[illegible]

[illegible]

[illegible]

[illegible]

([illegible])

MAY [illegible]

[illegible] AGENCY

GOVERNMENT OF JAPAN

REPUBLIC OF INDONESIA

DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT

REPORT ON
THE BRANTAS RIVER BASIN DEVELOPMENT PLAN

(MAIN REPORT)

MAY 1973

OVERSEAS TECHNICAL COOPERATION AGENCY

GOVERNMENT OF JAPAN

PREFACE

In response to the request of the Government of Indonesia, the Government of Japan agreed to undertake the survey for the overall planning of water resources development in the Brantas River Basin, which is necessary for determining the sequence of project priority, and entrusted the execution of the survey to the Overseas Technical Cooperation Agency, an executing organization of the Japanese Government.

The Agency signed a contract for the survey with Nippon Koei Co., Ltd. and dispatched a survey team comprised of eight experts headed by Mr. Kazuo Shibata, the Irrigation Advisor of the said company, to the Republic of Indonesia over a period from August 27 to December 26, 1972.

Meanwhile, the Agency organized an Inspection Committee comprised of nine experts, headed by Mr. Akira Miyazaki, Ministry of Construction, to give advices to the survey team on the technical problems related to the planning.

The survey team conducted a field investigation in close cooperation with the Indonesian Authorities concerned. After its return to Japan, the team made various studies and analyses of the data, fully reflecting the advices given by the Inspection Committee, and compiled a draft report. On May 7, 1973, the team visited Indonesia again, and discussed the contents of the said draft report with the Indonesian Authorities. Upon careful consideration of the comments made, the team revised the draft report. The report has been finalized and is herewith presented to the Indonesian Government.

I sincerely hope that this report will expedite the implementation of a project with high priority, which, we believe, will further promote the friendly relations between Indonesia and Japan.

Finally, I wish to express my heartfelt gratitude to the Authorities concerned of the Republic of Indonesia and the staff of the Japanese Embassy in Jakarta, Ministry of Foreign Affairs, Ministry of Construction and Ministry of Agriculture and Forestry for their wholehearted support and cooperation in the execution of this survey.

Keiichi Tatsuke
Director General,
Overseas Technical Cooperation Agency,
Tokyo, Japan

May, 1973

LETTER OF TRANSMITTAL

May, 1973

Mr. Keiichi Tatsuke
Director General
Overseas Technical Cooperation Agency
Tokyo, Japan

Dear Sir:

This is the final report on the Brantas River Basin Development Plan prepared by the Japanese Survey Team dispatched from the Overseas Technical Cooperation Agency.

In continuation of the 1971 investigation which aimed at working out mainly the flood control plans for the Brantas River Basin, the 1972 investigation was carried out to contemplate mainly the water utilization plans, to integrate the results of the 1971 and 1972 investigations and to determine the sequence of priority for the contemplated plans.

The survey team made a field investigation including data collection and surveying over a period of about four months from August 27, 1972 to December 26, 1972 in Indonesia in cooperation with the counterpart team which was organized by the Ministry of Public Works and Power, the Government of Indonesia. After its return to Tokyo, the studies were made in connection with analysis of data collected, planning of the flood control and water utilization projects and their economic evaluation.

After completing the draft report, meetings were held in Jakarta, Surabaya and Malang from May 8 to May 15, 1973 to discuss the Brantas River Basin Development Plans between the Japanese survey team and the Indonesian Government officials. Taking into account the results of the discussions made, the final report has been compiled and is herein submitted to the Overseas Technical Cooperation Agency.

During the study period in Tokyo, several meetings of the Inspection Committee comprising the Japanese authorities concerned were held to examine the results of the data analysis and project plannings. The final report was approved by this Committee.

The Japanese survey team wishes to express sincere appreciation and gratitude to the Government officials of the Directorate General of Water Resources Development, Irrigation Service in East Java Province and the Brantas Multipurpose Project, the staffs of the Japanese Embassy in Jakarta, the staffs of the authorities of the Overseas Technical Cooperation Agency and the officials of the Japanese authorities concerned for their kind cooperation and support extended to us in performing the field surveys and studies.

Yours faithfully,

T. Hashimoto

Toshio Hashimoto
President
Nippon Koei Co., Ltd.
Tokyo, Japan

ABBREVIATION AND EXCHANGE RATE

mm	Millimeter
cm	Centimeter
m	Meter
km	Kilometer
cm^2	Square centimeter
m^2	Square meter
km^2	Square kilometer
ha	Hectare
m^3	Cubic meter
gr	Gram
kg	Kilogram
ton	Metric ton
m/sec	Meter per second
m^3/sec	Cubic meter per second
km	Kilometer
kW	Kilowatt
MW	Megawatt
kWh	Kilowatt-hour
MWh	Megawatt-hour
El	Elevation
LWL	Low water level
HWL	High water level
^oC	Centigrade degree
%	Percent
HP	Horse power
Hr	Hour
Rp	Rupiah
$	US dollar
Study Report	Technical Study Report submitted to the Government of Indonesia in July, 1972

Exchange rate adopted in this report:

$1 = Rp415 = ¥308

CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

1. SUMMARY AND RECOMMENDATION

1-1 Socio-Economic Conditions for Development and Problems

The Brantas River Basin having 12,000 km^2 of the catchment area, blessed with favorable natural conditions such as water resources and the tropical climate, has been developed as the granary of Java. Besides, various industries have been recently developed around Surabaya city using its favorable conditions. This is attributable not only to the above available resources but also to the favorable transportation conditions, such as the well developed railway, highway linked with Middle Java and the second largest sea port located in center of inter-insular trade among Java, Kalimantan, Sulawesi and other islands.

The major industry in the basin is agriculture in which about 70 % of the population is engaged. The total farmland occupies 730,000 ha or about 60 % of the basin area. The remaining areas are mostly occupied by mountain slope where the lands are not so suitable for irrigation farming due to the topography and soils as well as less availability of water. These unfavorable conditions limit further reclamation of the lands into farmlands. Aside from this, it is not advisable to reclaim the forest from the viewpoints of the land and soil conservation as well as the water source conservation.

The major agricultural products in the basin are rice, sugar cane, cassava, soybean and maize. The total production of the milled rice in 1971 was about 600,000 tons accounting for about 5 % in the national production. The basin produces about 230,000 tons of sugar annually. It occupies about 30 % of the total production in Indonesia.

The population in the basin is about 10 million in 1971 which constitute about 13 % of the population of Java or 8 % of the country's total. The population density in the basin is as high as about 850 persons per km^2. It naturally limits the average holding size of farmland as small as about 0.5 ha per farming family. There are substantial surplus labor force in the rural area which should be available for industries to be developed in the future. However, such unemployment or underemployment now being absorbed in agriculture has to be mitigated by intensification of crop farming for the time being until future industrial development could absorb them. Thus special attention should be paid for increase of crop yield to raise the living standard and to stabilize farm economy. Future crop diversification will also have to be studied to improve the diet of the people from depending on the present stachy food to protein and vegetable fat.

Among about 730,000 ha of the farmlands in the basin, the paddy area occupies 321,000 ha. The irrigation areas depending on the Branstas main stream are about 77,000 ha. The existing irrigation intakes for these irrigation areas mostly face the river directly. However, the river water of the Brantas is not always effectively utilized for these areas due to the unfavorable condition of the intake structure, deterioration of the existing irrigation facilities and insufficient maintenance and management. The river water used for municipal and pollution control is so little yet at present. However, the water requirement for these uses will gradually increase along with the progress of industrialization of Surabaya. Thus, much more effective utilization of water has to be planned under a well balanced distribution of the available river discharge.

To plan the optimum use of the water resources, the first study was directed to know the correct river discharge available including flood discharge. As for the flood problems in the Brantas, a special attention shall be paid to the effect of eruption of Mt. Kelut on the river bed rising. At present, the flood carrying capacity of the middle stretch of the Brantas River has been much reduced by the aggradation of river bed due to the deposit of sediment originated from the eruption of Mt. Kelut.

The present flood peak discharge of the Brantas River is reduced by the retardation in the Pakel - Kediri stretch and the swamp storage at the confluence of the Widas River. To solve these flood problems, various measure shall be comprehensively studied in relation with the erosion control, flood control by reservoirs, heightening of levee or reinforcement and enlargement of the river channel.

1-2 River Flow Analysis

Among the river discharge data collected at 18 gauges along the Brantas main stream and its tributaries, the daily discharge records at 8 gauges along the main stream during 1951 - 1971 period are analyzed. The river flow analysis has revealed that the 1964 - 1971 records at the Jongbiru and Kertosono gauges contain some errers and discrepancies. Then such records are corrected based on the correlation among the discharges at the abovementioned gauges and Jabon gauge during the 1951 - 1963 period.

The effect of the Karangkates, Lahor and Selorejo reservoirs are studied. Average increase of the discharge by the joint regulations of the Karangkates and Lahor reservoirs during the period from June to November in an average year is estimated at 11 m^3/sec at the Karangkates damsite, and the average increase of the discharge by the regulation of the Selorejo reservoir during the period from June to November in an average year is estimated at 2.8 m^3/sec at the damsite.

The flood characteristics in the Brantas River is analyzed based on the hourly water level records at 4 gauges along the middle reaches of the main stream.

The flood analysis reveales that the flood peak in the Brantas River is largely reduced by the inundation over the land along the Pakel-Kediri stretch and the retardation in the swamp at the Widas mouth in the Kediri-Terusan stretch. The cut of flood peak due to the retardation in the Pakel-Kediri stretch is estimated to be 150 - 300 m^3/sec and that in the Kediri-Terusan stretch is presumed to be 300 - 400 m^3/sec.

A part of flood discharge in the downstream stretch is diverted to the Marmoyo River through the existing Gedek gate located 5 km upstream from the Terusan guage. The flood discharge diverted through the gate at the flood peak time is estimated to be 80 m^3/sec on an average.

The flood carrying capacity in the Brantas River is estimated based on the results of the river profile and cross section survey. The comparison of the estimated capacity with the probable flood peak discharge calculated at the existing gauges shows that the flood carrying capacity near Kediri with the water surface just coinciding the levee top corresponds to a flood peak of 5 to 10 years return period.

1-3 Sedimentation and Its Control

Mt. Kelut, located in the center of the Brantas River Basin, is an active volcano and erupted 10 times during the 1811 - 1966 period with interval of 3 to 37 years. The volcanic materials produced by an eruption are estimated to be the order to 100 to 200 million m^3. When much water is stored in the crater lake, the eruption causes a hot mud flow. This is called the "primary lahar". It rushes down on the mountain slope and destroys everything including forests, farms, roads and houses on its course.

The river bed of the Brantas has been heavily silted up due to the efflux of volcanic sand and silt from the mountain slopes of Mt. Kelut. The aggradation of the river bed of the Brantas during the 1951 - 1970 period was about 1.5 m on an average. It is especially remarkable for several years after an eruption.

The records of the river bed elevation measured at 22 sites in the stretch of the Brantas and Porong Rivers during the 1951 - 1970 period and the data of the debris control work on the slopes of Mt. Kelut were collected. Based on these data and the river discharge data, the studies are made for the sediment transporting capacity of the Brantas River, sediment yield from the mountain slopes and the required capacity of lahar pocket for future probable eruption.

The studies revealed that the annual sediment transporting capacity of the Brantas River is about 5 - 5.5 million m^3 on an average. The total sediment yield from the slopes of Mt. Kelut during the 1951 - 1970 period is estimated to be 128 million m^3. It is also estimated that the total capacity of 100 million m^3 of the lahar pocket is necessary for preventing the river bed rise of the Brantas if next eruption of the same scale as the 1951's occurs.

1-4 Planning of Water Utilization

The plan of irrigation development in the areas along the Brantas middle reaches is worked out. The envisaged areas comprise the existing irrigation areas and newly proposed irrigable areas. The existing irrigation areas, which depend on the Brantas main stream and where the irrigation facilities are superannuated, are about 24,800 ha in total, comprising the Warujayeng-Kertosono (13,300 ha), Turi-Tunggorono (9,600 ha) and Jatimlerek-Bunder (1,900 ha) areas (refer to Fig. 3-3). The newly proposed irrigable areas, locating along the Brantas River, which can be developed by using the river water if the irrigation facilities are provided, are about 48,300 ha in total, comprising the Lodoyo-Tulungagung (13,500 ha), Pace-Nganjuk (9,600 ha) and Blitar-Kediri (25,200 ha) areas (refer to Fig. 3-3).

For the planning of the irrigation development of these areas, the plan of river discharge distribution of the Brantas is prepared based on the results of the river flow analysis and the water requirements studies. The basic principles adopted for the plan are as follows.

1) The water requirements contemplated under this plan are those for the irrigation development projects in the four existing irrigation areas, namely, the Warujayeng-Kertosono, Turi-Tunggorono, Jatimlerek-Bunder and Sidoarjo delta areas, and in the three proposed irrigable areas

which are the Lodoyo-Tulungagung, Pace-Nganjuk and Blitar-Keridi areas, and also for the water utilization plan in Surabaya area.

2) The water requirements for the irrigation areas along the Brantas middle reaches are determined based on the proposed cropping pattern and other design criteria.

3) Water requirements in Surabaya area during the 1972-1992 period, which comprise those for irrigation use and municipal, industrial and other uses, have been forecasted in the feasibility report on Surabaya River Improvement project. Among the forecasted value for 1982, the irrigation water requirement is revised based on the proposed cropping pattern and the same criteria adopted in this study. The revised value is used in this plan, together with the water requirement for municipal, industrial and other uses in 1982 without revision. For meeting the additional water requirement in Surabaya area after 1982, it would become necessary to take the measures such as the introduction of more efficient use of the Brantas water through improvement of irrigation canals, utilization of groundwater, and utilization of other surface water resources.

4) The water requirement for irrigation rehabilitation project in Sidoarjo delta area is revised in accordance with the proposed cropping pattern and the same criteria as applied in this study.

5) The increase of the dry season discharge after regulation by the Karangkates reservoir is taken into account in this plan.

6) At present, the river water of the Brantas is not properly distributed to the existing irrigation areas because of the unfavorable condition of the intake structure. For this reason, an entirely new river discharge distribution plan is made without taking into account the present inflow condition.

The calculation of water balance for determining the river discharge distribution plan has proved that the river discharge can meet the water requirements for all the water utilization projects except the water requirement for Kediri-Blitar irrigation development project, if the operation rule of the Karangkates reservoir is slightly modified. The river discharge distribution plan thus determined is shown in Fig. 4-2 in main report.

Based on this plan, the irrigation development project of the envisaged irrigation areas is planned. The Blitar-Kediri irrigation development project is excluded from the river discharge distribution plan. However, the implementation of this project may become possible in the future stage when more Brantas water can be made available through the improvement of canals or utilization of groundwater. Then, the Blitar-Kediri irrigation development project is also studied together with other irrigation projects.

The proposed crops for the envisaged irrigation areas are paddy, pulses, sugar cane and other crops. The anticipated yield in the 5th year after the implementation of the development plan is estimated at 5 ton/ha for paddy, 120 ton/ha for sugar cane, 1.3 ton/ha for soybean and 1.8 ton/ha for groundnut, and 2.3 ton/ha for maize respectively.

The development project requires the rehabilitation works such as desilting of canals and remodelling of headworks in the existing irrigation areas, and construction of the headwork and canals for the newly proposed irrigable areas. The estimated construction cost and the construction period of the development projects are as follows.

Irrigation project	Construction cost ($10^3$$)	Construction period (year)
Warujayeng-Kertosono rehabilitation	2,300	2
Turi-Tunggorono "	1,350	2
Jatimlerek-Bunder "	426	2
Lodoyo-Tulungagung	10,100	4
Pace -Nganjuk	7,340	4
Blitar-Kediri	21,050	5

The increase in net farm income resulting from the realization of the project is regarded as the irrigation benefit. The increase in net farm income is derived from the difference in total net income in the projected area under the conditions with and without project. The annual irrigation benefit to be derivable at full operation stage is estimated as follows.

Irrigation project		Annual irrigation benefit (10^3\$)
Warujayeng-Kertosono rehabilitation		1,977
Turi-Tunggorono	"	1,346
Jatimlerek-Bunder	"	287
Lodoyo-Tulungagung		2,903
Pace-Nganjuk		1,635
Blitar-Kediri		3,357

The internal rate of return under the condition that the project life is 50 years is calculated as follows.

Irrigation project		Internal rate of return (%)
Warujayeng-Kertosono rehabilitation		29.7
Turi-Tunggorono	"	31.3
Jatimlerek-Bunder	"	26.8
Lodoyo-Tulungagung		15.7
Pace-Nganjuk		12.3
Blitar-Kediri		9.0

In addition to the irrigation development of the area along the Brantas main stream, it is roughly studied to develop the tributary areas by constructing a reservoir and canals. The envisaged areas comprise three arable lands, namely, about 4,000 ha in the Widas River Basin, about 4,000 ha along the Beng River, and about 4,000 ha along the Ngasinan River (refer to Figs. II-1-11 to II-1-13 in Supporting Report). The rough economic evaluation made for these irrigation developments shows that the internal rates of return is 15 % for the Beng project on the north of the Marmoyo River, 12 % for the Widas project in the Widas River Basin and 5 % for the Ngasinan project.

The feasibility report on the Wlingi multipurpose project prepared by the Government is reviewed both from technical as well as economical view points. This project is planned to have several functions such as power generation, irrigation water supply for the Lodoyo-Tulungagung area, afterbay function for the Karangkates peak power generation and flood and sand control to the downstream reaches.

The result of the re-study on the Wlingi power generation has proved that the dependable peak output is 27,000 kW and the annual energy output is 177.1 million kWh. The result of the flood routing calculation revealed that the effect of flood control by the Wlingi reservoir to the downstream reaches is negligibly small. The study on the sediment control by the reservoir has proved that the Wlingi reservoir will sustain its sand trapping function for 50 years under the condition that the eruption period is 15 years, and the reservoir will contribute to the aggradation reduction of the Brantas river bed in the downstream stretch to a certain extent.

This project involves the constructions of a 50 m-high dam above the estimated foundation rock, the power station and 25 km-long transmission line. The estimated construction cost of this project is about 17 million $ equivalent. The construction of this project will require a period of 4 years. The capitalized benefit of the project under the condition that the project life is 50 years and discount rate is 12 % is estimated at 25,395,000 $ equivalent comprising 17,166,000 $ equivalent from the power generation, 4,249,000 $ equivalent from afterbay function, 3,837,000 equivalent from irrigation function and 143,000 $ equivalent from flood and sand control. The internal rate of return of the project is calculated at 15.5 %.

In addition to the study on the Wlingi power generation, the hydro power potential in the Brantas River Basin, which is technically possible to develop, is studied on 33 possible project sites along the Brantas main stream and five major tributaries of the Amprong, Lesti, Metro, Ngrowo and Widas Rivers. The estimated hydro power potential is about 380 MW in power capacity and 1.3×10^6 MWh in annual energy output.

1-5 Flood Control Planning in the Middle Reaches

The flood control in the middle reaches of the Brantas River is planned by means of the river channel improvement. For the planning of the river channel improvement, a flood discharge distribution plan is prepared based on the result of the flood analysis. The basic principles adopted in preparation of the river improvement plan are as follows.

(1) The plan is formulated against the flood peak with 50-year recurrence taking into account the regulation by the Karangkates reservoir.

(2) The flood retardations near the Ngrowo mouth and the Widas mouth are tentatively left as they are now.

(3) The Gedek and Mlirip gates will be closed during the flood time to protect the urban area of Surabaya. No flood discharge wil be diverted through both gates.

The proposed design flood discharges in the main stream calculated based on the above principles are as follows (refer to Fig. 4-3).

1)	Stretch between the Ngrowo mouth and Kediri;	1,200 - 900 m^3/sec
2)	Stretch between the Kediri and Konto mouth;	900 m^3/sec
3)	Stretch between the Konto mouth and Widas mouth;	1,100 m^3/sec
4)	Stretch between the Widas mouth and Terusan;	1,500 m^3/sec

The effect of the flood control by the Wlingi reservoir is not taken into account for the flood discharge distribution plan because of small flood peak reduction.

The river improvement plan to pass safely the abovementioned design flood discharge through the respective river stretches is studied. This plan involves the dredging volume of about 15 million m^3 and the levee embankment volume of 7 million m^3. The estimated construction cost is 23.5 million $ equivalent. The construction of this plan will require a period of 10 years. The balance of the flood damage in the area along the river stretch between the Ngrowo mouth and Terusan gauge in the conditions with and without project is regarded as the benefit of this plan. The annual benefit derived from this plan is estimated to be 3,811,000 $ equivalent. The internal rate of return under the condition that the project life is 50 years is calculated at 10.4 %.

The above plan requires huge amount of dredging and embankment which will necessitate a long construction period and substantial amount of cost. The first stage plan is proposed to realize the river improvement which guarantees the minimum required safety in shorter time with limited initial cost. In this plan, the flood carrying capacity of the river channel is increased against 10-year recurrence flood. The earth works required for the first stage plan is estimated at about 7 million m^3 less than the overall plan. The estimated construction cost is about 14 million $ equivalent. The construction period will require a period of 5 years. The balance of the flood damages with and without project is also regarded as the benefit of this plan. The annual benefit derived from this plan is estimated to be 1,683,000 $ equivalent. The internal rate of return under the condition that the project life is 50 years is calculated at 8.2 %.

An alternative plan for the flood control in the main stream is roughly studied. This is a flood diversion scheme to divert flood discharge of the Brantas river from the upstream reaches to the Indian Ocean by constructing a gated weir near Pakel gauge and a 30 km-long canal (refer to Fig. II-3-6 in "Supporting Report"). The total construction cost will be about 40 million $ equivalent. This scheme seems not so economically feasible because of a higher construction cost.

1-6 Flood Control Planning in the Area along the Ngrowo River

In the Ngrowo River Basin which is located in the southwest corner of the Brantas River Basin, the habitual inundation occurs in the lowland near Tulungagung city along the Ngrowo River and the basins of the tributaries along the upstream of the Ngrowo River.

In view of the importance of the area near Tulungagung city, the flood control to improve such condition in this area is planned by means of the construction of about 10 km-long cut-off canal connecting the Song River with the Brantas River. For the planning of the cut-off canal, a flood discharge distribution plan in the Ngrowo River Basin is prepared assuming one-day rainfall with a return period of 10 years in the Ngrowo

River Basin. The basic principles adopted in preparation of the flood control plan are as follows (refer to Fig. 4-6).

(1) The Bendo and Sumbergayam gates on the Ngasinan River are completely closed.

(2) The water retained in the Gesikan and Bening swamps is not released during the flood peak time.

(3) The flood flows from the Song, Klantur and Babakan Rivers are diverted to the Brantas River by a new cut-off canal provided along the hill area.

The proposed design flood peak discharges in the stretch calculated based on the above principles are 350-500 m^3/sec in the Parit Raya canal, 0-80 m^3/sec in the Ngasinan River between the Bendo gate and Sembergayam gate, 80 m^3/sec in the Ngasinan floodway, 50 m^3/sec in the Ngrowo River and 240-630 m^3/sec in the new cut-off canal. It is presumed that the increase in the flood peak discharge of the Brantas River at the Kediri gauge due to the cut-off canal construction is 30 m^3/sec.

The cut-off canal is planned to pass safely the abovementioned design flood discharge through the channel. The construction of the cut-off canal requires about 1.8 million m^3 of earth excavation and about 100,000 m^3 of levee embankment. The estimated construction cost is about 2 million $ equivalent. The construction period will require a period of 4 years. The balance of the flood damages in the area of about 7 km-long range in the downstream reaches at the both banks of the Song and Klantur Rivers under the conditions with and without project is regarded as the benefit of this plan. The annual benefit derived from this plan is estimated to be about 180,000 $ equivalent. The internal rate of return under the condition that the project life for 50 years is calculated at 5.1 %.

1-7 Determination of Sequence of Priority

The sequence of priority for the implementation of the projects in the Brantas River Basin is determined not only from the viewpoint of the economic feasibility of the project evaluated by means of the internal rate of return but also such other aspects as regional consideration, timing relation with other projects or upholding of presently trained labourers and moving construction machineries etc.

The proposed projects in the basin are classified into two groups for the convenience of the priority study, i.e., the group of the irrigation projects and the group of the flood control and power projects. The sequence of priority is studied firstly within each of the abovementioned groups. Then all the projects in the basin are further compared on the overall basis to determine the final sequence of priority in the light of the results of the studies within the group, interrelation of the projects each other and other overall conditions.

The social and other factors contemplated for the group of the irrigation projects are as follows.

1) The unbalance in regional income
2) Amount of the construction cost

The farm economic survey in the proposed irrigation areas carried out in 1972 has clarified that the annual gross income in the rehabilitation area is generally much higher than in the new project area.

For realization of the project, no doubt, the smaller the required project cost, especially its foreign currency component, the earlier the financing. The construction cost as well as its foreign currency portion is much smaller in the rehabilitation project than those in the new project.

From the viewpoint of the economic viability, the rehabilitation projects are superior to the new project, while, the need of project, represented by low standard of regional farm income, is much stronger in the project area for the new projects. In comparing the two aspects, the importance is considered to be placed on the need of the project from the national viewpoint. In consideration of the fact, the priority for early implementation should be given to the new projects.

In addition, the construction costs of the rehabilitation project, which are smaller than those of the new project, can be easily financed by the Government's own fund with limited foreign aid. Since the purpose of determining of priority of projects is mainly to select the project for financing by the international financing agency, the rehabilitation projects are not necessary to be included in the list of the sequence of priority of the projects in the basin. Thus, the rehabilitation projects are excluded from the priority study.

Among the new projects, the Lodoyo-Tulungagung project is the most strong in the economic feasibility, Pace-Nganjuk project the second and Blitar-Kediri the third. Besides, the need of the project for those projects are also in this order. Therefore the sequence of priority is determined as shown below.

Irrigation project	Sequence of priority
Lodoyo-Tulungagung	1
Pace -Nganjuk	2
Blitar-Kediri	3

Though the rehabilitation projects are excluded from the priority study, it is recommended that these projects are implemented as early as possible by the Government itself, since these projects are with high economic efficiency and their realization will much contribute to improvement of the national economy.

The result of the economic evaluation for the group of flood control and power projects shows that the Wlingi project is superior to other flood control projects.

The social and other factors contemplated for the group of the flood control and power projects are as follows.

1) Effect on elimination of the unbalance in regional income.

2) Adequate time for implementation.

3) Effective utilization of the skilled labor and machinery in on-going projects.

It is concluded from the viewpoint of all the abovementioned factors that the Wlingi project is recommendable to be implemented as earlier as possible than other projects in this group. Taking into account both the economic feasibility and the social and other aspects, the sequence of priority for implementation of the flood control and power projects is determined as follows.

Project	Sequence of priority
Wlingi multipurpose	1
River improvement in the middle reaches	2 /1
Flood control in the area along the Ngrowo River	3

The development of the Lodoyo-Tulungagung area has been ranked as the first priority among the irrigation projects, while, the first priority for the development of the flood control and power projects is given to the Wlingi multipurpose project.

The Lodoyo-Tulungagung irrigation project is planned to take the irrigation water from the Wlingi reservoir. Thus, to achieve the full benefit in both the Wlingi multipurpose project and Lodoyo-Tulungagung irrigation project as early as possible, it is recommendable that the implementation of both projects proceed in parallel.

As to the development projects in the middle reaches of the Brantas River Basin, the Patje-Nganjuk irrigation project is ranked at high priority. Besides, the rehabilitation projects are also economically superior and early implementation is recommendable. However, to achieve

/1; It is assumed that the debris control works will be executed according to the existing master plan.

proper control of the irrigation water for those irrigation projects, it is recommendable to proceed with the river improvement project, ahead of the implementation of the irrigation projects.

The Blitar-Kediri irrigation project is proposed to be developed in the future stage when the utilization of the Brantas water in the downstream irrigation areas can be saved by the improvement of the canal or the utilization of the groundwater.

Judging from the abovementioned condition, the sequence of priority for the implementation of the projects in the Brantas River Basin is determined as follows.

Project	Sequence of priority
Wlingi multipurpose Lodoyo-Tulungagung irrigation	1
River improvement in the middle reaches	2
Pace-Nganjuk irrigation	3
Flood control in the area along the Ngrowo River	4
Blitar-Kediri irrigation	5

It is roughly studied to develop the tributary areas such as the land along the Widas River, the land along the Beng River and the land along the Ngasinan River by constructing a reservoir and canals. The results of the economic evaluation studied for these irrigation projects showed that the internal rate of return is so high as about 12 to 15 %. However, since this evaluation is based on many assumptions and uncertain factors, it is recommended to carry out further investigations to make clear these factors before integrating these projects for the priority study. Thus, the irrigation projects in the tributary areas have been excluded from the determination of the sequence of priority.

1-8 Recommendation

(1) Further investigation for the Wlingi dam

1) The Wlingi damsite is not considered geologically excellent according to the result of the geological investigation so far carried out by the

Indonesian Government. Detailed geological investigations are necessary to be carried out for preparation of the detailed design, especially for assessment of the foundation treatment cost.

2) In parallel with the further geological investigation, a detailed investigation and design should be conducted concerning the construction facilities, dam body, appurtenant structures and embankment materials.

3) The Feasibility Report prepared by the Indonesian Government does not set out the details of the investigation on the embankment materials and the proposed quarry sites and borrow pit. A more careful study of the above respects should be necessary for detailed design since the proposed Wlingi dam would be as high as about 50 m above the estimated foundation rock.

(2) Further investigation for Lodoyo-Tulungagung irrigation area

At present, a part of the canal network in the Lodoyo-Tulungagung area is being implemented in accordance with the results of the preliminary investigation carried out by the Indonesian Government. However, the details of the intake structure and the irrigation and drainage canals are not made clear yet. A more careful study of the above respects should be necessary.

(3) Reinforcement of the hydrological measurement

The water level and discharge records of the existing gauges were collected and evaluated in this investigation. However, these records involve some discrepancies, especially at the Jongbiru and Kertosono gauges along the Brantas main stream. The problems of flood and draught will become more serious with more intense land and water uses in the future. In such stages, the discharge record covering a long period with high accuracy must be needed. Thus it is recommended that the regular measurement should be periodically checked by current meter measurement to correct the inaccuracy.

In the Brantas River Basin, there are some discharge gauges in the tributaries. Reinforcement of the gauge network is necessary for the future planning of flood control and water utilization development in the tributaries.

(4) Measurement of sediment load

The measurement data of the sediment load in the river are so scarce to assess the silting quantity despite the special importance for planning. The study of the sediment analysis has certain limitation because of the scarce data available. For the planning of the river improvement of the Brantas River and the planning of the debris control around the slopes of Mr. Kelut, the measurement of the sediment load, especially in the wet season, in the Brantas River and tributaries around the slopes of Mr. Kelut should be carried out with proper measurement equipment.

(5) Recommendation for water utilization

1) Topographically, no suitable damsite is conceivable along the downstream reaches from the Wlingi and also even in the upstream reaches, there are almost no possibilities to create considerably large reservoir to regulate flood and seasonal flows. Several additional dams in small scale can be constructed on the tributaries mainly for the purpose of irrigation and power generation. However, these dams would not increase so much discharge in the dry season. Thus it is advisable that these dams are developed under a well-balanced combination of hydro and thermal power generation.

2) To improve the present unstable water supply for irrigation, it is necessary not only to improve the irrigation facilities but also to reinforce the water management with proper control of water distribution.

3) The investigation of the groundwater is being carried out in the middle reaches of the Brantas River Basin. Along with more intense land and water uses in the future, it will become necessary to contemplate the combination of the surface and groundwater resources for water utilization plans. Thus it is recommended to carry out more detailed groundwater investigation to assess its potentiality and to examine its technical and economic feasibility.

2. INTRODUCTION

2-1 Present Status and Major Problems in the Brantas River Basin

The Brantas is the second largest river in Java. The total length of its main stream is about 320 km and the catchment area 12,000 km^2 which corresponds to one quarter of 48,000 km^2 of the East Java Province. The basin is densely populated with about 10 million in 1971 accounting for 36 % of about 28 million in the East Java Province.

Surabaya, a capital of the East Java Province and the second largest port city in Indonesia, is located at the delta of Surabaya River. Surabaya having the population of more than 1.4 million has prospered as a center of administration, transportation and inter-insular trade. The total amount of the cargoes in inter-insular trade is about 1.5 million tons per annum at present.

The major industry in the basin is agriculture and about 70 % of the population engages in agriculture. The total farmland occupies 730,000 ha accounting for about 60 % of the basin area. The remaining areas are mostly occupied by mountain slopes where the lands are not suitable for farming due to the topography and soils as well as less availability of water. These unfavorable conditions limit further reclamation of the lands into farmlands. The total area of uplands, estates and orchards amounts to 409,000 ha which is mostly located at the outskirts of mountain slopes of Mt. Wilis in the west, Mt. Arjuno in the east and Mt. Kalut in the center of the basin. There are 321,000 ha of paddy lands which corresponds to 44 % of the farmland. The paddy fields are located mostly along the Brantas River and its tributeries where lands are flats and mostly irrigated. The irrigation areas fed from the Brantas main stream are 77,000 ha.

The major agricultural products in the basin are rice, sugar cane, cassava, soybean and maize. The prevailing crops are paddy in the wet season and cassava, soybean and maize in the dry season. Paddy is grown in the dry season in some areas where water is available.

The Brantas River Basin had been a major sugar producing area before the World War II. However, the sugar product was decreased due to insufficiency of foods and deterioration of sugar factories caused by the great confusion during and after the World War II. The total annual production of sugar cane is still as much as about 2.4 million tons at present.

The Brantas River Basin lies in the Torrid Zone between 7^{o} - 8^{o} south latitude and there are very little variation in mean monthly air temperature throughout a year. The annual rainfall in the basin is about 2,000 mm of which about 80 % occurs in the wet season from November to April of the following year. The soils in the basin are generally fertile because of the volcanic deposit of Mt. Kelut. The agricultural products will be largely increased when the water of the Brantas is effectively utilized with proper water control.

However, the most of the existing irrigation units along the main stream have not any barrage to control intake water levels because of wide river and large floods. The control of inflow into the irrigation canal is attained by adjusting the stop logs at the intake. But, the proper adjustment of inflow is difficult due to large variation of the river water level in the wet and dry seasons. Thus, the river water of the Brantas is not always effectively utilized in the dry season.

Furthermore, the existing irrigation facilities are seriously deteriorated and the irrigation water is not properly distributed. This is attributable to imcomplete facilities, insufficient maintenance and water management. One of the major difficulties to operate and maintain those facilities is the heavy silting transported in the river water.

Both the Karangkates and Selorejo dams were already constructed and their contributions not only for flood control in the wet season but also for the increase of the discharge in the dry season are expected. The average increase of the discharge by the two reservoirs during the period from June to November in an average year is estimated to be 11 m^3/sec at the Karangkates damsite and 2.8 m^3/sec at the Selorejo damsite respectively.

Mt. Kelut, an active volcano, is located at the center of the Brantas River Basin. It erupts at an interval of 15 to 30 years and produces a huge amount of the volcanic materials. These materials flow down along the tributaries on the mountain slope of Mt. Kelut and deposit not only on the Brantas main stream but also on the irrigation canals. The volcanic materials deposited in the river channel reduce the river discharge capacity. To keep the river cross sections safe against floods, the river banks of the Brantas in its middle stretch have been compelled to be raised every year.

For preventing the aggradation of the main stream, the measures for flood control, river channel maintenance and sediment control will have to be taken comprehensively in the Brantas River Basin. Besides, speciall attention should be paid to irrigation canal maintenance by constructing suitable desilting devices at the intakes and providing regular maintenance of canals.

In order to approach the possible solution for the abovementioned problems, fundamental surveys and studies of the survey team were directed to the following main items;

1) To collect and analyze all the available hydro-meteorological data.

2) To collect and analyze the available sediment data in the basin especially due to the eruption of Mt. Kelut.

3) To take into consideration the effect of major projects such as the Karangkates and Selorejo reservoirs.

4) To plan the proper design flood discharges for the future river improvement.

5) To plan a well - balanced river discharge distribution for the future water utilization schemes.

6) To recommend further actions to be taken for the detailed surveys and investigations for the water utilization and flood control schemes.

2-2 Scope of Works in the Investigation

The scope of works agreed in the meeting between the Government of Indonesia and Japanese Survey Team held on 29th August and 4th September, 1972 is as follows.

1) Collection of additional meteo-hydrological data and the data concerning to the present irrigation and agricultural conditions.

2) Study on (1) the present agricultural and irrigation conditions in the basin (2) flood damage estimate in the middle reaches of the Brantas River and the area along the Ngrowo River (3) Wlingi multipurpose project and (4) the possibility of future hydro power development in the basin.

3) Planning of (1) the irrigation development in the areas along the Brantas main stream and (2) the river discharge distribution in the basin.

4) Determination of sequence of priority of the proposed projects in the Basin.

2-3 Scope of Report

The results of the investigation and studies are compiled in three separate volumes, i.e, main report, supporting report and data book.

This report forms the main report and presents the summary of the supporting report. The presented in the supporting report are the technical background of the main report and involves the detailed analysis and calculation for project plannings. The further detailed explanations of the formula and various calculations are compiled in the appendices attached at the end of the supporting report. The original hydro-meteorological data, cross sections of the existing canals and river cross sections of the Brantas and its tributaries are compiled in the data book.

The main report comprises five chapters. Chapter 1 presents the summary and recommendation of this investigation. Chapter 2 gives the back ground for performance of the investigation. The presented in Chapter 3 are the present condition of the Brantas River Basin. Chapter 4 deals with the outline of the irrigation, flood control and power projects contemplated in the Brantas River Basin. The last chapter presents the project evaluation and determination of the sequence of priority.

2-4 Organization of the Japanese Survey Team

Prior to the dispatching the Japanese Survey Team to the site, Inspection Committee to examine the results of the second stage investigation was established in Japan. The member of Inspection Committee are listed as follows.

Name of member		Duties	Government office attached
(1)	A. Miyazaki	Head of Committee	Ministry of Construction
(2)	H. Kikkawa	Hydrology and sand arresting	Tokyo Institute of Technology
(3)	S. Okabe	Irrigation and agriculture	Ministry of Agriculture
(4)	K. Hosoda	Flood control	Water Resources Development Corporation
(5)	Y. Togano	Hydrology	Ministry of Construction
(6)	H. Nakamura	Hydro power	Ministry of International Trade and Industry
(7)	Y. Uchiyama	Irrigation	Ministry of Agriculture
(8)	A. Murakami	Agro-economy	"
(9)	Y. Miyazaki	Agronomist	"

Among the above members, Mr. H. Nakamura and Mr. Y. Uchiyama were dispatched to the site as an advisory team together with the survey team consisting of six members and took the duty of advices to the survey team at the site.

The member, their specific duties and investigation period of the survey team are as follows:

Name of member	Duties	Investigation period (day)
(1) K. Shibata	Head of survey team (Irrigation advisor)	60
(2) S. Ohnuma	Hydrology & planning	120
(3) A. Takasago	Agronomy	75
(4) Y. Yano	Irrigation	75
(5) N. Hirose	Irrigation hydrology	75
(6) T. Tamai	Agro-economy	30

The survey team and the staffs of the Directorate General of Water Resources Development (Ministry of Public Works and Power) and the State Electricity Corporation held the meeting about the scope of works in this second stage investigation at Jakarta on 29th August and at Malang on 4th September 1972. In conformity with the scope of works agreed in the meeting, the survey team engaged in the field investigations at the site during one to four months from the end of August 1972. While the advisory team engaged in the advising and study works for the investigation at the site during about half month from the end of August 1972. After returning to Tokyo, the survey team carried out the study on both the flood control and water utilization plannings and compiled the report. Throughout this work, the Inspection committee checked the results of the study and gave advices on planning process in several times.

2-5 Acknowledgement

The Japanese survey team wishes to express its highest appreciation for the valuable assistance, guidance and contribution made by the Directorate General of Water Resources Development, Ministry of Public Works and Power in Jakarta, East Java Irrigation Service and by the Brantas Multi-Purpose Project Office. Especially heart-felt thanks are hereby extended to the following staffs of the Government of Indonesia.

(1) Public Works Development in Jakarta

Ir. Sujono Sosrodarseno	Director General of Water Resources Development

Ir. Boesono Boedidarmo	Director of Planning & Programming
Ir. Mardjono	Head of River Basin Planning Division, Directorate of Planning and Programming
Ir. Jusuf Gayo	River Division, Directorate of Rivers & Swamps
Drs. Pintor Tambunan	Head of Development Programming Division, Directorate of Planning & Programming
Dr. Firman Sulaiman	Development Programming Division, Directorate of Planning & Programming
Drs. Rasjid Reda	General Affairs, Directorate of Planning & Programming
Ir. Daryanto	Directorate of Research & Design, State Electricity Corporation
Hatumesen B. E.	Directorate of Construction, State Electricity Corporation
Ir. Muslim	Directorate of Research & Design, State Electricity Corporation
Drs. Siswadji	Staff of Project Officer of Brantas Project
Ir. Sunaryo	Directorate of Irrigation

(2) East Java Irrigation Service and Its Branches

Asahri B.I.E.	Head of East Java Irrigation Service in Surabaya
Ir. Majangkoro	Chief of River Section in East Java Irrigation Service
Ir. Soetijono	Head of Malang Irrigation Service and his staffs
Soewito & R. Said	Head of Kediri Irrigation Service and his staffs
R. Soewasono	Head of Jombang Irrigation Service and his staffs
R. Maskoep	Head of Mojokerto Irrigation Service and his staffs

(3) Brantas Multi-Purpose Project Office

Ir. Surjono	General Manager of Brantas Multi-Purpose Project
Ir. Eddy Sutisna	Deputy of General Manager
Drs. Rob Suharno	Assistant of Financing & Personnal Affairs
Ir. Husni Sabar	Assistant of Planning & Design
Ir. Roedjito	Deputy Assistant of Planning & Design
U. Syachras B. E.	Specialist of Land Investigation
Ir. Isdjapan Djenalanom	Specialist of Geology
Ir. Satoto	Specialist of Design
Ir. Sukarno Wahab	Specialist of Planning
Ir. Sugijanto	Lecturer of Brawidjaja University

3. GENERAL DESCRIPTIONS OF THE BRANTAS RIVER BASIN

3-1 Topography and Geology

(1) Topography

The Brantas River Basin in East Java lies between 110°30' and 112°55' east longitude and 7°1' and 8°15' south latitude. The basin is bounded by Mt. Semeru in the east and Mt. Wilis in the west. A series of low hills 300 to 500 m high, separates the basin from the Indian Ocean in the south. Many tributaries originating in the volcanoes run down the alluvial cones and flow into the Brantas main stream with much sand eroded. The catchment area of the basin is about 12,000 km^2.

The Brantas River, originating in the southeastern slope of the Arjuno Mountain Complex, flows southward through the Malang plain and bends sharply westward near Kepanjen. After flowing down westward river channel of about 75 km, it turns to the north near Tulungagung. There the Ngrowo River joins from the south. The Brantas River reaches to alluvial plain at north of Kediri and flows in the wide and flat plain passing Kertosono. After joining with the Widas River which drains the northeastern slope of Mt. Wilis, it gradually changes its course eastward and branches near Mojokerto into the Surabaya River debouching to the sea at north of Surabaya city and the Porong River debouching to the Strait of Madura at north of Pasuruan. The total length of the Brantas River is approximately 320 km. The river course of the Brantas forms an open loop around the volcanic complex of Arjuno. Aerial distance between the river mouth of the Porong and head waters on the slope of Mt. Arjuno is merely 40 km.

The average river slope is 1/800 in the upstream stretch of the Pakel gauge, 1/1,250 to 1/1,900 in the middle stretch between the Pakel and Terusan gauges and 1/3,000 in the further downstream. The major tributaries joining with the Brantas main stream are the Lesti, Ngrowo, Widas and Konto Rivers.

(2) Geology

The most part of the Brantas River flows through a series of the mountain slopes of volcanoes. The first southward stretch which drains the slopes of two volcanic complexes of Arjuno and Semeru comprises the basaltic lava, agglomerate tuff and volcanic ash and loam. The second westward stretch forms a series of gorges running along the boundary line of Neogene Tertiary and volcanic lava and ejecta from the Butak and Kelut volcanoes. The third northward stretch forms rather wide and shallow channel, drainning the steep slope of the Wilis volcanic complex on the west and the gentle slope of the Kelut volcano on the east. In these three stretches, erosive agent is predominent rather than deposition.

The Brantas River Basin has another characteristic geological condition due to the eruption of Mt. Kelut. Mt. Kelut has a crater lake on its summit. Intermittent eruptions cause outflow of the lake water mixed with the ejected materials. It rushes down along the tributaries of Mt. Kelut as highly build and mobile "primary lahar flows" and heavily damages the farmlands, houses and other facilities on its course.

3-2 Meteorological Conditions

The climatic condition in the Brantas River Basin is characterized by two distinct seasons, a wet season from November to April and a dry season from May to October. The general meteorological condition throughout a year in the basin are as follows;

(1) Temperature

The Brantas River Basin lies in the Torrid Zone between $7^{o}10'$ to $8^{o}15'$ south latitude and $115^{o}13'$ to $114^{o}37'$ east longitude. Thus temperature in the basin is relatively high and scarcely differs throughout a year. The 1966 - 1970 average monthly temperature recorded at Pasuruan (5 m above sea water level, about 10 km northeastern of Malang) shows that the mean monthly temperature varies between $27.3^{o}C$ and $29.3^{o}C$ and the yearly mean is $28^{o}C$.

(2) Relative humidity

The humidity in the basin is relatively high. The 1966 - 1970 average monthly humidity recorded at Pasuruan shows that the humidity varies from 65.1 to 82.7 % throughout a year and the yearly mean is 74.9 %.

(3) Evaporation

The 1966 - 1970 average monthly eraporation recorded at Pasuruan is 60.4 mm in the wet season and 106.2 mm in the dry season respectively. The annual eraporation amounts to about 1,000 mm.

(4) Rainfall

The daily rainfall has been measured at 250 gauges in the Brantas River Basin. Among them the records of the mean monthly rainfall during the 1951 - 1971 perod at 52 gauges are compiled in "Data Book".

The isohyetes prepared based on these records show that the annual rainfall is as much as 3,000 to 4,000 mm on the southern and western slopes of Mt. Kelut and 1,500 to 2,000 mm in the downstream of the Brantas River. The 1951 - 1971 average annual rainfall calculated for about 10,000 km^2 upstream of the Terusan water gauge exceeds slightly over 2,000 mm of which more than 80 % occurs in the wet season of six months.

The records of the hourly rainfall recorded at Karangkates and Lodoyo gauges show that the rainfall occurrence in a day is regular in the wet season and most rainfall usually begins between two o'clock and seven o'clock in the afternoon. The duration time of one continuous rainfall ranges from three hrs to 15 hrs.

3-3 River Flow

(1) Discharge Record

The river flow measurement in the Brantas River Basin has long been carried out by the Provincial Irrigation Service in East Java. The daily water level and discharge record at 18 gauges along the Brantas main stream and its tributaries are available for the analysis.

The gauges located along the Brantas main stream are 8 in number and the remaining 10 gauges are located along the tributaries such as the Ngrowo, Konto, Widas, Surabaya and Porong Rivers. The location of these gauges is shown in Fig. 3-1. The measurement duration period of the daily water level and discharge is as shown in Fig. 1-4-2 in "Supporting Report". The monthly mean discharge calculated based on these data is compiled in "Data Book".

(2) Check of the Discharge Data

The daily water level observation is made twice a day at most of the gauges and regular surface velocity measurement is made by floating a stem of banana.

The regular flow measurement at the Pakel, Jongbiru, Kertosono and Jabon gauges along the Brantas main stream is checked by measurement with a current meter throughout this survey period. The results of the regular measurements at the Pakel and Jabon gauges are almost close to those of the check measurement but quite different at the Jongbiru and Kertosono gauges.

The annual rainfall-discharge correlation at the gauges along the main stream is evaluated based on the rainfall records obtained at 52 gauges. The discharge obtained at the Jabon gauge shows a good linear correlation with annual rainfall, but those at the Kertosono gauge has an unreasonable discrepancy from rainfalls.

The Jabon gauge is located 1.3 km upstream of the junction of the Surabaya and Porong Rivers. The Mlirip gauge on the Surabaya River is located just downstream of the junction. The Lenkong dam located on the Porong River, 200 m downstream of the junction diverts the Porong water to Voor irrigation canal. The Kepajaran gauge is located immediately downstream from the Lengkong dam.

To cross-check the Jabon records, the record at the Jabon gauge is compared with the records at the Mlirip, Kepajaran gauges and Voor canal. The result shows that most of the data are very close to the 45° line. All the results of the check measurement, rainfall-discharge

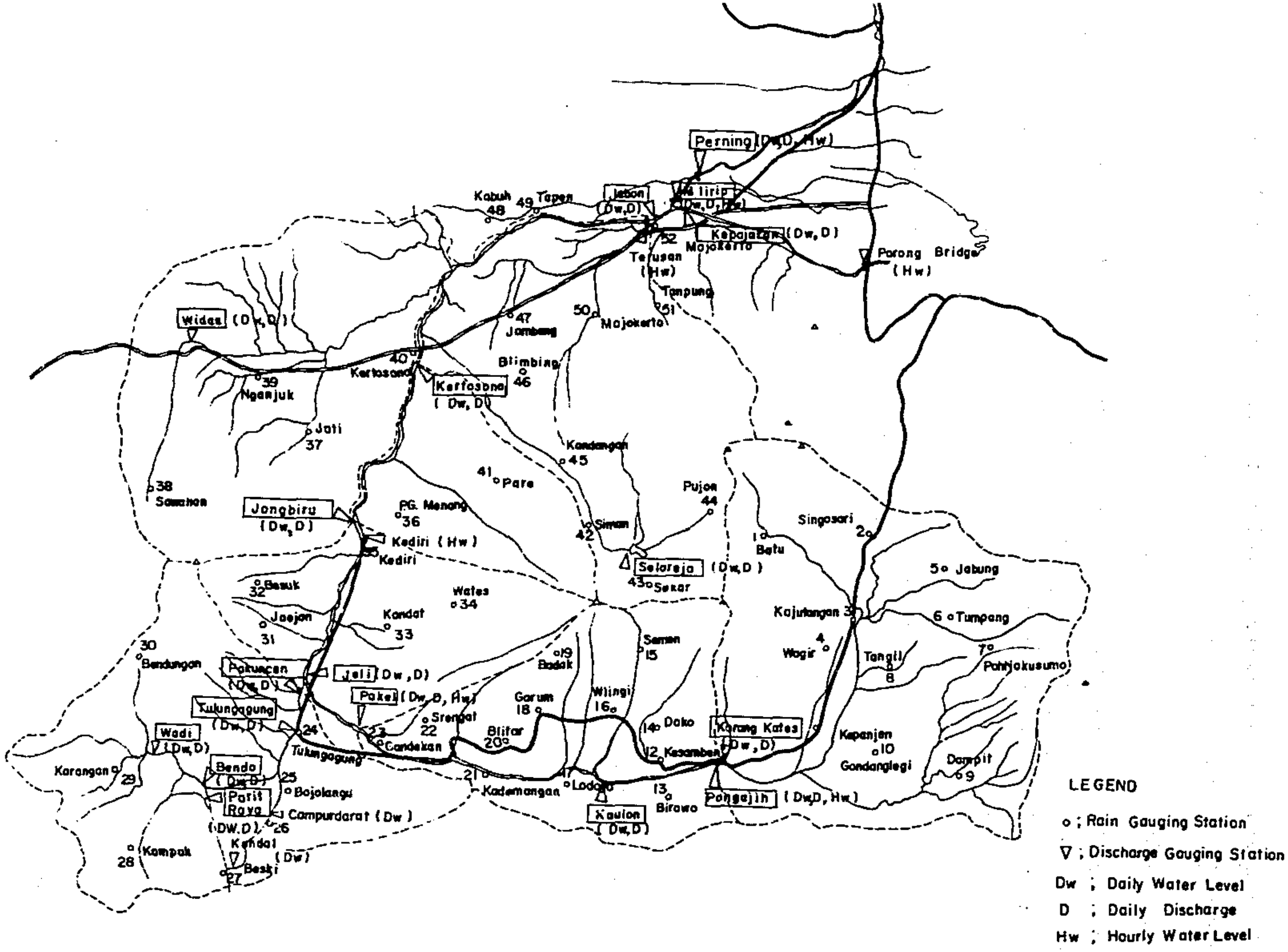


Fig. 3 - 1 Location Map of Rain and Discharge Gauge

correlation and cross-checking proved that the discharge record of the Jabon gauge is very reliable.

(3) Record Adjustment

The monthly discharge hydrograph of the gauges on the main stream prepared based on the 1951 - 1971 records shows that the 1964 - 1971 record at the Jongbiru, and Kertosono gauges seem rather high compared with the records of other gauges, and the records of both gauges for the period before 1964. Then, the 1964 - 1971 records of the Jongbiru and Kertosono gauges are corrected by the correlogram of the 1951 - 1963 monthly discharge records at the Jabon and Jongbiru gauges and those at the Jabon gauge and Kertosono gauge respectively. The following table shows the 1951 - 1971 average monthly discharge at 8 gauges on the Brantas main stream including the adjusted records at the Jongbiru and Kertosono gauges.

(Unit: m^3/sec)

Month	Karang-kates	Pohgajih	Kaulon	Pakel	Jeli	Jongbiru	Kertosono	Jabon
Jan	94.3	110.8	139.6	184.2	271.8	239.7	277.3	426.9
Feb	100.5	122.2	137.5	195.7	291.8	273.5	318.9	510.7
Mar	94.3	115.6	141.1	208.9	310.7	282.1	327.2	520.1
Apr	78.3	97.6	128.4	182.9	257.0	228.6	263.1	387.0
May	69.5	87.3	113.2	157.7	212.3	198.4	227.1	285.7
Jun	58.0	71.1	95.5	121.8	154.5	146.0	164.6	174.6
Jul	53.8	63.6	81.5	100.8	140.6	125.6	146.1	141.8
Aug	44.0	50.8	62.1	74.6	96.4	86.7	99.1	82.9
Sep	36.7	43.1	53.8	62.2	73.7	66.9	70.1	50.7
Oct	41.8	48.8	62.9	65.8	96.9	83.5	83.4	73.3
Nov	54.8	66.5	89.2	106.1	155.5	140.2	147.1	160.3
Dec	82.3	99.4	124.1	158.5	227.2	205.3	220.1	294.4
Mean	67.4	81.3	102.7	134.9	189.2	173.1	194.9	259.1

(4) Runoff Coefficient

The runoff coefficients in the 1951 - 1971 period at 7 gauges on the main stream are estimated based on the corrected discharge and the basin mean rainfall. They ranges between 59 and 47 % which seems reasonable taking into account the evaporation and infiltration loss.

(5) Effects of Karangkates, Lahor and Selorejo Reservoirs

The Karangkates dam has already been constructed at about 1 km upstream from Pohgajih gauge. The Lahor dam located on the upper reaches of the Lahor River which is one of the tributaries neighboring the Karangkates reservoir is being constructed by the Government. The 1951 - 1971 average discharge estimated at the Lahor damsite is 12.2 m^3/sec.

Based on the monthly discharge at the Karangkates and Lahor damsites during the 1951 - 1971 period, the increase and decrease of the monthly discharge after joint regulation of both reservoirs is estimated assuming that the reservoirs are operated in accordance with operation rule as mentioned in "Supporting Report". The average increase of discharge during the period from June to November in an average year is 11 m^3/sec at the Karangkates damsite.

The Selerorejo dam has already been constructed on the upstream reaches of the Konto River. The 1951 - 1971 average discharge at the damsite is estimated at 10.2 m^3/sec. Based on the monthly discharge during the 1951 - 1971 period at the Selorejo damsite, the increase and decrease of the monthly discharge after regulation by the Selorejo reservoir is estimated. The average increase of discharge during the period from June to November in an average year is 2.8 m^3/sec at the damsite.

3-4 Population

The population in the Brantas River Basin estimated from the data on the population divided by the administrative district is about 10 million in 1971 which constitutes about 13 % of the population of Java or 8 % of the country's total. The estimated average population density is 847 persons per km^2 and the average rate of annual population growth is 1.81 % during the 1961 - 1971 period.

The population of the basin comprises about 8 million in the rural area and 2 million in the urban area. More than 60 % of the urban population concentrates in Surabaya city. The estimated population density in the urban area of Surabaya is about 7,300 person per km^2. Approximately 70 % of the population of the basin is engaged in agriculture and the remaining 30 % in other industries and service business.

As the arable land suitable for farming are limited, an average holding size of farmland per family is as small as about 0.5 ha. Heavy population pressure even in the rural area tends to migrate to the urban area to find their way of living. However, the urban area is faced to serious unemployment problem due to insufficient growth of employment for them. Therefore, latent underemployed population is still absorbed in the farming families.

3-5 Eruption of Mt. Kelut and River Bed Movement

(1) Volcanic activity of Mt. Kelut

Mt. Kelut located at 35 km east of Kediri is an active volcano. It has erupted 10 times during the 1811 - 1966 period with interval of 3 - 37 years.

The crater of Mt. Kelut usually retaines water in it. If Mt. Kelut erupts when much water is stored in the crater, a huge amount of hot mud flow mixed with the crater water and hot muddy masses rushes down and destroys everything on its course. This hot muddy flow is called the "Primary lahar". After the 1919 eruption, the tunnel construction was commenced to drain the crater water through the southern crater wall. The tunnel was partly damaged in the 1951 eruption but no primary lahar was produced owing to this measure. The tunnel excavation has been carried out seven times altogether until 1972 and now the crater water decreases to about 4 million m^3. Judging from the past records of primary lahar and the present amount of crater water, the travelling distance of the primary lahar in next eruption is anticipated to be about 13 km.

Aside from the above mud flow, the volcanic ash, sand, lapillis and bombs deposited on the hill slopes travel down as a mud flow along the ravines mainly by the rain water in the wet season. This mud flow is called the "Secondary lahar". Both the primary and secondary lahars are destructive due to their high gravity. Most of these lahars settle on the slopes as loose deposits which are easily eroded by subsequent rain and travel toward the Brantas main stream. The total volume of the deposit on the hill slope in the 1966 eruption is estimated to be 90 million m^3 and that estimated for the 1951 eruption is 192 million m^3.

(2) Debris Control Works

After the 1966 eruption, the debris control works on the southern and western slopes of Mt. Kelut have been carried out by the Government. Major purposes of this debris control works are (1) to localize the spreading of lahar material (2) to safeguard the menaced area and (3) to prevent the lahar material from flowing into Brantas River. These works are featured by the construction of low check dam in the ravine and the dike to trap and settle the lahar deposit on the mountain slopes. The principal features of the lahar pockets constructed until 1970 are as follows.

Planned pocket capacity	$36.2 \times 10^6 m^2$
Trapped volume until 1970	$19 \times 10^6 m^2$
Area occupied by pockets	1840 ha
Construction cost	174×10^6Rp

The construction cost per m^3 of the pocket capacity ranges between 3.3 to 16.2 Rp. It is noted that this low cost is attributable to low man-power and no compensation cost for the land occupied.

(3) River Bed Movement

The river bed elevation of the Brantas has been measured at 22 sites on a 220 km-long river stretch between Ngambul near Wlingi and the estuary of the Porong River. The records of the river bed elevation cover most of the 1950 - 1970 period.

The volume increase in the river deposit between the adjacent measurement sites in each year is calculated based on these measurement records. The result of this calculation shows that the river deposit largely increases in about 5 years after the eruption and its increasing rate reduces thereafter. The total deposit in the 1951 - 1971 period on the river stretch between the Kaulon and the estuary of the Porong River is about 48 million m^3 as shown below;

Stretch	Distance of stretch (km)	Deposit volume ($10^6 m^3$)
Kaulon-Jongbiru	80.5	15.7
Jongbiru-Kertosono	33	8.3
Kertosono-Jabon	48	9.2
Jabon-Porong estuary	51	15.1
Total	212.5	48.3

The deposit increased in the initial 5 years after the eruption and the estimated deposit on the slopes of Mt. Kelut are compared as shown below;

Period of eruption	Mountain deposit ($10^6 m^3$)	5-yr river deposit ($10^6 m^3$)	Percentage
1951	192	26.86	14
1966	90	16.40	18
Total	282	43.26	

(4) River Sediment Load

The river sediment may be classified into two categories by its movement characteristics. These are the bed load moving on or near the river bed and the wash load in which finer materials are transported in suspension in the river water. The movement of the bed load material causes either aggradation or degradation depending on the discharge at the given site.

The sediment load sampling for the bed and wash load measurements was carried out at the Jongbiru, Kertosono and Jabon in 1959/1960 and 1971 on the Brantas River, and the Porong bridge in 1964 on the Porong River. The sediment loads passing through the above sites are estimated by a relationship between the sediment discharge and a hydraulic parameter of the river cross section. Applying this relationship to the 1951 - 1970 monthly mean discharge data, the sediment load in each year is obtained. The result of calculation shows that the annual bed load and wash load are within a range of 1-1.1 million m^3 and 4-4.5 million m^3 respectively on the Brantas River.

(5) Sediment Yield from the Slopes of Mt. Kelut

The sediment yield in a catchment area can be estimated as a sum of the increase of the river deposit and the sediment load carried to the outside of the area through the river.

The drainage area on the right bank of the Brantas River may be devided into two kinds by the source of the sediment yield. These are the affected area where much volcanic deposits distribute and unaffected area which is the rest of the drainage area. The affected area is the southern and western slopes of Mt. Kelut, mostly on the right bank of the Brantas River between the Kaulon and Kertosono. The sediment yield from the affected area can be obtained by deducting the yield in the unaffected area from the total yield. The bed and wash load yields in the affected area in the 1951 - 1955, 1956 - 1965, 1966 - 1970 period respectively are estimated as follows;

(Unit ; $10^6 m^3$)

Period	Bed load yield	Wash load yield	Total
1951 - 1955	30.85	25.74	56.59
1956 - 1965	10.27	33.35	43.62
1966 - 1970	18.09	9.51	27.60
Total	59.21	68.60	127.81

3-6 Flood Flow

(1) Flood Discharge Data

The flood characteristics in the Brantas River is investigated to obtain the necessary data for planning purpose. The data used for the flood analysis are the hourly water level records at the Pohgajih, Pakel, Kediri and Terusan gauges. The measurement duration period of the data is 20 years at the longest at the Pakel gauge and about 3 years at the shortest at Pohgajih gauge.

(2) Flood Characteristics

Based on the hourly records of the flood water level and the water stage-discharge relationship, the flood hydrographs are drawn for the case of the largest flood in each year during the 1951 - 1970 period. The hydrographs thus drawn are compiled in "Supporting Report". The flood hydrographs in the upstream reaches have remarkably rapid increase and decrease of flood discharge with very high peaks, while those in the downstream reaches have very flat and elongated pattern. This phenomenon can be explained from the fact that the retardation of flood by the river channel storage considerably flatterns the flood peak. Moreover, the inflow from the silted up tributaries is once retained in the back swamp and gradually drained. Thus the flood peak discharge in the downstream reaches of the Brantas River is very small in comparison of the large catchment area.

(3) Retardation Effect

The flood analysis has revealed that the flood peak discharge in the Brantas River is largely reduced by the inland inundation in the Pakel-Kediri stretch and retardation in the swamp located near the confluence of the Brantas River and Widas River in the Kediri-Terusan stretch.

The river stretch between the Pakel and Kediri is not provided with levees and the river width narrow after joining with the Ngrowo River. The water volume retained in this river stretch ranges between 15 - 30 million m^2 depending on the magnitude of floods. The reduction of the flood peak discharge in the downstream stretch by the retention of this retardation is estimated to be 150 - 300 m^3/sec.

The flood flow in the Brantas River and the flood inflow from the Widas River have been retarded by the swamp located at the Widas month. The water volume retained in the swamp is about 30 - 40 million m^3. It is presumed from the water volume capacity in the swamp that the flood peak in the downstream reached might be higher by about 300 - 400 m^3/sec without this swamp.

In addition, the flood in further downstream reaches is reduced by the flood diversion to the Marmoyo River through the Gedek gate located 5 km upstream from the Terusan gauge on the left bank of the Brantas River. Based on the hourly water level records during the 1951 - 1962 period at the end of the stilling pool of the gate, the flood discharge diverted through the gate at the flood peak time is estimated to be 80 m^3/sec on an average.

(4) Probable Flood

The probable floods at the Karangkates, Pakel, Kediri and Terusan gauges after the regulation by the Karangkates reservoir are estimated as follows by the flood rooting appling the storage function mehtod.

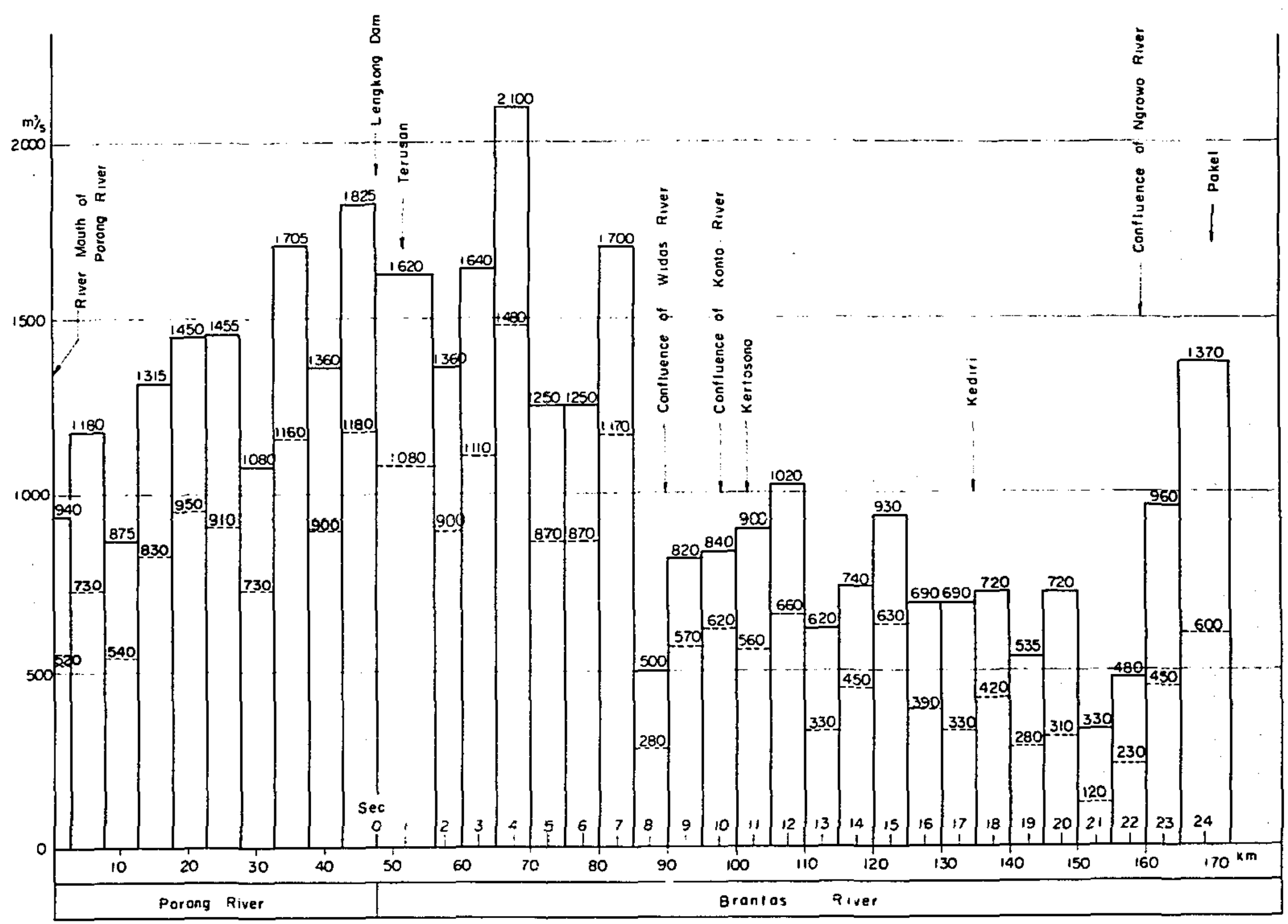
(Unit ; m^3/sec)

Return period (year)	Karangkates	Pakel	Kediri	Terusan
5	400	1,000	660	1,130
10	470	1,090	720	1,190
20	490	1,250	790	1,260
30	500	1,350	820	1,290
50	530	1,440	860	1,330
100	560	1,560	910	1,380

(5) River Discharge Capacity

Based on the river cross section surveys carried out at an interval of 5 km on the Porong River in 1970 and on the Brantas River up to the Pakel gauge in 1971, the river discharge capacity is calculated assuming a non-uniform steady flow.

The results of calculation is given in Fig. 3-2. A comparison of the river discharge capacity in this fugure with the estimated probable peak discharge at the Pakel, Kediri and Terusan gauges indicates the critical degree of the present river channel. The discharge capacity of 1,370 m^3/sec at Pakel corresponds to a flood peak of 30 years return period. The river channel between the Kediri and Widas month is leveed but its levees are too low to discharge large flood. The



Remarks ; The thick line shows the discharge capacity for the water surface just coinciding the levee top and dotted line shows that for the water surface 1 m below the levee top.

Fig. 3-2 Discharge Capacity of Brantas and Porong River discharge capacity of 690 m^3/sec corresponds to 5-10 years return period of flood. This indicates the levees along the Kediri-Widas mouth stretch are quite liable to be overtopped by floods. This meager discharge capacity of the middle stretch is attributable to the heavy silting due to the recent eruption of Mt. Kelut.

(6) Flood Damage

The flood damage in the areas along the river stretch between the Ngrowo confluence and Terusan gauge is estimated based on the results of the cross section survey along the Brantas river carried out in 1971 and 1972. The estimated potential annual flood damage is about 4.6 million $ equivalent except the indirect damages.

3-7 Irrigation and Agricultural Condition

(1) Soils

The soils in the Brantas River Basin are generally fertile because they contain much volcanic deposit of Mt. Kelut. They are classified into 9 great soil groups, namely, Alluvials, Mediterranean Soils, Lithosols, Regosols, Andosols, Grumusols, Humus Gley Soils, Latosols and Brown Forest Soils. Among those, Alluvials and Regosols occupy about 50 % of the basin area. Alluvials covering about 347,000 ha are most important agricultural soils. They are extensively used for rice cultivation.

(2) Land Use

The total farmland in the Brantas River Basin is 727,000 ha corresponding to about 62 % of the basin area, comprising 321,000 ha of paddy field, 360,000 ha of upland and 46,000 ha of estates and orchards.

The paddy fields extend along the Brantas River and its tributaries where the lands are flat and water is available. The upland areas mostly extend on the lower slopes of Mt. Kelut and Mt. Kawi.

(3) Irrigation Area and Canal System

Out of the total paddy field of about 321,000 ha, the irrigated areas depending on the Brantas main stream are about 77,000 ha. Most of them are the technical irrigation area in which the whole irrigation facilities are managed by the Irrigation Service. Major irrigation areas located along the main stream are five comprising the Morek, Warujayeng-Kertosono, Turi-Tunggorono, Jatimlerek-Bunder and Sidoarjo irrigation areas. In addition, there are promising new irrigable areas with about 48,300 ha which are located close to the Brantas River. These areas are the Lodoyo-Tulungagung, Pace-Nganjuk, and Britar-Kediri areas. The location of the existing irrigation areas and new irrigable areas is shown in Fig. 3-3.

The typical irrigation method in the Brantas River Basin is the gravity irrigation except very few cases of the pumping irrigation.

There are 18 intake structures along the Brantas main stream. The location of these intake sites is shown in Fig. 3- 3 . The irrigation intakes on the Brantas River face the river directly except for the Voor canal. These intakes are equiped with the stop log to control the inflow into irrigation canals. However, proper adjustment of inflow is very difficult by this method under the condition that the river water level widely fluctuates. The sediment-bearing water in the wet season reduces the canal discharge capacity by depositing sediment. The discharge capacity of the intake also decreases because of the sediment transported by floods.

The investigation of the existing irrigation canal system along the main stream carried out during this survey period has clarified that the most of the irrigation and drainage system including the related structures require rehabilitation such as the remodelling and repair of head works and desilting of canals to recover the proper function of the system.

(4) Irrigation Water Supply

The river water of the Brantas is mostly utilized for irrigation use. Among the 18 intakes along the main stream, the discharge records are available at only 7 intakes observed by the Irrigation Service. Average intake discharge and irrigation area are summarized as follows.

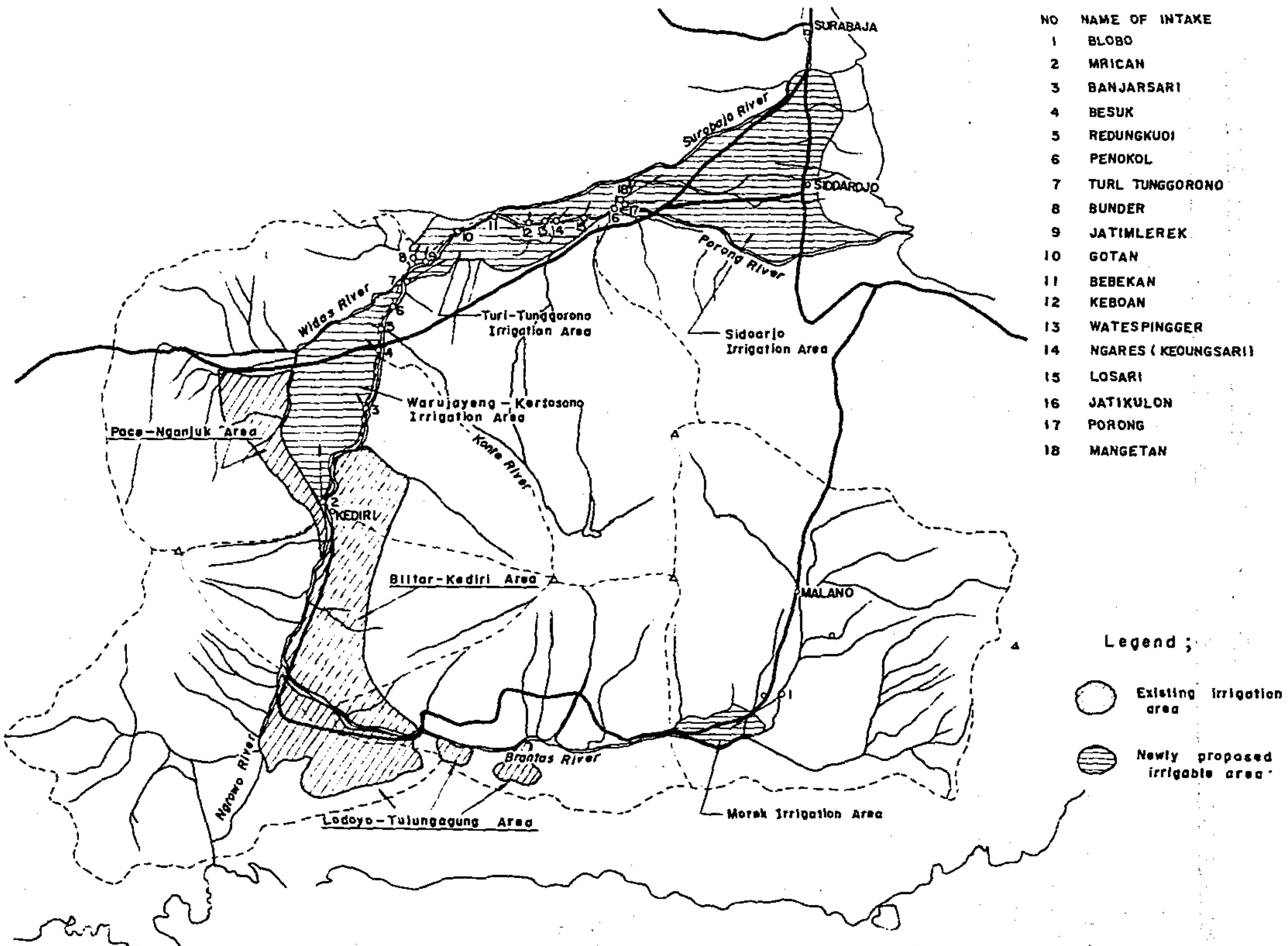


Fig.3-3 Location Map of Intake Structure and Irrigation Area along Brantas River Course

Name of intake	Irrigation area (ha) Dry season	Wet season	Intake discharge (m^3/sec) Min.	Mix.
Blobo	2,600	4,300	4.2	8.0
Mrican-Besuk	2,600	13,300	6.7	11.1
Turi-Tunggorono	3,900	9,500	3.6	6.7
Jatikulon	300	600	0.4	0.7
Porong-Mangetan	18,800	32,400	31.9	67.5

The irrigation efficiency in the dry season is relatively low due to inadequate operation and maintenance of the irrigation system. This fact suggests that more production is possible in the dry season, if the irrigation efficiency is improved by rehabilitation of the irrigation facilities.

(5) Cropping Pattern and Cropping Intensity

The prevailing cropping pattern in the paddy field in the basin can be classified into three types, namely, wet monsoon paddy-Polowijo for 254,000 ha, double cultivation of paddy for 50,000 ha and paddy-sugar cane-Polowijo for 17,000 ha respectively. In most of the upland area, the single cultivation of crops such as Polowijo and cassava is common.

The seeding time of the wet monsoon paddy ranges from mid-November to mid-February and the harvesting period from mid-April to mid-July. In case of the dry monsoon paddy, the seeding period is between mid-March and mid-June and the harvesting period from mid-July to mid-October.

The cropping intensity estimated based on the data of the cultivation areas for major crops in the basin during the 1966 - 1971 period is about 130 % for all the farmlands.

(6) Crop Yield

The average yield of the dry stalk paddy is estimated at 3.4 ton/ha for the wet monsoon paddy and 3.1 ton/ha for the dry monsoon paddy. The annual production of paddy in the whole basin amounts to about 1.2 million tons in dry stalk paddy which corresponds to about 10 - 12 % of the total production in Java.

The total production of sugar in the basin during the 1966 - 1970 period was about 230,000 tons per annum which constitutes about 30 % of the country's total.

(7) Farming Practice

The improved varieties of paddy such as PB-5, PB-8 and C4-63 are used in about half of the cultivation area. Besides, farmer uses the local varieties such as Bengawan, Syntha and Diwi. Most of the farmer in the basin use fertilizer for cultivation of paddy crop. However, the quantity used is about half of the amount recommended by the Agricultural Extension Service or BIMAS and INMAS programs.

The result of the farm survey for damage to paddy crop revealed that most of damage is caused by pest. Besides, the natural causes of damage are poor drainage, flooding and drought in the dry season due to the deterioration of irrigation and drainage system.

The cultivation of sugar cane is managed by the sugar refinery or the farmers themselves. The area under the management of the sugar refinary covers about 60 % of the total area developed mainly in Sidoarjo and Kediri areas. The varieties of sugar cane cultivated are common throughout the basin. The most common varieties are 3016 POJ, 3076 POJ and PS 41. The sugar cane is traditionally irrigated only during the dry season from May to October. The damages to sugar cane are mainly caused by the inadequate cultivation practice, poor transportation condition from farms to the refinery and poor condition of the refineries.

(8) Price and Tax.

The Bulog/1 are making the efforts to stabilize the price of the agricultural products. However, the market prices fluctuate largely from month to month. The market price of the rice at Jombang in 1971 varies between about 40 and 90 $ equivalent per ton for unhulled rice and 90 and 110 $ equivalent per ton for milled rice. These fluctuations

/1; Badan Urusan Logistic

of the market price is mainly due to the reasons that the amount of the agricultural products handled by the Bulog is very small compared with the amount in the whole agricultural product circulation, and besides, the structure of the market system is imperfect.

The average unit price of the agricultural products on farm in the basin is estimated as follows according to the results of the farm survey carried out in 1971 and 1972.

(Unit; $/ton)

Kind of agricultural product	Average farm gate price
Dry stalk paddy	42
Maize	36
Soybean	97
Ground Nuts	87
Sugar (domestic)	168
Sugar (import)	108

As to the taxes, the farmers pay land tax which is called IPEDA (Iuran Pembayuang Daerah), villige tax and mosque tax. IPEDA is collected mainly by administrative Kabupaten office. The rate of land tax is around 3,000 Rp per ha for the first class paddy field. No data on the rate of other taxes are available.

(9) Income from Agricultural Products

Annual net profit for main crops in the basin is estimated based on the average yield of the crops, farm gate price of agricultural products and production cost. Net profit for the main crops at present is estimated at 92 $ equivalent per ha for paddy, 410$ equivalent per ha for sugar cane, 50 $ equivalent per ha for soybeans, 62 $ equivalent per ha of ground nuts and 27 $ equivalent per ha for maize respectively.

Annual farm budget in typical farm is estimated based on the farm size, annual primary profit of the crops as well as three representative cropping patterns. Farm budget for typical farm of 0.5 ha with three representative cropping patterns is estimated as follows.

(Unit; $)

Description	Typical Farm/1 Type I	Type II	Type III
1. Gross income	82	104	111
2. Grop operation cost	26	33	28
3. Primary farm profit ; (1 - 2)	56	71	83
4. Farm management cost	6	7	7
5. Living expenses	50	50	50
6. Capacity to pay ; (4 - 5)	0	14	26

As shown above, capacity to pay on typical farm in each type is estimated at to 0$, 14$, and 26$ respectively.

Based on the present landuse, average unit yield, and farm input for the crops at present, the net value for major existing irrigation area and promising irrigable area along the middle stretch of the Brantas River is estimated as follows.

(Unit; $10^3$$)

Irrigation or Irrigable area	Total net value
Warujayeng-Kertosono	2,211.3
Turi- Tunggorono	1,640.9
Jatimlerek-Bunder	336.7
Sidoarjo delta	5,767.2/2
Lodoyo-Tulungagung	1,236.5
Pace-Nganjuk	1,376.2
Blitar-Kediri	4,045.8

/1: Farming practices are the prevailed paddy-polowidjo cropping in Type I, double cropping of paddy in Type II and Paddy-sugar cane rotation cropping in Type III.

/2: This figure is derived from the Report on "Brantas Delta Irrigation Rehabilitation Project"

(10) Extension Services and Credit Systems

In the Brantas River Basin, the National Agricultural Experiment Station has been established at Mojosari and Pasuruan. The major experimental works at Mojosari station are the variety test, seasonal test and fertilizer test for paddy and upland crops. The Pasuruan station is devoting itself to the experimental work on sugar cane cultivation. The agricultural extension service is conducted by the Agricultural Extension Branches of the Provincial Agricultural Office in East Java. However, the experiment and extension service are still insufficient despite the most of farmers are in need of sufficient technical guidance by the extension workers.

The BIMAS and INMAS programs proceed in the basin, aiming at self-sufficiency in foodstaff. The BIMAS program, which provides extension advice and credits for subsidized inputs of high-yielding seeds, fertilizers, chemicals and credit for living allowance, has been in operation since 1964 in the basin. The paddy field covered by this program was about 150,000 ha. Under the BIMAS program, a considerable increase in paddy yield was recorded as the result of proper application of the necessary input. However, since this program is available only for one year, some farmers switched to the INMAS program. This program provides the package of subsidized inputs to farmer but no credit nor advice are included. Consequently it seems that most of farmers hesitate to utilize the INMAS program due to the lack of sequrity for credit.

As to the credit system, the Bank Rakjat Indonesia (BRI) which provides the seasonal or short-term credits for agricultural credit is available. Besides the BRI, there are village banks and village paddy banks. However, the working capital of these banks is very small. Another source of credit is the private money lender. The interest rate of this credit is very high but the loan procedures are simple.

3-8 Present Power Condition

The power supply in East Java is being made by the Kalikonto system covering the Brantas River Basin, Madiun system around the Madiun city and several small scale systems.

The total installed capacity of the generating facilities of the Kalikonto system as of 1970 was about 96 MW as shown below.

(Unit; kW)

Power plant	Installed	Dependable peak
Hydro	36,400	25,000
Thermal	50,000	50,000
Diesel	9,200	5,500
Total	95,600	80,500

The major generating facilities are the Perah thermal power plant in the Surabaya and Mendaran and Siman hydro plants on the Konto River.

In addition to the above, the Selorejo and Karangkates hydro power plants are being constructed in the Brantas River Basin and are scheduled to be put in operation in 1973. The Selorejo power plant is located at the upper reaches of the Konto River and its installed capacity is 4.5 MW. The Karangkates power plant is located on the upstream reaches of the Brantas main stream and its installed capacity is 70 MW at the first stage. The installed capacity of the Karangkates power plant will be increased to 105 MW in the final stage after the river flow of the Lahor is diverted to the Karangkates reservoir through a tunnel connecting the Karangkates and Lahor reservoirs.

The annual consumption of the electric energy in the Kalikonto system in 1970 was about 276 million kWh comprising 209 million kWh for residential use and 67 million kWh for industrial and commercial uses. The power consumption per customer averaged by 164,000 customers is as small as about 1,700 kWh. The annual growth rate of the power consumption in 1969/1970 was about 10 %.

The long-range forecast of power demand estimated based on the growth of national economy is as follows.

Year	Assumed annual growth rate (%)	Peak demand (kW)	Energy requirement (million kWh)
1975	15	145,000	890
1980	15	280,000	1,720
1985	12	495,000	3,020

The expected increase in the power generating facilities by 1973 is 71.9 MW comprising 74.5 MW of both Karangkates and Selorejo power plants less the retirement of 2.6 MW at the Sengguruh due to its submergence by the Karangkates reservoir. The additional capacity together with the present available capacity of 95.6 MW amount to a total capacity of 167.5 MW. A comparison of the expected total capacity with the projected power demand indicates that a new source of the power supply will become necessary in the beginning of 1976.

4. THE PROJECT

4-1 Introduction

This chapter presents the outline of the development projects to be contemplated in the basin, which include the irrigation, sand control, flood control and hydro power projects. As to irrigation projects, Jatimrelek-Burder, Warujayeng-Kertosono and Turi-Tunggorono projects are contemplated as the rehabilitation project and Lodoyo-Tulungagung, Pace-Nganjuk, and Blitar-Kediri projects are contemplated as new project. As the sand control project, the future debris control works on the slopes of Mt. Kelut in connection with the prevention of aggradation of the Brantas River is contemplated. As the flood control project, the river improvement project in the middle reaches of the Brantas River and the cut-off canal project in the area along the Ngrowo River are contemplated. As the hydro power project, herein dealt with are the re-study on the Wlingi power generation and the preliminary study on the possibility of the future hydro power development in the Brantas River Basin.

4-2 Irrigation Project

The presented herein are the planning of irrigation development in the areas along the Brantas middle stream. The envisaged areas comprise the existing irrigation areas and newly proposed irrigable areas. The existing irrigation areas which depend on the Brantas main stream are about 24,800 ha in total, comprising the Warujayeng-Kertosono (13,300 ha), Turi-Tunggorono (9,600 ha) and Jatimlerek-Bunder (1,900 ha) areas. The newly proposed irrigable areas which are located close to the Brantas River are about 48,300 ha in total, comprising the Lodoyo-Tulungagung (13,500 ha), Pace-Nganjuk (9,600 ha) and Blitar-Kediri (25,200 ha) areas. The location of these areas is shown in Fig. 3-3.

4-2-1 Prospective Agricultural Development

(1) Cropping pattern and Future Land Use.

The cropping pattern for future development is determined on the basis of the following considerations.

1) Ecological condition of the area especially for crop growth.

2) Socio-economic condition of the area.

3) Domestic demand of agricultural products as well as foreign exchange saving from the food import, and

4) Effective water use during the dry season.

As the result, a pattern consisting of paddy, pulses and sugar cane as its main crops is formulated. The proposed cropping patterns consisting of three type, namely, type A, B and C, are shown in Fig. 4-1.

Based on the proposed cropping pattern and land capability classification, the future land use in each irrigation project is summarized as follows.

(Unit; ha)

Irrigation project	Area	Land Use in Future				
		Paddy	Pulses	Sugar cane	Maize	Total
Warujayeng-Kertosono	13,300	17,750	11,100	1,100	0	29,950
Turi-Tunggorono	9,600	11,950	7,800	900	650	21,300
Jatimlerek-Bunder	1,900	2,150	1,200	350	0	3,700
Lodoyo-Tulungagung	13,500	17,000	11,500	1,000	1,250	30,750
Pace-Nganjuk	9,600	13,000	8,200	700	0	21,900
Blitar-Kediri	25,200	29,650	22,600	1,300	5,550	59,100

(2) Farm Input

Proper irrigation farming under the efficient water management together with proper application of fertilizer and chemicals and the introduction of improved crop varieties is indispensable to increase the crop production.

1) Improvement of crop variety

Among the improved varieties of paddy developed recently, PB-5 and C4-63 are most widely used. These two varieties shows high yield

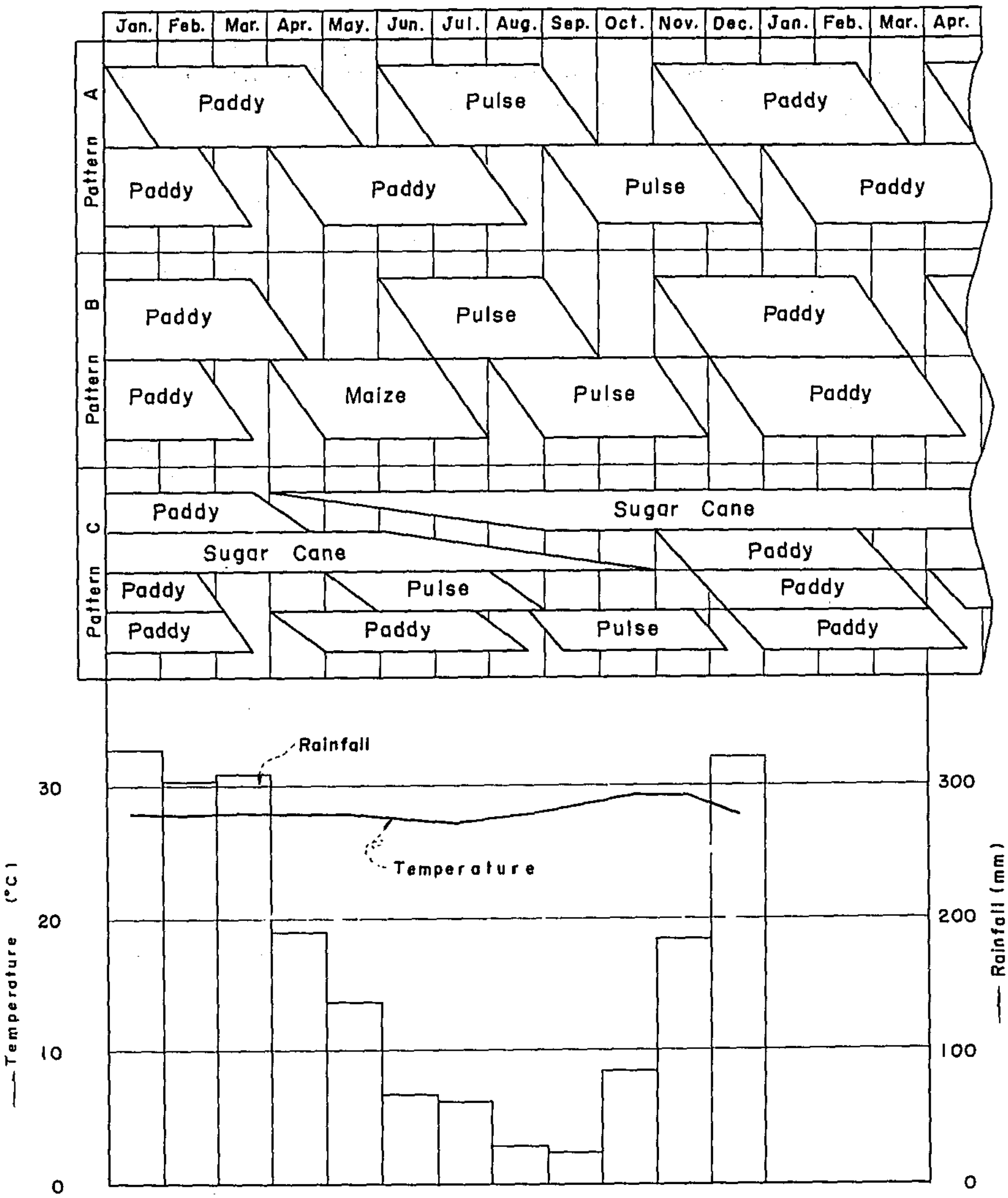


Fig. 4-1 Proposed Cropping Pattern

in the basin. Pelita I & II developed by hybrid seeding of IR-5 and Syntha have been produced in Agricultural Research Institute in Bogor recently. These two varieties have better cooking and milling quality than other improved varieties and also high yields.

In view of the above consideration, the improved varieties such as PB-5, C4-63, Pelita I and Pelita II are recommendable to be used in the project together with the introduction of proper water control and fertilizer application.

2) Fertilizer and Chemical Inputs

The results of experiments carried out at research institutes in Indonesia and the neighbouring countries indicate that the above mentioned improved varieties of crops require timely application of fertilizers and agricultural chemicals to obtain high yields.

Application of fertilizers and agricultural chemicals as shown in the following table is proposed.

Crop	Fertilizer			Agricultural Chemicals		
	Urea	Triple Super Phosphate	Lime	Insecticide	Rodenticide	Fungicide
	(kg/ha)	(kg/ha)	(kg/ha)	(ℓ/ha)	(gr./ha)	(ℓ/ha)
Paddy	200	50	0	3	600	2
Soybeans	50	50	100	1	300	0
Ground nuts	50	50	200	1	600	0
Maize	80	25	0	1	0	0
Sugar cane	500	300	0	3	0	0

(3) Project Output

The future yield of crops has been estimated on the basis of the results of various experiment carried out by the demonstration plot in the basin. The yield of proposed crops will increase gradually and will reach to the maximum in the 5th year after the introduction of irrigation farming. Anticipated yield and production of the proposed crops in each irrigation project are summarized as follows and details are shown in Table II-1-5 in the "Supporting Report".

(1) Agricultural Income

The prospective annual primary farm profit of an irrigated typical farm (0.5 ha) is obtained by deducting the annual gross outgo from the annual gross income from agricultural production.

There are three types of typical farm in each irrigation project, namely, standard farm I with cropping pattern A, standard farm II with pattern B and standard farm III with cropping pattern C.

For the estimation of primary farm profit for each type, as the first step, net profit in the 5th year after beginning of farming operation for the proposed crops is estimated at 140$ equivalent per ha for paddy, 600$ equivalent per ha for sugar cane, 93.5 $ equivalent per ha for pulses and 62.5$ equivalent per ha for maize respectively.

Based on the above estimation, annual primary farm profit in the 5th year after the beginning of farming operation is expected at 152$ for farm I, 132$ for farm II and 167$ for farm III respectively.

Farm budget in the 5th year is taken as representative farm budget as follows.

(Unit; $)

	Gross income (1)	Gross outgo (2)	Overhead (3)	Capacity to pay (4)=(1)-(2)-(3)
Standard farm I	216	64	111	41
Standard farm II	186	54	110	22
Standard farm III	223	56	112	55

Based on the anticipated crop production, the net value for each irrigation project in the 5th year after the completion of construction is estimated as follows.

(Unit; 10^3\$)

Irrigation project	Gross value	Production cost	Net value
Warujayeg-Kertosono	5,807.2	1,618.8	4,188.4
Turi-Tunggorono	4,121.9	1,135.1	2,986.8
Jatimlerek-Bunder	841.6	217.8	623.8
Lodoyo-Tulungagung	5,740.4	1,601.3	4,139.1
Pace-Nganjuk	4,185.8	1,175.0	3,010.8
Blitar-Kediri	10,302.4	2,900.1	7,402.3

2) Net incremental value of agricultural output

The net incremental value of the agricultural output is defined as difference of net value between with and without project. The increase of net farm income in future without project condition is disregarded because the current farming is still primitive. Therefore, net incremental value of agricultural output in the 5th year after the completion of irrigation system is estimated as difference of net value between with project and present condition. The estimated net incremental value of agricultural output is as follows.

(Unit; 10^3\$)

Irrigation project	Without project	With project	Net increment
Warujayeng-Kertosono	2,211	4,188	1,977
Turi-Tunggorono	1,341	2,987	1,346
Jatimlerek-Bunder	337	624	287
Lodoyo-Tulungagung	1,236	4,139	2,903
Pace-Nganjuk	1,376	3,101	1,635
Blitar-Kediri	4,046	7,403	3,357

4-2-2 Irrigation Development Project

(1) Water Requirement

The future water requirement in each project area along the Brantas main stream is estimated based on the following criteria.

1) The basic year for planning is set at the 20 % drought year of 1967 according to the rainfall record of past ten years during the 1962 - 1971 period.

2) The potential evapo-transpiration is estimated using the Talc's formula.

3) The proposed cropping patterns as mentioned in the foregoing paragraph are applied.

The irrigation requirements for each irrigation area estimated based on the potential evapo-transpiration, the proposed cropping patterns and the cropping areas are as follows:

(Unit: m^3/sec)

	Warujayeng-Kertosono (13,300 ha)	Turi-Tunggorono (9,600 ha)	Jatimlerek Bunder (1,900 ha)	Lodoyo-Tulungagung (13,500 ha)	Pace-Nganjuk (9,600 ha)	Blitar-Kediri (25,200 ha)
Jan.	-	-	-	-	-	-
Feb.	-	-	-	-	-	-
Mar.	2.5	1.5	0.2	0.3	1.9	2.7
Apr.	1.8	2.0	0.4	1.9	1.4	1.1
May	7.9	5.9	1.2	8.2	5.8	13.5
June	10.1	6.8	1.4	9.6	7.7	16.6
July	8.3	5.5	1.1	7.9	6.5	15.0
Aug.	4.1	3.0	0.5	4.4	3.2	9.7
Sept.	4.0	3.2	0.7	4.6	2.6	10.4
Oct.	6.9	4.8	1.0	6.7	4.8	12.8
Nov.	9.7	8.5	1.7	5.0	7.4	17.1
Dec.	-	0.1	-	-	-	-

Besides the above, the water requirements for the Sidoarjo delta (32,400 ha) and Surabaya (6,700 ha) areas are reviewed.

In the Sidoarjo delta area, the irrigation rehabilitation project is on going at present. The water requirements in this area have been determined based on the present cropping conditions and is used for the design discharge for irrigation facilities in the rehabilitation works.

However, the irrigation requirements in this area in future are estimated in accordance with the proposed cropping pattern and the same criteria used in this study. The estimated monthly water requirements in Sidoarjo delta are as follows.

(Unit; m^3/sec)

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0.3	0.3	3.4	8.4	22.3	25.5	21.2	11.6	11.5	18.7	28.9	0.8

The water requirements in Surabaya area during the 1972-1992 period, which comprise the water requirements for irrigation, municipal, industrial and river dilution uses, have been forecasted in the report on Surabaya River Improvement Project.

Among the these forecasted values, the future planning of this study is based on the condition in 1982. The irrigation requirements in 1982 is revised based on the cropping pattern and criteria proposed newly.

Thus, the total future water requirements in this area are calculated as shown below.

(Unit; m^3/sec)

	Jan.	Feb.	Mar.	Apr.	May	July	June	Aug.	Sept.	Oct.	Nov.	Dec.
Irrigation	-	-	2.0	2.0	4.6	5.4	4.7	2.3	1.8	3.5	6.6	-
Others	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
Total	8.1	8.1	10.1	10.1	12.7	13.5	12.8	10.4	9.9	11.6	14.7	8.1

(2) River Discharge Distribution

The major existing irrigation areas located along the Brantas middle and downstream stretches are the Warujayeng-Kertosono, Turi-Tunggorono, Jatimlerek-Bunder and Sidoarjo delta area. In addition, there are three newly proposed irrigable areas which are located close to the Brantas River. They are the Lodoyo-Tulungagung, Pace-Nganjuk and Blitar-Kediri areas.

Virtually the water of the Brantas River is not always effectively utilized for the existing irrigation areas due to the unfavourable condition of the intake structures, deterioration of the irrigation canal system and inadequate maintenance and management.

The river water use for municipal and pollution control is so little at present. However, the water requirement for these purpose will gradually increase along with the progress of industrialization of the Surabaya area.

Thus, more effective utilization of the water has to be planned under a well-balanced distribution of the available river discharge.

The river discharge distribution plan proposed herein is prepared based on the resultsof the river flow analysis and the water requirements for all water utilization plans. The distribution plan is made by checking the water balance between the total water requirements for irrigation and other uses for all water consuming areas and the potential river discharge/1 at the Jabon gauge during the period from June to November in the basic year of 1967.

1) Water balance

The water balance is made based on the following considerations and assumptions.

a) The irrigation water requirements for the all irrigation areas including the Sidoarjo delta area are estimated according to the proposed cropping pattern.

b) The water requirements in Surabaya area during the 1972 - 1992 period are forecasted. Among the forecasted value for 1982, the irrigation water requirement is revised based on the proposed cropping pattern and the same criteria applied in this study.

c) The increase of the dry season discharge after the regulation by the Karangkates reservoir is taken into consideration.

The monthly discharge at the Jabon gauge during the period from June to November in 1967 taking into account the effect of the Karangkates

/1 The potential river discharge is herein defined as the sum of the natural river discharge and the total intake discharge.

reservoir is as follows.

(Unit; m^3/sec)

June	July	Aug.	Sept.	Oct.	Nov.	Total
63.8	44.0	43.2	38.6	46.9	40.0	276.5

The monthly mean discharge of existing intakes along the Brantas middle stretch during the same period in 1967 is as follows.

(Unit; m^3/sec)

June	July	Aug.	Sept.	Oct.	Nov.	Total
12.9	11.1	10.3	9.7	9.3	12.2	65.5

Thus, the total potential river discharge during the period from June to November at the Jabon gauge is estimated as shown below.

(Unit; m^3/sec)

June	July	Aug.	Sept.	Oct.	Nov.	Total
76.7	55.1	53.5	48.3	56.2	52.2	342.0

The balance between the potential river discharge at Jabon gauge and the total water requirements for all the existing and proposed water consuming areas is as follows.

(Unit; m^3/sec)

	June	July	Aug.	Sept.	Oct.	Nov.	Total
Potential river discharge	76.7	55.1	53.5	48.3	56.2	52.2	342.0
Total water requirement	91.2	78.2	46.9	46.9	67.2	93.0	423.4
Water balance	-14.5	-23.1	6.6	1.4	-11.0	-40.8	-81.4

As seen the above table, the water deficit occurs every month except for August and September.

2) River discharge distribution

In order to meet the requirements, the following measures are contemplated;

a) To reduce the irrigation requirement.

b) To exclude the irrigation area which is the weakest in the economic feasibility among the new irrigation projects.

Since the first measure seems to be difficult to be adopted in this basin, the second measure is incorporated in this plan.

As explained in latter, the Blitar-Kediri new irrigation project is the weakest in the economic feasibility among the new irrigation projects.

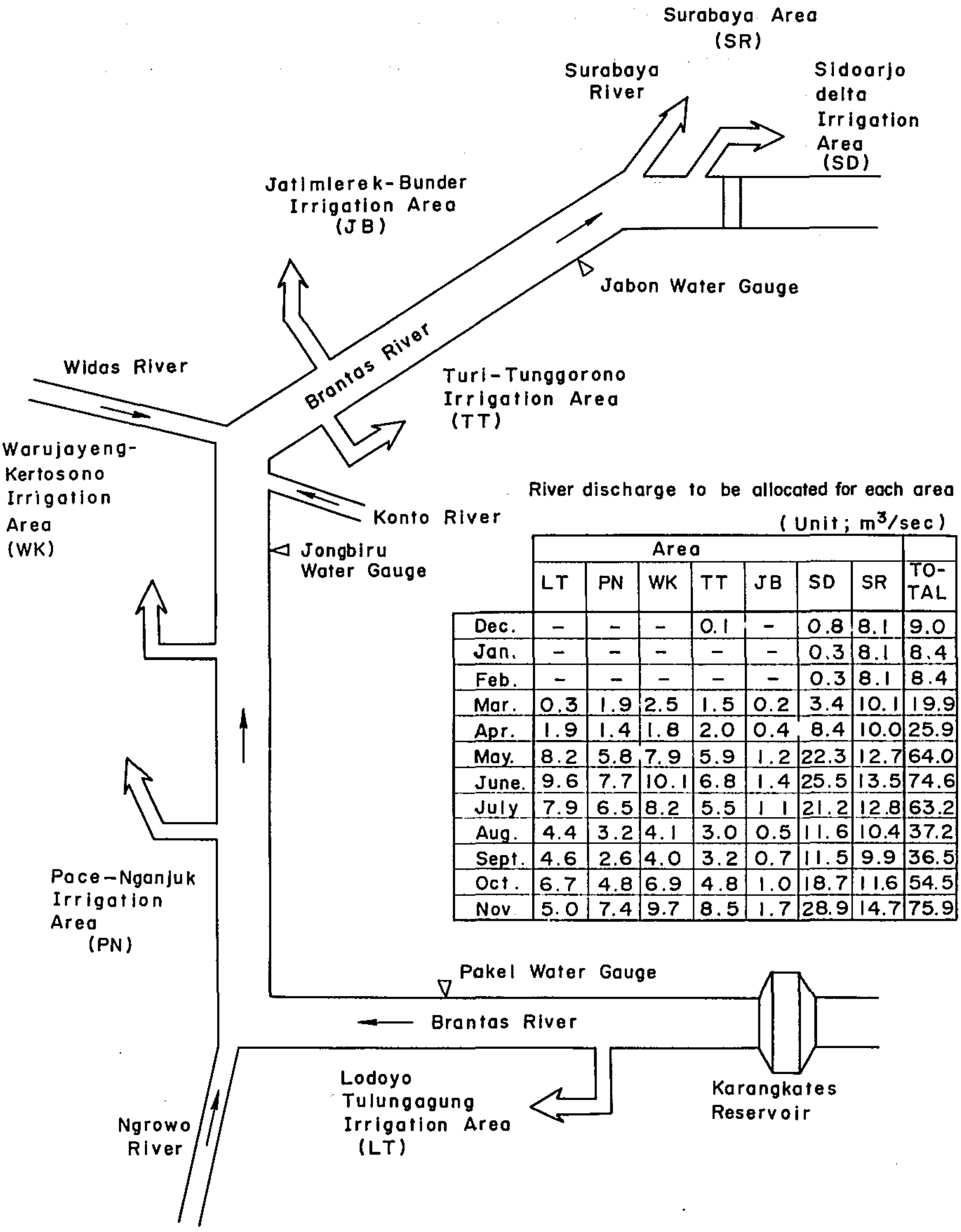
The water balance in case that the water requirement for the Britar-Kediri new irrigation project is excluded is as follows;

(Unit; m^3/sec)

	June	July	Aug.	Sept.	Oct.	Nov.	Total
(1) Potential river discharge	76.7	55.1	53.5	48.3	56.2	52.2	342.0
(2) Total water requirement: (a) ~ (g)	74.6	63.2	37.2	36.5	54.4	75.9	341.8
Area							
a) Warujayeng-Kertosono	10.1	8.2	4.1	4.0	6.9	9.7	43.0
b) Turi-Tunggorono	6.8	5.5	3.0	3.2	4.7	8.5	31.7
c) Jatimlerek-Bunder	1.4	1.1	0.5	0.7	1.0	1.7	6.4
d) Sidoarjo delta	25.5	21.2	11.6	11.5	18.7	28.9	117.4
e) Surabaya	13.5	12.8	10.4	9.9	11.6	14.7	72.9
f) Lodoyo-Tulungagung	9.6	7.9	4.4	4.6	6.7	5.0	38.2
g) Pace-Nganjuk	7.7	6.5	3.2	2.6	4.8	7.4	32.2
(3) Water balance; (1)-(2)	2.1	-8.1	16.3	11.8	1.8	-23.7	0.2

As seen in the above table, the water deficit occurs in July and November. But this water deficit problem can be solved if the operation rule of the Karangkates reservoir is slightly modified. Taking into account the above condition, the river discharge distribution plan is determined as shown in Fig. 4-2.

The Blitar-Kediri new irrigation project is excluded from the river discharge distribution plan. However, the implementation of



River discharge to be allocated for each area

(Unit; m^3/sec)

	Area							TO-TAL
	LT	PN	WK	TT	JB	SD	SR	
Dec.	–	–	–	0.1	–	0.8	8.1	9.0
Jan.	–	–	–	–	–	0.3	8.1	8.4
Feb.	–	–	–	–	–	0.3	8.1	8.4
Mar.	0.3	1.9	2.5	1.5	0.2	3.4	10.1	19.9
Apr.	1.9	1.4	1.8	2.0	0.4	8.4	10.0	25.9
May.	8.2	5.8	7.9	5.9	1.2	22.3	12.7	64.0
June.	9.6	7.7	10.1	6.8	1.4	25.5	13.5	74.6
July	7.9	6.5	8.2	5.5	1 1	21.2	12.8	63.2
Aug.	4.4	3.2	4.1	3.0	0.5	11.6	10.4	37.2
Sept.	4.6	2.6	4.0	3.2	0.7	11.5	9.9	36.5
Oct.	6.7	4.8	6.9	4.8	1.0	18.7	11.6	54.5
Nov	5.0	7.4	9.7	8.5	1.7	28.9	14.7	75.9

Fig. 4-2 River Discharge Distribution Plan

this project may become possible in the future stage when more water of the Brantas River can be made available through the improvement of the canals or the utilization of the groundwater. Then, the Blitar-Kediri new irrigation project is also studied together with other irrigation projects.

For meeting the additional water requirement in Surabaya area after 1982, it would become necessary to take the various measures such as the introduction of more efficient use of the Brantas River water through the improvement of irrigation canals or utilization of groundwater, and utilization of the other surfacewater resources.

(3) Rehabilitation project

The existing major irrigation areas depending on the Brantas middle stream are the Warujayeng-Kertosono, Turi-Tunggorono and Jatimlerek-Bunder areas. The irrigation canals in these areas are suffered from the heavy silting conveyed by the Brantas river flow. Furthermore, the irrigation facilities for these areas such as headworks and gates of turnouts are superannuated. In order to improve such conditions, the following rehabilitation works are required.

1) Warujayeng-Kertosono area (13,300ha)

a) Remodelling of the Mrican headworks including installation of the gates and provision of the stilling basin.

b) Desilting of the irrigation canals.

c) Repair and replacement of small gates of turnouts.

d) Additional construction of tertiary and distributary canal system including farm roads and small drain.

2) Turi-Tunggorono area (9,600 ha)

a) Installation of gates for the Turi and Tunggorono intakes.

b) Desilting of the canals.

c) Repairing or replacement of the gates of turnouts.

d) Additional construction of tertiary and distributary canal system including the small drains.

3) Jatimlerek-Bunder area (1,900 ha)

a) Replacement of the gate on Jatimlerek intake.

b) Desilting and improvement of the cross section of the canals.

c) Additional construction and repair of turnouts and bridges.

d) Construction of tertiary and distributary canal system including the small drain.

(4) New irrigation Project

The newly proposed irrigable areas which are located close to Brantas River comprise the Lodoyo-Tulungagung, Patje-Nganjuk and Blitar-Kediri areas. The outline of the development for these areas is as explained below:

1) Lodoyo-Tulungagung area (13,500 ha)

The construction of the new irrigation canal works in this area was commenced in 1969 and a part of the main canal has already been completed. However, the work is being suspended at present. The intake site is planned to be located at just upstream of the proposed Wlingi damsite. The principal features required for the development of this area are as follows;

a) Intake structure		
b) Main irrigation canal		28 km
c) Secondary irrigation canals		86 km
d) Tertiary and distributary system including the farm road and small drain by the following density per ha.		
	Tertiary canal	10 m
	Distributary ditch	50 m
	Field drain	55 m
	Farm road	60 m
e) Drainage canal		10 km
f) Main farm road		40 km
g) Land levelling		7,400 ha

2) Pace-Nganjuk area (9,600 ha)

The irrigation water for this area can be diverted from the Brantas River by providing the intake at 16 km upstream from Kediri city.

The main irrigation canal will run along the hill skirt and reach to near Nganjuk city.

The main features required for the development of this area are as follows.

a)	Intake structures with stilling basin	
b)	Main irrigation canal	47 km
c)	Secondary irrigation canals	62 km
d)	Tertiary and distributary system with the same density as those of the Lodoyo-Tulungagung area	
e)	Main Farm road	25 km
f)	Land levelling	1,900 ha

3) Blitar-Kediri area (25,200 ha)

The suitable intake site is proposed at 8 km downstream from the proposed Wlingi damsite.

The main canal will run along the skirt of Mt. Kelut, and will be extended to the Konto River in order to supply the water of the Brantas River supplementary to the commanded area of the Konto River when there is abundant water in the Brantas River. The required canals under this plan is the main irrigation canal of 70 km and the secondary irrigation canals of 130 km in length respectively.

(5) Project cost

The project costs required for the rehabilitation and new irrigation works in the envisaged areas are estimated. The cost estimate for the rehabilitation works is based on the work quantity calculated on the basis of the results of the cross section survey of the existing canals carried out in 1972. The cost estimate for the new works is mainly based on the 1 : 50,000 map.

The unit prices used for the cost estimate are mainly those prepared by East Java Irrigation Service.

The estimated construction cost of each projects are summarized as follows.

(Unit; 10^3 $)

Project	Construction cost
Rehabilitation	
Warujayeng-Kertosono	2,300
Turi-Tunggorono	1,350
Jatimlerek-Bunder	426
New work	
Lodoyo-Tulungagung	10,100
Pace-Nganjuk	7,340
Blitar-Kediri	21,050

4-3 Sediment Control Project

Herein presented is a rough orientation of the debris control works on the slopes of Mt. Kelut based on the results of the sedimentation analysis.

The sedimentation analysis shows that the total sediment yield in the affected area is about 100 million m^3 during 15 years after the 1951 eruption. About 32 million m^3 remained on the river bed out of the bed load yield of about 46 million m^3 in the same period. This mean that if an eruption of the same scale as that of the 1951's would occur in future, about 70 % ($32 \times 10^6 m^3 / 46 \times 10^6 m^3$) must be trapped on the mountain slope for preventing aggradation.

The lahar pocket should have a capacity of storing about 70 million m^3 (70 % x 100 x $10^6 m^3$) of the sediment materials against next eruption. Considering some allowance, it may be better to provide 100 million m^3 of pocket capacity for the sake of caution against unexpected eruption.

The distribution of the above pocket capacity is roughly estimated based on the result of the sediment deposit increase in the Kaulon-Jabon river stretch during the 1951 - 1965 period, assuming the sediment deposit in a certain river stretch is caused only by the sediment yield from the mountain slope along the river stretch. The result of this estimate shows that the appropriate distribution of 100 million m^3 in total capacity is 47 million m^3 for the Kaulon-Jongbiru stretch, 30 million m^3 for the Jongbiru-Kertosono stretch and 23 million m^3 for the Kertosono-Jabon stretch. Major tributaries located along the each of the river stretch on the right bank of the Brantas are the Putih, Semut, Jatipelen, Kajar, Gedok and Petungkobong Rivers in the Kaulon-Jongbiru stretch, the Sukorejo, Dermo and Srinding Rivers in the Jongbiru-Kertosono stretch and the Konto River in the Kertosono-Jabon stretch.

The Government envisaged that about 10,000 - 15,000 ha of the area can be made available for lahar pocket on the southern and western slope of Mt. Kelut, though their distributions are unknown. These areas may have a total pocket capacity of 100 - 300 million m^3. In addition, the existing lahar pocket can be increased to some extents by heightening the levees.

This means that it would be possible to construct with a capacity enough to prevent the aggradation of the river which may be caused by 1 to 2 eruptions in the future.

However, the amount of the lahar material flowing down along the tributaries on the southern and western slopes of Mt. Kelut varies widely depending on the topography of the tributary valley and the slope of the crater rim. Thus, the future lahar pocket should be planned after careful investigations on the probable distribution of the lahar material.

4-4 Flood Control Project

The need of flood control has recently been felt in the area along the middle reaches of the Brantas River and the area along the Ngrowo River. The study is made on the possible flood control measure for both areas.

4-4-1 Flood Control in the Area along the Middle Reaches of the Brantas River

(1) Introduction

There are three possible measures for controlling the flood in the area along the middle reaches of the Brantas River. The measures are (1) to increase the flood carrying capacity of the channel by carrying out the river improvement (2) to reduce the flood peak by constructing on upstream reservoir and (3) to divert the Brantas floods into the Indian Ocean.

As to the first measure which is to increase the flood carrying capacity of the channel, it is necessary to consider the retardation problem in the Brantas River. The flood analysis has proved that the flood discharge in the middle reaches of the Brantas is presently reduced by the retardation effect in the Pakel-Kediri stretch and the swamp at the Widas mouth. The increase of the flood discharge capacity in the downstream will solve the above retardation problem. However, this solution is not recommendable due to the reason that the downstream reaches of the Brantas are well developed and the reconstruction of the river structure for increasing the flood carrying capacity will cost much more than the expected benefit accruing from the elimination of the upstream retardation basin.

It is quite natural that the improvement of a river system proceeds from the main stream especially from its downstream reaches to the upstream tributaries depending on the intensity of the human activity. However, there had been many occasions in which more important area in the downstream reaches were compelled to repeat the reconstruction of river structures due to the endless increase of the flood discharge resulting from the progress of the improvement works on the upstream rivers.

Thus a systematic construction of river structure should be based on a well balanced allocations of flood discharge. Then the flood discharge distribution required for the river improvement plan is prepared based on the results of flood analysis.

As to the second measure which is to reduce the flood peak, the effect of the flood control by means of the Wlingi reservoir is studied. The Wlingi reservoir has a dead storage capacity of 21 million m^3. If this dead space is used for the purpose of trapping the sand, the aggradation of the river bed in the downstream stretch may be reduced to a certain extent. The Wlingi reservoir will also contribute to the flood peak reduction in the downstream stretch to some extent. Then the flood control by means of the Wlingi reservoir is studied as a combination of the flood discharge reduction and the sand control.

The third measure which is to divert the Brantas flood into the Indian Ocean had been studied only briefly as an alternative of the river improvement plan because the problem of the sediment in this plan in the diverson canal is still left unsolved.

(2) Flood Discharge Distribution

The basic principles of the flood discharge distribution plan are as follows.

1) The plan is formulated against the 50-year's flood peak in the Brantas River taking into account the regulation by the Karangkates and Selorejo reservoirs.

2) Retardation near the Ngrowo mouth and the Widas mouth is left as it is. Thus, the planned flood peak discharge in the main stream

between the Ngrowo mouth and the Widas mouth is smaller than those in the other stretches.

3) The inflow from the Konto River is 160 m^3/sec.

4) The Gedak and Mlirip gates, through which the flood discharge is being diverted to the Surabaya River at present, are closed to protect the unban area of Surabaya.

The flood discharge distribution based on the above principles are given in Fig. 4-3. The design flood discharge in the main stream is decided to be 1,200 - 900 m^3/sec between the Ngrowo mouth and Kediri, 900 m^3/sec between the Kediri and Konto mouth, 1,100 m^3/sec between the Konto mouth and Widas mouth and 1,500 m^3/sec between the Widas mouth and Terusan.

(3) River Improvement Project

The river improvement project comprises the overall and first stage plans. The overall plan is prepared based on the proposed distribution of the flood discharge in Fig. 4-3. The first stage plan is designed to be safe against 10 years flood, which is prepared for the purpose of saving the initial cost and time for construction for earlier realization of control effect, since a high amount of dredging and embankment in the overall plan will need a long construction period and a substantial amount of cost.

The overall river improvement plan comprises the increase of the discharge capacity of the Brantas River on its stretch between the Ngrowo mouth and the Lengkong dam by dredging and levee heightening and the improvement of the lower stretch of the Konto River.

The design criteria for determining the river cross sections are as follows.

1) The river width is confined to the present width.

2) The bottom elevation of the river channel is determined taking into account the elevations of the existing irrigation intakes, bridges and other structures.

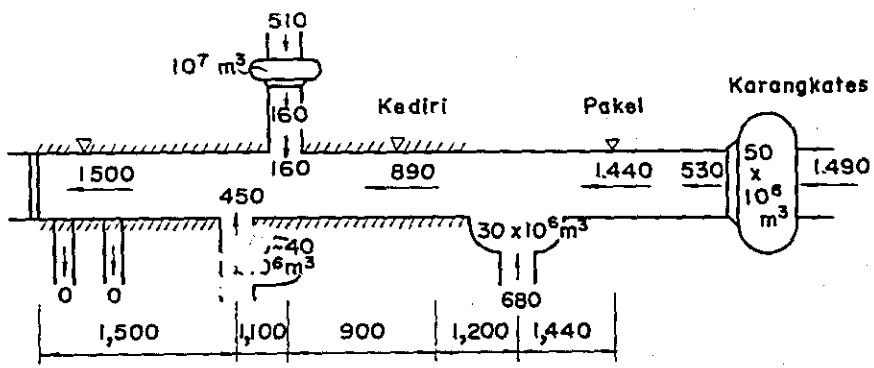


Fig. 4-3 Flood Discharge Distribution for Overall Plan

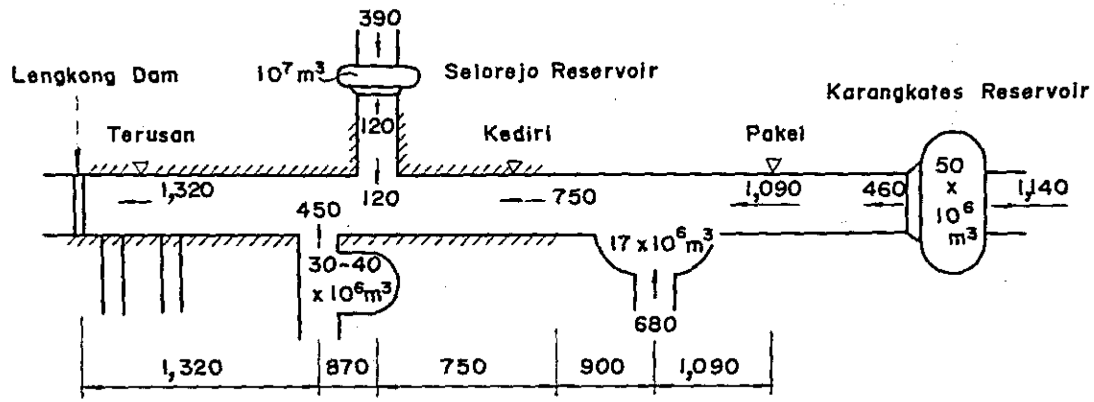


Fig. 4-4 Flood Discharge Distribution for First Stage Construction

3) The free board of the designed levee over the designed water level is 1 m.

4) The bottom width of the low water channel is 70 m upstream from the Widas mouth and 100 m downstream from the Widas mouth respectively.

The overall plan requires the dredging volume of 15 million m^3 and the embankment volume of 7 million m^3. The construction period will be 10 years and the estimated construction cost is about 24 million $ equivalent.

The first stage plan is formulated to be safe against the probable peak flood discharge with 10 years recurrence. The flood discharge distribution is shown in Fig. 4-4. The criteria applied for determining this flood discharge distribution and the proposed improvement of the stretch are almost the same as those for the overall plan. In determining the river cross section, the free board is decided at 80 cm. The bottom width of the low water channel is limited to 40 m upstream of the Widas mouth and 50 m downstream of the Widas mouth respectively.

The first stage plan requires 7 million m^3 of dredging and the similar quantity of embankment. The construction period will be 5 years and the estimated construction cost is about 14 million $ equivalent.

(4) Alternative for Overall Plan

As an alternative plan for the overall river improvement, a flood diversion canal scheme is contemplated to reduce the flood in the downstream reaches by diverting the flood discharge in the upstream reaches of the Brantas River into the Indian Ocean. The plan involves the construction of a gated weir near the Pakel gauge, a 30 km-long diversion canal from the upstream of the weir to Ngrowo site and the diversion tunnel to be constructed close to the present Neyama tunnel. This plan will make possible the drainage of the area along the Pakel and Kediri river stretch, the improvement of the Konto River and the closure of the Gedek and mlirip gates without changing the present cross section of the Brantas River.

The design flood discharge of the diversion canal is estimated to be 1,440 m^3/sec at the inlet and 2,040 - 2,240 m^3/sec at the outlet. The total construction cost will be 40 - 50 million $ equivalent.

The sediment problem in the lower river stretch will be much alleviated by this scheme, but it may cause the same trouble in the new diversion canal itself, especially when an eruption of Mt. Kelut would occur in the future. Since the sediment transportation mechanism in the volcano-affected Brantas River has not yet been clarified fully, the decision on the implementation of this diversion scheme should be left pending until the above sediment transportation mechanism is made clear after further investigation.

(5) Flood Control by Wlingi Reservoir

The effect of the flood peak reduction after the regulation by the Wlingi reservoir is evaluated by the flood routing appling the storage function method. The results of the flood routing calculation show that the flood peak reduction is only 40 m^3/sec at the Kediri gauge even for the flood of 500 years return period. This fact means that the effect of flood control by the Wlingi reservoir to the downstream reaches is negligible small. The calculation of the flood routing for further downstream is not made.

The effect of the sand trapping by the Wlingi reseroier on the aggradation reduction of the Brantas river bed is forecasted for 50 years during the 1977 - 2027 period assuming that the effect of the sand trapping by the Wlingi reservoir reaches to the Kediri site. The result of the forecast of the aggradation reduction of the river bed at the year of 1987, 1997, 2007, 2017 and 2027 is as follows.

Year	Aggradation reduction of the river bed (m)
1987	0.06
1997	0.12
2007	0.18
2017	0.24
2027	0.64

The above result is applied for the estimate of the flood and sand control benefit in the following Chapter.

4-4-2 Flood Control in the Area along the Ngrowo River

(1) Introduction

The Ngrowo River Basin is located in the southwest corner of the Brantas River Basin.

The basin is bounded by the Gamping hill which is a narrow, east-west trending ridge facing the Indian Ocean on the south, a series of mountain such as Mt. Sember, Mt. Bulu and Mt. Gepong on the west and Mt. Wilis on the north. The catchment area of the basin is about 1,500 km^2.

The Ngrowo River cuts the control plain and joins the Brantas River running northeastwords. The Ngasinan River originating from Mt. Gepong on the west runs eastwards collecting many small tributaries and joins the Ngrowo River. The main stem of the Ngrowo River is about 14 km long and further southern stretch forms the Gesikan and Bening swamps.

In the Ngrowo River Basin, the habitual inundation occurs in the area along the Ngrowo River and its tributaries. Tulungagung city is located on the right bank of the Ngrowo River about 7 km upstream of its mouth. The lowlands near this city are ill-drained because the Ngrowo River and its tributaries have been silted up.

In view of the importance of the area near Tulungagung city, the study is made herein on the flood control plan to improve such situation in this area. The plan should be based on a well-balanced flood discharge distribution of the Ngrowo River system. The flood characteristics and probable flood in the Ngrowo River and its tributaries are analyzed to provide the basis for deciding the distribution of flood discharge. A flood discharge distribution of the Ngrowo River is prepared to be safe against the 10-year flood peak. Based on this, the flood control plan to protect the lowland is planned.

(2) Flood Control Structure

In 1939, the Government contemplated a plan of retaining the flood flow from the Ngasinan River by diverting it to the Gesikan swamp though new Ngasinan flood way in order to reduce the flood peak of the Brantas River. The structures constructed under this plan are the Sumbergayam gate on the Ngasinan River, the Ngasinan floodway connected with the gate and the Gesikan swamp, the Ngasinan-Ngrowo canal connected with the gate and the Ngrowo River and the Cluwok gate on the upstream of the Ngrowo River.

However, the diversion of the Ngasinan flood largely silted up the Gesikan swamp. The Cluwok gate has become unmovable due to the sediment and since then this Cluwok gate to connect directly the Gesikan swamp with the Ngrowo River has lost its function.

The 1951 eruption of Mt. Kelut caused a considerable aggradation of the Brantas river bed. Then, the discharge capacity of the Ngrowo River has decreased to such an extent that the lowland near Tulungagung city is often inundated. To cope with this situation, the Government contemplated a diversion plan to drain the floods in the Ngrowo River Basin into the Indian Ocean. The plan involves the construction of the Parit Raya canal connecting the upstream reaches of the Ngasinan River with the Gamping hill, a diversion canal passing through the Gamping hill and Kendal canal connecting the Bening swamp with the Parit Raya canal.

The main purpose of this plan was to lessen the flood discharge by diverting the Ngasinan and Tawing Rivers to the Indian Ocean through the Parit Raya canal and diversion canal. In implementing this plan, the diversion canal was changed to a diversion tunnel because the excavation of an open diversion canal required a long construction period and considerable amount of cost. The Neyama diversion tunnel with a maximum discharge capacity of 500 m^3/sec was completed in 1962.

With the abovementioned structures, the flood discharge in the Ngasinan River is diverted to the Indian Ocean through the Parit Raya canal and Neyama tunnel by operating the Bendo gate as far as the capacity of the Parit Raya canal allows. For larger discharge, a part of flood flow is diverted to the downstream of the Ngasinan River through the Bendo gate and bifurcated into the Ngasinan floodway and Ngasinan-Ngrowo canal by operating the Sumbergayam gate. The flood discharge diverted to the floodway flows into the Gesikan swamp and finally released to the Neyama tunnel through the Bening swamp and Kendal canal.

(3) Flood Characteristics

The 19 hourly water level gauges were newly established along the Ngrowo River and its tributaries in this survey period. The locations of these gauges are shown in Fig. 4-5. The measurement duration period is about two months from December 10th, 1972 to the end of January 1973.

Based on the hourly water level and assumed stage-discharge relatioship, the flood hydrographs are drawn for large flood during two months. The hydrographs thus drawn are compiled in the "Supporting Report". The flood hydrographs in the tributaries of the Ngrowo River generally show sharp rise and recession. Those at the Tawing and Ngasinan gauges which have the drainage area larger than 100 km^2 are rather flat and have long duration time. The flood hydrographs at the gauges located along the Ngrowo River are very flat and have elongated pattern. This is because that the high water stage in Ngrowo River reduces the discharge capacity in the tributaries by flattening the hydraulic gradient in the lower reaches of the tributaries and the flood discharge from the tributaries is once retained in the back swamp and gradually drained.

(4) Probable Flood

The sufficient data are not available for estimating the flood peak discharge-rainfall relationship. Then the probable flood peak discharge from the tributaries is estimated assuming that the flood characteristics of the tributaries in the Ngrowo River are similar to those of the Konto River at the Selorejo damsite. The estimated probable flood peak discharge in the major tributaries is as follows.

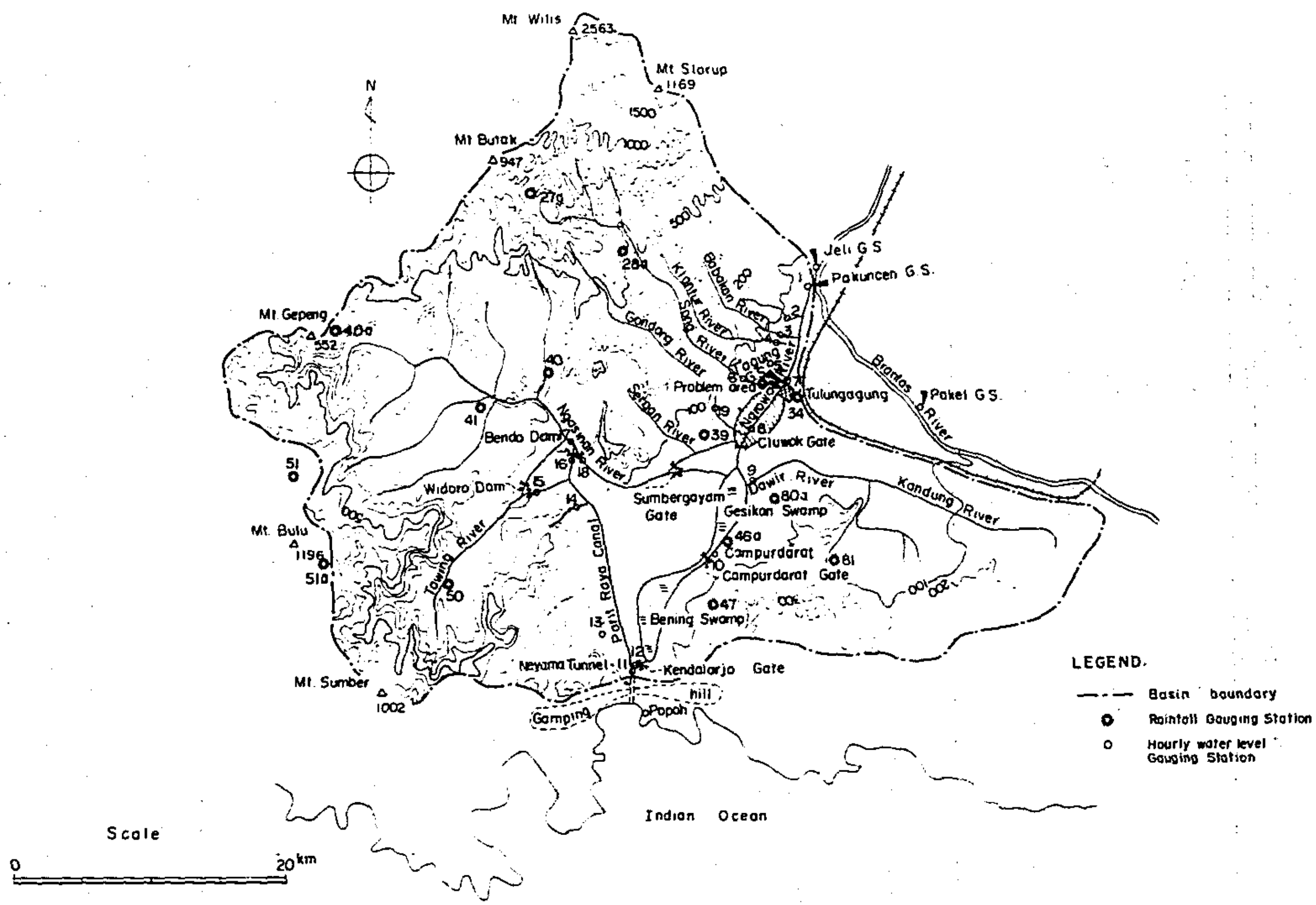


Fig. 4 — 5 Location Map of Rainfall and Water Level Gauges in the Ngrowo River Basin

(Unit; m^3/sec)

Tributary	Drainage area (km^2)	Return period (yr) 2	10	50	100
Babakan	72	143	214	278	306
Klantur	64	135	202	262	288
Song	104	172	257	335	367
Gondang	63	134	200	260	286
Ngasinan	424	348	519	676	742
Tawing	156	211	315	410	450

(5) River Discharge Capacity

The river cross sections are surveyed at intervals of 1 to 2 km for the Ngrowo River, Ngasinan-Ngrowo canal, Ngasinan River up to the Bendo gate and Parit Raya canal. Based on these data, the river discharge capacity in each stretch is calculated assuming a uniform flow.

The results of calculation show that the discharge capacity of the Ngrowo River is generally small in comparison with other river stretch. Especially the capacity upstream of the Ngrowo River is as small as about 50 m^3/sec even at the levee top. The poor discharge capacity of the Ngrowo River is attributed to the aggradation of the river bed due to the sediment transported from the tributaries.

(6) Habitual Inundation Area

The survey on the past inundations in the areas along the Ngrowo River and its tributaries carried out in 1972 has clarified that the habitual inundation occurs in the downstream reaches of the Ngrowo River, lowlands near Tulungagung city on the left bank of the Ngrowo River, upstream reaches of the Ngasinan River and the area on the right bank of the Parit Raya canal.

The inundation in the downstream reaches of the Ngrowo River is caused by the rise of flood water level in the Brantas River. The inundation area ranges from 500 - 1,000 ha depending on the magnitude of the Brantas flood. The dredging of the river bed of the Brantas confluence may solve this inundation problem to a certain extent.

The inundation in the lowland near Tulungagung city is caused by the flood flow from the tributaries such as the Gondong, Song, Klantur and Babakan Rivers. The inundation area is about 400 - 500 ha. The area remaines inundated throughout the wet season.

The inundation in the upstream reaches of the Ngasinan River occurs mainly at the Trenggalek flat plain where the tributareis with steep slope debouch on to the flat plain along the Ngasinan River. The inundation area is about 600 - 750 ha.

The inundation on the right bank of the Parit Raya canal occurs at the month of the Tawing and Keboireng Rivers. The inundation area is about 1,000 ha on an average.

(7) Possible Solution for Inundation Problem in the Lowland near Tulungagung City

In view of the importance of the area near Tulungagung city, which is among the habitual inundation areas, the flood control plan to improve such unfavorable situation in this area is studied.

The conceivable alternative measures to protect the lowland near Tulungagung city from floods area;

1) The lower the flood water level of the Ngrowo River by dredging the river bed.

2) To drain the water retained in the lowland into the Brantas River.

3) To elevate the ground level of the lowland by earth embankment.

4) To prevent the flood water of the tributaries from flowing into the lowland by providing a cut-off canal on the hill slope.

The first alternative is not appropriate due to the following reasons; The discharge capacity of the downstream stretch of the Ngrowo River is largely reduced by the Brantas flood. The lowering of the bed in the Ngrowo River will flatten the hydraulic gradient of the Ngrowo River because the bed elevation of the Brantas near the Ngrowo mouth does not much lower even after the overall river improvement of the Brantas is realized. Thus, much increase in flood discharge capacity of the Ngrowo River, is not expected by lowering the flood water level. The water level of the Ngrowo can be substantially lowered only by the enlargement of the river width. However, the enlargement will not be economically justified because the area along the Ngrowo River is densely populated.

The second and third alternatives are also not practical due to extremely high construction cost. The fourth alternative seems to be the best from the technical as well as the economical viewpoints among the above conceivable alternatives.

The fourth alternative, therefore, has been adopted in this study.

(8) Flood Discharge Distribution

The flood discharge distribution plan is prepared assuming one-day rainfall with a return period of 10 years in the Ngrowo River Basin. The basic principles of the proposed flood discharge distribution plan are as follows.

1) The Bendo gate and Sembergayam gate on the Ngasinan River are completely closed.

2) The water retained in the swamps is not released during the flood peak time.

3) The retardations along the Tawing, Karangtuwo, Keboirang and Gondang Rivers are left as they are.

4) The flood flows from the Song, Klantur and Babakan Rivers are diverted to the Brantas River by a new cut-off canal provided along the hill area.

The flood discharge distribution based on the above principles is shown in Fig. 4-6. Then the design flood peak discharge is decided to be 350 - 500 m^3/sec in the Parit Raya canal, 0 - 80 m^3/sec in the Ngasinan River between the Bendo gate and Sembergayam gate, 80 m^3/sec in the Ngasinan floodway, 50 m^3/sec in the Ngrowo River and 240 - 630 m^3/sec in the new cut-off canal.

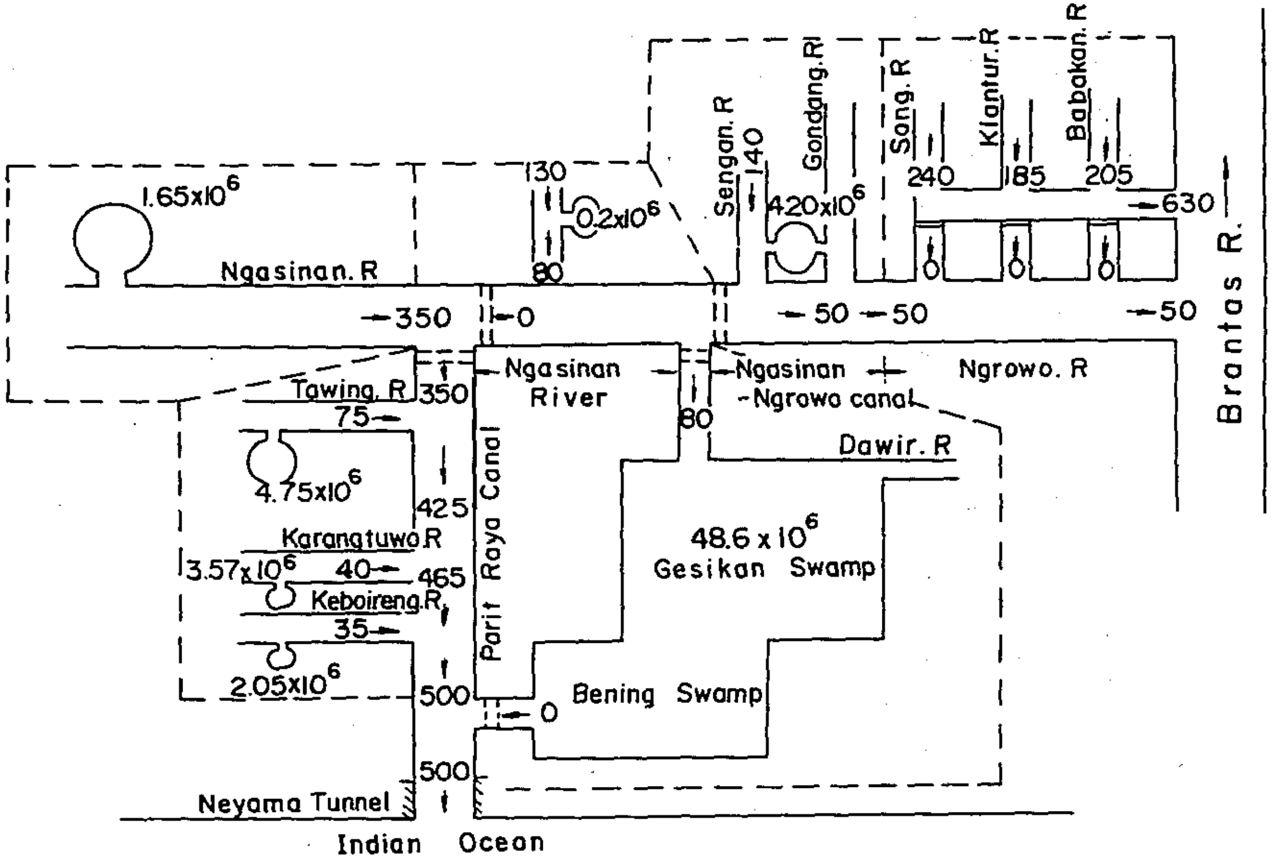


Fig. 4-6 Flood Discharge Distribution Diagram in the Ngrowo River Basin

It is presumed that the increase in the flood peak discharge of the Brantas River at the Kediri gauge due to the cut-off canal construction is 30 m^3/sec.

(9) Cut-off Canal Scheme

The cut-off canal scheme is prepared based on the flood discharge distribution in Fig. 4-6. The scheme involves the construction of about 10 km-long cut-off canal connecting the Song River with the Brantas River at about 1,500 m downstream of the Ngrowo confluence, construction of the barrages on each tributary to divert the flood flow into the cut-off canal and the provision of the gate on the barrage to supply irrigation water to the downstream reaches in the dry season.

The proposed plan of the cut-off canal is shown in Fig. 4-7. The alignment of the canal is determined based on 1:10,000 map.

The construction of the cut-off canal requires about 1.8 million of earth excavation and about 100,000 m^3 of levee embankment. The construction period will be 4 years and the estimated construction cost is about 2 million $ equivalent.

4-5 Hydro Power Project

Herein presented are the re-study on the Wlingi power generation and the preliminary study on the possibility of the future hydro power development in the Brantas River Basin.

4-5-1 Re-study on Wlingi Power Generation

Based on the result of the river flow analysis and on the design criteria applied in determining the river discharge distribution for the irrigation projects, the energy output and the dependable peak output of the Wlingi power plant are checked.

For checking the energy output, the monthly discharge available for the Wlingi power generation is estimated by deducting the irrigation water for the Lodoyo-Tulungagung area from the river discharge at the Wlingi damsite. Based on this estimated discharge, the energy output is calculated

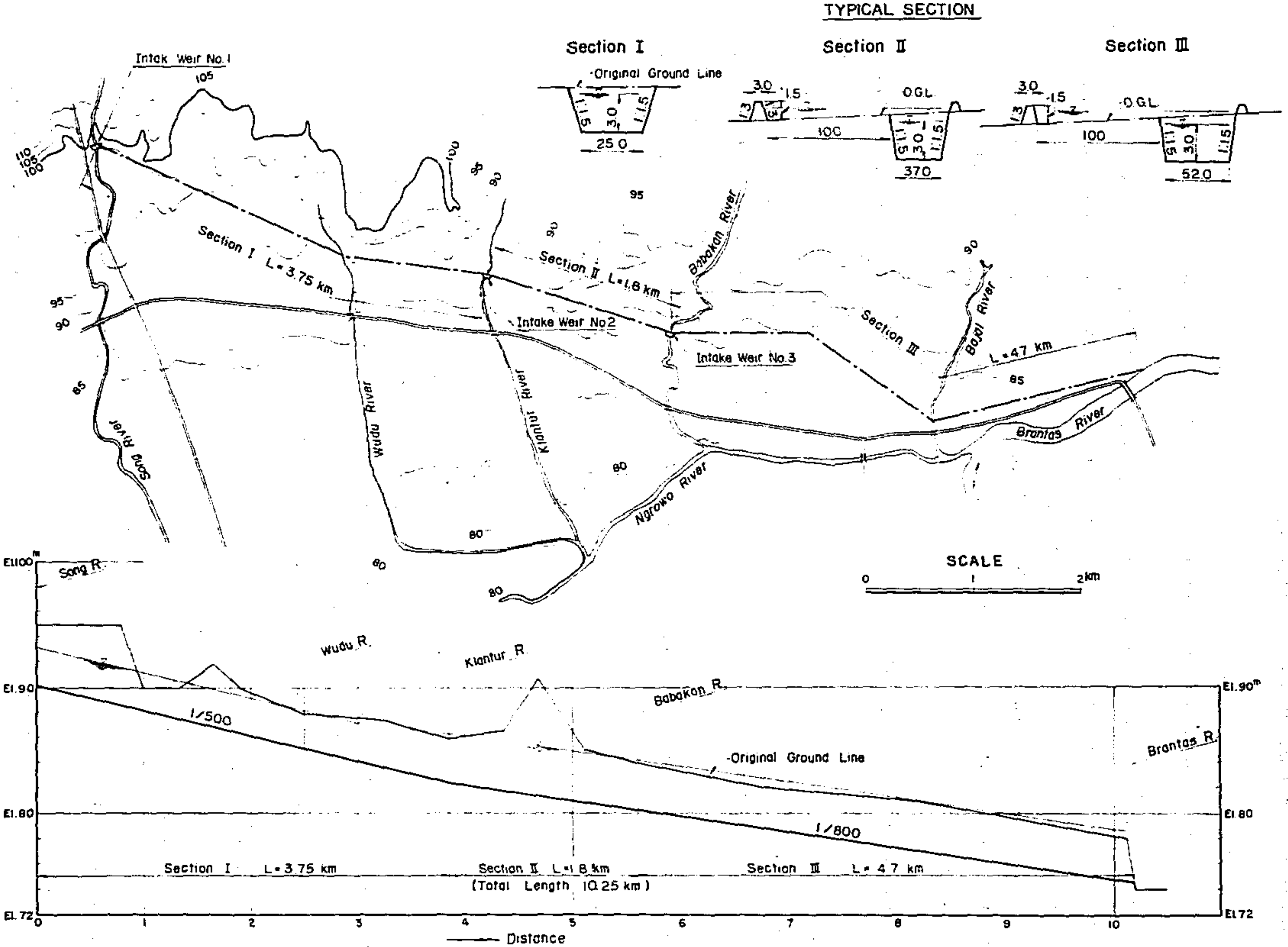


Fig. 4—7 General Plan of Cut-off Canal

under the condition with installed capacity of 27,000 kW. The result of the calculation is summarized as follows.

Mean power output	20,200 kW
Mean annual energy output	177,100,000 kWh

Based on the monthly mean output in each month of a normal year of 1956, the dependable peak output of the Wlingi power plant is checked from two aspects, i.e, if the plant can keep the peaking operation for sufficiently long hours in a day in view of the available discharge, and if the peaking operation does not have any adverse effects on the downstream reaches carsed by the excessive fluctuation of the river water level.

The result of this checking has proved that the possible duration time for generating the peak power output of 27,000 kW is very long in comparison with the actual peak time in the Kalikonto power system, and the fluctuation of the river water level when the discharge of the plant is changed from the peak discharge to the off-peak discharge is so small that the peak operation does not seem to cause any unfavorable effect on the water utilization in the downstream river stretch. Taking into account the above facts, it is judged that the peak operation at the Wlingi power plant to that extent is not objectionable and the dependable peak output of 27,000 kW is reasonable.

4-5-2 Possibility of Hydro Power Development in Whole Brantas River Basin

The hydro power potential, which is technically possible to develop, is studied along the Brantas main stream and five major tributaries of the Amprong, Lesti, Metro, Ngrowo and Widas Rivers. The study is made roughly based on the 1:50,000 map and no actual survey and field reconnaissance are conducted because of the limited survey period.

The envisaged possible damsites are 33 comprising 8 along the Brantas main stream, 7 along the Amprong River, 6 along the Lesti River, 1 along the Metro River, 4 along the Ngrowo River and 7 along the Widas River. The location of each project site together with the scale of power capacity is shown in Fig. II-4-1 in "Supporting Report".

The estimated hydro power potential is about 380 MW in power capacity and 1.3×10^6 MWh in annual energy output.

5. PROJECT APPRAISAL

This chapter deals with the economic evaluation of the irrigation, flood control and power projects studied by means of the internal rate of return, and the determination of the sequence of priority for implementation of the project. The internal rate of return of each project is calculated under the conditions that the project life is 50 years and the base year of the project evaluation is fixed at the final year of the completion of the project.

5-1 Economic Evaluation of the Irrigation Projects

5-1-1 Project Cost

The construction cost of each irrigation project has been estimated as follows.

(Unit; 10^3 $)

Project	
Warujayeng -Kertosono rehabilitation	2,300
Turi - Tunggorono "	1,350
Jatimlerek - Bunder "	426
Lodoyo - Tulungagung	10,100
Pace - Nganjuk	7,340
Blitar - Kediri	21,050

The annual disbursement of the construction cost for each project is assumed to be made in accordance with the construction schedule as shown in Fig. 5-1. The proposed disbursement schedule is as follows.

(Unit; 10^3 $)

Construction year	Warujayeng -Kertosono	Turi - Tunggorono	Jatimlerek - Bunder	Lodoyo - Tulungagung	Pace- Nganjuk	Blitar -Kediri
1st	1,380	810	256	2,165	1,920	2,875
2nd	920	540	170	2,450	1,830	3,620
3rd				2,900	2,265	5,105
4th				2,585	1,325	4,725
5th						4,725
Total	2,300	1,350	426	10,100	7,340	21,050

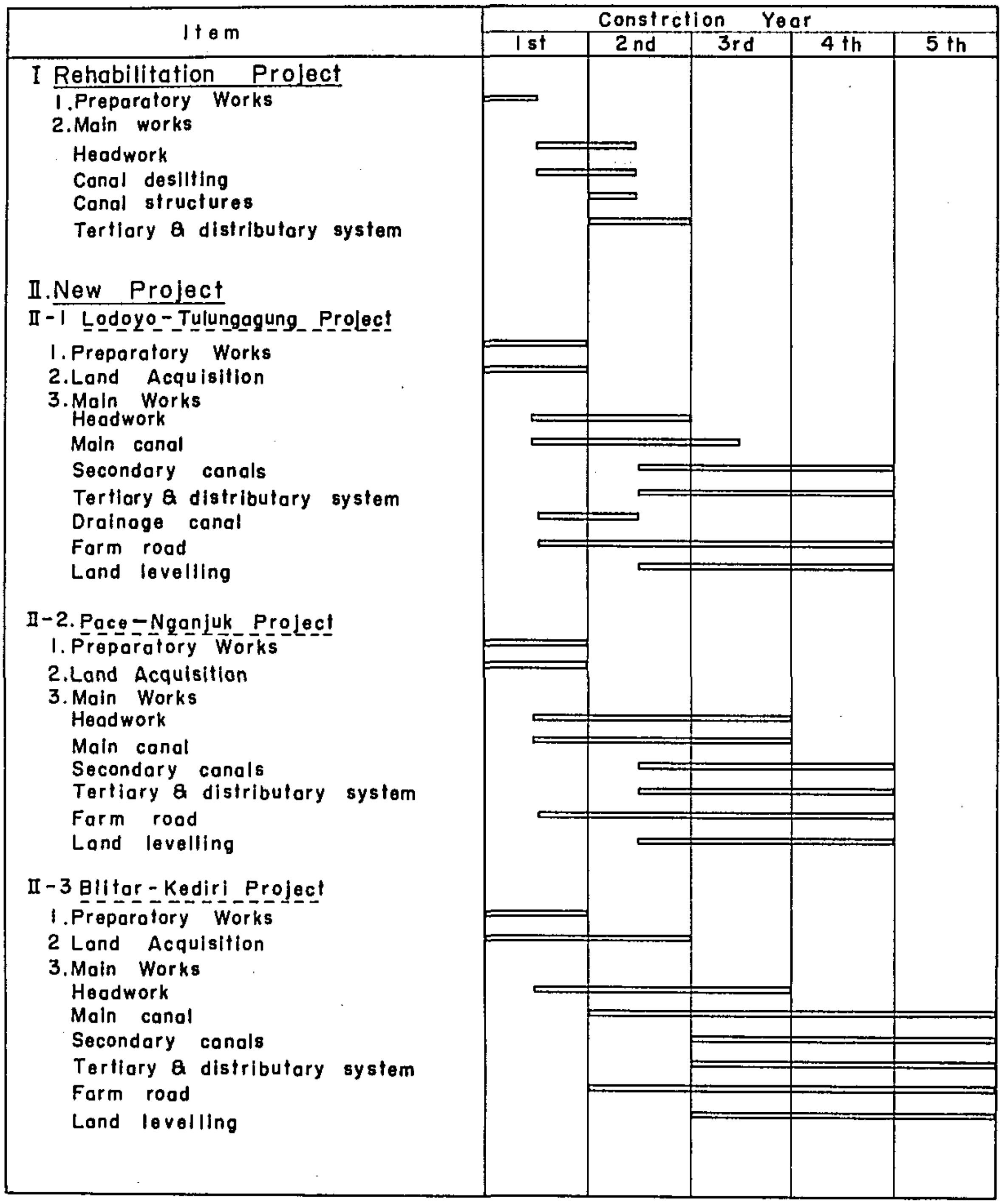


Fig. 5-1 Construction Time Schedule of Irrigation Project

The capitalized construction cost of each project at the final year of the construction under the condition with four different discount rates is calculated as shown in Table 5-1 based on the above annual allotment schedule.

The annual operation and maintenance cost of the irrigation system of each project is estimated as follows.

(Unit; 10^3 $)

Project	Operation and maintenance cost
Warujayeng - Kertosono	146
Turi - Tunggorono	106
Jatimlerek - Bunder	21
Lodoyo - Tulungagung	149
Pace - Nganjuk	120
Blitar - Kediri	340

These operation and maintenance costs during the project life of 50 years are capitalized to base year under the conditions with four different discount rates. The results are as shown in Table 5-2. Then the total capitalized cost for each project is summarized as shown in Table 5-3.

5-1-2 Project Benefit

The increase in net farm income resulting from the realization of the project is regarded as the irrigation benefit. The increase in net farm income is derived from the difference in the total net income in the project area with and without project.

The annual irrigation benefit is estimated assuming the full benefit is attained through the gradual increase during the build-up period of 5 years.

The full irrigation benefit in a year of each irrigation project after the build-up period have been estimated as follows.

Table 5-1 Capitalized Construction Cost

(Unit; $10^{3}\ \$$)

Irrigation Project	Discount Rate (%) 24.0	26.0	28.0	30.0	32.0	34.0
Warujayeng-Kertosono rehabilitation		3,525	3,618	3,712	3,808	
Turi-Tunggorono "			2,138	2,194	2,250	2,307
Jatimlerek-Bunder "	604	621	637	654		

(Unit; $10^{3}\ \$$)

Irrigation Project	Discount Rate (%) 6	8	10	12	14	16	18
Lodoyo-Tulungagung				13,382	14,002	14,645	15,311
Pace-Nganjuk			9,445	9,917	10,408	10,918	
Blitar-Kediri	24,815	26,194	27,640	29,154			

Table 5-2 Capitalized Operation and Maintenance Cost in Each Irrigation Project

(Unit; $10^{3}\ \$$)

Irrigation Project	Discount Rate (%) 24.0	26.0	28.0	30.0	32.0	34.0
Warujayeong-Kertosono rehabilitation		1,027	933	964	940	
Turi-Tunggorono "			707	687	670	655
Jatimlerek-Bunder "	150	144	139	135		

(Unit; $10^{3}\ \$$)

Irrigation Project	Discount Rate (%) 6	8	10	12	14	16	18
Lodoyo-Tulungagung				1,646	1,478	1,352	1,255
Pace-Nganjuk			1,513	1,326	1,191	1,089	
Blitar-Kediri	6,525	5,344	4,574	4,045			

Table 5-3 Capitalized Project Cost in Each Irrigation Project

(Unit; 10^3 $)

Irrigation Project		Discount Rate (%) 24.0	26.0	28.0	30.0	32.0	34.0
Warujayeng-Kertosono rehabilitation	Const. Cost		3,525	3,618	3,712	3,808	
	O.M. Cost		1,027	993	964	940	
	Total		4,552	4,611	4,676	4,748	
Turi-Tunggorono rehabilitation	Const. Cost			2,138	2,194	2,250	2,307
	O.M. Cost			707	687	670	655
	Total			2,845	2,881	2,920	2,962
Jatimlerek-Bunder rehabilitation	Cosnt. Cost	604	621	637	654		
	O.M. Cost	150	144	139	135		
	Total	654	765	776	789		

Irrigation Project		Discount Rate (%) 6.0	8.0	10.0	12.0	14.0	16.0	18.0
Lodoyo-Tulungagung	Const. Cost				13,382	14,002	14,645	15,311
	O.M. Cost				1,646	1,478	1,352	1,255
	Total				15,028	15,480	15,997	16,566
Pace-Nganjuk	Const. Cost			9,445	9,917	10,408	10,918	
	O.M. Cost			1,513	1,326	1,191	1,089	
	Total			10,958	11,243	11,599	12,007	
Blitar-Kediri	Const. Cost	24,815	26,194	27,640	29,154			
	O.M. Cost	6,525	5,344	4,574	4,045			
	Total	31,340	31,538	32,214	33,199			

(Unit; 10^3 $)

Project		Annual irrigation benefit
Warujayeong - Kertosono rehabilitation		1,977
Turi - Tunggorono	"	1,346
Jatimlerek - Bunder	"	287
Lodoyo - Tulungagung		2,903
Pace - Nganjuk		1,635
Blitar - Kediri		3,357

These benefits of each irrigation project during the project life of 50 years are capitalized to the basy year under the conditions with four different discount rates. The results are as shown in Table 5-4.

5-1-3 Economic Evaluation

Based on the capitalized costs as given in Table 5-3 and the capitalized benefits as given in Table 5-4, the internal rate of return of each project is calculated as follows.

Project		Internal rate of return (%)
Warujayeong - Kertosono rehabilitation		29.7
Turi - Tunggorono	"	31.3
Jatimlerek - Bunder	"	26.8
Lodoyo - Tulungagung		15.7
Pace - Nganjuk		12.3
Blitar - Kediri		9.0

In addition to the irrigation development of the area along the Brantas main stream, it is roughly studied to develop the tributary areas by constructing a reservoir and canals. The envisaged areas comprise three arable lands, namely, about 4,000 ha in the Widas River Basin, about 4,000 ha along the Beng River, and about 4,000 ha along the Ngasinan River (refer to Figs. II-1-11 to II-1-13 in Supporting Report). The rough economic evaluation made for these irrigation developments shows that the internal rates of return is 15 % for the Beng project along the Beng River, 12 % for the Widas prcject in the Widas River Basin and 5 % for the Ngasinan project.

5-2 Economic Evaluation of the Flood Control Projects

5-2-1 Economic Evaluation of the River Improvement Project in the Middle Reaches of the Brantas River

Table 5-4 Capitalized Project Benefit in Each Irrigation Project

(Unit; 10^3 $)

Irrigation Project	Discount Rate (%)					
	24.0	26.0	28.0	30.0	32.0	34.0
Warujayeng-Kertosono rehabilitation		5,519	5,032	4,615	4,255	
Tri-Tunggorono "			3,357	3,075	2,831	2,618
Jatimlerek-Bunder "	886	802	732	671		

Irrigation Project	Discount Rate (%)						
	6.0	8.0	10.0	12.0	14.0	16.0	18.0
Lodoyo-Tulungagung				21,530	18,211	15,716	13,781
Pace-Nganjuk			14,289	11,720	9,863	8,471	
Blitar-Kediri	47,701	36,038	28,424	23,178			

Table 5-5 Construction Cost of River Improvement Project in the Middle Reaches of the Brantas River (First Stage Plan)

Item	Unit Price	Quantity	Amount ($)
1. Preparatory works		L.S.	100,000
2. Dredging			
Main stream	0.5 $/m^3	7,000,000 m^3	3,500,000
Konto River	0.5 "	300,000	150,000
3. Embankment	0.8 $/m^3	6,500,000 m^3	5,200,000
4. Revetment	10 $/m^2	180,000 m^2	1,800,000
5. Compensation	3,000 $/ha	200 ha	600,000
6. Construction machines (Depreciation only)			1,200,000
Sub-total			12,470,000
7. Engineering service (5% of sub-total)			620,000
8. Contingency and reserve (10% of sub-total)			1,250,000
Grand-total			14,340,000

Table 5-6 Construction Cost of River Improvement Project in the Middle Reaches of the Brantas River (Overall Plan)

Item	Unit Price	Quantity	Amount ($)
1. Preparatory works		L.S.	100,000
2. Dredging			
Main stream	0.5 $/m^3	14,600,000 m^3	7,300,000
Konto River	0.5 "	300,000 m^3	150,000
3. Embankment	0.8 $/m^3	7,200,000 m^3	5,760,000
4. Revetment	10 $/m^2	450,000 m^2	4,500,000
5. Compensation	3,000 $/ha	260 ha	780,000
6. Construction machines (Depreciation only)			1,850,000
Sub-total			20,440,000
7. Engineering service (5% of sub-total)			1,020,000
8. Contingency and reserve (10% of sub-total)			2,040,000
Grand-total			23,500,000

(1) Project Cost

The construction cost of the river improvement project is estimated to be about 14 million $ equivalent for the first stage plan and 24 million $ equivalent for the Overall plan as shown in Tables 5-5 and 5-6 respectively.

The annual disbursement of the construction cost for both plans is assumed to be made in accordance with the construction schedule as shown in Fig. 5-2. The proposed disbursement schedule is as follows.

(Unit; 10^3 $)

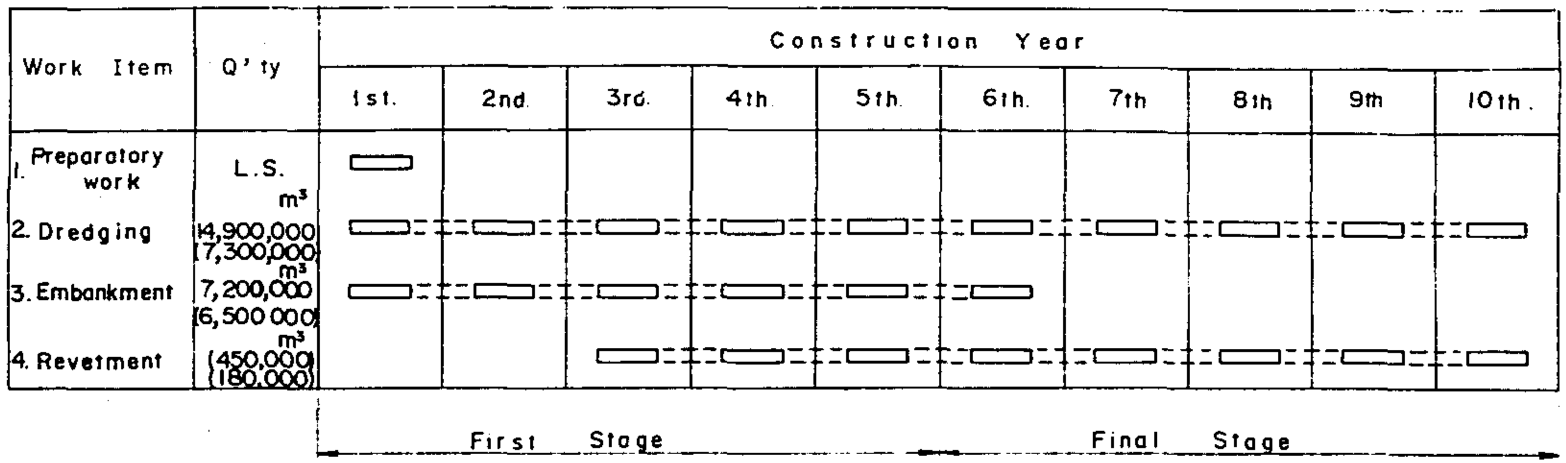
Construction year	First stage plan	Overall plan
1st	2,546	2,546
2nd	2,431	2,431
3rd	3,121	3,121
4th	3,121	3,121
5th	3,121	3,121
6th		2,411
7th		1,766
8th		1,661
9th		1,661
10th		1,661
Total	14,340	23,500

The capitalized construction cost at the final year of the construction under the conditions with the discount rates of 6, 8, 10, 12% respectively is calculated based on the annual disbursement schedule. The capitalized construction cost under the conditions with four different discount rates is as follows.

(Unit; 10^3 $)

Plan	Discount rate (%) 6	8	10	12
First stage	17,008	17,988	19,024	20,107
Overall	33,825	38,204	43,157	48,744

The annual maintenance cost for the river channel is estimated at 143,000 $ equivalent for the first stage plan and 235,000 $ equivalent for



Remarks : The figure in branket shows the work quantity for first stage plan.

Fig. 5-2 Construction Time Schedule of River Improvement Project

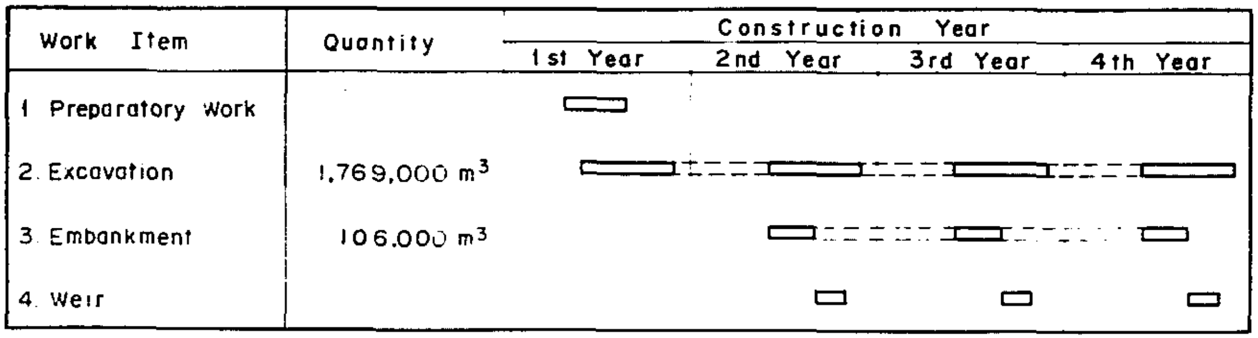


Fig. 5-3 Construction Time Schedule of Cut-off Canal

the overall plan respectively assuming that the annual maintenance cost is 1% of the total construction cost. These maintenance costs during the project life of 50 years are capitalized to the base year under the condition with the discount rates of 6, 8, 10 and 12%.

The capitalized maintenance cost under each conditions is as follows.

(Unit; 10^3 $)

Plan	Discount rate (%) 6	8	10	12
First stage	2,254	1,749	1,418	1,188
Overall	3,704	2,875	2,330	1,952

Then, combining the capitalized construction and maintenance costs, the total capitalized project costs for the river improvement project are summarized as follows.

(Unit; 10^3 $)

	Discount rate (%) 6	8	10	12
First stage plan				
Capitalized construction cost	17,008	17,988	19,024	20,107
Capitalized maintenance cost	2,254	1,749	1,418	1,188
Total capitalized cost	19,262	19,737	20,442	21,295
Overall plan				
Capitalized construction cost	23,825	38,204	43,157	48,744
Capitalized maintenance cost	3,704	2,875	2,330	1,952
Total capitalized cost	37,529	41,079	45,487	50,696

(2) Project Benefit

The benefit of the river improvement project is regarded to be equivalent to the balance of the flood damages under the conditions with and without project.

The river cross section in the stretch downstream of the Ngrowo confluence is designed so as to discharge the flood with 10 years return period safely for the first stage plan and the flood with 50 years return period for the overall plan. In case where the floods larger than the design flood occure, the levee will be destroyed by the floods overtopping the levee. It is assumed that the destruction of the levee causes the inundation of the protected areas to the same extent as that caused under the condition without levee. The flood damages in both cases are assumed to be same. Then, the total probable flood damages which may be caused by all the floods smaller than the design flood under the condition without levee is regarded as flood control benefit of the project.

The estimated annual flood control benefit is about 1,683,000 $ equivalent for the first stage plan and 3,811,000 $ equivalent for the overall plan. These annual flood control benefits during the project life of 50 years are capitalized to the base year under the conditions with the discount rates of 6, 8, 10 and 12%. In this case, the flood control benefit of the overall plan is derived by adding the benefit of first stage plan during the period of 5 years from the time of completion of the first stage through the time of completion of the second stage plan to the benefit of the second stage plan. The capitalized flood control benefit in each case is summarized as follows.

(Unit; 10^3 $)

Plan	Discount rate (%)			
	6	8	10	12
First stage	26,526	20,587	16,686	13,977
Overall	69,562	56,499	48,064	42,346

(3) Economic Evaluation

Based on the capitalized cost and capitalized benefit, the internal rate of return of the project is calculated to be 8.2% for the first stage plan and 10.4% for the overall plan.

5-2-2 Economic Evaluation of Cut-off Canal Project in the Area along the Ngrowo River

(1) Project Cost

The construction cost of the cut-off canal project is estimated at about 2 million $ equivalent as shown in Table 5-7.

Table 5-7 Construction Cost of Cut-off Canal

	Item	Unit price	Quantity	Amount ($)
1.	Preparatory work			20,000
2.	Excavation	0.7 $\$/m^3$	1,769,000 m^3	1,238,000
3.	Embankment	0.8 $\$/m^3$	106,000 m^3	85,000
4.	Intake weir		21,400 $/nos. x 3 nos.	64,000
5.	Compensation	1,500 $/ha	132.6 ha	199,000
6.	Construction machines (Depreciation only)			128,000
	Sub-total			1,734,000
7.	Engineering service (5% of Sub-total)			87,000
8.	Contingency & Reserve (10% of Sub-total)			173,000
	Grand-total			1,994,000

The annual disbursement of the construction cost is assumed to be made in accordance with the construction schedule shown in Fig. 5-3. The proposed disbursement schedule is as follows.

(Unit; 10^3 $)

Construction year	Annual disbursement
1st	489
2nd	525
3rd	503
4th	477
Total	1,994

The capitalized construction cost at the final year of the construction under the condition with the discount rates of 4, 6, 8 and 10% is calculated based on the annual disbursement schedule. The capitalized construction cost under the conditions with four different discount rates is as follows.

(Unit; 10^3 $)

	Discount rate (%)			
	4	6	8	10
Capitalized construction cost	2,203	2,313	2,428	2,549

The annual maintenance cost for the cut-off canal is estimated at 20,000 $ equivalent assuming that the annual maintenance cost is 1% of the total construction cost. The annual maintenance cost during the project life of 50 years is capitalized to the base year under the condition with discount rates of 4, 6, 8 and 10%. The capitalized maintenance cost under each condition is as follows.

(Unit; 10^3 $)

	Discount rate (%)			
	4	6	8	10
Capitalized maintenance cost	430	315	245	198

Then, combining the capitalized construction and maintenance costs, the total capitalized cost for the cut-off canal project is summarized as follows.

(Unit; 10^3 $)

	Discount rate (%)			
	4	6	8	10
Capitalized construction cost	2,203	2,313	2,428	2,549
Capitalized maintenance cost	430	315	245	198
Total capitalized cost	2,633	2,628	2,673	2,747

(2) Project Benefit

The lowland near Tulungagung city on the left bank of the Ngrowo River, which may be protected from floods by constructing the cut-off canal, is confined within the area of about 7 km-long range in the downstream reaches of the both banks of the Song and Klantur Rivers. This area is herein called the "protected area". Further downstream reaches of the Ngrowo River is excluded from the area to be protected by this project because it may be largely affected by the Brantas flood.

The benefit accruing from the cut-off project is regarded to be equivalent to the balance of the flood damages in the protected area under the conditions with and without project. The flood damages with and without project condition are estimated as follows.

The estimated annual flood damage without project condition is 180,700 $ equivalent, while, the annual flood damage with project is estimated at 33,700 $ equivalent. The balance of the annual flood damages under the conditions with and without project is regarded as the annual flood control benefit of the cut-off canal, which is estimated at 147,000 $ equivalent.

The annual flood control benefit in each year during the project life of 50 years is capitalized to the base year under the conditions with discount rates of 4, 6, 8 and 10%. The capitalized benefit under each condition is as follows.

(Unit; 10^3 $)

	Discount rate (%)			
	4	6	8	10
Capitalized benefit	3,158	2,317	1,798	1,458

(3) Economic Evaluation

Based on the capitalized cost and capitalized benefit, the internal rate of return of the project is calculated to be 5.1%.

5-3 Economic Evaluation of Wlingi Multipurpose Project

5-3-1 Project Cost

The construction cost of the Wlingi multipurpose project has been estimated at about 17 million $ equivalent as shown in Table 5-8.

It is strongly requested by the Indonesian Government that the Wling multipurpose project is implemented during the period from 1974/1975 to 1977/1978. Then, the annual disbursement of the Wlingi project is assume to be made in accordance with the construction schedule covering a period of 4 years as shown in Fig. 5-4. The proposed disbursement schedule is a follows.

(Unit; $10^3$$)

Construction year	Annual disbursement
1st	1,764
2nd	3,965
3rd	6,717
4th	4,146
Total	16,592

The capitalized construction cost at the final year of the construction under the conditions with the discount rates of 8, 10, 12 and 14% is calculated on the basis of the annual disbursement schedule. The capitalized cost under each condition is as follows.

(Unit; 10^3 $)

	Discount rate (%)			
	8	10	12	14
Capitalized cost	19,705	20,548	21,415	22,313

Table 5-8 Construction Cost of the Wlingi Project

(Unit: 10^3 $)

I. Preparatory Works	1,720
1. Residential buildings, offices, access road, etc.	720
2. Land and Right	1,000
II. Main Construction Works	9,541
1. Dam, incl. diversion channel and coffer dam	2,470
2. Spillway, incl. sand flush	1,461
3. Power intake and penstock	677
4. Power House	530
5. Tailrace	548
6. Outdoor switchyard	35
7. Power generating equipment (27 MW x 1 unit)	2,900
8. Transmission line (154 kV, 25 km between Wlingi and K'Kates)	700
9. Irrigation Intake and Canal	220
III. Construction Machines and Plants	1,440
Sub Total	12,701
IV. Engineering service and Govt. Administration Expenses	1,732
V. Contingency (17 % of the total of items I, II and III)	2,159
Grand Total	16,592

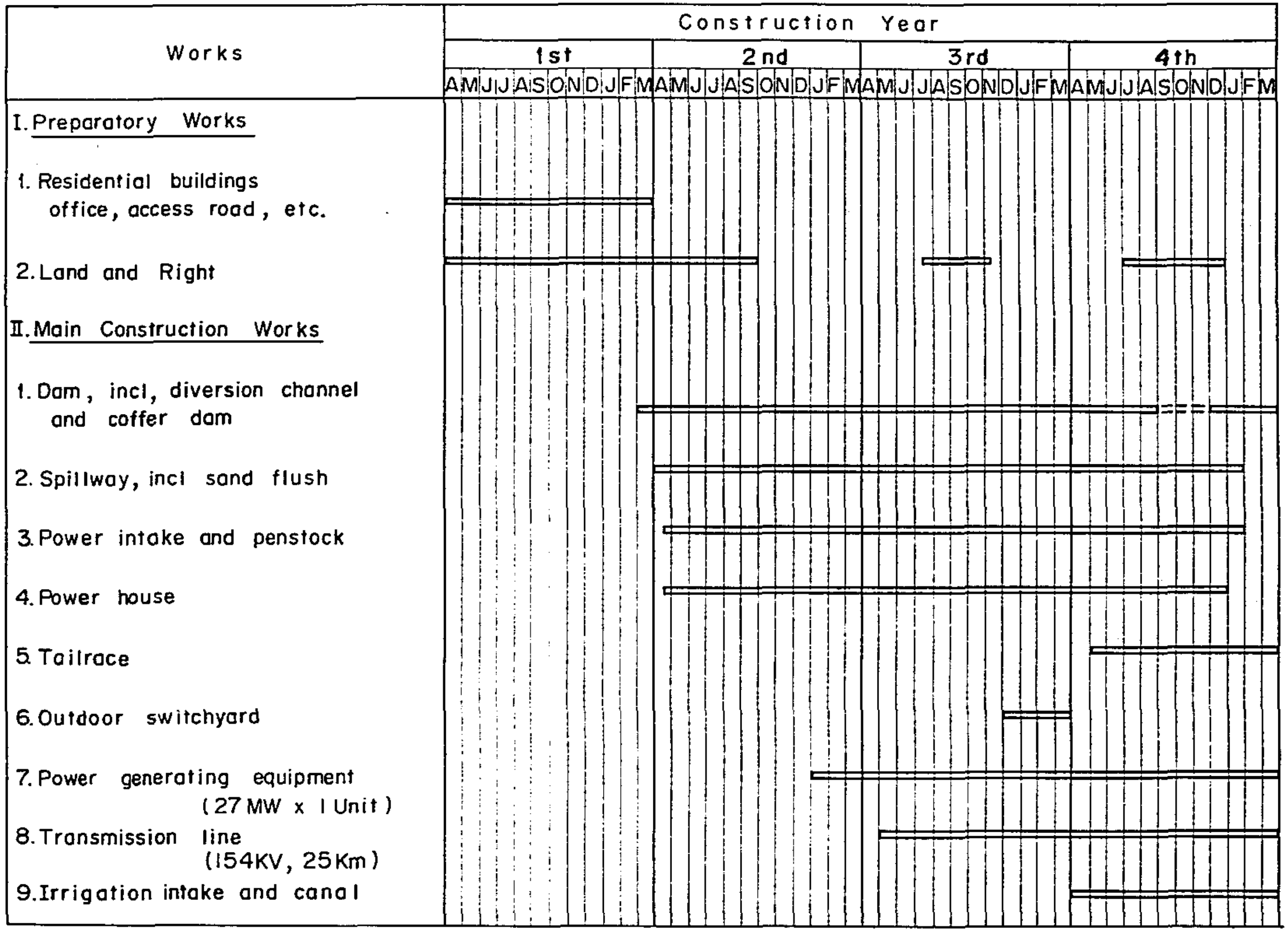


Fig. 5-4 Construction Time Schedule of the Wlingi Project

The annual operation and maintenance cost for the Wlingi dam and power station has been estimated at 84,200 $ equivalent. The operation and maintenance cost during the project life of 50 years is capitalized to the base year under the conditions with discount rates of 8, 10, 12 and 14%. The capitalized operation and maintenance cost under each condition is as follows.

(Unit; 10^3 $)

	Discount rate (%)			
	8	10	12	14
Capitalized operation and maintenance cost	1,028	833	698	599

Then, combining the capitalized construction cost and operation and maintenance cost the total capitalized cost for the Wlingi multi-purpose project is summarized as follows.

(Unit; 10^3 $)

	Discount rate (%)			
	8	10	12	14
Capitalized construction cost	19,705	20,548	21,415	22,313
Capitalized operation and maintenance cost	1,028	833	698	599
Total	20,733	21,381	22,113	22,912

5-3-2 Project Benefit

The Wlingi multipurpose project is planned to have several functions such as power generation, irrigation water supply for Lodoyo-Tulungagung area, afterbay function for the Karangkates peak power generation and flood and sand control to the downstream reaches. The benefits derivable from this project are estimated as follows.

(1) Power Benefit

The dependable peak capacity and annual energy output in the Wlingi power plant have been estimated to be 27,000 kW and 177.1 million kWh respectively. The power benefit is estimated as a sum of the capacity benefit and energy benefit.

For estimating the capacity and energy unit values, a standard thermal plant with two units of 50,000 kW, is taken up as a competitive alternative of the Wlingi power plant. Assuming that the unit construction cost of the above thermal plant is 210 $/kW and its useful life is 20 years, the capacity unit values are estimated under the conditions with the discount rates of 8, 10, 12 and 14% by using the same criteria as explained in the "Study Report on Long-Range Power Development Program in East Java" submitted to the Government in 1972. The estimated capacity unit value for four different discount rates is as follows.

(Unit; $/kW)

	Discount rate (%)			
	8	10	12	14
Capacity unit value	36.4	42.0	48.0	53.6

The energy unit value is estimated at 0.0047 $/kWh assuming a thermal power plant with two units of 50,000 kW as the most competitive alternative and the unit fuel cost of 0.01565 $/liter.

Based on the estimated capacity and energy unit values, the annual power benefit under the condition with the respective discount rates of 8, 10, 12 and 14% is estimated as follows.

(Unit; 10^3 $)

	Discount rate (%)			
	8	10	12	14
Annual power benefit	1,758	1,907	2,067	2,216

These annual power benefits to be derivable during the project life of 50 years are capitalized to the base year. The capitalized power benefit under the condition with four different discount rates is as follows.

(Unit; 10^3 $)

	Discount rate (%)			
	8	10	12	14
Capitalized power benefit	21,506	18,908	17,166	15,807

(2) Benefits of Afterbay and Irrigation Functions

An afterbay to regulate the discharge fluctuation caused by the Karangkates peak power generation will be required when the demand is changed from night-peak type to day-peak type.

If the Wlingi dam is not constructed, the afterbay shall be constructed at the Kesamben site. The Kesamben afterbay weir in this case shall be considered as the appurtenant structure of the Karangkates power station. If the Wlingi dam is constructed, the Wlingi dam will play the role of the afterbay weir instead of the Kesamben afterbay weir.

In view of the above situation, the benefit of the afterbay function of the Wlingi multipurpose project is regarded to be equivalent to the construction cost of the alternative facility, i.e., the construction cost of the Kesamben afterbay weir.

The construction cost of the Kesamben afterbay weir is estimated at about 3.3 million $ equivalent. This construction cost is allotted assuming construction period of three years. The annual disbursement of the construction cost is capitalized to the final year of construction under the conditions with the discount rates of 8, 10, 12 and 14% respectively. The capitalized cost under each condition is as follows.

(Unit; 10^3 $)

	Discount rate (%)			
	8	10	12	14
Capitalized cost	3,915	4,080	4,249	4,424

This capitalized cost is regarded to be the capitalized benefit of the afterbay function.

The benefit of irrigation function is also regarded to be equivalent to the construction cost of the alternative facility. If the Wlingi dam is not constructed, the irrigation water for the Lodoyo-Tulungagung area will be fed from the Brantas River by constructing an irrigation intake at Jajar site and a 4.5 km-long canal between the Jajar and Wlingi sites.

The construction cost necessary for the above irrigation structures is estimated at about 3.27 million $ equivalent. This construction cost is allotted assuming construction period of two years. The annual disbursement of the construction cost is capitalized to the final year of construction under the conditions with the discount rates of 8, 10, 12 and 14% respectively. The capitalized cost under each condition is as follows.

(Unit; 10^3 $)

	Discount rate (%)			
	8	10	12	14
Capitalized cost	3,664	3,741	3,837	3,937

The above capitalized cost is regarded to be the capitalized benefit of the irrigation function.

(3) Flood and Sand Control Benefit

The aggradation of the Brantas river bed after 1970 in the 70 km-long stretch between the Wlingi damsite and Kediri gauge has been forecasted assuming the following three cases;

1) Case-1: The sediment coming from the Putih and Semut Rivers flows into the Brantas River without being trapped by the lahar pockets.

2) Case-2: The sediment is trapped by the Putih and Semut lahar pockets but not trapped by the Wlingi reservoir.

3) Case-3: The sediment is trapped by the abovementioned pockets and also the Wlingi reservoir.

The river bed aggradation will result in the decrease of the discharge capacity in the river channel. In order to keep the discharge capacity of the river channel in future equivalent to the capacity at present, it will be necessary to heighten the levee.

The sediment control effect of the Wlingi reservoir will mitigate river bed aggradation to some extent, thus, result in the decrease in the construction cost of levee heightening. Then, the balance of the construction cost for levee heightening necessary in Case-2 and Case-3 is regarded as the sand control benefit of the Wlingi project. The flood control effect of the Wlingi reservoir can be expected to some extent but the benefit accrued from this effect is not taken into account in this study because the peak discharge reduction is small, only 40 m^3/sec at the Kediri gauge even for the flood with 500 years return period.

Based on the forecasted figures of the river bed aggradation, the balance of the earth embankment volumes necessary for heightening the levee against the river bed aggradation in Case-2 and in Case-3 at the year of 1987, 1997, 2007, 2017 and 2027 is calculated. Assuming the unit cost of the earthwork is 1 $/$m^3$, the construction cost for levee heightening at each year is estimated and capitalized to 1977 under the condition with respective discount rates of 8, 10, 12 and 14%. The capitalized cost for levee heightening under the conditions with four different discount rates is as follows.

(Unit; 10^3 $)

	Discount rate (%)			
	8	10	12	14
Capitalized construction cost	205	167	143	128

The above capitalized cost is regarded to be the capitalized benefit of the flood and sand control function.

(4) Total Project Benefit

The capitalized benefits of power generation, afterbay irrigation and sand and flood control aspects estimated in the foregoing paragraphs are summarized as follows.

(Unit; 10^3 $)

Purpose	Discount rate (%)			
	8	10	12	14
Power generation	21,506	18,908	17,166	15,807
Afterbay	3,915	4,080	4,249	4,424
Irrigation	3,664	3,741	3,837	3,937
Flood and sand control	205	167	143	128
Total	29,290	26,896	25,395	24,296

5-3-3 Economic Evaluation

Based on the capitalized cost and the capitalized benefit, the internal rate of return of the Wlingi project is calculated to be 15.5%.

Besides, in order to evaluate roughly the economic viability of the respective purpose, the cost of the Wlingi project is allocated to each purpose under the condition with discount rate of 12% by applying the separable cost - remaining benefit method. In the calculation, the interest during construction is disregarded for simplicity of the calculation. The details of the calculation for cost allocation are explained in the "Supporting Report". The result of the cost allocation of the Wlingi project is shown in Table 5-9. Based on the cost allocation, the benefit-cost ratio of the respective purpose is calculated as follows.

Purpose	Benefit-cost ratio
Power generation	1.16
Afterbay	1.46
Irrigation	1.40
Flood and sand control	1.52
Total	1.24

The results shows that all the functions of the Wlingi multipurpose project are economically viable.

Table 5-9 Cost Allocation of the Wlingi Project

(Unit: 10^3\$)

Item	Power	Afterbay	Irri-gation	Flood & sand control	Total
1. Cost to be allocated					16,592
2. Alternative cost	16,592	3,300	3,270	8,500	
3. Benefit (Capitalized)	13,816	3,300	3,270	120	20,506
4. Justifiable expenditure (less one between (2) and (3))	13,816	3,300	3,270	120	20,506
5. Separable cost	7,789	0	290	0	8,079
6. Remaining justifiable expenditure; (4)-(5)	6,027	3,300	2,980	120	12,427
7. Percent distribution	48.5	26.6	24.0	0.9	100
8. Remaining joint cost	4,129	2,264	2,043	77	8,513
9. Total allocated cost; (5) + (8)	11,918	2,264	2,333	77	16,592
10. Interest during construction (0.192)	2,288	435	448	15	3,186
11. Total Cost; (9)+(10)	14,206	2,699	2,781	92	19,778
12. Benefit-cost ratio; (4)/(9)	1.16	1.46	1.40	1.52	1.24

5-4 Determination of Sequence of Priority

The sequence of priority for the implementation of the projects in the Brantas River Basin is studied not only from the view point of the economic aspect but also from such other aspects as regional concideration, timely relation with other projects or upholding of presently trained labourers and moving construction machineries etc.

The proposed development projects in the basin are classified into two groups for the convenience sake, i.e. the group of the irrigation projects, and the group of the flood control and power projects.

The sequence of priority is studied firstly within each of the abovementioned groups. Then, all the projects in the basin are further compared on the overall basis to determine the final sequence of priority in the light of the results of the studies within the group, interrelation of projects each other and other overall conditions.

5-4-1 Determination of Sequence of Priority for Irrigation Projects

(1) Economic Aspect

The economic feasibility of each irrigation project was studied in the foregoing paragraph by means of internal rate of return. The internal rate of return of each project is compared as follows.

Irrigation project	Internal rate of return (%)	Ranking
Jatimlerek-Bunder rehabilitation	26.8	3
Warujayeng - Kertosono "	29.7	2
Turi - Tunggorono "	31.3	1
Lodoyo - Tulungagung	15.7	4
Pace - Nganjuk	12.3	5
Blitar - Kediri	9.0	6

The result of the comparison shows that the rehabilitation projects are economically much superior to the new projects and, among the new projects, the Lodoyo-Tulungagung project is economically most feasible.

(2) Social and Other Aspects

The priority of the project should not be determined only in view of economic aspect but also be determined in view of social and other related aspects.

The social and other factors contemplated herein are as follows.

(i) The unbalance in regional income.

(ii) Amount of the construction cost.

The following table shows the annual gross income of the typical farm in the proposed irrigation project areas estimated based on the farm economic survey carried out in 1972.

Irrigation area			Annual gross income (Rp/farm)
Jatimlerek-Bunder	rehabilitation	project	59,000
Warujayeng-Kertosono	"	"	54,000
Turi - Tunggorono	"	"	52,000
Lodoyo - Tulungagung project			20,000
Pace - N	"		33,000
Blitar - Kediri	"		42,000

The above table shows that the annual gross income in the rehabilitation project areas is generally much higher than that in the new project area and that in the Lodoyo-Tulungagung project area is extremely low. In order to eliminate such unbalance in the regional income which is liable to cause social instability, the realization of new projects, especially of the Lodoyo-Tulungagung project is much significant.

For realization of project, financing of construction fund is one of the big problems. No doubt, the smaller the required project cost, especially its foreign currency component, the easier the financing. The construction cost of the irrigation projects and its component ratio of the domestic and foreign currency portions are as shown below.

(Unit; 10^3 $)

Irrigation project		Const-ruction cost	Domestic currency portion	Foreign currency portion
Jatimlerek-Bunder	rehabilitation	426	243	183
Warujayeng-Kertosono	"	2,300	1,600	700
Turi - Tunggorono	"	1,350	820	530
Lodoyo - Tulungagung		10,100	6,540	3,560
Pace - Nganjuk		7,340	4,290	3,050
Blitar - Kediri		21,050	12,050	9,000

The above table shows that the construction cost as well as its foreign currency portion is much smaller in the rehabilitation project than those in the new projects. The fact means that the rehabilitation projects can be implemented even with the fund financed by the Government herself with limited foreign aid. Whereas, for implementation of new project, the financing by international financing agency is considered indispensable.

(3) Determination of Sequence of Priority of Irrigation Projects

From the view point of economic aspect, the rehabilitation projects are superior to the new project with much higher internal rate of return. On the other hand, need of project, represented by low standard of regional farm income, is much stronger in the project areas for the new projects. In comparing the two aspects, the importance is considered to be placed on the need of the project from the national view point. In consideration of the fact, the priority for early implementation should be given to the new projects.

In addition, construction costs of the rehabilitation projects are much smaller than the new projects and their foreign currency portions are also small. They can be easily financed by the Government's own fund with only limited foreign aid. Since the purpose of determining of priority of projects is mainly to select project for financing by international financing agency, the rehabilitation projects are not necessary to be included in the list of the sequence of priority of the projects in the basin. Thus, the rehabilitation projects are excluded from the priority study.

Among the new projects, the Lodoyo-Tulungagung project is the most strong in the economic feasibility and the Pace-Nganjuk project the second, Blitar-Kediri the third. Beside, the need of the project for these projects are also in this order. Therefore sequence of priority is naturally determined as shown below.

Irrigation project	Sequence of priority
Lodoyo - Tulungagung	1
Pace - Nganjuk	2
Blitar - Kediri	3

The cost allocated for the irrigation function in the Wlingi multipurpose project is not included in the construction cost of the Lodoyo-Tulungagung irrigation project. Even if this allocated cost is added to this irrigation project, the economic evaluation for the Lodoyo-Tulungagung project is still the highest among the new irrigation projects.

Though the rehabilitation projects are excluded from the priority study, it is recommended that these projects are implemented as early as possible by the Government herself, since these projects are with high economic efficiency and their realization will much contribute to improvement of national economy.

5-4-2 Determination of Sequence of Priority for the Development of Flood Control and Power Projects

(1) Economic Aspect

The economic feasibility of the flood control and power projects in the basin is studied in the foregoing paragraph by means of internal rate of return. The internal rate of return of each project is compared as follows.

Project	Internal rate of return (%)	Ranking
1. River improvement in the middle stretch		
First stage plan	8.2	
Overall plan	10.4	2
2. Flood control in the area along the Ngrowo River	5.1	3
3. Wlingi multipurpose	15.5	1

The result of comparison shows that the internal rate of return for the Wlingi multipurpose project is highest and economically feasible.

(2) Social and Other Aspects

The priority of the project should not be determined only in view of economic aspect but also in view of social and other related aspect.

The social and other factors contemplated are as follows.

(i) Effect on elimination of the unbalance in regional income

(ii) Adequate time for implementation

(iii) Effective utilization of the skilled labor and machinery in on-going projects

1) Effect on elimination of the unbalance in regional income

At present, in the upstream reaches, the Karangkates multipurpose project is being implemented, and in the downstream reaches, the Porong River improvement and the Brantas Delta irrigation rehabilitation projects are also being implemented in the Brantas River Basin. However, in the middle reaches, no big project is implemented yet. In order to achieve balanced development in the basin, an adequate project should be taken up for implementation in the middle reaches. As the projects in the area, the river improvement of the middle stretch of the Brantas River, flood control project in the area along the Ngrowo and Widas Rivers, and Wlingi multipurpose project are contemplated.

The Indonesian Government, however, has strong intension to proceed with the development of the irrigation project in the Lodoyo-Tulungagung area in order to eliminate unbalance in regional farm income where the annual gross farm income is the lowest in the Brantas River Basin, and a part of the canal network is being implemented in accordance with the policy of the Government. The Wlingi multipurpose project which is planned by the Government includes the purpose to supply the irrigation water to the Lodoyo-Tulungagung area.

In view of the abovementioned situations, it will be reasonable to proceed the implementation beginning with the Wlingi multipurpose projects among the proposed projects.

2) Adequate time for implementation

The benefit of the Wlingi multipurpose project accrues mostly from power generation. As explained in Chapter 5, Part II, Supporting Report, the expanding demand in the Kalikonto system is forecasted to exceed the capacity of supply facilities in 1978. Thus, the Wlingi project is recommendable to be implemanted as early as possible.

While, the result of the economic evaluation made for the river improvement project shows that the internal rate of return is lower than that of the Wlingi multipurpose project. However, in view of the present poor discharge capacity of the river channel especially such as the river stretch near Kediri city, it is advisable to materialize this project stage-wise as early as possible.

3) Effective utilization of the skilled labor and machinery in on-going project

The construction of the Karangkates dam has already been completed, and the skilled labor and machinery used in the Karangkates dam construction are scheduled to be shifted to the Lahor dam construction on the upper reaches of the Lahor River. After the completion of the Lahor dam, such skilled labor and machinery would be left as they are or dispersed unless a suitable development project is put into implementation. In order to utilize effectively these skilled labor and machinery, it is desirable to implement the dam project successively to the Lahor dam construction.

Aside from the above dam project, the river improvement project on the Porong River is being carried out since 1970. If the river improvement project in the middle stretch is implemented successively to the Porong river improvement, it will be smoothly promoted by using effectively the skilled labor trained and the machinery used in the Porong river works.

Considering the construction time schedule of the Lahor dam (1972-1975) and the Porong river improvement (1970-1978), it is recommendable to proceed with the implementation in the order of the Wlingi multipurpose project and river improvement project in the middle reaches.

(3) Determination of Sequence of Priority for Implementation for Flood Control and Power Projects

Taking into account both the economic aspect and social and other aspects, the sequence of priority for implementation of the flood control and power projects is determined as follows.

Project	Sequence of priority
Wlingi multipurpose	1
River improvement in the middle stretch	2
Flood control in the area along the Ngrowo River	3

5-4-3 Determination of Sequence of Priority for Implementation of Irrigation, Flood Control and Power Projects

The development of the Lodoyo-Tulungagung area has been ranked as the first priority among the irrigation projects, while, the first priority for the development of the flood control and power projects is given to the Wlingi multipurpose project.

The Lodoyo-Tulungagung irrigation project is planned to take the irrigation water from the Wlingi reservoir. Thus, to achieve the full benefit in both the Wlingi multipurpose project and Lodoyo-Tulungagung irrigation project as early as possible, it is recommendable that the implementation of both projects proceeds in parallel.

As to the development projects in the middle reaches of the Brantas River Basin, the Pace -Nganjuk irrigation project is ranked at high priority. Besides, the rehabilitation projects in the area such as the Jatimlerek-Bunder, Warujayeng-Kertosono and Turi-Tunggorono are also economically superior and early implementation is recommendable. However, to achieve proper control of the irrigation water for those irrigation projects, it would be recommendable to proceed with the river improvement project, ahead of the implementation of the irrigation projects.

The Blitar-Kediri irrigation project is proposed to be developed in the future stage when the utilization of the Brantas water in the downstream irrigation area can be saved by the improvement of the canal or the utilization of the groundwater.

Judging from the abovementioned conditions, the sequence of the priority for the implementation of the projects in the Brantas River Basin is determined as follows.

Project	Sequence of priority
Wlingi multipurpose Lodoyo-Tulungagung irrigation	1
River improvement in the middle reaches	2
Pace -Nganjuk irrigation	3
Flood control in the area along the Ngrowo River	4
Blitar-Kediri irrigation	5

It is roughly studied to develop the tributary areas such as the land along the Widas River, the land along the Beng River and the land along the Ngasinan River by constructing a reservoir and canals. The results of the economic evaluation studied for these irrigation projects showed that the internal rate of return is so high as about 12 to 15 %. However, since this evaluation is based on many assumptions and uncertain factors, it is recommended to carry out further investigations to make clear these factors before integrating these projects for the priority study.