	2.6	LiC	46.3	2.0	10.4	41.3
11 - I	0.54	7.3	0.30	-	-	SL	56.9	13.2	10.1	19.8
11 - II	-	-	-	-	-	SC	48.1	16.0	2.3	33.6
11 - III	-	-	-	-	-	HC	29.0	10.0	13.0	48.0
12 - I	trace	15.8	0.04	1.3	2.4	HC	7.9	4.7	27.5	59.9
12 - II	-	-	-	0.3	2.7	HC	1.1	3.5	28.6	66.8
14 - I	0.33	59.9	0.09	-	-	LiC	30.6	20.7	16.5	32.2
14 - II	-	-	-	-	-	SC	25.0	31.9	13.3	29.8
14 - III	-	-	-	-	-	LiC	20.2	29.3	17.5	33.0
16 - I	3.33	61.8	0.17	-	-	LiC	5.5	40.3	22.5	31.7
16 - II	-	-	-	-	-	LiC	2.7	36.1	31.8	29.4
16 - III	-	-	-	-	-	LiC	5.4	27.9	30.7	36.0

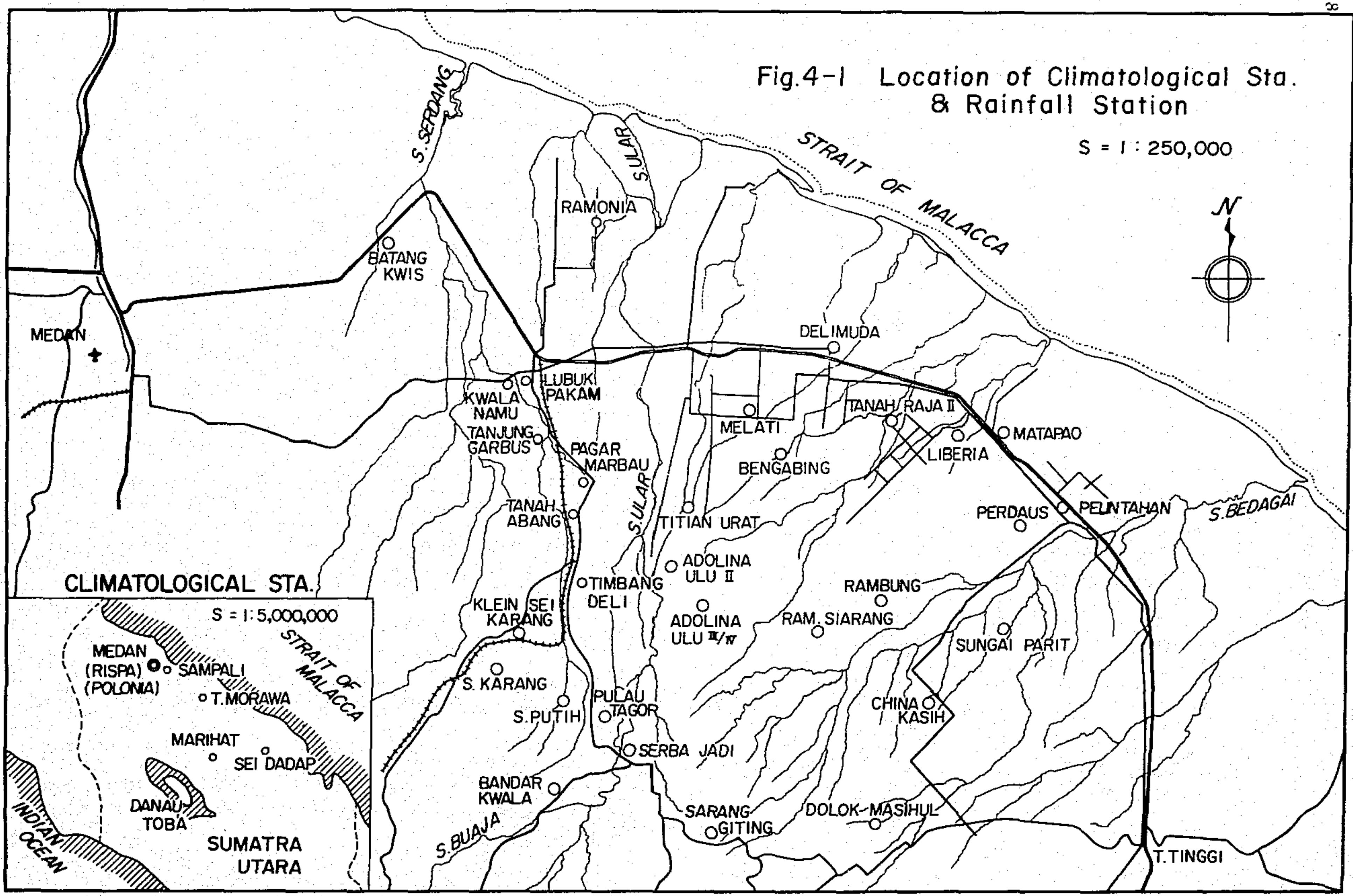


Fig. 4-1 Location of Climatological Sta. & Rainfall Station

Table 4-3 Climatological Data

Item	Unit	J	F	M	A	M	J	J	A	S	O	N	D	Year	Wet s	Dry s
Monthly rainfall	mm	145	89	117	141	156	139	140	173	220	289	251	196	2,056	1,274	782
Rainy days		8	5	7	8	9	7	8	10	12	14	13	10	111	67	44
Air temperature	°C	25.2	25.7	26.1	26.5	26.6	26.5	26.2	26.2	25.9	25.8	25.5	25.4	25.9	25.7	26.3
Relative humidity	%	87	84	84	86	86	87	86	86	88	88	89	89	87	88	86
Wind direction																
Calm	%	6	2	7	-	5	5	1	5	3	2	3	4	3.5	3.8	3.3
N	%	31	22	28	31	24	11	22	17	21	25	15	24	22.5	22.2	23.0
NE	%	47	67	56	60	58	70	58	58	64	57	62	52	59.5	57.7	61.5
E	%	-	-	1	3	4	3	6	5	9	6	-	-	3.3	3.3	2.8
SE	%	1	-	-	5	2	6	6	6	1	3	3	1	2.8	2.5	3.2
S	%	-	-	1	1	1	-	1	1	-	-	-	-	0.3	0.1	0.7
SW	%	-	1	4	-	4	2	2	2	-	3	-	1	1.5	1.0	2.2
W	%	6	1	-	-	-	-	1	1	-	-	-	4	1.1	1.8	0.3
NW	%	9	7	3	-	2	3	3	5	2	4	17	14	5.7	8.5	3.0
Wind velocity	m/sec	1.05	1.12	1.13	1.00	1.00	0.95	0.95	0.97	0.88	0.86	0.83	0.93	0.98	0.92	1.03
Sunshine duration	%	45	48	57	38	53	55	57	52	43	40	40	37	49	43	55
Solar radiation	cal/cm^2	367	386	398	394	380	371	382	386	366	364	332	331	371	358	385
Evaporation	mm	2.00	2.52	2.44	2.20	2.07	2.26	2.41	1.96	1.71	1.68	1.69	1.67	2.06	1.80	2.32

There are two discharge observation stations on the Ular River where records are available for the study on the existing and planning irrigation systems in the Area. The station at Bandar Tiga, however, records automatically the water levels which contain floods. The records kept at the station at Serbajadi by the DPMA show smaller figures than those of Bandar Tiga and are more available for the study on the irrigation systems as safer records.

Table 4-4 shows mean ten-day discharges of each year at Serbajadi. According to the records, the Ular River has more than 40 m^3/sec throughout the observation period except from the middle of July to the beginning of September in 1972, and the mean discharges of the wet and dry seasons from August to January and from February to July are 57.3 m^3/sec and 50.4 m^3/sec respectively. The above fact shows that the Ular River has comparatively sufficient discharge for the irrigation in the project area.

The river water depth, however, is generally very shallow at the time of small discharges, and this means that the river water has to be drawn by wide and shallow canals to the intakes along the Ular River. Fig.4-2 shows the relation between the small discharge and the water level of the Ular River at the main existing intakes.

4.2.5. Land Use.

The project area, about 40,000 ha has already been fully developed, so there leaves no room for further reclamation. The land under cultivation is estimated at 35,400 ha. The remaining area of 4,600 ha covers village areas, roads, infrastructural area, etc.

The land under cultivation mainly consists of estate crop area and paddy field. Estate crop area occupies an area of 13,400 ha or 33% of the project area where oil palm, rubber and coconut trees are planted on 8,700 ha, 3,500 ha and 1,200 ha respectively. Paddy field totals 18,500 ha or 46% of the project area. The paddy field is not always provided with good irrigation and drainage facilities. The irrigated paddy field presently accounts for 7,000 ha or 38% of total paddy field, which consists of 3,000 ha of technical irrigation area, 1,500 ha of semi-technical area and 2,500 ha of non-technical area. The remaining 11,500 ha of paddy field is the rain-fed paddy field, dependent on natural rainfall. In addition, 5,700 ha are being used as horticulture field, houses area and roads.

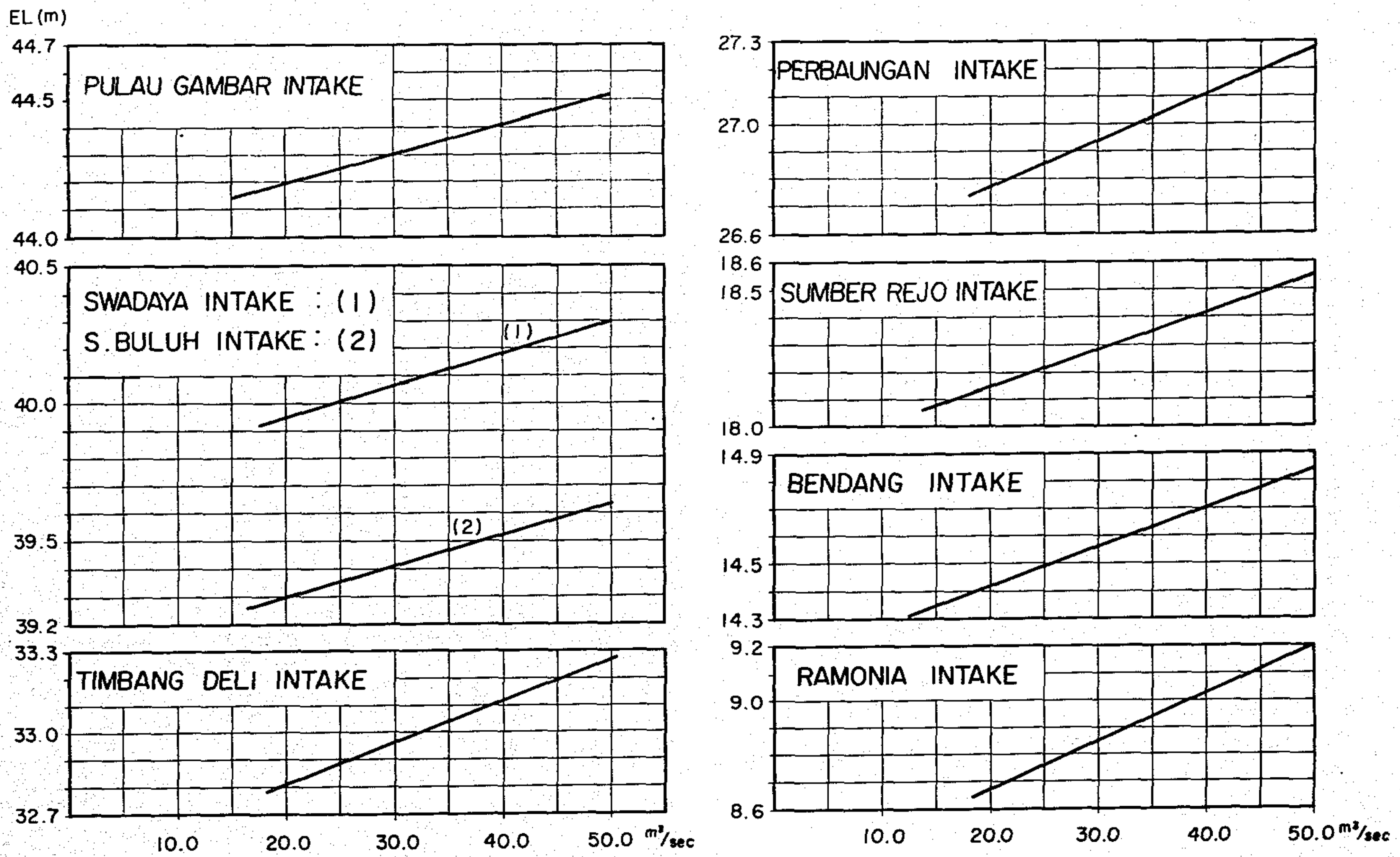
Predominant crop in the project area except estate crops is paddy, which occupies about 100% in the rainy season and about 25% in the dry season. Second crops are polowijo crops cultivated in the paddy field after harvesting rainy season paddy which covers an area of 1,100 ha. As described in the section of Climate and Hydrology in the dry season, much excess rainfall in a short period or long drought period occurs. Consequently, polowijo crops are damaged by root-rot due to excess water or are not able to grow due to drought. Such area where polowijo crops are cultivated is limited to only 6% of the total paddy area.

Table 4-4 Mean Ten Day's Discharge at Serbadjadi Bridge of the Ular River by DPMA

Unit: m^3/sec

Month	Period	1971	1972	1973	1974	Average
Jan.	first		52.0	70.2	68.7	61.6
	middle		50.4	57.6	56.0	54.7
	last		57.5	49.8	56.7	54.7
Feb.	first		55.8	44.7	60.2	53.6
	middle		52.0	39.7	63.5	51.7
	last		48.4	39.6	57.1	48.4
Mar.	first		50.1	46.5	48.3	48.3
	middle		48.5	46.7	48.5	47.9
	last		47.5	60.3	46.7	51.5
Apr.	first		49.6	62.6	52.6	54.9
	middle		57.4	55.2	46.2	52.9
	last		63.7	56.9	45.6	55.4
May	first		53.6	52.3	45.7	50.5
	middle		61.2	48.0	54.2	54.5
	last		56.3	58.1	45.0	53.1
Jun.	first		51.3	73.6	45.2	56.7
	middle		52.8	48.4	40.3	47.2
	last		47.3	47.1	49.8	48.1
Jul.	first		40.6	45.9	40.7	42.4
	middle		38.8	44.5	47.4	43.6
	last		33.3	54.3	49.3	45.6
Aug.	first	51.0	30.6	48.6	49.1	44.8
	middle	60.1	30.4	46.4	44.6	45.4
	last	53.3	38.3	46.9	46.1	46.2
Sep.	first	52.4	38.8	48.5	55.8	48.9
	middle	69.9	46.6	57.8	64.1	59.6
	last	69.5	45.6	48.2	76.5	60.0
Oct.	first	54.2	54.8	46.5	75.8	57.8
	middle	57.2	48.5	53.5	55.6	53.7
	last	58.1	58.0	79.5	52.6	62.1
Nov.	first	57.8	53.1	58.1	55.9	56.2
	middle	54.9	64.5	57.0	66.2	60.7
	last	51.8	76.6	61.0	66.5	64.0
Dec.	first	63.3	68.3	81.6	57.9	67.8
	middle	78.7	63.3	86.7	43.9	68.2
	last	66.0	55.9	96.4	45.8	66.0

Fig. 4-2 Small Discharge – Water Level Curve of the Ular River ($Q \leqq 50.0 m^3/sec$)



Multi-cropping index for paddy field is about 1.3/1. The characteristics of the present land use are summarized in Table 4-5 and are mapped in Fig.4-3.

Table 4-5 Land Use in the Project Area

Item	Area (ha)
1. Rice field	18,500
a) Technical irrigation area	3,000
b) Semi-technical irrigation area	1,500
c) Non-technical irrigation area	2,500
d) Rain-fed area	11,500
2. Estate field (P.N.P. and Private estate farm)	13,400
a) Oil palm area	8,700
b) Rubber area	3,500
c) Coconut area	1,200
3. Horticulature field	1,100
a) Vegetable	400
b) Fruits	700
4. Houses and roads	4,600
5. Others	2,400
Total	40,000

/1: Multi-cropping index
= rainy season paddy + dry season paddy + polowijo/18,500
= 18,500 + 4,500 + 1,100/18,500

4.2.6. Irrigation and Drainage Systems.

(1) Irrigation Systems.

The existing irrigation area is estimated at about 7,000 ha which

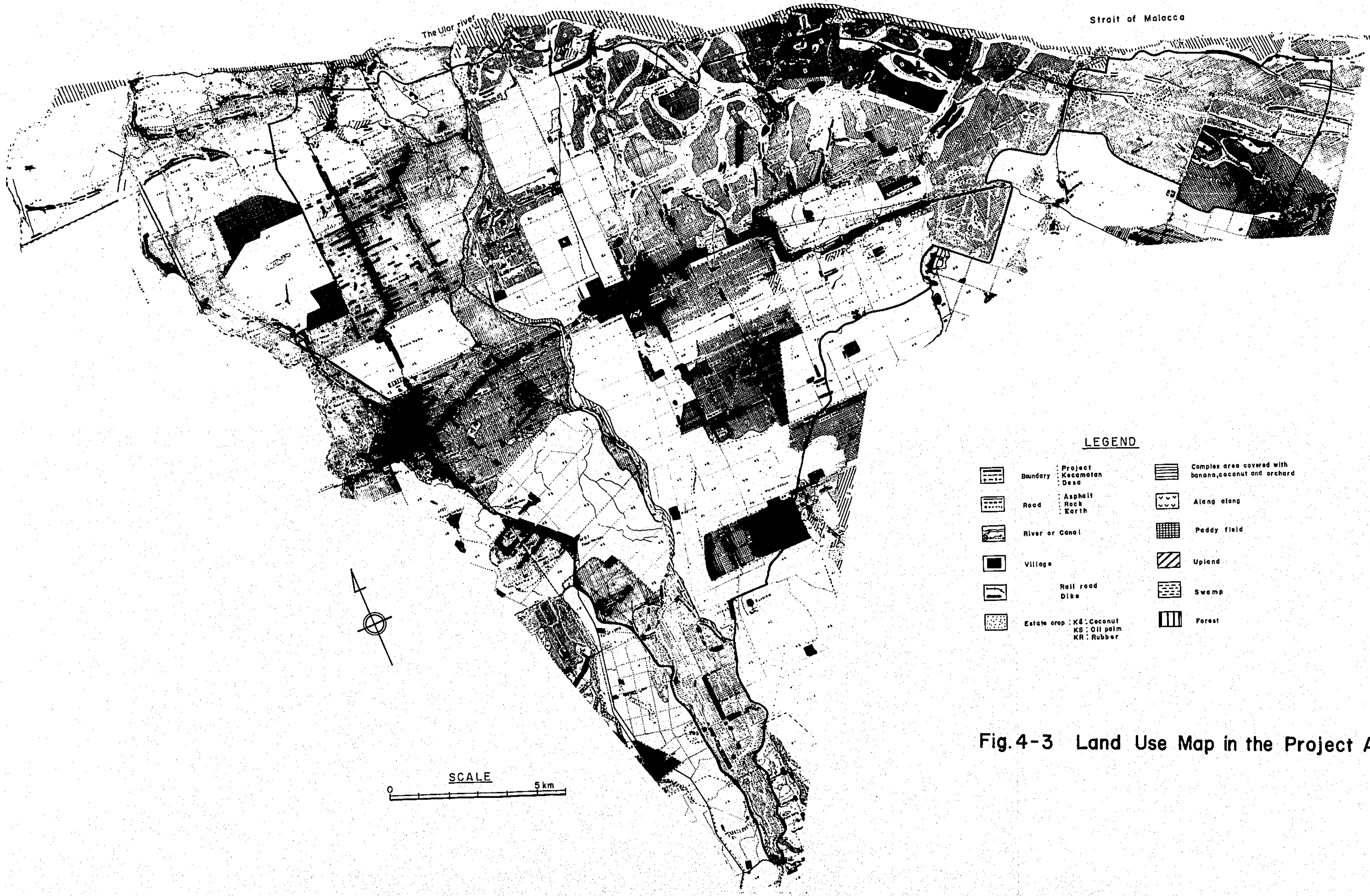


Fig. 4-3 Land Use Map in the Project Area

is divided into the technical irrigation area of 3,000 ha, the semi-technical irrigation area of 1,500 ha and the non-technical irrigation area of 2,500 ha in the project area of 18,500 ha. The remaining area of about 11,500 ha mostly along the coast is the rain-fed area and almost no reclamable area is found. The water resources for the irrigation mostly depend on the Ular River except the small amount of drainage water also used for the irrigation by the dual-purpose canals in the project area. The irrigation area covers about 38% of the project area and the area for double cropping of paddy per year is about 4,500 ha.

At present, there are fourteen intake facilities which are equipped along a distance of about 32 km between Serbajadi Bridge and the estuary of the Ular River. All intake facilities except a pumping station for PNP VI Adolina are being used for the irrigation of paddy fields. The length of the main canals and secondary canals are totalized to be 50.3 km and 90.4 km respectively.

The existing conditions of the irrigation systems, intake facilities and canal structures are as shown in Fig.4-4, and Tables 4-6, 4-7 and 4-8.

a. Each intake capacity is restricted by the water level of the Ular River because the intakes are of free-intake type except the syphon-type intakes on Singosari. Besides, the bed of each intake at high elevation. Requires the water to be taken at the time when the Ular River has a considerably large discharge and entails the shortage of intake capacity notwithstanding the comparatively large capacity of the successive canal.

   Table 4-7 shows the maximum capacity of the successive canal and the related river discharge and also the intake capacity at the time of the river discharge of 40.3 m^3/sec which will be the design discharge for the irrigation plan.

b. There are considerably large amounts of sedimentation deposits of sand near the intakes at present. These sediments reduce the canal capacities and the intake discharges. Actually, however, the sedimentation volume of the inflowing water is estimated to be 20-80 PPM under the velocity from 0.60 m/sec to 0.80 m/sec and the particle sizes mostly range from 0.1 mm to 0.5 mm. Accordingly, the suspended sand precipitates in some distances in the upstream of the canal under the low velocity of the flow and its sedimentation volume is considered to be the extent which can be removed from the canal or sedimentation basin.

c. As the Area has a steep slope of about 1/1000, most of the canal systems in the Area which mainly consist of earth canal, need drop structures to prevent the errosion and failure of inside slope of the canals.

Fig.4-4 Existing Irrigation System

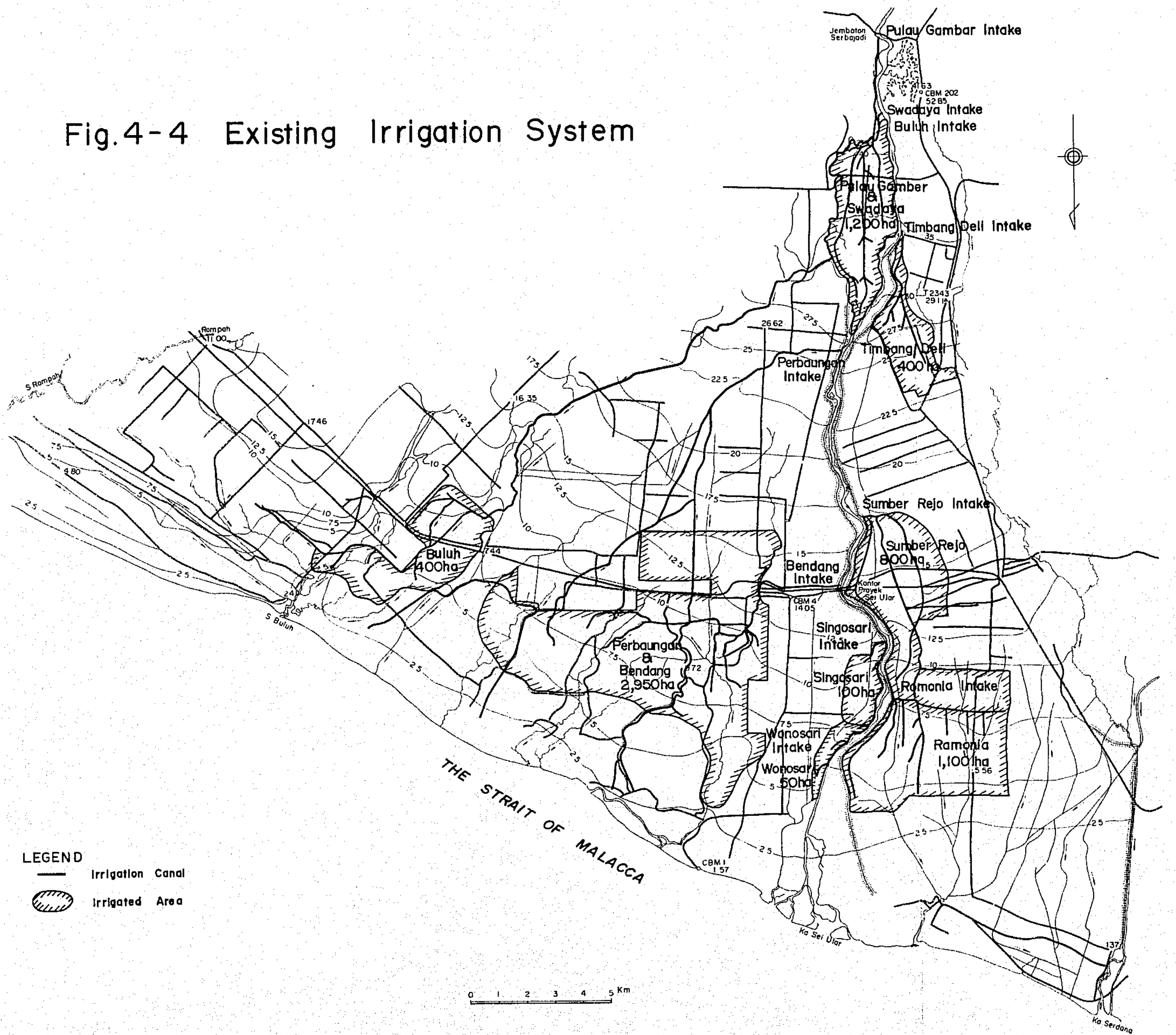


Table 4 – 6 EXISTING INTAKE FACILITIES OF THE ULAR RIVER (I)

Name	Location	Site	Completion year	Authorities concerned	Authority's planning	Irrigation area		Control of gate operation	Remarks
						Wet season	Dry season		
	km				ha	ha	ha		
Pulau Gambar	+22.5	Right	1965	P.U.Province				Sektor L.Pakam	
					1.200	1.200	800		
Swadaya	+19.7	Right	1976	P.U.Kabpaten				P.U.Kabpaten	Supplementary intake for Pulau Gambar area.
S. Buluh	+19.0	Right	1975	P.U.Kabpaten	4.000	400	—	P.U.Kabpaten	Project INPRES (Constructed by the budget from the President)
Timbang Deli	+14.3	Left	1975	P.U.Province	800	400	400	Sektor L.Pakam	
Perbaungan	+ 9.6	Right	1960	P.U.Province	4.400	1.950	1.800	P.U.Province	Rehabilitated in 1975
Sumber Rejo	+ 3.1	Left	1970	P.U.Kabpaten	3.500	800	100	Sektor L.Pakam	Rehabilitated in 1975 by the Ular River Project, now under P.U.Province.
Bendang	+ 0.2	Right	Before 1935	P.U.Province	1.000	1.000	900	Sektor L.Pakam	Rehabilitated in 1974 by the Ular River project.
Adolina	− 0.2	Right	1976	Public	—	—	—	Public	Constructed by PNP. VI ADOLINA
Singosari (2 places)	− 2.6 − 3.2	Right	1970	P.U.Kacamatan	150	100	—	Farmer	
Ramonia	− 4.7	Left	1967	P.U.Province	1.000	1.100	500	Sektor L.Pakam	
Wonosari (3 places)	− 6.0 − 7.0 − 8.0	Right	1974	P.U.Kacamatan	50	50	—	Farmer	
Total					16.000	7.000	4.500		

Table 4-7 Existing Intake Facilities of the Ular River (2)

Elevation : UP. (m)

Name	Type	Size of intake structure (gate width x number)	Bed elevation of intake	Canal						Drought Intake Discharge		
				Bed width	Side slope	Gradient	Max. Capacity	Intake water El.	River discharge	River Discharge	Intake Water El.	Intake Discharge
		m	EL (m)	m			m^3/sec	m	m^3/sec	m^3/sec	m	m^3/sec
Pulau Gambar	Free intake	Concrete 1.00 x 2	44.0	2.30	1 : 1	0.00035	1.6	44.9	105	40.3	44.4	0.4
Swadaya	Free intake	Concrete 1.00 x 2	40.0	2.60	1 : 1	0.00015	2.5	40.7	95	39.9	40.2	0.2
S. Buluh	Free intake	Concrete 1.20 x 3	39.6	4.20	1 : 1	0.00040	3.4	40.6	260	39.7	39.5	—
Timbang Deli	Free intake	Concrete 0.75 x 2	33.2	1.00	1 : 1	0.0013	1.6	33.7	95	39.7	33.1	—
Perbaungan	Free intake	Concrete 1.20 x 4	26.0	6.00	1 : 1	0.00016	6.8	27.5	80	39.7	27.1	3.8
Sumber Rejo	Free intake	Concrete 1.00 x 4	18.0	3.00	1 : 1	0.0011	2.8	18.8	85	35.9	18.4	0.8
Bendang	Free intake	Concrete 0.80 x 2	13.4	4.00		0.0008	2.3	14.2	5	35.1	14.6	4.5
Adolina	Pump station	Yanmer TS 60mm pipe ø 4" x 2	no data	At present 150 m^3/day (12 hours/day, future plan 600 m^3/day)								
Singosari (2 places)	Syphon	(I) Steel pipe ø 100 x 12 (II) -ditto- ø 100 x 8	no data	—	—	—	—	—	—	—	—	—
Ramonia	Free intake	Concrete 1.20 x 3	7.8	2.00	1 : 1	0.0006	2.1	8.8	20	30.6	8.9	2.9
Wonosari (3 places)	Free intake	(I) Concrete pipe ø 500 x 3 (II) -ditto- ø 500 x 1 (III) -ditto- ø 500 x 1	no data	—	—	—	—	—	—	—	—	—
Total							23.1					12.6

Table 4-8 *List of Existing Irrigation Facilities*

Facilities	Unit	Pulau Gambar	S.Buluh	Timbang Deli	Perba-ungan	Sumber Rejo	Bendang	Singosari	Wonosari	Ramonia	Total
1) Intake	No.	2	1	1	1	1	1	2	3	1	13
2. Canal structures											
Diversion work	No.	2	1	-	2	4	2	1	-	4	16
Secondary diversion Work	No.	1	2	-	6	-	-	-	-	-	9
Turnout	No.	10	2	4	1	-	-	-	-	-	17
Drop	No.	4	6	-	6	-	-	-	-	-	16
Aqueduct	No.	1	-	-	1	-	3	-	-	7	12
Syphon	No.	-	-	-	2	1	-	-	-	1	4
Conduit	No.	-	1	-	-	2	-	-	-	-	3
Wooden bridge	No.	5	2	-	15	-	-	-	-	-	22
Spillway	No.	-	3	-	2	-	-	-	-	-	5
3) Canal length											
Main canal	km	4.4	27.2	2.9	9.3	2.0	4.0	0.5	-	-	50.3
Secondary canal	km	11.8	18.9	4.2	26.0	15.0	3.0	4.5	3.0	4.0	90.4
Total	km	16.2	46.1	7.1	35.3	17.0	7.0	5.0	3.0	4.0	140.7

On the contrary, there are cases in which the diverted water does not reach the objective area and aquatic plants grow in the canal because of the shortage of water head.

d. The water distribution systems in the Area generally exhibit complicated canal net works due to the dual purposes of irrigation and drainage, and the connection of irrigation systems by their canals. This fact makes the water management in the Area difficult.

e. In general, facilities on farm remain in an unconsolidated state. Especially, small density of tertiary canals seems to hamper the expansion of benefited area. In addition, complicated canal system without measuring devices and proper water management results in affluent water use in the upstream part of the benefited area and along canals.

f. One of the most important things for the irrigation systems in the Area is proper coordination among the organizations for water management and operation and maintenance of the irrigation facilities. In addition, drainage for the plantation area should be taken into consideration.

In order to carry out successful paddy cultivation and produce the target yield, it is dispensable to improve the above problems.

(2) Drainage Systems.

At present, eight natural rivers and the drainage canals of about 57 km in total such as Busuk, S. Buluh and Tungtung canals perform important roles in the existing drainage systems in the project area. Fig.4-5 and Table 4-9 show the existing drainage systems.

The Area, however, has poor drainage conditions due to the shortage of capacities of the above rivers and drainage canals, several sand dunes developed along the coast, tidal action, national road and railways.

In general, the plantation areas have beeter drainage systems. The left side of the Ular River, in which most part was plantation area in the past, is favored with better drainage conditions than the right side which had almost no plantation area except PNP. Adolina in the lower part from the national road. Especially, the right side of the Buluh River is an area with the poorest drainage conditions. In this area, rivers run between roads built on the past dunes along the coast.

One of the most important problems concerning the drainage systems in the Area is the existence of the canals used both for irrigation and drainage. Naturally, dual-purpose canal economically enables to supplement water for irrigation purpose. The paddy cultivation in the

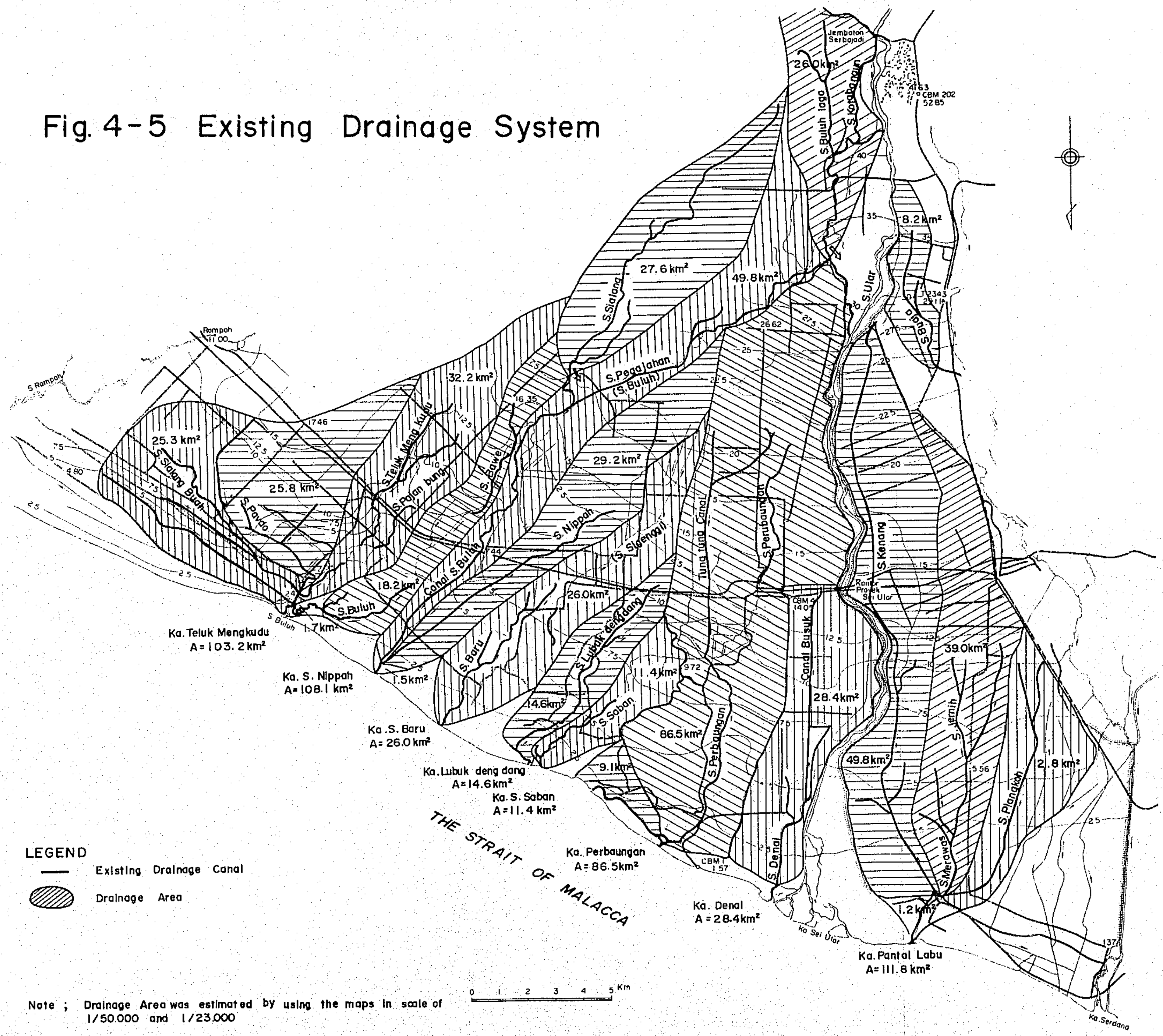


Fig. 4-5 Existing Drainage System

Note ; Drainage Area was estimated by using the maps in scale of 1/50.000 and 1/23.000

Table 4-9 Existing Drainage System

Name of river mouth	Side of the Ular	Distance from Ular	Name of tributary	Length	Gradient	Catchment area	Flood (1/5 year)
		km		km		km^2	m^3/sec
Pantai Labu	Left	3.5		23.9	1/ 900	111.8	60.0
			S.Kenang	22.1	1/ 800	(54.3)	31.5
			S.Merawas	9.7	1/ 800	(39.0)	23.0
			S.Plangkoh	10.4	1/1100	(21.8)	14.3
Denai	Right	1.8	Canal Busuk	11.5	1/ 800	28.4	17.5
Perbaungan	Right	6.4	Tungtung canal	9.5	1/ 800	(31.1)	19.0
			S.Perbaungan	18.1	1/ 900	86.5*	48.0
S.Saban	Right	5.0		3.7	1/ 700	11.4	7.6
S.Lubuk-dendang	Right	5.5		9.7	1/1000	14.6	9.5
S.Baru	Right	15.0		7.8	1/1000	26.0	16.0
S.Nippah	Right	18.0		31.8	1/ 800	108.1	58.0
			S.Nippah	10.1	1/ 900	(29.2)**	18.0
			Canal S.Buluh	31.3	1/ 800	(77.4)	43.0
			S.Sialang	16.0	1/ 500	(27.6)	17.0
S.Teluk Mengkudu	Right	22.0		14.2	1/ 900	103.2	56.0
			S.Buluh and S.Bawe	13.6	1/ 900	(19.0)	12.0
			S.T.Mengkudu	10.2	1/1000	(32.2)	19.5
			S.Pavdo	3.8	1/ 500	(25.8)	19.0
			S.Sialang Buah	8.3	1/1100	(20.0)	12.5
Total						490.0	

Remarks: In addition to the above rivers, both Kotabaungan and Buluhlaya rivers, which have the total catchment area of 26.0 km^2, flow into Buluh area's main canal surrounding the Pulau Gambar area.

* : including the catchment area of Tungtung canal.

** : including the catchment area of S.Sialang.

Area, however, requires fresh water to control the farm inputs, produce the high yield and prevent some diseases.

Therefore, it is desirable to provide separately irrigation and drainage canals as much as possible for at least the main canal except in some inevitable cases and the improvement of the existing drainage systems will promise easier farming practices and successful paddy cultivation.

4.2.7. Cropping Patterns and Farming Practices.

As described before, the prominent crops in the project area are paddy, polowijo and estate crops.

Paddy cultivation is generally dependent on the onset of the rainy season and seedling period fluctuates from year to year. However, broadly speaking, planting is done during the period of October to December and harvesting from February to April for improved high yielding varieties and from April to June for local varieties, respectively. In the irrigated area, the dry season paddy is planted during the period of March to June.

As regards varieties of rice, improved high yielding varieties such as IR-5, IR-26, IR-30, IR-34, etc. have widely spread in the project area as the result of the development projects promoted under PELITA-I and PELITA-II. In addition, local varieties such as Jambu, Kodok, Rendah, Rendah Pisang, Manik are being cultivated in the project area. Their growing period ranges from 5 to 7 months.

The volume of farm inputs is different depending on locations. It is however estimated that about 40 kg of urea, 20 kg of triple super phosphate and one liter of chemicals are used on one ha on an average.

Farming in the project area is labor intensive from seedling to harvesting. Land preparation is carried out by draught animals or sometimes by human power. Harvesting is done by sickles, not ani-ani equipment. Irrigation water control is not sufficiently conducted even in the irrigation area.

In the light of such low farm inputs and improper water control, it appears that high yield of paddy cannot be expected.

Polowijo crops are planted during March to May, after harvesting of the rainy season paddy. No fertilizer and chemicals are applied in general and the unit yield of these crops is low.

4.2.8. Crop Yield and Agricultural Production.

Production of crops in the project area is estimated according to the available data provided by the Agricultural office of Deli Serdang Province, P.N.P. and privately owned estates.

Unit yield of paddy and polowijo crops is estimated as an average yield for the period between 1971 and 1975. Estate crop yield is the value for 1975. Estimated unit yields are shown in Table 4-10. Total production of paddy is about 70,000 tons, while 5,700 tons of polowijo 146,000 tons of palm oil and 5,000 tons of rubber are produced.

Livestock breading and poultry raising are not popular in the project area, but they are important for the production of protein food and for provision of draught animals for land preparation.

Table 4-10 Present Crop Yield and Productions

	Harvested Area (ha)	Unit Yield (t/ha)	Total Production (t)
Paddy	23,000	3.1	71,300
Polowijio	1,100	5.16	5,680
Oil palm	8,700	16.8	146,200
Rubber	3,500	1.4	4,900

4.2.9. Land Tenure and Land Holding.

For land tenure in Indonesia, the Basic Agrarian Law No. 5 of 1960 known as "Land Reform Law" is applicable. It is enforced by the Directorate General of Agrarian, Ministry of Interior. Local activities are carried out by the Provincial Agrarian Office.

According to the Law, the limitation of private ownership of farmland in the North Sumatra Province is 10 ha for paddy field and 12 ha for up-land field in less crowded areas.

In the project area, the public land mostly under the control of the National Plantation Estates and the Private Plantation Estate comprises about 13,400 ha. The remaining 26,600 ha of farmland are owned by 16,122 farmers or more than 83% of the total number of farmers. The numbers of tenants and landless farmers in the project area in 1975 were 1,460 and 1,693 respectively, as shown in Table 4-11.

Table 4-11 Number of Farmers by Type in the Project Area

	Number	Percent
Landowners	16,122	83.64
Tenants	1,460	7.58
Landless farmers	1,693	8.78
Total	19,275	100.00

Source: Agricultural Extension Office, Deli Serdang District, 1975

The average farm size in the project area is estimated at 1.138 ha of which 0.96 ha or 84.36% is under being used for the cultivation of rice.

The average farm size in the project area is much larger than in Jawa Island, but what hampers the agricultural development here is the lack of well irrigated paddy field. Technical and semi-technical irrigation paddy fields comprise only 0.236 ha on an average farm, or only about 24.58% of the total acreage of paddy field, as shown in Table 4-12.

Table 4-12 Land Condition on an Average Farm

Average farm size	ha 1.138		% 100
Rice field	0.960		84.36
Irrigation paddy field	0.369		
Technical		0.158	
Semi-technical		0.078	
Non-technical		0.133	
Non irrigated paddy field (Rain-fed area)	0.597		
Upland and orchard	0.178		15.64

4.2.10. Agricultural Suport Services.

(1) Operation and Maintenance of the Irrigation Facilities.

In Indonesia, operation and maintenance of the irrigation facilities down to the secondary canals are, in general, under the responsibility of the Provincial Public Works Department.

Below tertiary canals, construction, operation and maintenance of irrigation system are carried out by the Water Users' Association (P3A) under the supervision and guidance of the Provincial Public Works Department.

In the project area, out of 14 intake facilities including canals, 6 are constructed and managed by the Provincial Public Works Department, 5 by the Public Works Office of Deli Serdang District, 2 by the farmers themselves, and 1 is under the control of the National Plantation Estate.

In North Sumatra Province, the Water Users' Associations (P3A) have been organized following the guide line set by the Central Government. In the project area, 6 Water Users' Associations have been established.

The number of member farmers of the Association is 1,077 which corresponds to only 5.59% of the total number of farmers in the project area.

There is no tertiary canal constructed by the farmers in the project area. Operation and maintenance of the irrigation facilities in the project area are only done partially by each foreman in his own way at present. No records of the daily discharge, distribution area as well as the planting calendar are being kept at the intake facilities.

(2) Research and Extension Service.

The research activities of agriculture in Indonesia are centralized and undertaken by the Central Research Institute of Agriculture (CRIA) at Bogor in Jawa. One of the three branch stations is located in West Sumatra, and this is the only branch station in the whole-Sumatra island.

The CRIA performs an important function of seed breeding in addition to its original research works.

In 1974, extension service in Indonesia was strengthened with the establishment of the Agency for Agricultural Education, Training and Extension as one of the extraministerial bureaus under the Ministry of Agriculture. At the same time, the Government intended to establish an Agricultural Development Center with an additional function of seed multiplication center at the Provincial level, and the Rural Extension Center at the level between District and Sub-district. The function of the former is to carry out experiments and training at Provincial level and that of the latter is to prepare extension programs, disseminate agricultural information and to train the leading farmers at the field level.

According to the new extension program, North Sumatra Province is required 19 Rural Extension Centers and 304 Field Extension Workers graduated agricultural high school at final stage. However, present condition of no Rural Extension Center and 220 Field Extension Workers is far from the said target of the program, except its extremely high educational standard of present Field Extension Workers who are all constituted by the graduates of agricultural high school.

In Deli Serdang District, no Rural Extension Center exists at present and the number of Field Extension Workers is 48. Each of the 48 Extension Workers is in charge of more than 2,500 farmers and about 18 villages on an average.

In the project area, extension service is being provided by 14 Field Extension Workers, who also are in charge of 58 villages outside of the project area.

(3) Seed Multiplication.

As for the improved seeds of rice, the Provincial Seed Center (Kebun Benih Sentral) located at Tanjung Morawa in Deli Serdang District, near the project area plays an important role in not only multiplication of improved seed of rice but also for training of scientific agricultural technique for local leading farmers and seed growers.

The stock seed produced by this Seed Center with 17 ha of rice field are distributed to 12 Seed Station (Balai Benih) managed by District Agricultural Offices and many private seed growers. Seed Stations produce the extension seeds which are distributed to the farmers through the village unit agricultural cooperatives (KUD).

One of the Seed Stations is located at Lubuk Pakam Sub-District in the project area, and the extension seeds of recommended improved varieties of rice such as PB26, PB30, PB34, etc. are produced in this Station with 5 ha of rice field.

The improved seeds required for 37,000 ha of irrigated paddy field at the full development stage of the Project is estimated at 9 ton annually under the seed renewal system of 5 year interval. It would be required more than 20 ha of multiplication fields of the extension seed in the project area.

(4) Co-operatives and Credit.

Aiming at farm production increase and rural community development through facilitating distribution of agricultural requisites supply and marketing of farm products, the Indonesian Government has placed its emphasis on the establishment of the village level agricultural cooperative (KUD) especially in the area planned for the development of intensified farming.

Following the guideline of the Central Government, the North Sumatra Provincial Government has promoted the establishment of KUD in recent years. As a result, out of 304 villages, (WUD), 87% or 265 KUD have been established by the end of 1975. However, the numbers of members and the prospective members of the KUD are only 6.4% and 35.5% of total number of farmers respectively in North Sumatra.

In the project area, out of 14 villages (WUD), 9 KUD have already been organized, but their activities are hampered mainly due to the lack of intensification program area, a limited number of skillful leading farmers and a small number of trained staff for management.

The Indonesian People's Bank (BRI) is the state bank specialized in farm credit all over the country. To provide loan service, the

Bank has established a wide network consisting of many regional offices and branch offices known as "Unit Desa BRI".

The Bank is authorized to finance BIMAS package credit for qualified individual farmers. Besides, using its own credit funds, the Bank provides the loans to various agricultural associations including farmer's cooperatives.

The loan condition is based on the monthly interest of 1% with 7-month maturity period under BIMAS program, 3-year repayment period in case of cattle credit and 7-year repayment period including 2-year grace period for the construction of on-farm irrigation service facilities.

In the project area including 5 village units (WUD) outside of the project area, loan service is provided by 4 branch offices.

About Rp 3,500 million or 25% of total amount of loan in North Sumatra is provided for BIMAS package loan in 1976. In Deli Serdang District, the BIMAS loan has been repidly increased on loan amount and number of lenders in recent few years as shown in Table 4-13, however, it would be serious problem that the rate of outstanding is so high as still 50% of loan.

Table 4-13 BIMAS Package Loan in Deli Serdang

		1974	1975	1976
Number of lender		20,786	31,267	42,388
Amount of loan	10^3 RP	364,488	630,249	987,018
Per capita 2/1	RP	17,535	20,157	22,106
Amount of repayment	10^3 RP	48,413	283,792	471,652
Per capita 3/1	RP	2,329	9,076	11,127
Amount of outstanding	10^3 RP	316,075	346,457	465,366
Per capita 4/1	RP	15,206	11,081	10,979
Ratio of repayment	%	13.3	45.0	50.3
Rate of outstanding	%	86.7	55.0	49.7

4.3. Irrigation and Drainage Plan.

4.3.1. General.

(1) Selection of the Project Area.

The project area for agricultural development plan was decided according to the following conceptions.

The agricultural development plan is formulated as a part of the Overall Ular River Improvement Project and does not cover the areas topographically connected with the Serdang River on the left side and the Rampah River on the right side of the Ular River. The project area, therefore, roughly appears in the alluvial fan which extends from the vicinity of Serbajadi Bridge on the Ular River and is bordered by the both catchment areas of the Serdang and Rampah.

Further, some plantation areas and watershed located near the borders of the alluvial fan are excluded from the project area because the expansion of technical irrigation for paddy cultivation is the main objective of the Project. The area along the coast with complicated topography and possibility of salinity damages is also excluded.

The project area is delineated as shown in Fig.4-10, and covers approximately 40,000 ha in total.

(2) Irrigation Plan.

The objective area for irrigation plan is decided to cover all rice field of 18,500 ha which comprises technical, semi-technical and non-technical irrigation areas and rain-fed area in the project area. No area is newly reclaimed. (Refer to 4.2.6) The conversion from plantation area to paddy field will face some difficulties under the present circumstances. Double cropping of paddy is proposed in the whole objective area.

Water resources to irrigate the objective area are entirely dependent on the Ular River. Inevitable dual-purpose canal, however, will collect drainage water from its catchment area, but the amount of the inflow discharge is disregarded.

The Ular River has sufficient discharge even in the dry season. Dam for irrigation purpose will certainly supply more stable river discharge, but it will only serve to increase intake water level slightly if a weir is not installed simultaneously.

The establishment of a weir in coordination with some existing intakes is advantageous only for securing the stable intake water depth. The water level of the Ular River, however, will enable to supply diversion water requirement if each intake has proper bed elevation and width. Further, the site for weir is hardly found because the construction of a weir in the alluvial fan will require the heightening of dike of the Ular River again and the upstream of the alluvial fan also has the difficulties as to topograph and foundation.

Consequently, the improvement of some existing intakes should be carried out urgently in the Area to further promote the improvement of the irrigation and drainage systems.

(3) Drainage Plan.

The Area to be covered by the drainage plan is delineated to improve the drainage condition in the objective area for irrigation. This simply means that the drainage plan does not cover the plantation areas not direcly connected with the improvement of the drainage condition of the irrigation area. The drainage plan, however, will give some good effects to the plantation areas as well.

It is considered that the dredging of the new mouth of drainage canal will be encountered by some difficulties because of the complicated tidal current, higher tidal water level and a large amount of drift sand. The main object of the drainage plan, therefore, will be the improvement of the main river systems which pose comparatively serious problems especially in the coastal area.

4.3.2. Agricultural Development Plan.

(1) Land Use and Cropping Pattern.

After the implementation of construction of irrigation and drainage facilities as well as the flood protection dike, the introduction of the year round irrigation farming can be expected in the entire project area.

The project area has already been fully developed, so there leaves no room for further reclamation. However, all the paddy field in the project area will be turned into technical irrigation paddy field where year-round irrigation farming can be done.

Under these circumstances, rice cultivation has been selected for this agricultural development plan for the following reasons.

1) The Indonesian Government is importing annually about one million tons of rice spending about US$270 million of foreign currency. Therefore, rice production is especially required for meeting the rapidly growing demand for foodstuffs as well as for saving the foreign currency.

2) In North Sumatra province, 0.12 million tons of rice is either imported or shifted from other provinces annually. It is furthermore forecasted that a shortage of 0.4 million tons of rice will occur in 2000. This indicates high marketing potentiality of rice in the future.

3) Rice price is relatively stable at present. It is expected that this trend will continue hereafter. The benefit cost evaluation has proved that rice production will be highly profitable.

4) Farmers in the project area who are familiar with paddy cultivation have sufficient incentives to produce paddy.

The proposed cropping pattern in the project area is the double croppying of paddy per year as shown in Fig.4-6.

Physiologically, there is no limitation of paddy seed germination due to the constant high temperature which indicates the possibility of seedling at any time. However, special attention should be paid to the increase in photosynthetic efficiency of paddy in order to increase rice production. The critical growth period for such efficiency is about 15 days before heading and 25 days after heading. Cropping pattern of paddy, therefore, should be prepared in such a way that the said period falls on the period of long duration of sunshine. It is also necessary to consider the effective use of natural rainfall at the puddling periods when much irrigation water is required.

Polowijo crops will not be cultivated in the project area because all the cultivation area can be improved for more profitable use through paddy production.

Multi-cropping index in the project will rise to 1.8 from the present 1.3.

(2) Farm Inputs and Farm Practices.

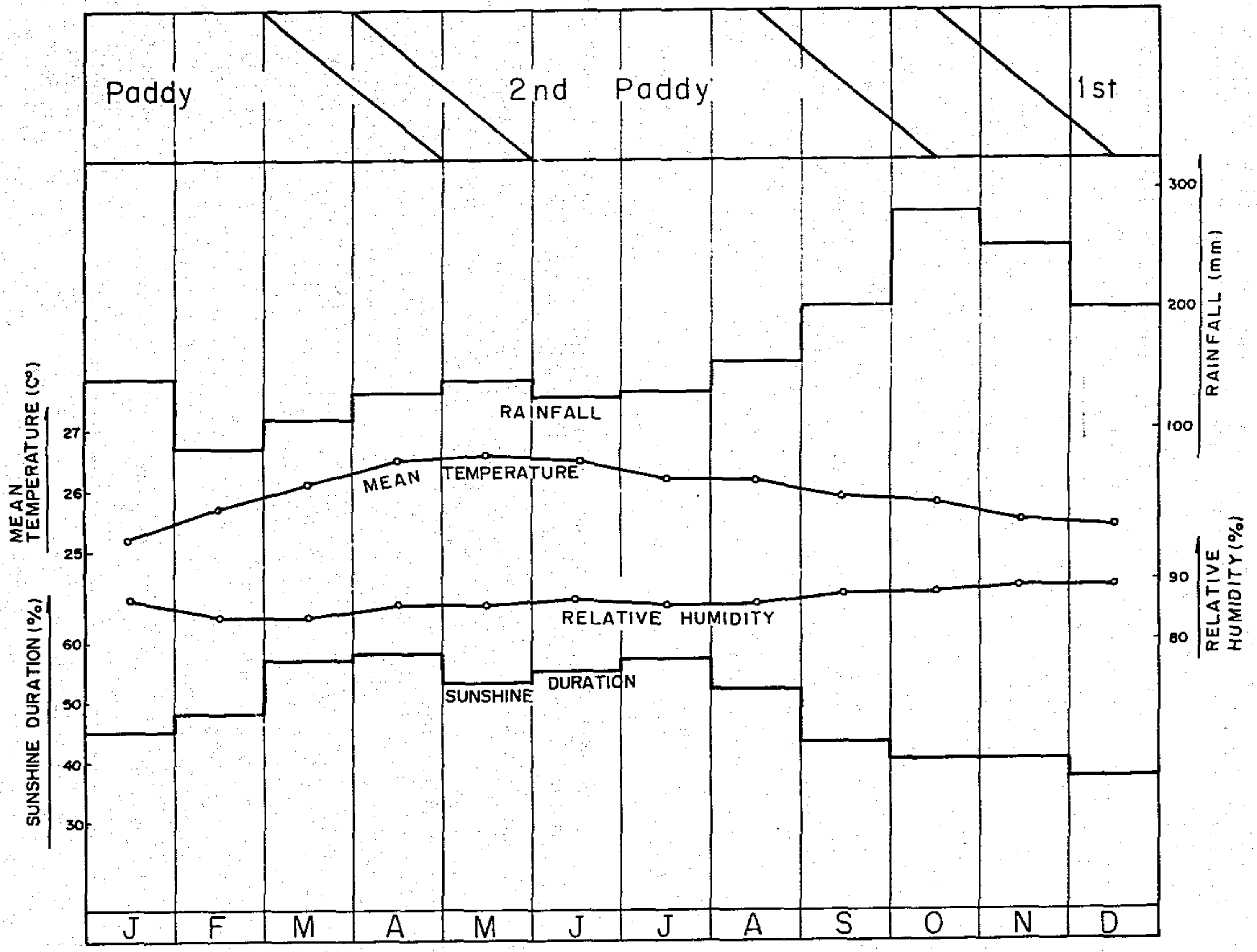
In the project area, improved high yielding varieties such as IR-series will be introduced. Proper application of fertilizers and agricultural chemicals is essential for the full exploitation of rice production for such high yielding varieties under irrigation farming.

The estimated total fertilizer requirement for paddy is 250 kg of urea and 100 kg of triple super phosphate per ha, respectively. As regards fertilization, split application of urea is practiced in order to increase rice yield and its heavy top-dressing is specially done in the late period of the young panicle formation stage. The total amount of triple super phosphate will be applied as basic dressing.

As to the damages to rice, the desease caused by grassystant virus and hopperfurn was conspicuous from 1973 to 1976. In addition damages by rice borer are principally found. In due consideration of these aspects 4ℓ per ha of insecticides such as diazinon, MPMC should be used. It is absolutely necessary to carry out joint prevention of plant diseases at the same time.

Proper water management during the growing stage of paddy is also an important factor for attaining the target yield of rice. The required technics are the drying practice, and application of deep or shallow water, etc.

Fig.4-6 Proposed Cropping Pattern



It is expected on the other hand, that there will be no substantial change in input requirement for future without project condition except some increase in fertilizer input.

Input requirements for rice in the future with and without project conditions are as summarized in Tables 4-14 to 4-16.

(3) Anticipated Yields and Crop Production.

The present crop yield is low, mainly because of the low farm inputs, and improper water control. The productivity of paddy in future with project condition is expected to increase through the introduction of improved irrigation farming as recommended in the previous section. The expected rice yield is estimated at 4.5 tons of paddy per ha on the basis of the experimental data made in the Provincial Seed Center located at Tanjung Morawa, International Rice Research Institute in the Philippines and Bogor Agricultural Experimental Station as well as the data on well-irrigated land in the project area in which more than 6 tons paddy per ha are often observed. The yield will increase gradually from year to year and will reach the maximum in the seventh year after introduction of improved irrigation farming.

The unit yields of crops in future without project condition are estimated, taking into consideration the past trend of the productivity in North Sumatra Province and the assumed input increase.

The future unit yield and production of crops both with and without project conditions are summarized in Table 4-17.

Table 4-14 Input Requirement for Paddy per ha for Rainfed Area including Non-technical Area (Without Project)

Item	Amount (Rp.)
Seed	2,500
Fertilizer	
Urea	12,000
T.S.P.	4,000
Insecticide	1,800
Rodenticide	460
Labor Cost	
Land Preparation & Nursery	12,000
Planting	8,400
Weeding, Fertilizing & Spraying Chemicals	25,000
Harvesting	10,000
Miscellaneous Cost	4,840
Total Cost	81,000

Table 4-15 Input Requirement for Paddy per ha for Irrigated Land (Double Cropping Area of Paddy for 4,500 ha) (Without Project)

Item	Amount (Rp)
Seed	3,750
Fertilizer	
Urea	16,400
T.S.P.	6,200
Insecticide	2,800
Rodenticide	840
Labor Cost	
Land Preparation & Nursery	13,000
Planting	8,600
Weeding, Fertilizing & Spraying Chemicals	29,800
Harvesting	11,500
Miscellaneous Cost	5,110
Total Cost	98,000

Table 4-16 Input Requirement for Paddy per ha (With Project)

Item	Amount (Rp)
Seed (25 kg, Rp.150/kg)	3,750
Fertilizer	
Urea (850 kg, Rp.80/kg)	20,000
TSP (100 kg, Rp.80/kg)	8,000
Insecticide	
(4ℓ, Rp.900/ℓ)	3,600
Rodenticide	
Zinc phosphide (0.5 kg, Rp.2,300/kg)	1,150
Labor Cost	
Land Preparation & Nursery	14,000
Planting	8,800
Weeding, Fertilizing & Spraying Chemicals	33,700
Harvesting	13,000
Miscellaneous Cost	7,000
Total Cost	113,000

Table 4-17 Future Unit Yield and Production of Crops

	Without Project			With Project			
	Unit yield (t/ha)	Area (ha)	Production (t)	Unit yield (t/ha)	Area (ha)	Production (t)	Increase
	(1)	(2)	(3) = (1)x(2)	(4)	(5)	(6) = (4)(5)	(7) = (6)-(3)
Paddy	3.4	14,000 /1	47,600	4.5	33,300 /3	149,850	66,250
	4.0	9,000 /2	36,000				
Polowijo	5.16	1,100	5,680	-	-	-	-5,680

/1 : Rainfed-area & non-technical area

/2 : Doucle cropping of paddy area (or technical & semi-technical area) (4500 ha x 2)

/3 : Wet season paddy area (18,500 h a) + Dry season paddy area (14,800 ha)

(4) Marketing and Price Prospects.

Future prospects of the demand-supply condition of rice in North Sumatra Province are projected for the period of 1980 to 2000 on the basis of the following assumptions.

1) Annual population growth rate of 2.9% will continue during the said period (Refer to Table 4-18).

2) Annual per capita consumption of rice is 150 kg (or 250 kg of paddy).

3) Annual increasing ratio of rice production in North Sumatra Province is 33,540 tons (or 55,900 tons of paddy) (Refer to Table 4-19).

Although the projection is made on the basis of rather simple assumptions and comparison, the results suggest that the shortage of rice will continue in the future and will reach about 382,000 tons of rice in 2000. The estimated shortage of rice which may occur during the period of 1980 to 2000 is as summarized in Table 4-20.

An increase of about 53,000 tons of rice (or 88,300 tons of paddy) can be expected at the stage of full development in the project area. This amount of increase will easily find its outlet in the domestic markets.

As regards prices of the farm products in the future with project, the economic farm gate price for paddy is estimated at Rp.65 per kg of paddy on the basis of the projected international market price/1 taking into consideration the transportation, processing and other costs and expenses. Details are as shown in Table 4-21.

/1 : The international price as forecast by IBRD for the period of 1980 to 1985 is used.

Table 4-18 Population in North Sumatra Province

Year	Population	Population Growth rate
1961	4,964,723	
1962	5,105,700	2.8
1963	5,321,900	4.2
1964	5,362,500	0.8
1965	5,498,300	2.5

Year	Population	Population Growth rate
1966	5,639,300	2.6
1967	5,785,200	2.6
1968	5,936,600	2.6
1969	6,094,000	2.6
1970	6,413,270	5.2
1971	6,690,723	4.3
1972	6,889,960	3.0
1973	7,091,866	2.9
1974	7,297,927	2.9
1975	7,509,113	2.9
1976	7,726,737	2.9

Source: Statistical Year Book of North Sumatra, 1975

Table 4-19 Harvested Area and Total Production of Rice in North Sumatra Province

Year	Harvested area	Total production of rice /4	
1969	501,519	846,746 /1	(1,411,243) /2
1970	512,435	866,869	(1,444,781)
1971	556,539	947,006	(1,578,343)
1972	564,969	1,001,758	(1,686,264)
1973	502,251	1,014,579	(1,690,965)
1974 /3	521,896	922,609	(1,537,681)
1975 /3	518,241	826,682	(1,377,804)

/1 : Rice

/2 : Paddy (conversion ratio from paddy is rice = 100:60)

/3 : Harvested area and total production of rice decreased due to damages by leaf hopper 1974 and 1975 are excepted for estimation of increasing rate of rice production per annum.

/4 : Increasing rate of total production of rice between 1969 and 1973 is estimated at 33,540 tons per annum (or 55,900 tons of paddy).

Table 4-20 Forecast of Rice Shortage in North Sumatra Province

Year	Population/1	Demand/2	Production/3	Balance
1980	8,663,000	1,299,000	1,249,359	- 50,000
1985	9,994,000	1,499,000	1,417,059	- 82,000
1990	11,580,000	1,730,000	1,584,759	-145,000
1995	13,301,000	1,995,000	1,752,459	-243,000
2000	15,345,000	2,032,000	1,920,159	-382,000

/1 : Annual population growth rate = 2.9%
/2 : Per capita consumption of rice = 150 kg of rice per year.
/3 : It is assumed that the annual increased production is 33,540 tons of rice after 1973.

Table 4-21 Rice Price for Economic Evaluation of the Project

			Rp./t
International market price FOB Bangkok	US$270/t		112,050
Transportation cost Bangkok-Belawan	US$ 10/t	Rp./t 4,150	116,200
Handling charge & warehouse charge (handling charge Rp 1,000 10 Rp/day x 60 days = Rp 600)		1,600	117,800
Transportation cost Belawan-Medan		2,600	120,400
Processing cost			
a. Package & handling charge		4,000	116,400
b. Milling charge		2,500	113,900
c. Selling price of paddy	b x 0.6		68,340
Transportation and broker's margin		2,500	65,840
Farm gate price			65,840 (65,000)

4.3.3. Irrigation and Drainage Plan.

(1) General Plan of Irrigation and Drainage.

As described under 4-2-6 and 4-3-1 in CHAPTER IV, the irrigation and drainage plan for the agricultural development in the project area is mainly to improve the existing systems and expand the technical irrigation area without the construction of special structures such as dam or weir.

The coverage areas of the irrigation plan are located in the alluvial fan of the Ular River mainly along the coast, and totalized to be 18,500 ha of net paddy field planned to produce rice products twice a year.

The water source for the irrigation entirely depends on the Ular River which can supply total diversion water requirements of each intake throughout the past discharge observation period. The drainage water which inflows into the dual-purpose canal from its catchment area is disregarded.

After deciding the coverage area of each intake in accordance with the check of its elevation and capacity to the benefited area, the improvement of existing irrigation systems is planned as shown in Fig. 4-10. As for intakes, three intakes are left as they are, five are unified to one and other five are improved within thirteen existing intakes for irrigation. Nine intakes, therefore, cover 18,500 ha.

All existing drainage systems are not improved, but some drainage rivers which flow in the proposed irrigation areas or connected with them and moreover have comparatively bigger drainage requirements are selected to be the objectives for the improvement. Fig. 4-11 shows the plan of the drainage system.

(2) Water Resources.

The discharge observation station on the Ular River avaiable for the study on the irrigation plan is installed at Serbajadi near the Pulau Gambar intake in the upper reaches of the river in the project area and it has the catchment area of 1,030.6 km^2. Almost no residual catchment area is found between Serbajadi and the estuary of the Ular River. The river discharge at the time of drought, therefore, can be regarded to be gradually decreased in proportion to the intake discharges on the downstream.

Irrigation plan is usually decided to be based on the drought discharge of the 1 in 5 year probability in Indonesia. Actually, however, discharges only for three and half years have been observed at Serbajadi and no correlation can be found between the river discharge and the areal rainfall in the catchment area. Therefore, it is difficult to calculate the drought discharges of the 1 in 5 year probability.

Accordingly, the irrigation plan rests on the basis of ten-day discharge. The total diversion water requirement of each month shows smaller value than the ten-day river discharge of the same month in all past records. The minimum difference between the total diversion requirement and the ten-day discharge was 10.7 m^3/sec and appeared in the last ten days of July in 1972, and the river discharge at that time near Pulau Gambar intake was 33.3 m^3/sec.

This means that the Ular River still sustain a discharge more than 10.0 m^3/sec even in the most dangerous ten days after taking the total diversion discharge. Fig.4-7 shows the relation of the ten-day discharge and the total diversion requirement using the past records of discharge.

(3) Irrigation Water Requirement.

Almost no data on the crop water requirement is available in the project area and the neighboring area. The consumptive water use for paddy cropping, therefore, is obtained using the climatological data and other requirements are decided by reference to the observation record and the data which are empirically adopted in Indonesia.

Table 4-22 shows the results of calculation of the unit and total diversion water requirements. In the table, the monthly effective rainfall is assumed to be 80% of the average of the dry monthly rainfall of each station in the project area occuring once in 5 years. The consumptive water use is calculated by the modified Penman formula using the climatological data at Sampali. The daily percolation assumed is at 3 mm for dry months and 2 mm for wet months. The puddling water requirement including the land preparation requirement is taken as 200 mm for the initial twenty days of each cropping and the total efficiency except the conveyance loss assumed is 0.64. During the last fifteen days before harvest of the crop, no irrigation water is supplied.

The maximum monthly diversion water requirements, which are calculated in accordance with the proposed cropping pattern, appear in February for the first cropping and in June for the second. Their amounts for the total irrigation area of 18,500 ha are 22.6 m^3/sec and 25.2 m^3/sec respectively.

(4) Drainage Water Requirement.

Rice plants can not be submerged, without undue damages, for a period of more than 4 or 5 days. After submergence, the water level in the paddy fields must be lowered, so as to leave 15 cm of plant exposed above the water, within a period of not more than 4 days.

Drainage capacity is decided to provide sufficient conveyance capacity for protection against 5-year frequency rainfall storms in addition to the above consideration and in accordance with the recommended method of PROSIDA which is the special authority for the projects of International Development Association in Indonesia.

Fig.4-7 Relation of River Discharge and Diversion Requirements with and without Effective Rainfall

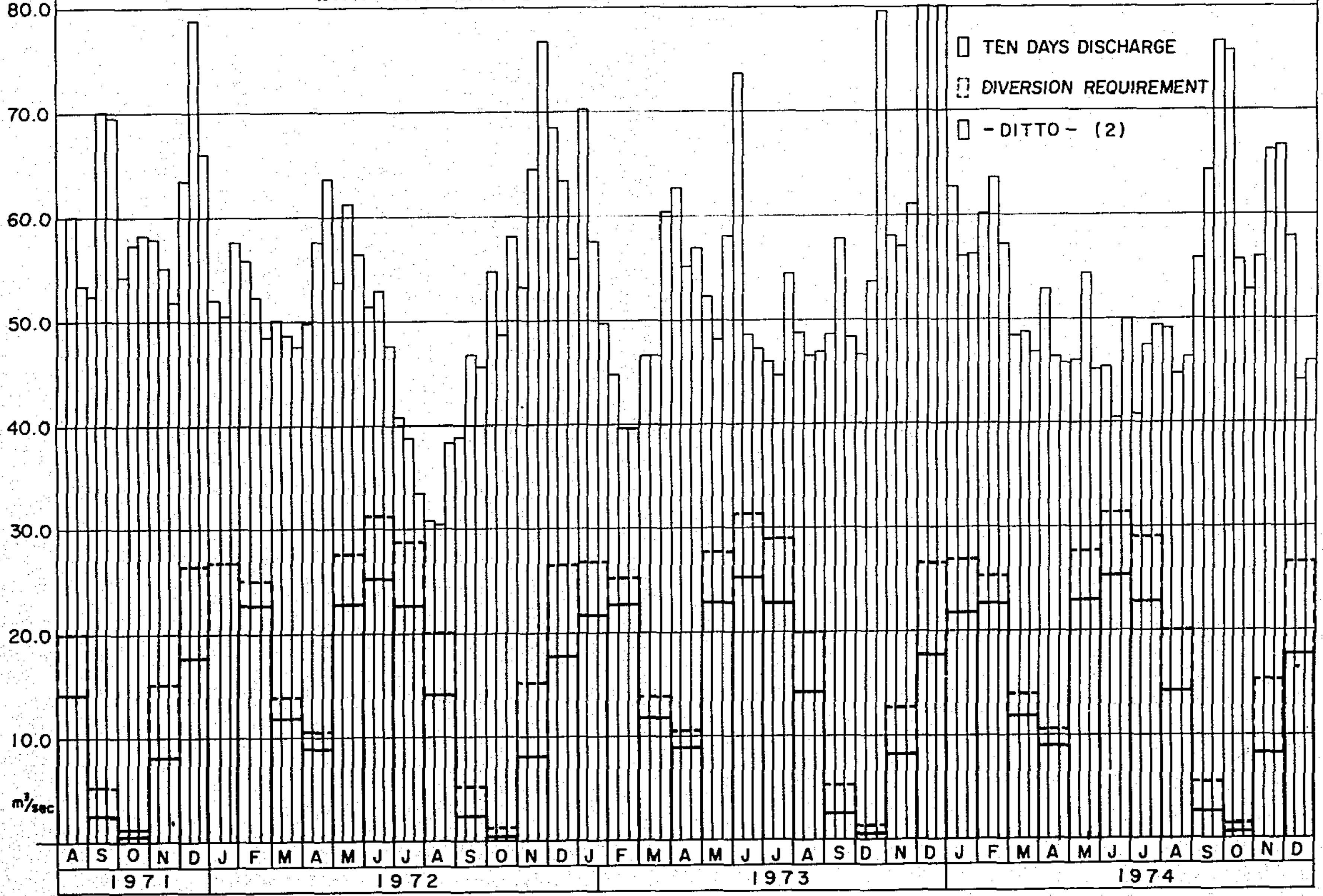


Table 4 - 22 UNIT AND TOTAL DIVERSION WATER REQUIREMENTS

Item	Unit	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1. Effective rainfall	mm	45	23	37	51	59	55	57	74	105	149	128	89
Cropping pattern			15d		20d				15d		20d		
2. Comsumptive water use	mm	153	141	163	146	147	158	174	155	131	114	115	119
3. Percolation	mm	93	84	93	90	93	90	33	93	60	62	60	62
4. Puddling water requirement	mm	2	—	—	67	100	33	—	—	—	19	95	81
5. Field delivery requirement	mm	203	202	219	252	281	226	210	174	86	46	145	173
6. — ditto —	l/s/ha	0.758	0.835	0.817	0.972	1.049	0.872	0.764	0.649	0.332	0.172	0.559	0.646
7. Ratio of area		1.000	0.938	0.500	0.313	0.750	1.000	1.000	0.750	0.250	0.062	0.500	0.938
8. Unit diversion requirement	l/s/ha	1.18	1.22	0.64	0.48	1.23	1.36	1.22	0.76	0.13	0.02	0.44	0.95
9. -ditto-(without effective rainfall)	l/s/ha	1.45	1.36	0.75	0.57	1.49	1.69	1.56	1.08	0.29	0.07	0.62	1.43
10. Total diversion requirement	m^3/s	21.8	22.6	11.8	8.9	22.8	25.2	22.6	14.1	2.4	0.4	8.1	17.6
11. -ditto-(without effective rainfall)	m^3/s	26.8	25.2	13.9	10.5	27.6	31.3	28.9	20.0	5.4	1.3	15.2	26.5

According to the PROSIDA's recommendation, the rational formula is applicable to the surface drainage from agric land and the empirical formula by Macmath for the runoff from the drainage area comprising villages, roads and non-agric land.

Fig. 4-8 shows the calculation result and its deriviation notes of the drainage water requirement for the project area. In the calculation, the ratios of the agric land and the other area are assumed to be 75% and 25% respectively. The maximum daily rainfall for a return period of 5 years is 122 mm of the average value at the rainfall stations in the project area.

In view of the fact that there is a distinct difference between point intensity of climatic quantity and average intensity over a larger area, value of the former quantity was applied to 50 ha and 90% thereof was applied to 5,000 ha. Regarding the drainage channels, an allowance of 15% was added to the carrying capacity for design in consideration of possible future reduction of carrying capacity due to sedimentation. This allowance was taken into consideration primarily in the estuary reaches of the drainage channels.

(5) Irrigation and Drainage System.

As shown in Figs. 4-9 and 10, the irrigation systems in the project area are planned by nine intakes, and the irrigation area totals 18,500 ha.

Swadaya intake, which is proposed to be improved, covers the Pulau Gambar area of 1,200 ha with the existing Pulau Gambar intake. S. Buluh intake also proposed to be improved increases the benefited area from existing 400 ha to 4,600 ha. The main canal for the S. Buluh area, however, is left to be dual-purpose canal for both irrigation and drainage because the canal length is long and the separation needs big construction cost. The original planning area of P.U. for the expansion of the Timbang Deli area is plantation at present and the improved intake intensifies the existing irrigation system of 400 ha.

Bendang intake is left as it is, but Perbaungan intake is proposed to be improved. The areas irrigated by both the intakes are connected with canal and therefore can be considered to be one irrigation system which expands the coverage area from 2,959 ha to 7,200 ha mainly along the coastal area. The improved Sumber Rejo intake magnifies the objective area from 800 ha to 2,700 ha taking in the area which Ramonia intake can not cover. The Ramonia intake spreads the irrigation system from 1,100 ha to 1,700 ha without the improvement of the intake. Singosari intake is proposed to unify five small intakes along the right side in the downstream of the Ular River and expands the irrigation area from existing 150 ha to 700 ha.

The improvement of the drainage system is planned to concentrate on the basins of the Buluh River and the Perbaungan River with bigger drainage requirement. Especially, the drainage water conveyed by the

Fig. 4 - 8 Drainage Water Requirement

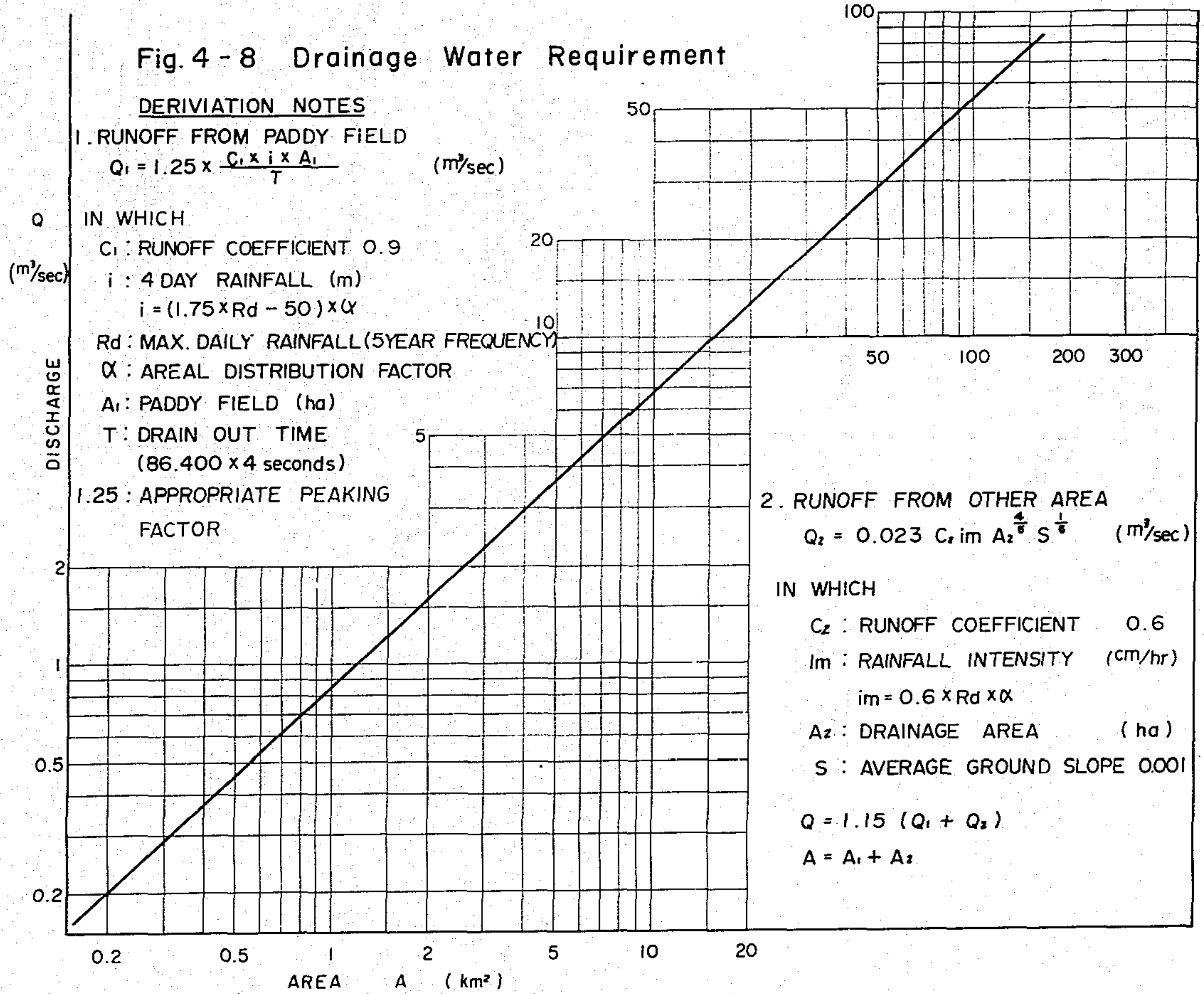


Fig.4-9 Diagram of Irrigation Water Distribution System (with Project)

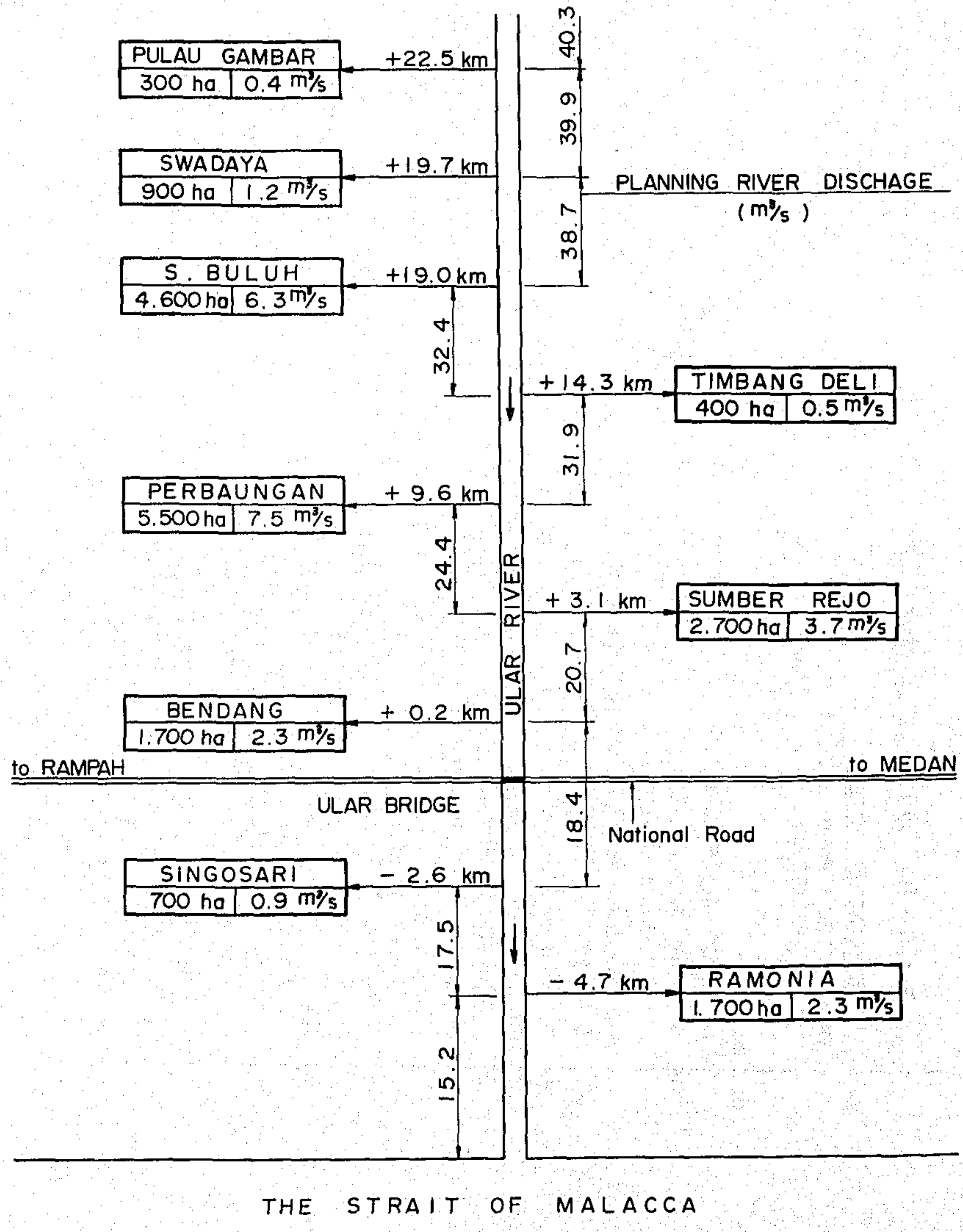
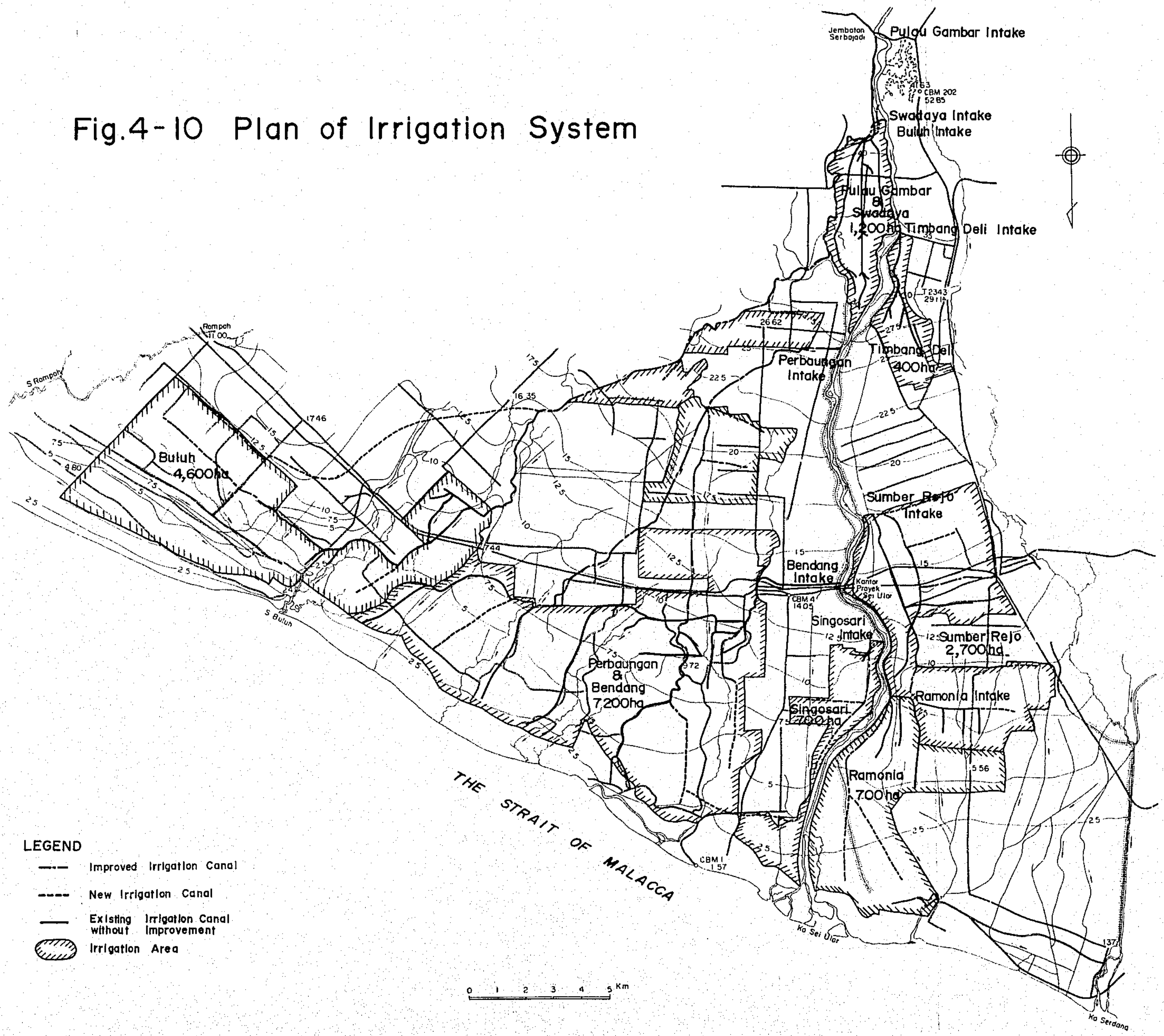


Fig.4-10 Plan of Irrigation System



dual - purpose main canal for the Buluh area casts a burden upon the Buluh drainage canal which is a tributary of the Nippah River at present. The main drainage work is to decentralize the drainage requirement of the above Buluh main canal to the tributaries of the Buluh River and Nippah River because the Buluh main canal is also used as the irrigation canal. Further, important tributaries of the Buluh, Nippah and Perbaungan rivers are planned to be enlarged in the area benefited by irrigation. Fig.4-11 shows the improvement plan of the drainage systems.

4.3.4. Proposed Irrigation and Drainage Works.

(1) Intakes.

Fig.4-9 shows the diagram of irrigation water distribution system from the Ular River during the last ten days of June when the intakes take maximum discharge of 25.2 m^3/sec in total and the river shows the minimum ten-day discharge of 40.3 m^3/sec. Actually, however, the minimum difference between total diversion requirement and ten-day discharge appears in the last ten days of July, and the amounts of the total diversion requirement, ten-day discharge of the river and their difference at that time are 22.6 m^3/sec, 33.3 m^3/sec and 10.7 m^3/sec respectively.

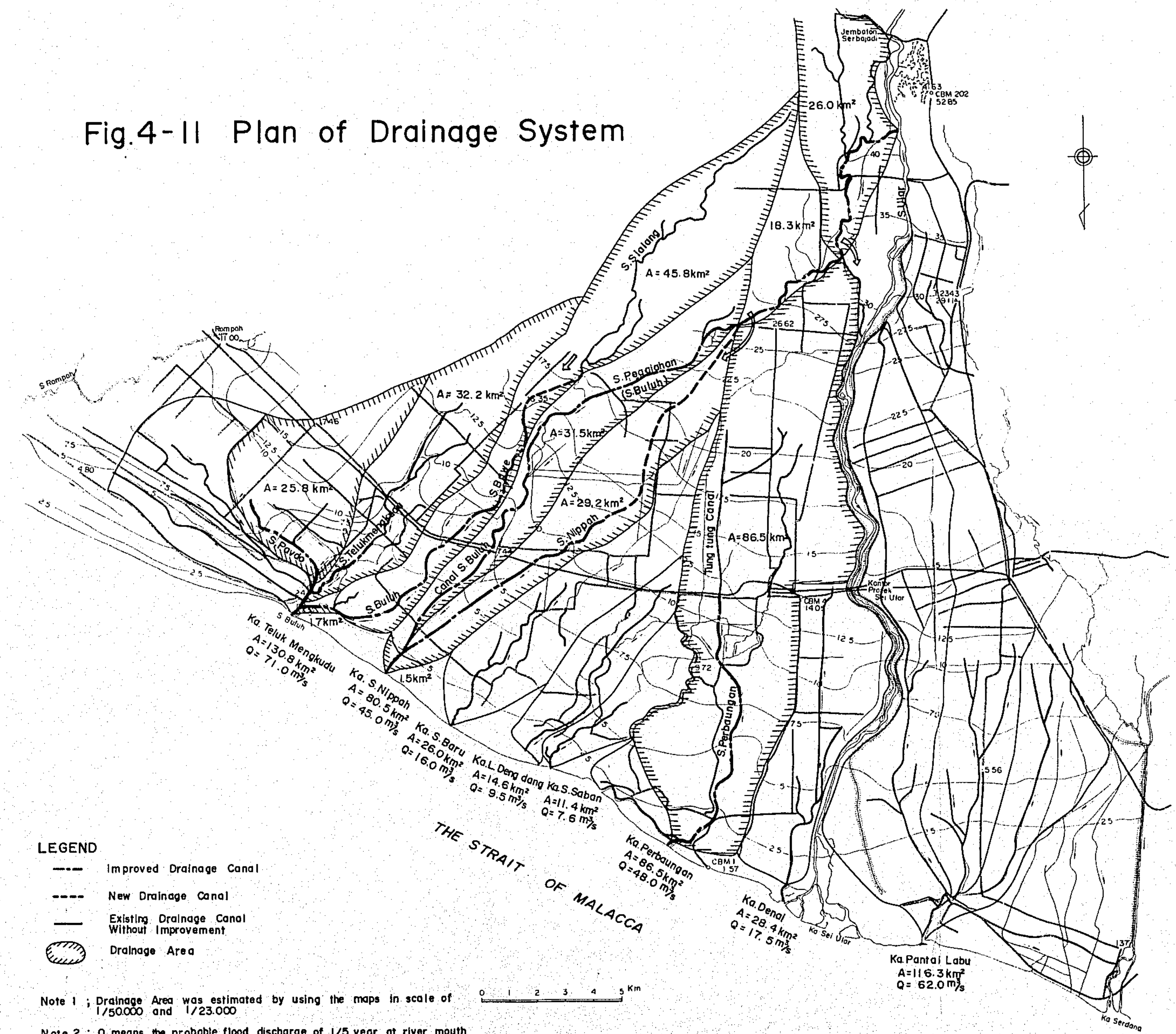
The improvement of the existing intakes mainly consists of lowering the elevation and enlarging the width slightly to assure the total diversion water requirement. The above two cases are applied to decide the elevation and capacity of each intake and its successive canal. The relation between the river discharge and the water level necessary for this study depends on Fig.4-2 because the relation has almost no changes after the river improvement. The result is shown in Table 4-23. Three intakes of Pulau Gambar, Bendang and Ramonia have no necessity for improvement.

The design velocity of inflowing water at the intakes is from 0.6 m/sec to 0.8 m/sec and the maximum velocity for earth canal is assumed to be 0.6 m/sec. The suspended sand, therefore, is considered to precipitate in some distances in the upstream of the canal. The proper operation of intake gate to keep the intake velocity at less than the design velocity and the occasional operation and maintenance of intake and canals will be required. The necessity and availability of sedimentation basin is proposed to be studied in the coming feasibility study.

(2) Related Structures.

Table 4-24 shows the number of proposed irrigation facilities and the length of canal which cover the tertiary irrigation unit of about 150 ha at every intake, classifying the facilities into structures not to be improved, to be improved and to be newly constructed.

Fig.4-11 Plan of Drainage System



LEGEND

- —·— Improved Drainage Canal
- - - - New Drainage Canal
- —— Existing Drainage Canal Without Improvement
- Drainage Area

Note 1 ; Drainage Area was estimated by using the maps in scale of 1/50.000 and 1/23.000

Note 2 ; Q means the probable flood discharge of 1/5 year at river mouth

Table 4 – 23 PLANNING INTAKE FACILITIES FOR IRRIGATION

Elevation : UP

Name	Location	Site	Irrigation area	Max.intake discharge	River discharge	Intake water level	Gate width x number	Bed elevation of intake	Canal			Remarks
									Bed width	Sideslope	Gradient	
	km		ha	m³/sec	m³/sec	EL.(m)	m	EL. (m)	m			
Pulau Gambar	+22.5	Right	300	0.4 (0.4)	40.3 (33.3)	44.4 (44.3)	1.00 x 2	44.0	2.30	1 : 1	0.00035	not improved
Swadaya	+19.7	Right	900	1.2 (1.1)	39.9 (32.9)	40.2 (40.1)	1.00 x 2	39.5	2.60	1 : 1	0.00038	
S. Buluh	+19.0	Right	4.600	6.3 (5.6)	38.7 (31.8)	39.5 (39.4)	1.20 x 5	38.4	7.38	1 : 1	0.00018	dual-purpose canal
Timbang Deli	+14.3	Left	400	0.5 (0.5)	32.4 (26.2)	33.0 (32.9)	1.00 x 2	32.6	1.00	1 : 1	0.00030	
Perbaungan	+ 9.6	Right	5.500	7.5 (6.7)	31.9 (25.7)	27.0 (26.9)	1.20 x 6	25.9	8.78	1 : 1	0.00014	
Sumber Rejo	+ 3.1	Left	2.700	3.7 (3.3)	24.4 (19.0)	18.2 (18.1)	1.20 x 4	17.3	5.43	1 : 1	0.00019	
Bendang	+ 0.2	Right	1.700	2.3 (2.1)	20.7 (15.7)	14.4 (14.4)	0.80 x 2	13.4	4.00	0	0.00080	not improved
Singosari	– 2.6	Right	700	0.9 (0.8)	18.4 (13.6)	11.6 (11.6)	0.80 x 2	10.9	1.65	1 : 1	0.00036	
Ramonia	– 4.7	Left	1.700	2.3 (2.1)	17.5 (12.8)	8.6 (8.5)	1.20 x 3	7.8	2.00	1 : 1	0.00060	not improved
Total			18.500	25.1 (22.6)								

( ) In case of min. ten days discharge

Table 4－24 PROPOSED IRRIGATION FACILITIES

Note ; A : Facilities not improved
B : Facilities improved
C : New facilities

Name of Intake	Item	Intake (Unit : No)	Canal structure Unit : No									Canal length (km)		
			Deversion Work	Secondary deversion work	Turn out	Drop	Aqueduct	Syphon	Conduit	Bridge	Spillway	Main Canal	Secondary Canal	Total
Pulau Gamlar	A	1	2	1	10	4	1	—	—	5	—	4.4	11.8	16.2
	B	—	—	—	—	—	—	—	—	—	—	—	—	—
	C	—	—	—	—	—	—	—	—	—	—	—	—	—
Swadaya	A	—	—	—	—	—	—	—	—	—	—	0.3	—	0.3
	B	1	—	—	—	—	—	—	—	—	—	0.8	—	0.8
	C	—	—	—	—	—	—	—	—	—	—	—	—	—
S. Buluk	A	—	—	—	2	—	—	—	—	—	—	0.5	16.0	16.5
	B	1	1	2	—	6	—	—	1	2	3	26.7	2.9	29.6
	C	—	1	5	7	—	—	5	1	—	—	—	33.5	33.5
Timbang Deli	A	—	—	—	—	—	—	—	—	—	—	—	0.9	0.9
	B	1	—	—	4	—	—	—	—	—	—	2.9	3.3	6.2
	C	—	—	—	—	2	—	—	—	—	—	—	—	—
Perbaungan	A	—	—	6	—	—	—	—	—	6	—	—	3.2	3.2
	B	1	2	—	1	6	1	2	—	9	2	9.3	22.8	32.1
	C	—	—	4	3	—	—	4	—	—	—	—	15.5	15.5
Sumber Rejo	A	—	—	—	—	—	—	—	—	—	—	—	9.7	9.7
	B	1	4	—	—	—	—	—	1	—	—	2.0	5.3	7.3
	C	—	—	2	3	—	—	—	—	—	—	—	8.1	8.1
Bendang	A	1	—	—	—	—	3	—	—	—	—	4.0	1.6	5.6
	B	—	2	—	—	—	—	—	—	—	—	—	1.4	1.4
	C	—	—	—	1	—	—	—	—	—	—	—	3.2	3.2
Singosari	A	—	—	—	—	—	—	—	—	—	—	—	1.1	1.1
	B	1	1	—	—	—	—	—	—	—	—	—	3.7	3.7
	C	—	—	1	1	—	—	—	—	—	—	—	3.8	3.8
Ramonia	A	1	3	—	—	—	6	1	—	—	—	—	—	—
	B	—	1	—	—	—	1	—	—	—	—	—	4.0	4.0
	C	—	—	2	3	—	1	—	—	—	—	—	9.5	9.5
Total	A	3	5	7	12	4	10	2	1	11	0	9.2	44.3	53.5
	B	6	11	2	5	12	2	2	2	11	5	41.7	43.4	85.1
	C	—	1	14	18	2	1	9	1	0	0	—	73.6	73.6

One of the most important structures is the measuring device attached to diversion works. The proper water manaement by means of the measuring devices will entail the successful development in project area.

Besides, the provision of drop work will prevent the erosion of the inside slope of canals to some extent.

(3) Farm Ditch and Farm Road.

As stated before, facilities on farm in the project area are left in the unconsolidated condition. Especially, the small densities of tertiary canal, farm ditch and farm road seem to prevent the expansion of the irrigated area. On-farm works to increase the densities of tertiary canal, farm ditch, branch road and farm road at least to 20 m, 40 m, 30 m and 15 m per ha respectively should be taken into account as the project works.

(4) Drainage Works.

Drainage works are proposed as shown in Fig.4-11 and the following table. The construction of new bridges and the improvement of existing bridges also should be taken into account as the project works.

Table 4-25 Proposed Drainage Works

Name of river	Improvement	New construction	Total	Bridges
	km	km	km	places
S. Perbaungan incl. Tungtung canal	10.8	-	10.8	3
S. Nippah	10.1	8.1	18.2	3
S. Buluh and Baweh	10.5	5.8	16.3	3
S. Telukmengkedu	3.6	-	3.6	1
S. Pavdo	3.8	-	3.8	1
Total	38.8	13.9	52.7	11

4.4. Cost Estimate for Irrigation and Drainage Works.

4.4.1. Construction Schedule.

The irrigation system in the project area is divided into eight areas. Taking it for granted that each area should be developed for one year, the construction period is decided to be 3 years because the development of the Buluh area requires the biggest construction volume, and the numbers and capacities of the construction equipment for the project area decided by the above construction volume.

The construction schedule to develop eight areas is decided from their technical and economical points of view. In the first year, Sumber Rejo, Ramonia, Pulau Gambar and Singosari areas are scheduled to be developed. The Buluh area will be developed in the second year after the drainage work in the downstream has progressed to some extent. In the last year, the irrigation systems in the Bendang, Perbaungan and Timbang Deli areas are improved.

Before starting the construction of main civil works, detailed design, procurement of construction equipment, land aquisition including some compensation works and the construction of temporary work, offices and quarters should be preceded.

Fig. 4-12 and Table 4-26 show the proposed construction schedule and the sequence of area to be developed.

Fig.4-12 Construction Schedule

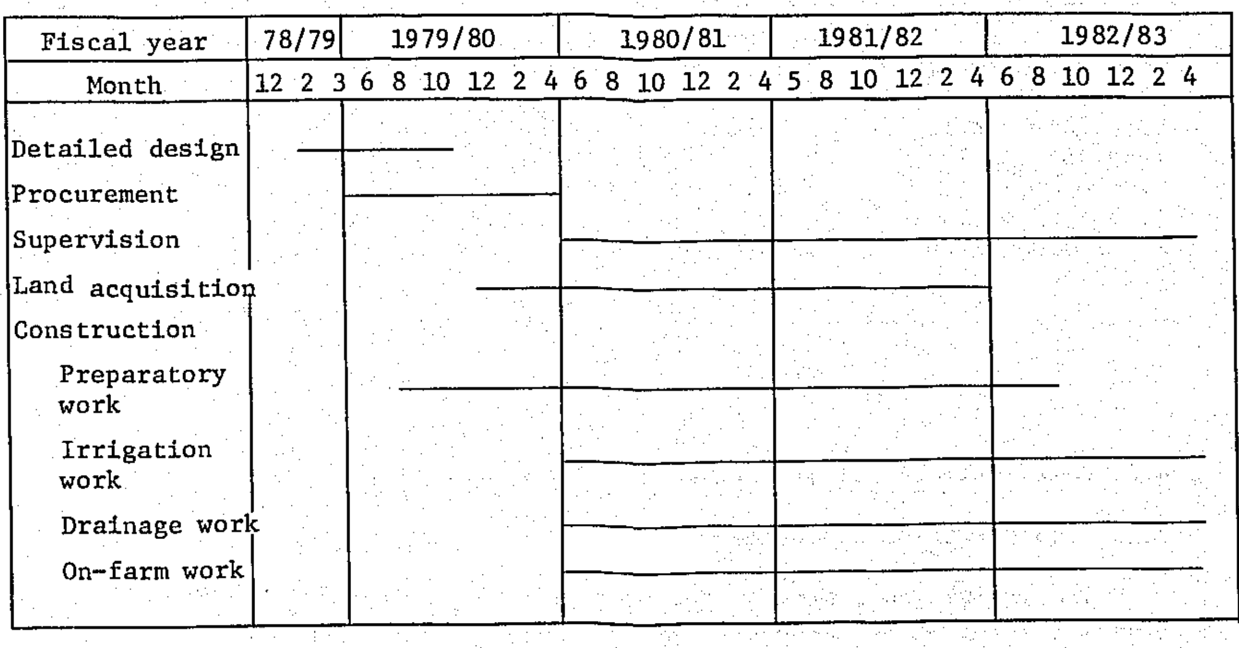


Table 4-26 Sequence of development by area

Year	Area	Existing condition			Develop
		First cropping		Second cropping	Double cropping
		Irrigated	Rain-fed		
		ha	ha	ha	ha
1980/81	Sumber Rejo	800	1,900	100	2,700
	Ramonia	1,100	600	500	1,700
	Pulau Gambar	1,200	-	800	1,200
	Singosari	150	550	-	700
	Sub-total	3,250	3,050	1,400	6,300
1981/82	S. Buluh	400	4,200	-	4,600
1982/83	Bendang	1,000	700	900	1,700
	Perbaungan	1,950	3,550	1,800	5,500
	Timbang Deli	400	-	400	400
	Sub-total	3,350	4,250	3,100	7,600
	Total	7,000	11,500	4,500	18,500

4.4.2. Construction Cost.

The costs described here are all construction expenses necessary for the improvement of the irrigation and drainage systems in the project area on the basis of the afore-mentioned scale. The construction costs are estimated under the condition that the construction is carried out by local contractors and the construction equipment are procured from abroad and lent to the contractors by the Government of Indonesia.

The cost of construction equipment, however, is included in the construction costs as depreciation cost. All administrative staffs and laborers are locally mobilized except consultants to be invited for engineering services and all materials are proposed to be locally purchased except big gates.

All construction costs were estimated based on the standard prices in the 1976/77 fiscal year in Tokyo and Medan. The cost of miscellaneous work is expected to be 10 per cent of the cost for all civil works. About twenty (20) per cent of the total cost for all civil works including miscellaneous work is applied to engineering and administration cost. Land Compensation expenses consist of the costs of land aquisition for right-of-way of canals, temporary works, etc. Physical contingency is assumed to be 20% of the total costs for civil works, land compensation, engineering and administration.

Tables 4-27 and 28 show the construction costs and their annual disbursement program which follow the construction schedule and the sequence of area to be developed.

Table 4-27 Construction Cost

Unit: 10^6Rp.

Item	Amount
Civil Works	
Preparatory work	224
Irrigation work	1,355
Drainage work	804
On-farm work	375
(Sub-total)	2,758
Miscellaneous work	275
Sub-total	3,033
Land Compensation expenses	50
Engineering and administration cost	580
Physical contingency	732
Total	4,395

Table 4-28 Annual Disbursement Program

Unit: 10^6Rp.

Item	1978/79	1979/80	1980/81	1981/82	1982/83	Total
Civil works						
Preparatory work	-	15	109	50	50	224
Irrigation work	-	-	354	590	411	1,355
Drainage work	-	-	268	268	268	804
On-farm work	-	-	80	150	145	375
Miscellaneous work	-	1	81	106	87	
Sub-total	-	16	892	1,164	961	3,033
Land Compensation expenses	-	25	13	12	-	50
Engineering and administration cost	87	203	98	96	96	580
Physical contingency	17	49	201	254	211	732
Sub-total	104	277	312	362	307	1,362
Total	104	293	1,204	1,526	1,268	4,395

4.4.3. Operation, Maintenance and Replacement Cost.

Operation and maintenance cost of the irrigation and drainage facilities after completion of construction is expected to run to about 2 percent of the costs of civil works per year. Operation and maintenance cost during construction period is assumed to be in proportion to the area to be developed.

The cost to replace facilities for irrigation and drainage within the period of project life is mainly for big gates of which the life year is expected to be 30 years. The requirement cost is totalized to be 132,000,000 Rp.

The following table shows the annual disbursement program of the operation and maintenance cost and the installation cost of big gates.

Table 4-29 Operation, Maintenance and Replacement Cost

Unit: 10^6Rp.

Item	1980/81	1981/82	1982/83	1983/84	Remarks
O.M. cost	-	20	35	60	fixed on and after 1893/84
Replacement cost	45	33	54	-	Replacement after 30 years

4.5. Irrigation Benefit and Farm Budget.

4.5.1. Estimate of Irrigation Benefit.

The land in the project area is now under insufficient seasonal irrigation or rain-fed. Consequently, the percentage of paddy cropping in the dry season is restricted to be less than 25%. Furthermore unit yield of paddy crop remains in low level due to such improper water control as well as insufficient farm management.

The project will provide year-round irrigation and drainage to the entire project area and will thereby provide the basis for a major increase in rice yield and production.

Irrigation benefit is defined as the difference of primary profit from crops between future without project and with project conditions.

The irrigation benefit will come immediately after the implementation of the construction of irrigation and drainage facilities. The benefit will be expected to increase linearly year by year and attain its maximum of Rp 2,478 million in and after the 7th year after the completion of construction of irrigation and drainage facilities as shown in Table 4-30.

Table 4-30 Annual Irrigation Benefit in the Full Stage

(Unit: Rp)

Gross Income	Without project		With project
Paddy			
Unit yield (t/ha)	4.0	3.4	4.5
Harvested area (ha)	9,000	14,000	33,300
Total production (t)	36,000	47,600	149,850
Unit price (Rp/t)	65,000	65,000	65,000
Gross income ....(A)	$2,340x10^6$	$3,094x10^6$	$9,740x10^6$
Polowijo			
Harvested area (ha)	1,100		0
Total production (t)	5,680		0
Gross Income ....(B)	$102x10^6$		0
Total gross income (A+B)	$5,536x10^6$		$9,740x10^6$
Gross outgo			
Paddy	(4.0t/ha)	(3.4t/ha)	
Unit farming expense (Rp/ha)	98,000	81,000	113,000
Input area	9,000	14,000	33,300
Gross outgo ....(C)	$882x10^6$	$1,134x10^6$	$3,763x10^6$
Polowijo			
Gross outgo ....(D)	$21x10^6$		0
Total gross outgo (C+D)	$2,037x10^6$		$3,763x10^6$
Primary profit (A+B-C-D)	$3,499x10^6$		$5,977x10^6$
IRRIGATION BENEFIT	($5,977x10^6$-$3,499x10^6$)		$2,478x10^6$

Furthermore, the more intensive and extensive farming as a result of the Project will foster trade in agricultural inputs. Also the surplus rice for the region will require commercial milling and improvement in the distribution system for rice. The overall impact of the Project will be to expand commercial activity in the Project area, increase employment and improve the living conditions of farmers in the Project area.

4.5.2. Farm Budget.

The Project will improve the economic conditions in farmers. An average farm budget for a farm of 0.96 ha and a family of 5.58 is roughly estimated as Table 4-31. The gross income with future project condition is projected at about Rp. 646,000 and after farm inputs and living expenses, disposable income (or capacity to pay) amounts to about Rp. 212,000. This value is about ten times of present income.

Table 4-31 An Average Farm Budget in Future with Project

(Unit: Rp)

Gross Income	646,000
Gross Outgo	
Farming expenses	122,000
Living expenses	312,000
Capacity to pay	212,000