REPUBLIC OF INDONESIA
MINISTRY OF PUBLIC WORKS AND ELECTRIC POWER
DIRECTORATE GENERAL OF WATER RESOURCES
DEVELOPMENT

FEASIBILITY REPORT ON THE WONOGIRI MULTIPURPOSE DAM PROJCET

—ANNEX II STUDY REPORT (2)—

OCTOBER, 1975

JAPAN INTERNATIONAL COOPERATION AGENCY

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ANNEX II

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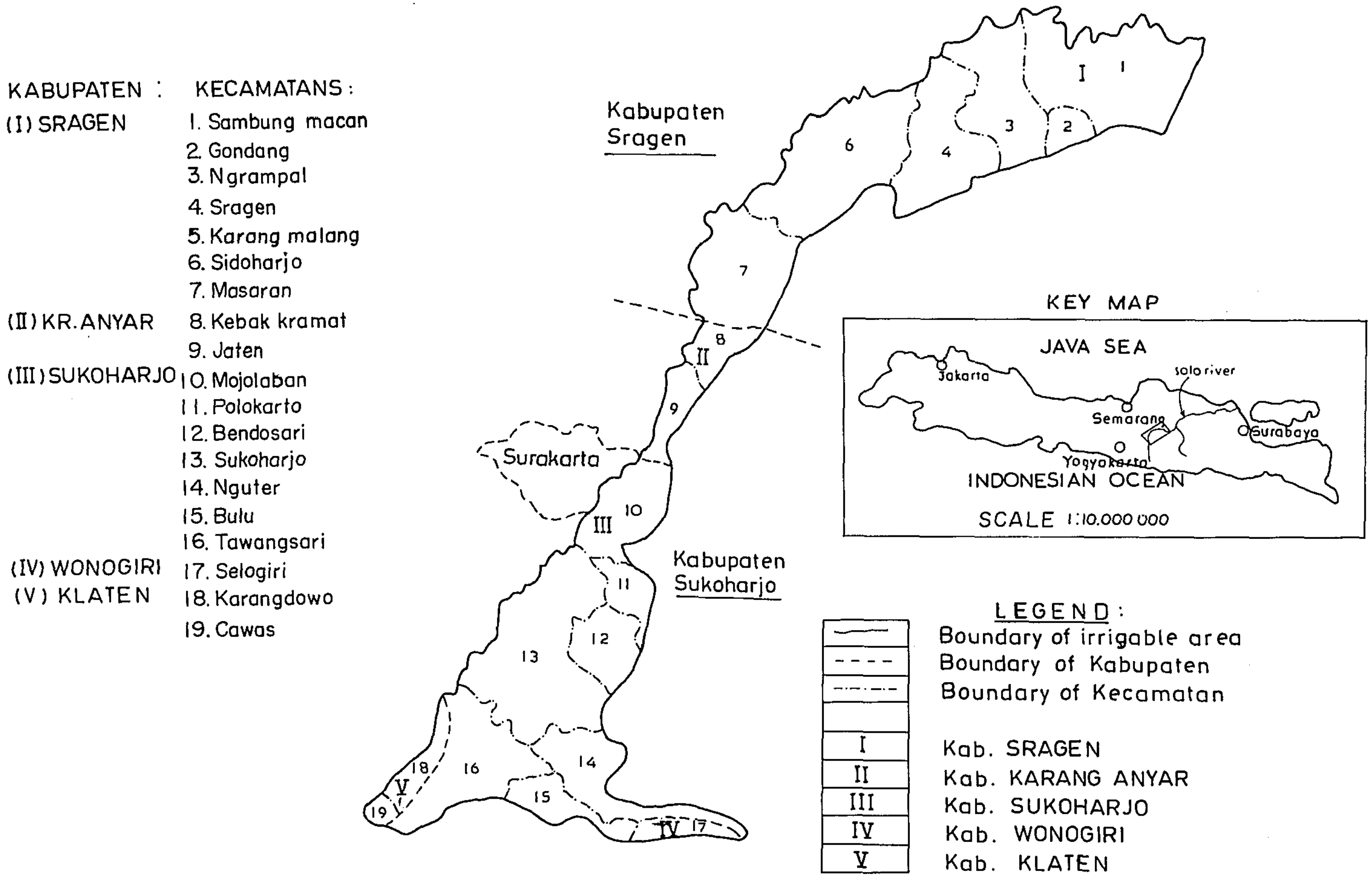

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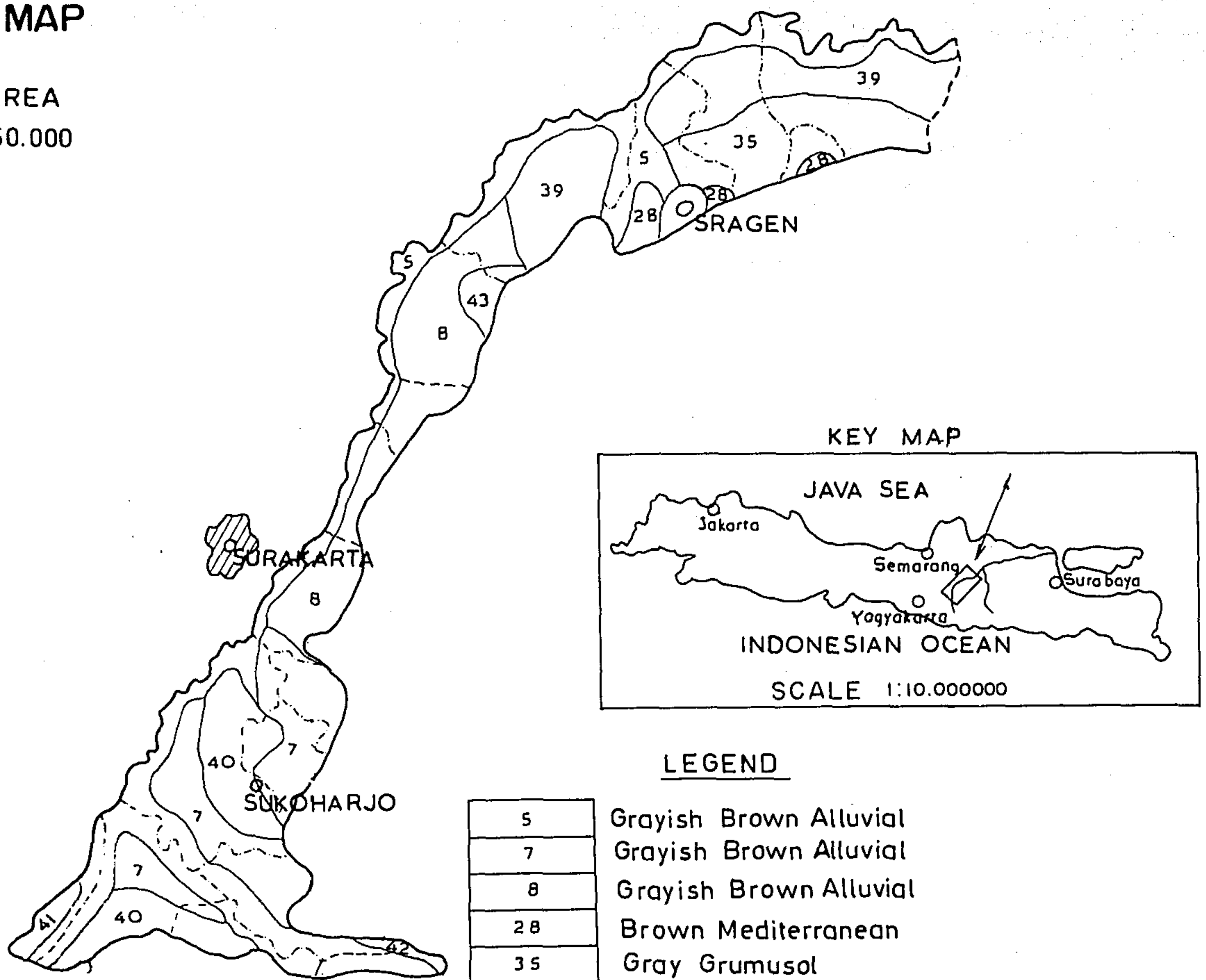

LEGEND

5	Grayish Brown Alluvial
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1973
SOIL RESEARCH INSTITUTE

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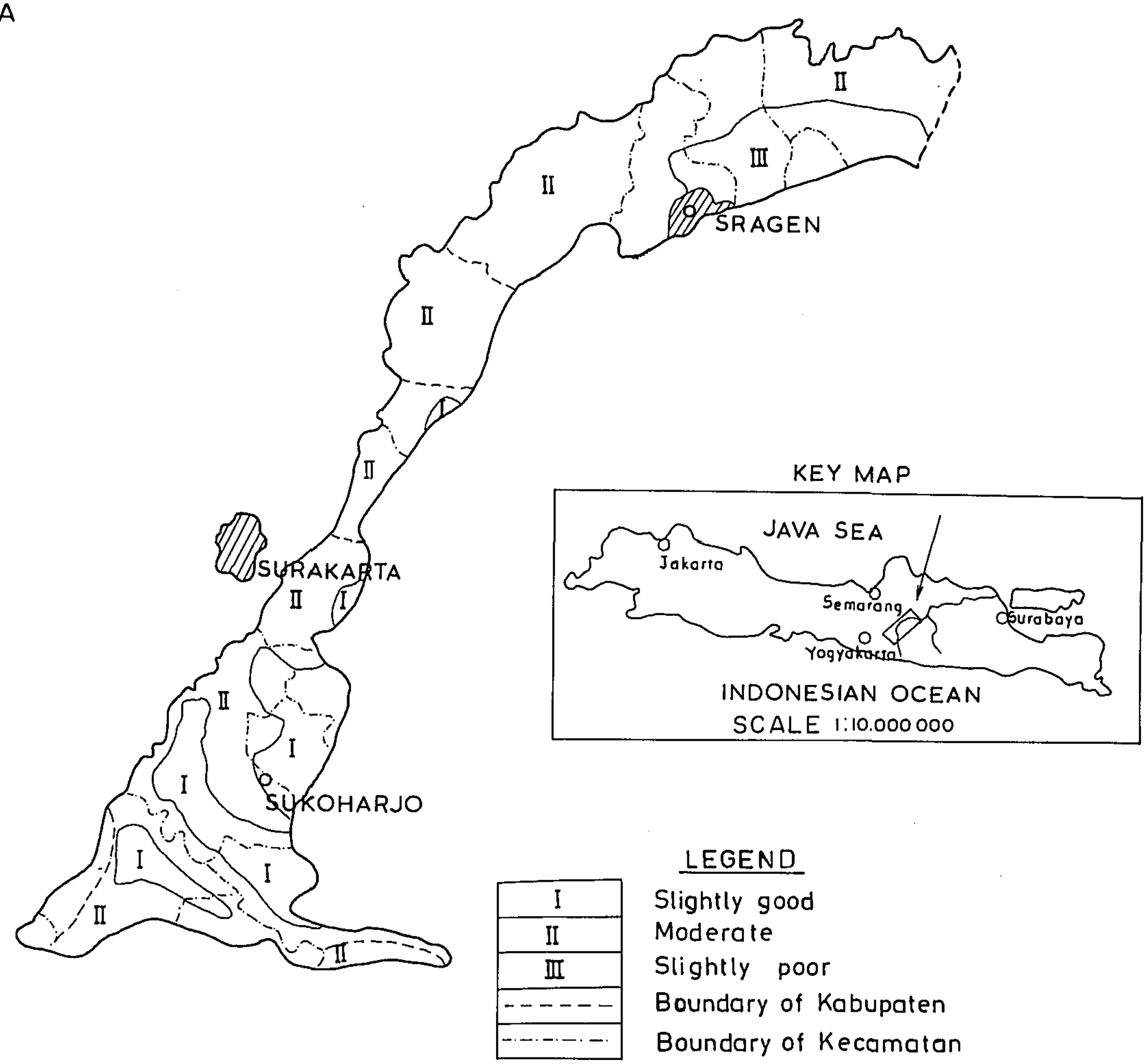

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1. INTRODUCTION

Main objective of this study is to plan agricultural development in the Upper Sala River Basin, particularly, in the irrigation area to be benefited by the Wonogiri reservoir. The studies include analysis of the present agricultural situation, formulation of future cropping pattern based on irrigation farming and forecast of production increase in agricultural products with the irrigation project.

Since the Master Plan of the Bengawan Sala River Basin Development, formulated on the basis of overall survey for about two years from 1972 to 1973, gave the highest priority for the Wonogiri Multipurpose Dam Project among various development plans, a feasibility study for the project is followed for early implementation entrusted by Japanese Government. Detailed study on the agricultural sector has been carried out by collecting supplemental data and analysing the most recent situation in the project area based on the fundamental conception established in the Master Plan.

2. BACKGROUND OF IRRIGATION DEVELOPMENT

2.1 General Economic and Agricultural Situation

Economy of Indonesia in terms of GDP has increased by about 30 % in 1972 from the level of 1968 (See Table IV-1). High growth rate was attained in mining and manufacturing sector, while relatively low rate in agricultural sector. This trend implies that Indonesia is going on the process of industrialization as the developed countries have gone through. Although Indonesia has been affected seriously by the influence of price increase since late autumn of 1973, it is undoubtful that quadruple price of oil is greatly contributing to the national economy.

Balance of trade excluding oil shows continuous deficit since 1961 while gross balance of trade including oil has marked a surplus since 1962.

Export by goods in 1972 appears that mineral products including oil occupy about 56 %, while agricultural products share about 42 %. Import by goods indicates that the largest share, about 46 % belongs to capital goods followed by raw materials of about 38 % and consumable goods about 16 % in the same year. In comparison with the trend in 1968, share of the capital goods is increasing and this also indicates that industrialization is progressing in this country.

For the trade in agricultural goods, import of fertilizer increased by about 2.4 times in these three years and foodgrains such as rice and wheat still occupy more than half of the total import of the consumable goods except the good harvest year in 1971. This fact suggests that the country would have to make further effort for the increase in food crop production.

Total farm land in Indonesia occupies about 11.6 % of the total land area of 1.9 million km^2. Out of food crops, paddy rice is the most important; its harvested area in 1973 was 8.38 million ha producing about 14.45 million tons in the country. Other crops such as cassava, sweet potatoes, maize, soybeans and peanuts are also important crops. As perennial estate crops, rubber, coffee, oil palm and sugar cane are prominent.

2.2 Agricultural Development in the Second Five-Year Plan (REPELITA-II)

During the period of the First Five-Year Plan from 1968 to 1973, annual increase rate of agricultural production marked 4.4 %. Increase in rice production has been achieved by the wide extension of the BIMAS and INMAS programs. About 36 % increase against the 1968 production was attained in 1973.

Based on the achievement stated above, the Second Five-year Plan places the following targets in the agriculture sector:

(1) Increase the productivity of agriculture and fishery and enable them to take part in the construction of the national economy.

(2) Give necessary credits to rice cultivators and achieve self-sufficiency in foodgrain.

(3) Promote export of agro-products by increasing the agricultural production.

(4) Decrease unemployment and under-employment now prevailing in the farm villages.

(5) Achieve balanced growth between agriculture sector and industrial sector by reinforcing agricultural production.

(6) Use the natural resources and conserve natural assets for future generation.

Based on the above, an overall policy is set out for rice production as follows:

(1) Increase farm income per capita.

(2) Attain self-sufficiency in rice.

In order to carry out the aforementioned policy, efficient utilization of irrigation facilities is stressed as well as the distribution of improved seeds, extension of new rice field, effective application of fertilizer, stabilization of dry season cropping, increase in unit yield of crops by improvement of farming technique. Besides, the development of upland crops, vegetables, fruits, estate crops, livestock, fishery, are also set out in detail in the Plan (See Table IV-3).

2.3 Development Potential of Irrigation in Upper Sala Basin

To realize the fundamental policy for raising farmers' income in the project area, there are three (3) approaches, namely, expansion of farmland, increase in unit yield of crops and raising of the prices of farm products. Among these, the first approach is impractical because most farmlands are fully cultivated and held in small fractions of less than one ha per farmer, while the third solution may suppress the consumers' daily life in quick reflection of price increase. Only the second approach can be attainable.

However, there exist many difficulties at present in introduction of new varieties and the improvement of farming technique for stable yield mainly due to the lack of stable supply of sufficient irrigation water.

Under this situation, the realization of all-weather irrigation through the construction of the Wonogiri Multipurpose Dam Project will make possible the cultivation not in the dry season and also assure stable crop yield in the rainy season when the distribution of rainfall is uneven. Moreover, gravity irrigation is applicable in this area, which enables to introduce the irrigated farming in an economical way.

In the Upper Sala Basin extending along both sides of the Sala River, land use of farmland is classified into paddy field of 184,000 ha (41.3 %), upland field of 137,000 ha (30.9 %) and yard of 124,000 ha (27.8 %) respectively. Total population of this basin is about 4.43 million, and the farm population and the number of farms are about 3.19 million and about 580,000 families respectively. Average size of the farm family is about 5.5 persons.

Statistics from Kabupaten (regency) level indicate that about 70 % of the total paddy field is being irrigated and the remaining 30 % is under the rainfed condition.

Although the above figures suggest that the area has rather been well provided with irrigation facilities, the actual situation appears that cultivation area in dry season hardly reaches half of the cultivation area in rainy season because of insufficiency of irrigation water. Therefore, the crop production of paddy and upland crops the growing period of which comes in the mid dry season, June to August, is limited.

Under such a situation, it would be easily expected that the Wonogiri reservoir can bring about considerable benefits to this area by the realization of the year-round irrigation with stable water supply.

2.4 Selection of Irrigation Area

Selection of irrigation area by the Wonogiri reservoir should be made taking into account the most efficient utilization of the storage water and maximizing the benefit from irrigation at the least construction cost.

From the topographical viewpoint, about 32,000 ha of the area is selected as the project land of which about 23,400 ha of cultivable land extending in Kubupaten Sukoharjo and Sragen is classified into the irrigation area. The selected irrigation area is larger than that mentioned in the Master Plan, in which about 22,000 ha of cultivable land is proposed as the project area. The additional land is attributable to the increased accuracy of the survey and the inclusion of an additional area of about 500 ha in Klaten district.

In the project land, the soil consists of mainly alluvial type and partly of grumusol, lithosol, latosol and regosol. Land capability indicates that more than 60 % of the total farmland is classified as good or moderate, and only 17 % is graded as poor. From this, it can be said that the selected area has a considerably high latent productivity of land. Besides, near the center of the selected irrigation area, Surakarta city with a population of about 450,000 is located and plays the role of trade and consumption center in the project area. So, the project area selected has quite good condition for agricultural production.

Table IV-1 Economic Growth by Industry

(Unit: 10^9 Rp.)

Industry	1968	1969	1970	1971	1972
1. Agriculture, Forestry, Fishery	255.2	260.1	270.7	280.5	284.6
a. Food	169.5	170.2	135.7	181.5	178.8
b. Non food	35.4	35.5	36.1	36.5	37.6
c. Estate crops	11.6	13.0	13.7	13.9	14.9
d. Livestock	20.2	21.1	22.2	23.3	25.0
e. Forestry	6.8	8.0	10.3	12.5	16.4
f. Fish	11.7	12.3	12.7	12.8	12.8
2. Mining	22.8	27.7	52.2	34.0	40.9
3. Manufacturing	40.8	46.6	51.1	56.7	60.8
4. Construction	9.2	12.1	15.2	15.5	15.9
5. Power, Gas	2.3	2.6	3.0	3.3	3.3
6. Transportation, Communication	15.9	16.5	17.4	22.1	22.4
7. Wholesale, Retail trade	78.8	88.8	100.2	108.5	126.9
8. Finance	4.0	6.6	8.6	11.3	12.9
9. Ownership of dwelling	9.7	10.4	11.2	11.9	12.8
10. Public administration	28.8	29.3	30.4	31.8	31.8
11. Service	29.4	30.1	30.9	31.7	32.5
Gross Domestic Product	496.9	530.8	570.9	608.9	650.8

Note : At constant 1960 Prices.
Sources : Statistic Indonesia 1972/1973.

Table IV-2 **Balance of Trade**

(Unit: 10^6 US$)

	Including Oil			Excluding Oil		
	Export	Import	Balance	Export	Import	Balance
1965	708	695	13	436	682	-246
1966	679	527	152	475	519	- 44
1967	665	649	16	426	637	-211
1968	731	716	15	436	710	-274
1969	854	781	73	471	770	-299
1970	1,161	1,002	159	714	987	-273
1971	1,234	1,103	131	756	1,082	-326
1972	1,778	1,562	216	865	1,531	-666

Source: Statistical Pocketbook, Indonesia 1972/1973.

Table IV-3 The Second Five Year Plan

	Rice												
	Cultivation area (1,000ha)	Unit Yield (t/ha)	Production (1,000t)	Maize ha (1,000)	Cassava ha (1,000)	Soybean ha (1,000)	Peanuts ha (1,000)	Rubber ha (1,000)	Sugar cane ha (1,000)	Cattle head (1,000)	Buffalo head (1,000)	Goat head (1,000)	Chicken head (1,000)
1974	8,400	1.84	15,032	290	1	75	22	149	1,089	6,539	2,935	6,950	85,802
1975	8,530	1.89	15,633	370	10	150	44	152	1,194				
1976	8,599	1.96	16,383	600	50	200	70	154	1,236				
1977	8,736	2.03	17,235	950	100	240	94	156	1,319				
1978	8,982	2.09	18,183	1,400	200	270	110	161	1,356	7,218	3,177	8,439	125,622

Source; Draft summary of PELITA - II.

3. PRESENT AGRICULTURAL SETTING

3.1 Physical Condition of the Project Area

3.1.1 *Location and topography*

The project area can be explained by two representative areas of Sukoharjo and Sragen as follows.

Sukoharjo area

The area is situated between the Wonogiri dam and Surakarta city and its topography is relatively flat along the River with an altitude of 90 to 105 m. Rainfall is slightly less than that in Sragen area. Soil in the area is mostly of alluvial type and land capability is classified generally into good or moderate rank. Infrastructures are also relatively well established.

Sragen area

The area is situated at north-east of Surakarta on the right bank of the downstream of the Sala River. The topography is relatively flat with an altitude of 75 to 85 m. Average rainfall amounts to about 2,000 mm a year. Soil in the area consists of alluvial and grumosol types and land capability is mostly classified as moderate. Infrastructures in the area are rather well established than in the Sukoharjo area.

3.1.2 Climate condition

At Surakarta, temperature ranges from 27°C to 29°C on an average and indicates an annual mean of 28.2°C. Annual rainfall amounts to about 2,170 mm, about 80% of which falls during six (6) months from November to April and about 20% falls during the remaining six (6) months from May to October. The latter period makes cultivation very difficult with slight rainfall. Annual mean humidity is about 69%, nearly 100% in the rainy season, and drops below 50% in the dry season. Evaporation is about 3.0 mm/day in annual average, ranging from the minimum of 1.4 mmm/day in February to the maximum of 4.3 mm/day in September. Sunshine rate observed is about 50% at mean.

3.1.3 Soil and land capability

Table IV-4 shows the types of soil found in the project area. Table IV-5 shows land capability in the project area. About 74% of land is classified as moderate, about 16% as good, and about 10% as poor. In Sukoharjo area about 33% is classified as slightly good while none as poor at all. This implies that Sukoharjo area has relatively higher land productivity than Sragen area. Judging from the soil and land capability, it is expected that stable production increase can be attained in the project area by increasing the cultivation of rice as a main crop together with the introduction of other cash crops if sufficient quantity of water is available.

3.2 Present Land Use

Present land use in the project area is shown in Table IV-6. Lowland (sawah) occupies about 65% followed by upland (tegal) 8%, yard 21% and others 6%. The ratio of sawah to tegal in this project area is about 88:12; this ratio indicates considerably high occupancy of sawah compared with that of 57:43 in the whole Upper Sala Basin. About 68% of the sawah irrigated in one form or another.

Within the project area, percentage of occupancy of sawah and tegal in Sukoharjo is about 58% and 18% respectively while it is about 71% and 4% respectively in Sragen area. Sawah-tegal ratios in both areas are about 79:21 and 95:5 respectively. The rate of paddy field in Sragen area is quite high and it could be said that the land is almost fully utilized in the Sragen area. While in the Sukoharjo area, about 10% of the land still remains unclassified. In this project area, there exist no estates and forestland, and orchard is generally situated in the yard area.

3.3 Average Size of Farm and Land Tenure

The average farm size in the Upper Sala Basin appears to be about 0.72 ha according to the Master Plan. For all the project area, the size is the same on an average, while farm size in the Sukoharjo area is little larger than in the Sragen area. As for the land held by each farm in view of land use, the size of sawah and yard seems to be 0.46 ha and 0.15 ha respectively, which is almost the same as that in the Upper Sala Basin. However, if tegal and others are included, the average farm size in the project area is little smaller than the Basin average, due to flat topography.

With repsect to land tenure in the Upper Sala Basin about 90% of the land belongs to farmers and about 10% to village offices. Among the farmer's land, about 60% is owned fully by farmers and the remaining 40%, partly by farmers and partly by landlords.

Land rent is about Rp.50,000/ha on an average, ranging from Rp.11,000/ha to Rp.70,000/ha.

3.4 Kind of Crops and Cropping Pattern

In the Project area, quite many kinds of crops are cultivated at present, such as paddy rice, upland rice, cereals, beans, root crops, vegetables, fruits and industrial crops. The typical cropping pattern is shown in Fig. IV-4.

On the sawah, mixed culture is prevailing because of lack of water in the dry season, and partly in the rain season and also because of the sparseness of upland area. As shown in Fig. IV-4, the present cropping pattern is established to practice crop cultivation mainly in the wet season. Most crops are seeded and transplanted during the period from October at the outset of the rainy season to May at the end of the rainy season. Thus, it is recognized that the availability of water is the most important factor for crop growing in the project area.

3.5 Prevailing Farming Practice

Paddy rice

On irrigated sawah, both the dry season paddy and the rainy season paddy are cultivated while on the upland area mainly the rainy season cropping is performed. Varieties of paddy now being cultivated are rather diversified from high yield varieties such as PB-5, PB-8, C-4, and Pelita to the traditional varieties such as Bengawan, Brandol, Cempo, Cemporandu, and Srigunung. Growth period of paddy is usually about 125 to 170 days.

Nursing period is normally about 25 to 30 days for high yield varieties and 30 to 40 days for local varieties but in some deep water area, it requires about 50 days.

Fertilizer is generally applied but its dose widely varies from 50 kg/ha to 200 kg/ha of urea, and the farmers under BIMAS program use about 200 kg/ha of urea on an average.

As for insecticide, Diazinon is used for pest control at the rate of 1 ℓ/ha and once in the growing period. Plant desease is generally not observed except blast for C-4 variety in some small areas.

Unit yield of paddy varies considerably depending on the area and farmers. Farms under BIMAS program yields about 5 to 6 t/ha (dry stalk paddy) while farms under traditional farming attain substantially low unit yield.

Maize

Maize is generally cultivated as one of the staple foods in a relatively wide area, not only in tegal but as polowijo crop in sawah, on about 30% of the total area in the dry season. Varieties grown are Metro and Perta. Cultivation is so simple as to direct seed in the ridges of the field and no fertilizers and chemicals are used. Unit yield generally is as low as 0.4 to 0.6 t/ha and there is a possibility of increasing the unit yield in future.

Cassava

This crop is also cultivated widely as one of the staple foods not only in tegal area and yard but also in sawah as porowijo crop. The varieties are generally the traditional ones such as Patangpuluhan, Bestak, Genderuwo, Kodok and Sawi.

Soybeans, greenbeans and peanuts

These crops are introduced as polowijo crops in the rainy season at the rate of about 20 to 30% of the total sawah but yield is generally low because of no application of fertilizers. The varieties are local ones such as Ambang, Kedele laut and Kedele gendjar for soybeans, Gundul, Teparo and Brol for peanuts.

Cash crops (Tobacco, Sugar cane)

Tobacco is mainly cultivated in the Sukoharjo area on the project area under the contract base with PNP. Varieties are, therefore, specified as vorstenland Virginia and Javanese and the cultivation practice is also guided by PNP. Sugar cane is cultivated mainly in the Sragen area under contract with sugar factories. Variety is mainly P.O.Y. which is specified by the factories, and cultivation practice is also guided by the factories.

3.6 Unit Yield of Crops

Unit yields of main agricultural products under the present conditions are shown in Table IV-9. These yields are estimated on the basis of the data collected at the agricultural offices of Kecamatan in the project area and the statistical data of Central Java. Since the yeilds vary from one year to another depending on the natural conditions such as rainfall and temperature, average yields are estimated.

For the future without the project, only slight increases are expected in paddy yields. The increase will be attributable partly to variety improvement and partly to some increase in fertilizer and chemical use. The expected unit yield in the future without project is shown in the same Table IV-9.

3.7 Cropping Area and Crop Production

Table IV-10 shows the cropping area and the production of crops at present in the Project area. Table IV-11 shows the cropping area which will remain the same and the production of crops in the future without project.

As stated in the paragraph of "Land use", the project area has a considerably high paddy field ratio, in another words, the main crop is paddy rice. However, due to the unstable water supply and sparseness of tegal, polowijo area usually planted on the sawah.

Cropping area by crops is rated at about 60% for paddy rice followed by cassava and maize. In the project area as a whole, crop intensity has reached 1.76 and this indicates that the intensive use of the farmland is being practiced.

3.8 Livestock

Livestock breeding in the project area is not so significant. Average holding of large and medium livestock is less than two heads per farm family and about six small fowls are being held at present. Compared these figures with the number of livestock in 1970 in the project area, cattle remained at the same level, buffaloes increased in the Sukoharjo area but only slightly increased in the Sragen area, sheep increased to about 2 times in the Sukoharjo but decrease slightly in the Sragen area, goat decreased in both areas, pig increased in the Sukoharjo area but decreased in the Sragen area and fowls increased in both areas. In the project area as a whole, buffaloes, sheep and fowls marked an increase in the number of holding but cattle, goat and pig decreased or remained unchanged.

Livestock production in the project area is shown in Table IV-13.

3.9 Marketing and Agricultural Institution

Marketing

Fig. IV-5 illustrates the market flow of rice. Dry stalk paddy harvested from the field is collected at BUUD (Badan Usaha Unit Desa), milled there into rice and sold to the market. Rice for government stock is purchased by BULOG with stable price. Some parts are sold to the buyers who resell to the rice seller. Various prices of rice are now prevailing and they vary widely depending on the locality and season.

Other crops than rice have been transacted in free market. In other words, their prices are sholly controlled by the speculative buyers. However, since such crops as tobacco and sugar cane are cultivated under contract with PNP, their prices are relatively stable.

Although crop cultivation in the project area is characterised as self consumption and the volume of crops to be sold to the market is not large, unstable prices of such crops prevailing in the project area suggest that the farmers are affected more or less by the price control enforced by such speculative buyers. It is important to strengthen the farmers' organization and the cooperative activities for stabilization of the prices of the farm products.

Agricultural institution

The economic organization of farmers, BUUD (Agricultural Cooperative Society) has been organized on a nation wide scale. The main activities of this organization are set out:

(i) supply of inputs for agricultural production,

(ii) collection of agricultural products and marketing thereof;

(iii) agricultural credit service

However this can rarely work for supporting the farmers because BUUD is now quite busy for collection, quality control, milling and transporting of rice.

As for other crops such as tobacco and sugar cane, respective farmers' organizations have been set up and have worked for the contract cultivators.

Agricultural extension service

Extension services have been managed through a systematic structure from the Ministry of Agriculture down to desa (village unit) as shown in Fig. IV-7.

Extension services are conducted under close cooperation with the extension workers and technical workers for the specified crops. Fig. IV-8 and Fig. IV-9 show the organization of the extension services in Kabupaten. As shown in these figures, services are divided into technical and administration departments under which various sections are provided for the detailed guidance services. This organization is not uniform throughout all Kabupaten but somewhat reformed to meet special situation of each Kabupaten to work most efficiently. Present capability of the extension services is about 700 to 800 ha per worker including both extension and technical personnel.

Seed multiplication system of paddy rice is also established in a systematic structure from Central Agricultural Institute of Bogor down to farmers as shown in Fig. IV-10. Improved seeds are distributed through this channel.

3.10 Prices of Agricultural Products

Prices of agricultural products widely vary according to locality and season. It is quite difficult to seize typical prices of the products in the project area in terms of economic value. For this study, the farm gate price of each crop is estimated as shown in Table IV-14 based on the international price forecasted by IBRD. Transportation cost and processing cost are also taken into account for the estimate.

Besides the economic prices estimated above, financial prices (or actual price) at farm gate are estimated by referring to the local market prices for farm budget analysis. The financial prices are also presented in Table IV-14.

3.11 Agricultural Products Values

Based on the crop production and the economic price stated in the preceding paragraphs, the value of agricultural products is calculated in Table IV-15 and Table IV-16 under the present condition and the future without-project condition respectively.

In the estimate of the value of the agricultural products, only the major crops are taken into consideration excluding the values raised from livestock and other minor crops.

Gross value at present in the Project area amounts to about Rp.5.9 billion (US$14 million) and gross value in the future without project amounts to Rp.6 billion (US$14 million).

Gross income of paddy is predominant, about 70% of the total value is raised from the paddy. It is evident that the paddy plays a very important role in the project area.

3.12 Production Cost

Based on the data obtained from the related Kabupaten offices and farmers in the Project area, unit production cost is estimated as shown in Table IV-17. This includes all necessary costs for seed, fertilizer, chemicals, materials, agricultural implement, animal power, labourers and other direct cost for crop growth, except indirect costs and family labour cost. Estimated international prices are applied to the cost of fertilizer, chemical and seed for the evaluation of the economic production cost. Details of unit production cost are presented in Appendix I.

Besides, financial cost for crop production is evaluated for farm budget analysis by applying actual prices of agricultural inputs, which are also presented in Table IV-17.

Total production costs (economic cost) in the Project area are presented in Table IV-18.

3.13 Net Values of Agricultural Production

Table IV-19 shows the net value of the agricultural production in the Project area in the future without project condition.

Total net value is estimated at about Rp.4.2 billion (US$10.1 million) out of which about 80% is raised from paddy production.

Table IV-4 Classification of Soil Type

(Unit: Ha)

	Sukoharjo	Sragen	Total
Alluvial Soil			
5	5,700	5,000	10,700
7	3,900	-	3,900
8	1,500	2,500	4,000
Mediterranean Soil 28	-	700	700
Grumosol			
35	-	1,700	1,700
39	-	6,000	6,000
40	3,500	-	3,500
42	500	-	500
43	-	500	500
Other	-	500	500
Total	15,100	16,900	32,000

Note,
5 : Grayish Brown Alluvial
7 : Grayish Brown Alluvial
8 : Grayish Brown Alluvial
28 : Brown Mediterranean
35 : Gray Grumosol
39 : Dark Gray Grumosol
40 : Dark Gray Grumosol
42 : Association of Dark Gray Grumosol & Reddish Brown Mediterranean
43 : Association of Dark Gray Grumosol & Reddish Brown Mediterranean

Table IV-5 Land Capability Class

(Unit: Ha)

	Sukoharjo	Sragen	Total
Slightly Good	5,000	-	5,000
Moderate	10,100	13,700	23,800
Slightly Poor		3,200	3,200
Total	15,100	16,900	32,000

Table IV-6 Present Land Use

(Unit: Ha)

Item	Area
Sawah	20,900
Irrigation	14,400
Rainfed	6,500
Tegal	2,500
Yard	6,800
(Orchard)	(1,500)
Others	1,800
Total	32,000

Source: Each Kecamatan Data

Table IV-7 Present Land Use Per Farm Household

(Unit: Ha)

Item	Unit Area
Sawah	0.46
Irrigation	0.31
Rainfed	0.15
Tegal	0.06
Yard	0.15
(Orchard)	(0.03)
Others	0.05
Total	0.72

Note: Orchard is included in the Yard.

Data Source: Each Kecamatan Data

Table IV-8 Nos. of Population and the Number of Households

		Sukoharjo	Sragen	Total
Population	1961	107,717	136,948	244,665
	1971	157,012	178,180	335,192
	(1971/1961)	(145.8%)	(130.1%)	(137.0%)
Household	1961	21,867	31,294	53,161
	1971	31,861	38,605	70,466
	(1971/1961)	(145.7%)	(123.4%)	(132.6%)
Family	1961	4.9	4.4	4.6
	1971	4.9	4.6	4.8
Farm Population	1961	67,504	97,328	164,832
	1971	97,003	119,331	216,334
	(1971/1961)	(143.7%)	(122.6%)	(131.2%)
Farm Household	1961	13,640	20,764	34,404
	1971	19,540	24,983	44,523
	(1971/1961)	(143.3%)	(120.3%)	(129.4%)
Farm Family	1961	4.9	4.7	4.8
	1971	5.0	4.8	4.9

Data Source : Jawa Tengah Dalam Angka 1971.

Table IV-9 Unit Yield at Present, and Future Without-Project

(Unit: ton/ha)

Kind of Crops	Present	Future without-Project
Paddy /1		
Dry Season Paddy	3.3	3.5
Wet Season Paddy	3.4	3.6
Upland Paddy	1.8	1.9
Maize	0.5	0.5
Cassava	3.3	3.3
Peanuts	0.5	0.5
Soybean	0.4	0.4
Tobacco /2	0.4	0.4
Sugar cane	85.0	85.0

Note /1 Dry stalk paddy
/2 Dry leaf

Table IV-10 Cropping Area and Crop Production at Present

Kind of Crops	Unit Yield (t/ha)	Cropping Area (ha)	Crop Production (t)
Paddy /1			
Dry Season Paddy	3.3	5,320	17,556
Wet Season Paddy	3.4	14,640	49,776
Upland Paddy	1.8	1,140	2,052
Maize	0.5	5,640	2,820
Cassava	3.3	6,470	21,351
Peanuts	0.5	1,020	510
Soybeans	0.4	2,450	980
Tobacco /2	0.4	90	36
Sugar cane	85.0	2,580	219,300

Note /1 Dry stalk paddy /2 Dry leaf

Data Source: Data from Agricultural offices at each Kecamatan.

Table IV-11 Cropping Area and Crop Production in Future Without Project

Kind of Crops	Unit Yield (t/ha)	Cropping Area (ha)	Crop Production (t)
Paddy /1			
Dry Season Paddy	3.5	5,320	18,620
Wet Season Paddy	3.6	14,640	52,704
Upland Paddy	1.9	1,140	2,166
Maize	0.5	5,640	2,820
Cassava	3.3	6,470	21,351
Peanuts	0.5	1,020	510
Soybeans	0.4	2,450	980
Tobacco /2	0.4	90	36
Sugar cane	85.0	2,580	219,300
Total		39,350	344,287

Note /1 Dry stalk paddy

/2 Dry leaf

Data Source: Data from Agricultural Offices at each Kecamatan.

Table IV-12 Number of Livestock Under Present Condition (1973)

(Unit: Head)

Kind of Livestock	Sukoharjo	Sragen	Total
Cattle	8,800	7,900	16,700
Buffalo	7,600	4,500	12,100
Sheep	5,000	4,900	9,900
Goat	10,600	8,300	18,900
Pig	1,800	1,500	3,300
Fowl	125,500	143,900	269,400

Data Source : Each Kecamatan Office.

Table IV-13 Livestock Production Under Present Condition

(Unit: t)

Production	Sukoharjo	Sragen	Total
Meat	672	542	1,214
Cattle	248	222	470
Buffalo	214	127	341
Sheep, Goat	88	75	163
Pig	72	60	132
Fowl	50	58	108
Egg	439	504	943
Hides	13	9	22

Data Source : Each Kecamatan Office.

Table IV-14 Farm Gate Prices of Agricultural Products

Kind of crops	Economic Price	Financial Price
	(x 10^3 Rp)	(x 10^3 Rp)
Paddy /1	60	59
Maize	30	33
Cassava	13	13
Peanuts	95	143
Soybeans	69	111
Tobacco /2	360	520
Sugar cane	5	5

Note /1 Dry stalk paddy
/2 Dry leaf

Table IV-15 Value of Agricultural Products at Present

Kind of crops	Unit Price (x 10^3 Rp)	Products (t)	Value (x 10^3 Rp)
Paddy /1	60	69,384	4,163,040
Maize	30	2,820	84,600
Cassava	13	21,351	277,563
Peanuts	95	510	48,450
Soybean	69	980	67,620
Tobacco /2	360	36	12,960
Sugar cane	5	245,100	1,225,500
Total		340,181	5,879,733

Note /1 Dry stalk paddy

/2 Dry leaf

Table IV-16 Value of Agricultural Products in Future Without Project

Kind of crops	Unit Price (x 10^3 Rp)	Products (t)	Value (x 10^3 Rp)
Paddy /1	60	73,490	4,409,400
Maize	30	2,820	84,600
Cassava	13	21,351	277,563
Peanuts	95	510	48,450
Soybean	69	980	67,620
Tobacco /2	360	36	12,960
Sugar cane	5	219,300	1,096,500
Total			5,997,093

Note /1 Dry stalk paddy
/2 Dry leaf

Table IV-17 Unit Production Cost (Without Project)

Kind of crops	Unit	Economic Cost	Financial Cost
Paddy /1		(10^3 Rp.)	(10^3 Rp.)
Dry Season Paddy	(Ha)	55.9	58.7
Wet Season Paddy	(Ha)	54.8	57.6
Upland Paddy	(Ha)	36.0	37.3
Maize	(Ha)	8.9	9.1
Cassava	(Ha)	15.2	15.2
Peanuts	(Ha)	20.6	25.6
Soybeans	(Ha)	15.4	17.8
Tobacco /2	(Ha)	107.2	109.8
Sugar cane	(Ha)	172.8	171.1

Note /1 Dry stalk paddy
/2 Dry leaf

Table IV-18 Agricultural Production Cost
(Future Without-Project)

Kind of crops	Unit Cost (x 10^3 Rp)	Crop Area (Ha)	Production Cost (x 10^3 Rp)
Paddy /1			
Dry Season Paddy	55.9	5,320	297,388
Wet Season Paddy	54.8	14,640	802,272
Upland Paddy	36.0	1,140	41,040
Maize	8.9	5,640	50,196
Cassava	15.2	6,470	98,344
Peanuts	20.6	1,020	21,012
Soybeans	15.4	2,450	37,730
Tobacco /2	107.2	90	9,648
Sugar cane	172.8	2,580	445,824
Total			1,803,454

Note /1 Dry stalk paddy /2 Dry leaf

Table IV-19 Net Values of Agricultural Production
(Future without-Project)

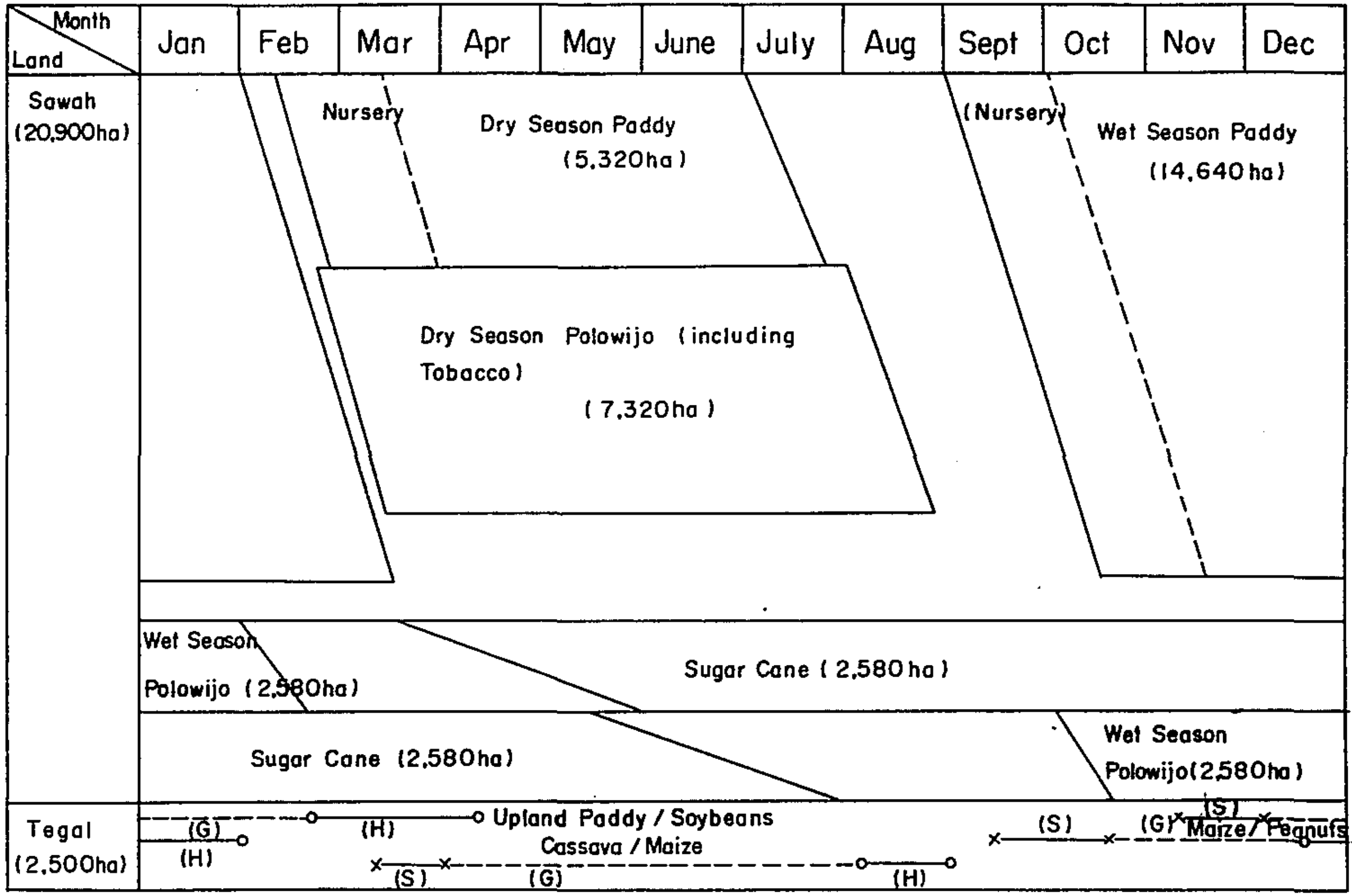
(Unit: 10^3 Rp.)

Kind of crops	Gross Value	Prod. Cost	Net Value
Paddy /1	4,409,400	1,140,700	3,268,700
Maize	84,600	50,196	34,404
Cassava	277,563	98,344	179,219
Peanuts	48,450	21,012	27,438
Soybeans	67,620	37,730	29,890
Tobacco /2	12,960	9,648	3,312
Sugar cane	1,096,500	445,824	650,676
Total	5,997,093	1,803,454	4,193,639

Note /1 Dry stalk paddy

/2 Dry leaf

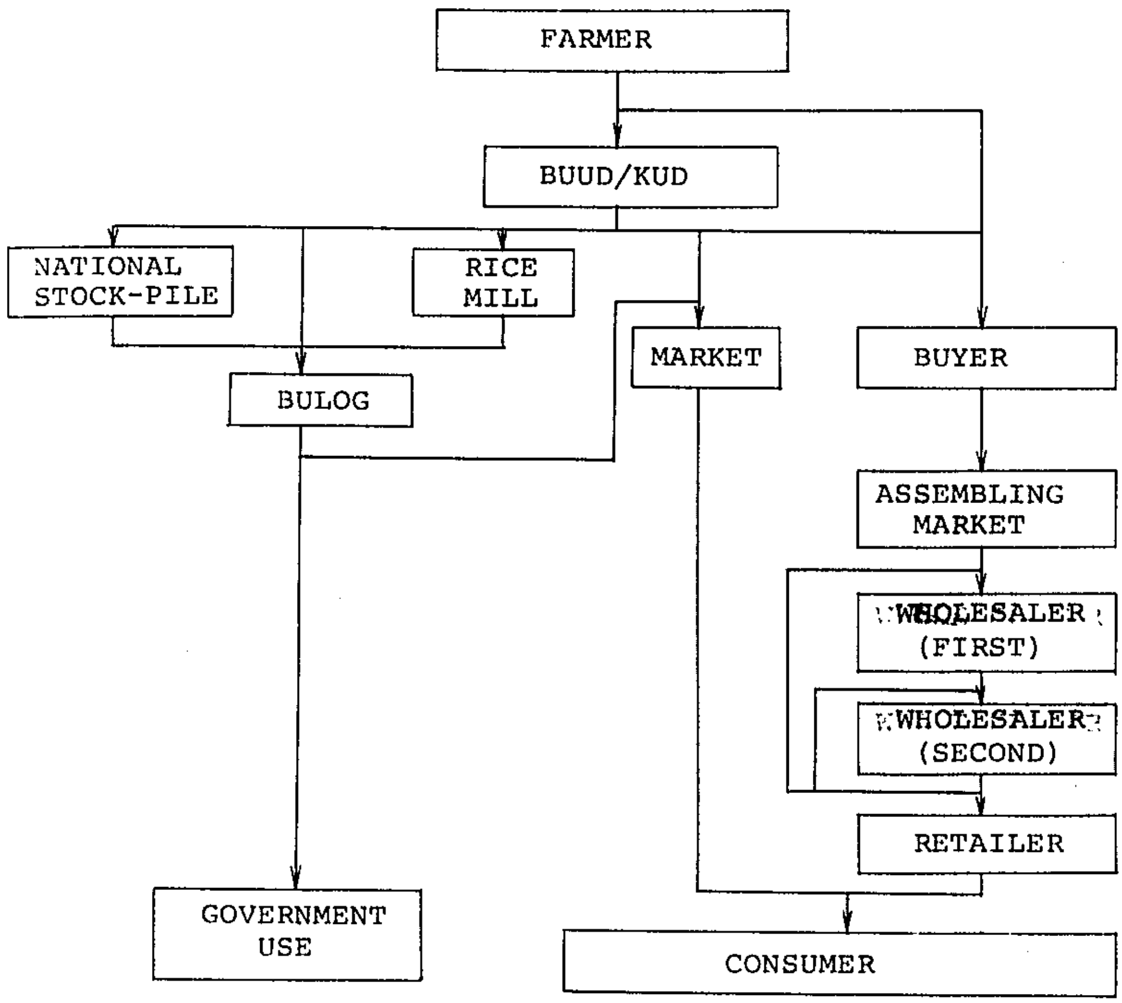
Fig IV-4. Present Cropping Pattern



Note : (S)·········Sowing (G)·········Growing (H)·········Harvesting

Badan Usaha Unit Desa (B.U.U.D.)
(Village Welfare Unit)

Fig. IV-5 MARKET FLOW OF RICE



BADAN URUSAN LOGISTIK

Fig. IV-6 MARKET FLOW OF MINOR AGRICULTURAL PRODUCTS

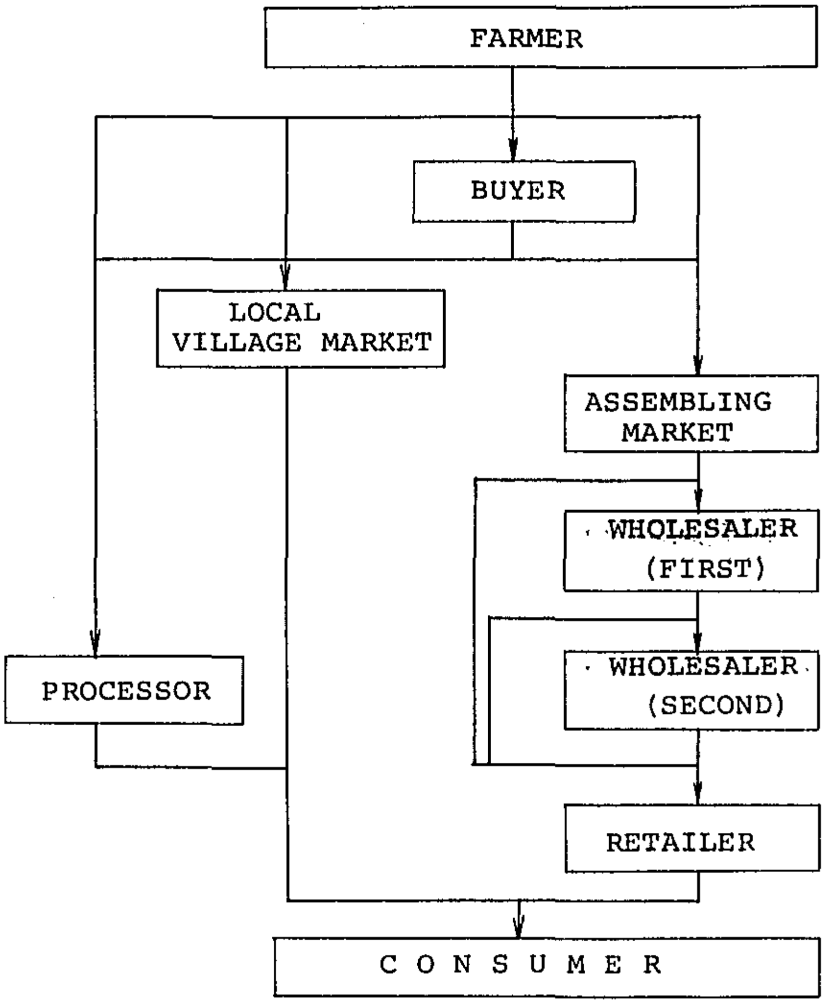
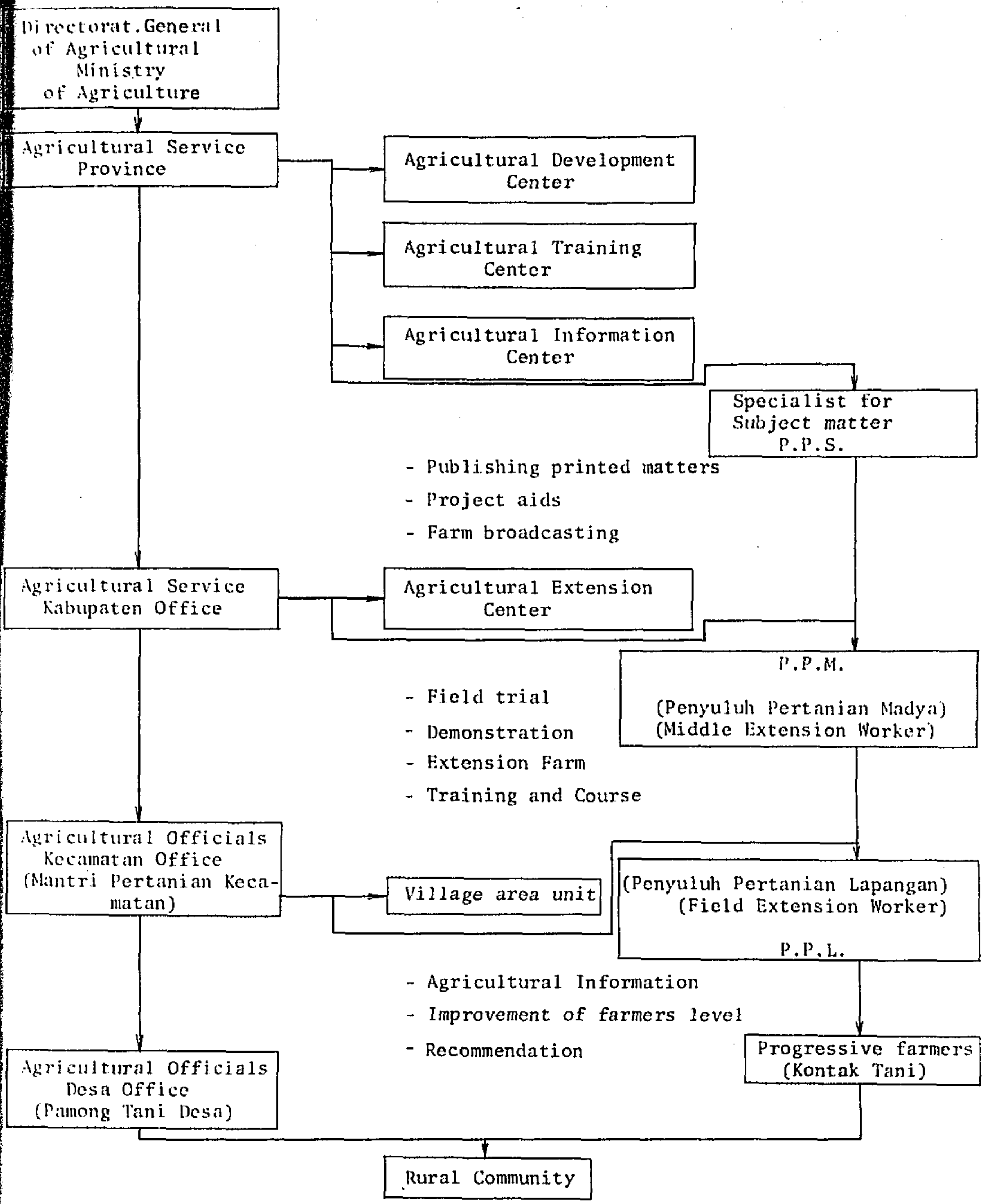
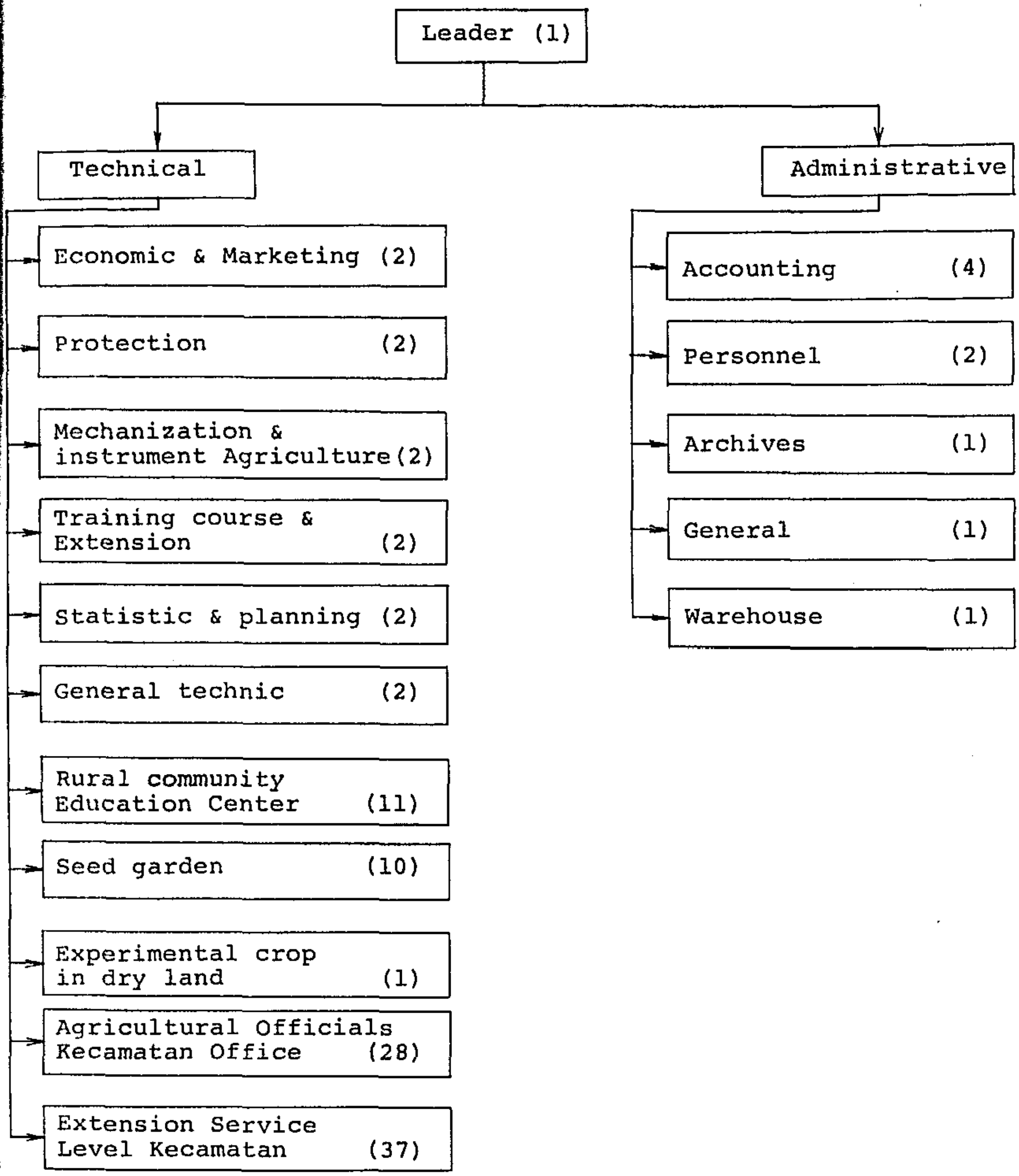


Fig. IV-7 Organization of Agricultural Extention Service.



Source: Strategi dan Program Pengembangan Tata Penyuluhan Pertanian oleh Ir. Drs. Raharjo Direktorat Penyuluhan Pertanian.

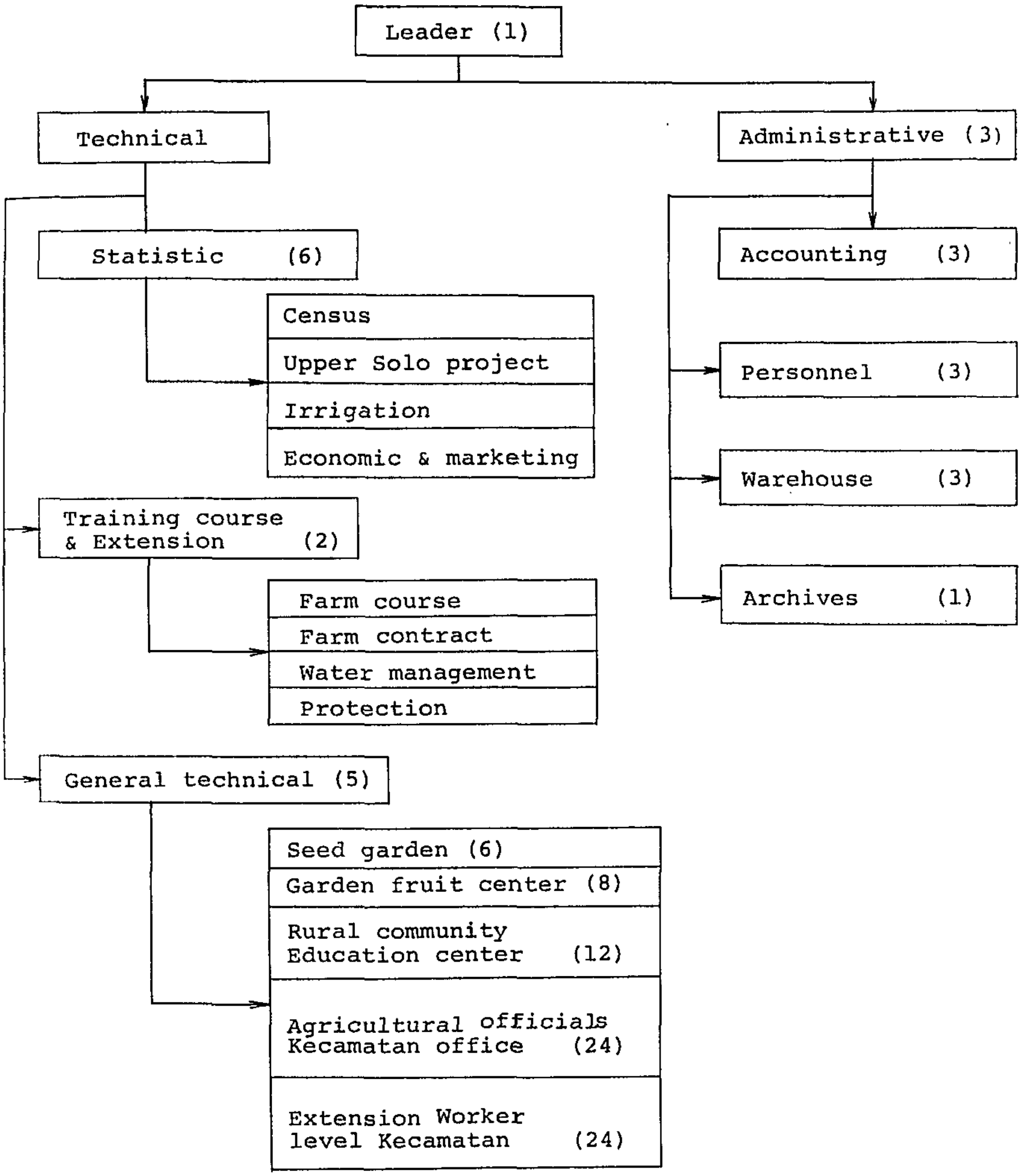
Fig. IV-8 Organization of Agriculture Extension Service
Kabupaten Sragen



Data Source : Agricultural Service
Kabupaten Office Sragen 1974.

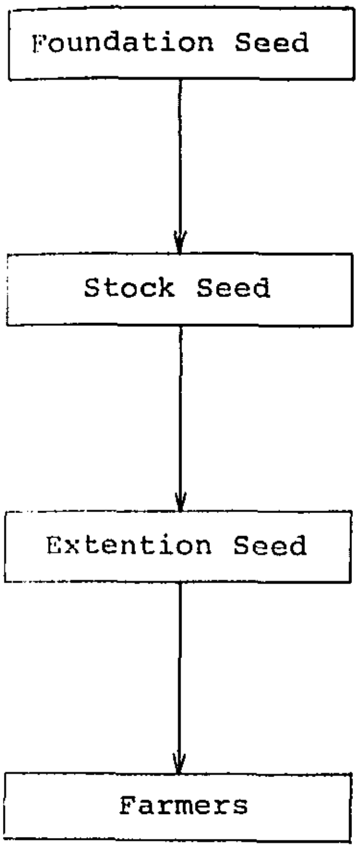
Fig. IV-9 Organization of Agriculture Extension Service

Kabupaten Sukoharjo



Data Source : Agricultural Service
Kabupaten Office Sukoharjo 1974.

Fig. IV-10 <u>Paddy Rice Seed Multiplication System Organization/Facility</u>



Foundation Seed: Central Agricultural Research Institute Bogor

Stock Seed: Branch of Central Agricultural Research Institute Tegalgondo (Klaten), Central Java

Extention Seed:
Seed Garden Kabupaten
Seed Garden Kecamatan
Seed Grower Village
Demonstration Farm
Demonstration Plot

Source : Bercocok Tanam Padi
oleh: Soemartono
Bahrin Samad
Drs. R. Harjono

C.V. Yasaguna, Jakarta 1972

4. AGRICULTURAL ECONOMY WITH PROJECT

4.1 General

To complete fruitfully the irrigation project, it is quite essential to provide sufficient water supply and efficient drainage systems and to introduce suitable crop farming. However, precise forecast of the future production pattern is rather difficult because it is closely related to prices, farming technic, socio-economic situation, and so on.

On the basis of the past data and trend, survey and analysis of the present agricultural pattern, future agricultural production in the project area is forecast as follows.

4.2 Land Use

Future land use in the Project area is basically considered to remain as it is, because even at present, the sawah along the Sala River is fully cultivated; the area classified as grass land, bushland, forestland, road and water ways is only 1% in the Sragen area, and about 10% even in the Sukoharjo area where less developed area is still seen near the hilly region.

Therefore, only limited areas of grassland and tegal will be reclaimed into paddy field and the total cultivable land will increase to 23,600 ha. However, all the sawah and tegal will be turned into irrigation land with the introduction of all weather irrigation.

4.3 Size of Farm

In the project area as a whole, there is no room to extend farm land any more. The size of a farm in future is, therefore, considered to remain at the present level. Even if the future increase of sawah of about 200 ha in the Sukoharjo area is taken into account, the future increase in the size of a farm in this area is neglegible.

As for land tenure, the present condition will be maintained even in future but with some minor changes. However, the land rent is expected to increase gradually in proportion to increase in the agricultural productivity.

4.4 Kind of Crops and Cropping Pattern

There is a little possibility that other kinds of crops than those now being cultivated in the project area will be introduced. But it is necessary to replace the cassava crop for instance, which is widely cultivated on the upland and paddy field in the dry season into other profitable crops in order to increase the productivity of the farmland. Judging from the limited land size per family in the project area, crops to be cultivated in future would be more profitable ones such as beans, tobacco and sugar cane. Paddy rice must be cultivated as much as possible as the main crop.

Kinds of crops to be introduced are usually much influenced by the price, and the regional and national requirements of the agricultural sector.

Under these concepts, basic considerations for the determination of the future cropping pattern with project are explained hereunder.

(i) Suitability of natural conditions for crop production
(ii) Socio-economic conditions such as future demand for the products and price
(iii) Increasing export and decreasing import of agriculture products
(iv) Effective water utilization not only for the dry season crops but also for the rainy season crops

Reasons for selection of each crop are explained hereunder.

<u>Paddy rice</u>

Although it is the most important crop as a main staple food, rice is still being imported. In 1973, about US$408 million of foreign exchange was spent to import about 1.2 million tons of rice. The production increase will be still required in the future because the demand for rice is expected to increase in view of the relatively high income elasticity and the anticipated steady population increase. It is also noted that rice is taken up as the most important crop in the Second Five-Year Plan.

Maize

As the production of paddy rice increases, its significance as a staple food will gradually diminish except for varieties suitable for export. But it is still listed as one of the crops for increased production in the Second Five-Year Plan.

Pulses

(Soybeans, Peanuts); These are an important vegetable protein source in the country as well as in this region. Moreover, the world demand for pulses is expected to increase in the future.

Cash crops

(Tobacco and Sugar cane); For the cultivation of these crops, natural condition is quite favorable, and the farmers in the region have a long experience of cultivating such crops. However, the present sugar production cannot meet the domestic demand. These crops are the important sources of cash income at present and the weight will be expected to increase in the future.

Under these principles future cropping pattern is projected as shown in Fig. IV-11.

Paddy will be planted extensively both in the rainy season and the dry season on sawah, while sugar cane is another crop to be planted on sawah.

In this cropping pattern, dry season paddy is nursed during April to May and harvested about 135 days after transplanted on the paddy field. Rainy season paddy is nursed during October to November and harvested after the same growth period as that of the dry season paddy. Varieties of rice to be introduced are PB-8, IR-20, B-57, C-4.

Although the varieties of paddy to be introduced with irrigation project will make short of the growing period, any change in growing period for other crops than paddy is expected. The growing period of Sugar cane introduced in the cropping pattern is of 14 months.

As for polowijo crops, they will be cultivated only on tegal. However, the present cropping pattern will be continued for some time in future on tegal cultivation because no drastic change from the present mixed culture to monoculture can be expected.

Table IV-20 shows the future land use with the project and Table IV-21 shows the acreage of crop cultivation in the future calculated on the basis of the proposed cropping pattern. Future crop intensity based on this cropping pattern will be 1.92 on an average in the project area.

4.5 Anticipated Crop Yield

Good soil condition in the Project area indicates a large potentiality of increasing crop production. It is quite possible to increase crop production, if all weather irrigation together with the introduction of improved high yielding varieties and improvement of farming practice including fertilizer application are realized.

As stated in the section of the present condition there are farms that attained 2 or 3 times higher yield compared with the local average yield. This fact indicates the future possibility of production increase in the project area. In Table IV-22, anticipated crop yield with project condition is estimated. Basic data used for this estimate are as follows:

Paddy rice

(i) Unit yield attained 4.4 - 5.8 t/ha on an average for BIMAS program during the First Five-Year Plan.

(ii) Average growth rate of unit yield per ha of 4.4 % was attained on the national level during the First Five-Year Plan.

(iii) It is reported by the Central Agriculture Institute of Bogor that the unit yield of a high yield variety at the experimental station has marked about 4.7 - 5.4 t/ha in paddy grain (about 7 t/ha in dry stalk paddy).

(iv) New varieties such as B-9-C and B-57-C which are bred from traditional varieties have attained increased unit yield of 4.6 - 5 t/ha in paddy-grain.

(v) Several experimental farms in the project area have succeeded in attaining a higher unit yield of 5 - 6 t/ha.

Other crops

(i) Recently many new high yielding varieties are bred at the Central Agricultural Institute of Bogor.
It is reported that the unit yield of new maize variety marked about 4 - 5 t/ha, cassava about 5 - 10 t/ha, peanuts 3 - 4 t/ha and so on.

(ii) Agricultural survey in the project area shows that 2 or 3 times of the present average unit yield is attained on the irrigated land.

(iii) With the project, stable increase of production can be expected by introducing new high yielding varieties and by improving the farming practice.

Total crop production with project is estimated as shown in Table IV-23 and the gross values are also estimated by applying the estimated economic price of crops in Table IV-24.

4.6 Production Cost

As the crop production increases in future, the production cost will also increase. The required amounts of agricultural inputs are estimated for each crop production taking into account the necessary incremental volume of inputs such as fertilizer, chemical and labors. The unit costs of the inputs estimated from the international forecast price are applied. The results of the estimate are presented in APPENDIX II and the production cost for each crop per ha is shown in Table IV-25. Total production costs are estimated on the basis of the unit cost and are also presented in Table IV-25.

4.7 Net Values of Prospective Agricultural Production

Table IV-26 shows prospective net values of the future agricultural production calculated based on the preceding production values and cost.

Total net values are expected at about Rp.10.1 billion (about US$24.4 million) out of which about 85% will be raised from paddy crops.

Table IV-20 Future Land Use

(Unit: Ha)

Land Category	Area
Irrigated lowland	21,200
Irrigated upland	2,400
Yard	6,800
Others	1,600
Total	32,000

Table IV-21 Acreage of Crops Cultivation in Future

Kind of Crops	Area (ha)
Paddy/1	
Dry Season Paddy	15,800
Wet Season Paddy	18,500
Maize	1,500
Cassava	1,500
Peanuts	1,500
Soybean	2,300
Tobacco/2	800
Sugar cane	2,700
Others	800
Total	45,400

Note /1 Dry stalk paddy

/2 Dry leaf

Table IV-22 Anticipated Crop Yield

Kind of Crops	Unit	Yield
Paddy/1	(ton)	5.5
Maize	(ton)	2.0
Cassava	(ton)	5.0
Peanuts	(ton)	1.5
Soybeans	(ton)	1.4
Tobacco/2	(ton)	0.8
Sugar cane	(ton)	120.0

Note /1 Dry stalk paddy
/2 Dry leaf

Table IV-23 Total Crop Production in Future

Kind of Crops	Amount (t)
Paddy/1	
Dry Season Paddy	86,900
Wet Season Paddy	101,750
Maize	3,000
Cassava	7,500
Peanuts	2,250
Soybeans	3,220
Tobacco/2	640
Sugar cane	324,000
Total	529,260

Note /1 Dry stalk paddy
/2 Dry leaf

Table IV-24 Total Production Value

Kind of Crops	Unit Price (10^3 Rp)	Production (t)	Total Value (10^3 Rp)
Paddy/1	60	188,650	11,319,000
Maize	30	3,000	90,000
Cassava	13	7,500	97,500
Peanuts	95	2,250	213,750
Soybean	69	3,220	222,180
Tobacco/2	360	640	230,400
Sugar cane	5	324,000	1,620,000
Total		529,260	13,792,830

Note /1 Dry stalk paddy
/2 Dry leaf

Table IV-25 Future Production Cost

Kind of Crops	Unit Cost (10^3 Rp/ha)	Crop Area (ha)	Prod. Cost (10^3 Rp)
Paddy/1	79.0	34,300	2,709,700
Maize	17.8	1,500	26,700
Cassava	21.3	1,500	31,950
Peanuts	42.4	1,500	63,600
Soybean	37.6	2,300	86,480
Tobacco/2	141.4	800	113,120
Sugar cane	234.4	2,700	632,880
Total		45,400	3,664,430

Note /1 Dry stalk paddy
/2 Dry leaf

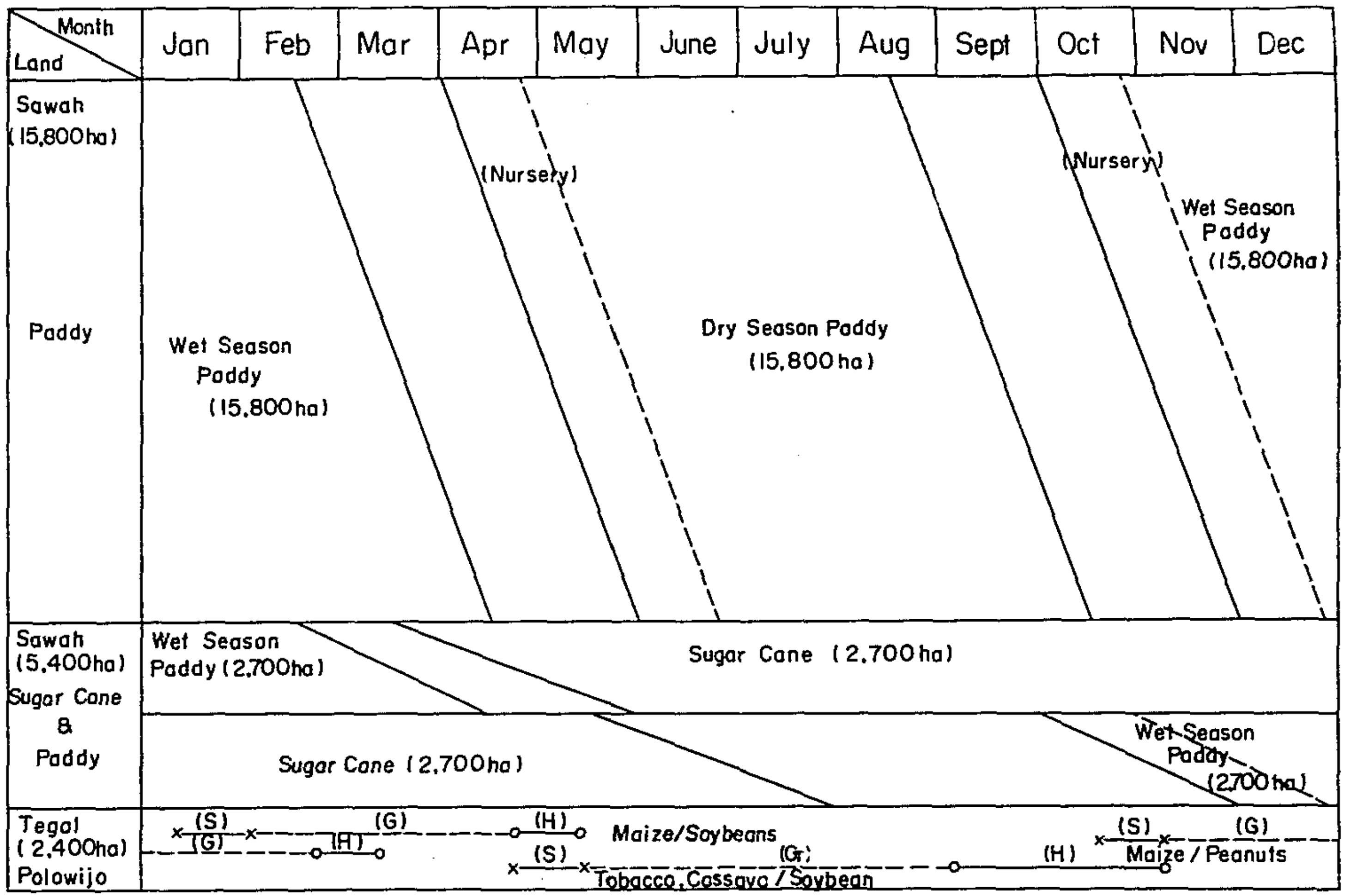
Table IV-26 Net Values of Prospective Agricultural Production

(Unit: 10^3 Rp)

Kind of Crops	Gross Value	Prod. Cost	Net Value
Paddy /1	11,319,000	2,709,700	8,609,300
Maize	90,000	26,700	63,300
Cassava	97,500	31,950	65,550
Peanuts	213,750	63,600	150,150
Soybean	222,180	86,480	135,700
Tobacco /2	230,400	113,120	117,280
Sugar cane	1,620,000	632,880	987,120
Total	13,792,830	3,664,430	10,128,400

Note /1 Dry stalk paddy
/2 Dry leaf

Fig IV-11. Future Cropping Pattern (with Project)



Note : (S) ········ Sowing (G) ········ Growing (H) ········ Harvesting

5. ESTIMATE OF IRRIGATION BENEFIT

5.1 Irrigation Benefit

Benefit of the irrigation project is evaluated from the incremental values of production of farm crops, quality improvement of the products, improvement of living environment, etc. by the implementation of the project. Some of them can be evaluated directly in monetary values, while others cannot be. Only the incremental value expected from the agricultural production is evaluated as the benefit of the irrigation project in this study. Table IV-27 shows the annual net incremental value of the agricultural products with the project.

Table IV-27 Annual Net Incremental Value at Full Operation Stage

Item	Amount (10^3Rp)
Net Value of Prospective Agricultural Production (With Project)	10,128,400
Net Value of Agricultural Production (Future Without Project)	4,193,639
Annual Incremental Value	5,934,761 (≑ US$14,300,000)

Since the estimated net incremental income is calculated on a condition that the whole of the irrigation area will be completely protected from flooding, the expected flood damage in the Sragen area should be deducted for getting the net irrigation benefit.

The anticipated flood damage in the project area is estimated at US$680 thousand in ANNEX I Study Report (1). The resulting annual benefit from the irrigation project is finally estimated at US$13,620 thousand.

The development period of the irrigation project is considered as 5 years, within which annual increase rate of the production level is assumed at 20 %.

Besides, it is expected that an additional benefit will accrue from the production increase in the area outside the project.

Upon completion of the irrigation system, the water so far used through the existing channel will not be required in the project area. Such water will be used for the increase in agricultural activities in the area outside the project area.

The amount of water additionally available is estimated at 1.0 m^3/sec in the dry season which will be able to irrigate sufficiently 1,050 ha of cultivated land outside the project area.

Since soil and land capability are considered to be almost the same as in the project area, the ancillary benefit expected is roughly estimated at about US$240 thousand/1.

5.2 Farm Budget Analysis

Farm budget in the project area is estimated by applying the financial prices of crops and the financial production costs as shown in Tables IV-28 and IV-29 for without the project and with the project conditions respectively. The typical farm size for this estimate is assumed at 0.72 ha per farm family.

As mentioned in the preceding section, crop intensity rises to 1.92 from 1.76. Gross income of the farmer will increase to about Rp.326,640 from about Rp.151,450 and the net reserve of the farmer will rise from Rp.28,650 to Rp.124,360. This increase amounts to about 4 times and indicates considerable soundness of the project from the farmers' viewpoint.

Note /1 Net value of paddy production per ha (incremental)
Rp.251,000 - Rp.154,100 = Rp.96,900/ha
(≑ US$230/ha)
1,050 ha x US$230 = 241,500 (for dry season paddy)

Table IV-28 Typical Farm Budget Without-Project

Item		Amount (Rp)
I.	Farm Income	
	Crop Income /1	122,710
	Other Income /2	28,740
	Total Gross Income	151,450
II.	Farm Expenses	
	Production Cost	
	Crop Production Costs /3	41,530
	Other Expenses /4	7,220
	(Sub-total)	(48,750)
	Living Expenses	
	Food Consumption	44,720
	Other Living Expenses	27,930
	Taxes	1,400
	(Sub-total)	(74,050)
	Total Farm Expenses	122,800
III.	Net Reserve (or Capacity to Pay)	28,650

Note /1, /3: Estimated on the basis of the average farm holding per family of 0.72 ha.

/2, /4: Includes the incomes from livestock breeding and off-farm labor which are evaluated using the "Master Plan of Sala River Basin Development".

Table IV-29 Typical Farm Budget With-Project

	Item	Amount (Rp)
I.	Farm Income	
	Crop Income /1	290,740
	Other Income /2	35,900
	Total Gross Income	326,640
II.	Farm Expenses	
	Production Costs	
	Crop Production Costs /3	82,570
	Other Expenses /4	11,790
	(Sub-total)	(94,360)
	Living Expenses	
	Food Consumption	58,580
	Other Living Expenses	46,600
	Taxes	2,740
	(Sub-total)	(107,920)
	Total Farm Expenses	202,280
III.	Net Reserve (or Capacity to Pay)	124,360

Note /1, /3: Estimated on the basis of the average farm holding per family of 0.72 ha.

/2, /4: Includes the incomes from livestock breeding and off-farm labor which are estimated using the "Master Plan of Sala River Basin Development".

APPENDIX I. COST AND RETURNS TO THE CROPS PER HA (WITHOUT - PROJECT)

1. Cost and Returns to Dry Season Paddy per Ha (Future Without-Project)

Item	Amount (RP)
Receipts (3.5 t, 60,000 RP/t)	210,000
Expenses	
Seed (40 kg, 78 RP/kg)	3,120
Fertilizer	
Urea (100 kg, 38 RP/kg)	3,800
TSP (25 kg, 38 RP/kg)	950
Pesticide	
Insecticide (1.0 ℓ, 1,500 RP/ℓ)	1,500
Labor Cost	
Land preparation (80 men, 200 RP/man day)	16,000
Planting (40 men, 150 RP/man day)	6,000
Harvesting (70 men, 150 RP/man day)	10,500
Rent of Animal (10 days, 400 RP/day)	4,000
Land Tax	2,200
Miscellaneous Expenses	7,830
Total Expenses	55,900
Net Income	154,100

2. Cost and Returns to Wet Season Paddy per Ha
(Future Without-Project)

Item	Amount (RP)
Receipts (3.6 t, 60,000 Rp/t)	216,000
Expenses	
Seed (40 kg, 78 Rp/kg)	3,120
Fertilizer	
Urea (100 kg, 38 Rp/kg)	3,800
TSP (25 kg, 38 Rp/kg)	950
Pesticide	
Insecticide (1.0 ℓ, 1,500 Rp/ℓ)	1,500
Labor Cost	
Land preparation (75 men, 200 Rp/man day)	15,000
Planting (40 men, 150 Rp/man day)	6,000
Harvesting (70 men, 150 Rp/man day)	10,500
Rent of Animal (10 days, 400 Rp/day)	4,000
Land Tax	2,200
Miscellaneous Expenses	7,730
Total Expenses	54,800
Net Income	161,200

3. Cost and Returns to Upland Paddy per Ha
(Future Without-Project)

Item	Amount (RP)
Receipts (1.9 t, 60,000 Rp/t)	114,000
Expenses	
Seed (50 kg, 78 Rp/kg)	3,900
Fertilizer	
Urea (50 kg, 38 Rp/kg)	1,900
Pesticide	
Insecticide (0.5 ℓ, 1,500 Rp/ℓ)	750
Labor Cost	
Land preparation (50 men, 200 Rp/man day)	10,000
Sowing (30 men, 150 Rp/man day)	4,500
Harvesting (50 men, 150 Rp/man day)	7,500
Rent of Animal (5 days, 400 Rp/day)	2,000
Land Tax	750
Miscellaneous Expenses	4,700
Total Expenses	36,000
Net Income	78,000

4. Cost and Returns to Maize per Ha
(Future Without-Project)

Item	Amount (RP)
Receipts (0.5 t, 30,000 Rp/t)	15,000
Expenses	
Seed (25 kg, 39 Rp/kg)	975
Fertilizer	
Urea (20 kg, 38 Rp/kg)	760
Labor Cost	
Land Preparation (5 men, 200 Rp/man day)	1,000
Sowing (5 men, 150 Rp/man day)	750
Harvesting (10 men, 150 Rp/man day)	1,500
Rent of Animal (5 days, 400 Rp/day)	2,000
Land Tax	750
Miscellaneous Expenses	1,165
Total Expenses	8,900
Net Income	6,100

5. Cost and Returns to Cassava per Ha
(Future Without-Project)

Item	Amount (RP)
Receipts (3.3 t, 13,000 Rp/t)	42,900
Expenses	
Seed (15,000 stalks, 0.1 Rp/stalk)	1,500
Labor Cost	
Land preparation (12 men, 200 Rp/man day)	2,400
Planting (15 men, 150 Rp/man day)	2,250
Harvesting (20 men, 150 Rp/man day)	3,000
Rent of Animal (5 days, 400 Rp/day)	2,000
Land Tax	450
Miscellaneous Expenses	3,600
Total Expenses	15,200
Net Income	27,700

6. Cost and Returns to Peanuts per Ha
(Future Without-Project)

Item	Amount (RP)
Receipts (0.5 t, 95,000 Rp/t)	47,500
Expenses	
Seed (40 kg, 91 Rp/kg)	3,640
Labor Cost	
Land preparation (30 men, 200 Rp/man day)	6,000
Sowing (17 men, 150 Rp/man day)	2,550
Harvesting (20 men, 150 Rp/man day)	3,000
Rent of Animal (5 days, 400 Rp/day)	2,000
Land Tax	750
Miscellaneous Expenses	2,660
Total Expenses	20,600
Net Income	26,900

7. Cost and Returns to Soybeans per Ha
(Future Without-Project)

Item	Amount (RP)
Receipts (0.4 t, 69,000 Rp/t)	27,600
Expenses	
Seed (24 kg, 90 Rp/kg)	2,160
Labor Cost	
Land preparation (20 men, 200 Rp/man day)	4,000
Sowing (10 men, 150 Rp/man day)	1,500
Harvesting (20 men, 150 Rp/man day)	3,000
Rent of Animal (5 days, 400 Rp/day)	2,000
Land Tax	750
Miscellaneous Expenses	1,990
Total Expenses	15,400
Net Income	12,200

8. Cost and Returns to Tobacco per Ha
(Future Without-Project)

Item	Amount (RP)
Receipts (0.4 t, 360,000 Rp/t)	144,000
Expenses	
Seed (12 g, 15 Rp/g)	180
Fertilizer	
ZA (200 kg, 19 Rp/kg)	3,800
Pesticide	
Insecticide (1.0 ℓ, 1,500 Rp/kg)	1,500
Labor Cost	
Land preparation (80 men, 200 Rp/man day)	16,000
Planting (40 men, 150 Rp/man day)	6,000
Weeding (180 men, 200 Rp/man day)	36,000
Harvesting (100 men, 150 Rp/man day)	15,000
Drying (50 men, 200 Rp/man day)	10,000
Rent of Animal (10 days, 400 Rp/day)	4,000
Land Tax	750
Miscellaneous Expenses	13,970
Total Expenses	107,200
Net Income	36,800

9. Cost and Returns to Sugar Cane per Ha
(Future Without-Project)

Item	Amount (RP)
Receipts (85 t, 5,000 Rp/t)	425,000
Expenses	
Seed (22,500 stalks, 1.9 Rp/stalk)	42,750
Fertilizer	
Urea (150 kg, 38 Rp/kg)	5,700
TSP (150 kg, 38 Rp/kg)	5,700
Pesticide	
Insecticide (6 ℓ, 1,500 Rp/ℓ)	9,000
Labor Cost	
Land preparation (60 men, 200 Rp/man day)	12,000
Planting (40 men, 150 Rp/man day)	6,000
Weeding and Piling (150 men, 200 Rp/man day)	30,000
Harvesting (80 men, 200 Rp/man day)	16,000
Cleaning (70 men, 200 Rp/man day)	14,000
Rent of Animal (10 days, 400 Rp/day)	4,000
Land Tax	5,100
Miscellaneous Expenses	22,550
Total Expenses	172,800
Net Income	252,200

APPENDIX II COST AND RETURNS TO THE CROPS PER HA
(WITH - PROJECT)

1. Cost and Returns to Paddy per Ha
(With - Project)

Item	Amount (Rp)
Receipts (5.5 t, 60,000 Rp/t)	330,000
Expenses	
Seed (30 Kg, 78 Rp/Kg)	2,340
Fertilizer	
Urea (200 Kg, 38 Rp/Kg)	7,600
TSP (70 Kg, 38 Rp/Kg)	2,660
Pesticide	
Insecticide (3 ℓ, 1,500 Rp/ℓ)	4,500
Rodenticide (600 g, 2 Rp/g)	1,200
Fungicide (2 ℓ, 3,000 Rp/ℓ)	6,000
Labor Cost	
Land preparation (80 men, 200 Rp/man day)	16,000
Planting (40 men, 150 Rp/man day)	6,000
Weeding and others (20 men, 200 Rp/man day)	4,000
Harvesting (80 men, 150 Rp/man day)	12,000
Rent of Animal (10 days, 400 Rp/day)	4,000
Land Tax	2,200
Miscellaneous Expenses	10,500
Total Expenses	79,000
Net Income	251,000

2. Cost and Returns to Maize per Ha
(With - Project)

Item	Amount (Rp)
Receipts (2.0 t, 30,000 Rp/t)	60,000
Expenses	
Seed (30 Kg, 39 Rp/Kg)	1,170
Fertilizer	
Urea (70 Kg, 38 Rp/Kg)	2,660
TSP (100 Kg, 38 Rp/Kg)	3,800
Pesticide	
Insecticide (1.0 ℓ, 1,500 Rp/ℓ)	1,500
Labor Cost	
Land preparation (5 men, 200 Rp/man day)	1,000
Sowing (5 men, 150 Rp/man day)	750
Harvesting (12 men, 150 Rp/man day)	1,800
Rent of Animal (5 days, 400 Rp/day)	2,000
Land Tax	750
Miscellaneous Expenses	2,370
Total Expenses	17,800
Net Income	42,200

3. Cost and Returns to Cassava per Ha
(With - Project)

Item	Amount (Rp)
Receipts (5.0 t, 13,000 Rp/t)	65,000
Expenses	
Seed (15,000 stalks, 0.1 Rp/stalk)	1,500
Fertilizer	
Urea (80 Kg, 38 Rp/Kg)	3,040
Labor Cost	
Land preparation (20 men, 200 Rp/man day)	4,000
Planting (20 men, 150 Rp/man day)	3,000
Harvesting (30 men, 150 Rp/man day)	4,500
Rent of Animal (5 days, 400 Rp/day)	2,000
Land Tax	450
Miscellaneous Expenses	2,810
Total Expenses	21,300
Net Income	43,700

4. Cost and Returns to Peanuts per Ha
(With - Project)

Item	Amount (Rp)
Receipts (1.5 t, 95,000 Rp/t)	142,500
Expenses	
Seed (50 Kg, 91 Rp/Kg)	4,550
Fertilizer	
Urea (100 Kg, 38 Rp/Kg)	3,800
Lime (100 Kg, 16 Rp/Kg)	1,600
Pesticide	
Insecticide (2 ℓ, 1,500 Rp/ℓ)	3,000
Rodenticide (600 g, 2 Rp/g)	1,200
Fungicide (1 ℓ, 3,000 Rp/ℓ)	3,000
Labor Cost	
Land preparation (40 men, 200 Rp/man day)	8,000
Sowing (20 men, 150 Rp/man day)	3,000
Harvesting (40 men, 150 Rp/man day)	6,000
Rent of Animal (5 days, 400 Rp/man day)	2,000
Land Tax	750
Miscellaneous Expenses	5,500
Total Expenses	42,400
Net Income	100,100

5. Cost and Returns to Soybeans per Ha
(With - Project)

Item	Amount (Rp)
Receipts (1.4 t, 69,000 Rp/t)	96,600
Expenses	
Seed (30 Kg, 90 Rp/Kg)	2,700
Fertilizer	
Urea (80 Kg, 38 Rp/Kg)	3,040
Lime (100 Kg, 16 Rp/Kg)	1,600
Pesticide	
Insecticide (2 ℓ, 1,500 Rp/ℓ)	3,000
Rodenticide (300 g, 2 Rp/g)	600
Fungicide (1 ℓ, 3,000 Rp/ℓ)	3,000
Labor Cost	
Land preparation (35 men, 200 Rp/man day)	7,000
Sowing (20 men, 150 Rp/man day)	3,000
Harvesting (40 men, 150 Rp/man day)	6,000
Rent of Animal (5 days, 400 Rp/day)	2,000
Land Tax	750
Miscellaneous Expenses	4,910
Total Expenses	37,600
Net Income	59,000

6. Cost and Returns to Tobacco per Ha
(With - Project)

Item	Amount (Rp)
Receipts (0.8 t, 360,000 Rp/t)	288,000
Expenses	
Seed (12 g, 15 Rp/g)	180
Fertilizer	
ZA (200 Kg, 19 Rp/Kg)	3,800
Lime (200 Kg, 16 Rp/Kg)	3,200
Pesticide	
Insecticide (5 ℓ, 1,500 Rp/ℓ)	7,500
Fungicide (3 ℓ, 3,000 Rp/ℓ)	9,000
Labor Cost	
Land preparation (100 men, 200 Rp/man day)	20,000
Planting (50 men, 150 Rp/man day)	7,500
Weeding (200 men, 200 Rp/man day)	40,000
Harvesting (100 men, 150 Rp/man day)	15,000
Drying (60 men, 200 Rp/man day)	12,000
Rent of Animal (10 days, 400 Rp/day)	4,000
Lant Tax	750
Miscellaneous Expenses	18,470
Total Expenses	141,400
Net Income	146,600

7. Costs and Returns to Sugar Cane per Ha
(With - Project)

Item	Amount (Rp)
Receipts (120 t, 5,000 Rp/t)	600,000
Expenses	
Seed (22,500 stalks, 1.9 Rp/stalk)	42,750
Fertilizer	
Urea (300 Kg, 38 Rp/Kg)	11,400
TSP (300 Kg, 38 Rp/Kg)	11,400
Lime (200 Kg, 16 Rp/Kg)	3,200
Pesticide	
Insecticide (6 ℓ, 1,500 Rp/ℓ)	9,000
Fungicide (2 ℓ, 3,000 Rp/ℓ)	6,000
Labor Cost	
Land preparation (80 men, 200 Rp/man day)	16,000
Planting (50 men, 150 Rp/man day)	7,500
Weeding and Piling (250 men, 200 Rp/man day)	50,000
Harvesting (120 men, 150 Rp/man day)	18,000
Cleaning (130 men, 150 Rp/man day)	19,500
Rent of Animal (10 days, 400 Rp/day)	4,000
Land Tax	5,100
Miscellaneous Expenses	30,550
Total Expenses	234,400
Net Income	365,600

ANNEX II

V. IRRIGATION

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1. THE PROJECT AREA

1.1 Present Condition of Irrigation Area

Well developed irrigation networks in Java had not been maintained properly for about 20 years since 1940. Irrigation systems in the project area, without exception, have deteriorated and their efficiency has dropped tremendously.

Since 1969, when the First Five-Year Development Plan (Pelita I) was enforced, the Government has made great efforts to rehabilitate the irrigation systems to increase rice production in combination with the introduction of the BIMAS and INMAS programs through the expansion of paddy fields.

However, the long neglect of maintenance and repairs prevented completion of the rehabilitation work in the short scheduled period of 5 years, and the work had to be continued during the period of the Second Five-Year Development Plan (Pelita II).

Besides the rehabilitation of the irrigation systems, the Government has adopted the following measures for the agricultural sector in Pelita - II.

As for the development of agricultural infrastructure for which the Ministry of Public Works and Power is responsibile, the sequence of priority is set out as follows:

(a) Rehabilitation works for the existing public works such as irrigation flood control and reclamation of swampy area,

(b) Continuation of the construction projects started during the period of Pelita - I,

(c) Construction of quick yielding projects to increase rice production,

(d) Development of the projects for which technical and financial aid has been provided by foreign countries,

(e) Improvement of the system of investigation, planning and design of development projects and implementation of phased development in order to obtain quick effects,

(f) Construction of new large-scale projects for which the construction period required is more than 5 years.

On the production side, the Ministry of Agriculture stresses the following five points;

(a) Improvement of cultivation techniques,

(b) Introduction and distribution of high yielding varieties of crops,

(c) Increase in the use of fertilizers,

(d) Protection from pests and plant diseases,

(e) Effective water management in irrigation water use.

On the ground mentioned above, the present condition in this project area is being improved as far as the irrigated agriculture is concerned. The existing irrigation facilities in this area presumably have been rehabilitated. Especially, the irrigation system including farm consolidation in the Sragen area and those fed by the existing irrigation reservoirs in the Karanganyar area are now functioning well.

However, at present the water sources of those existing irrigation systems mostly depend on the tributaries and several small reservoirs. Distinct variation of rainfall in the dry and wet seasons has greatly affected the utilization of such water sources for irrigation since most of the tributaries maintain running water only during the wet season of 6 months and remain dry in the dry season. Usually, water available in the dry season can hardly irrigate the area of about 40% of the existing irrigation area; this situation results in unstable production.

Compared with the existing irrigation systems, farm road networks are far from consolidated. There are almost no roads passable by motor vehicles throughout the year for hauling products, fertilizers, etc. to and from the farm. At present, considerable labor is being used for this purpose.

1.2 Traditional Water Use and Operation and Maintenance

1.2.1 Traditional Water Use

Water from the irrigation reservoirs is distributed uniformly to each block where the irrigated area is usually divided into several areas by cropping rotation. While, in the area served by tributary weirs, the most downstream areas where early cropping is practised can receive the water first, followed by the upstream areas. In the severe dry season, most upstream areas usually have preferential rights of water use.

1.2.2 Operation and maintenance

Large scale irrigation systems are operated by the provincial irrigation office. Control of water distribution is managed by directing personnel (Juru Pengairan) at sites with the assistance of the operation officer of the irrigation office. Other irrigation systems are under the management of villages (Desa). Daily operation is usually entrusted to operators (Ulu-Ulu) selected from among the villagers. Recently, organizations for water management are being established in the area, one example is the "Dharma Tirta."

Maintenance of the irrigation systems is mostly carried out by the Gotong Royong system (mutual cooperation) of the villagers with the financial support from the local Government.

As the hinterland of this project area is situated on the slope of G. Lawu where most arable lands have been cleared for crop cultivation, surface erosion is severe at times of heavy rainfall and most tributaries carry off the eroded materials. The existing diversion weirs therefore are often affected by heavy silting. These weirs are maintained by frequent operation of sand flush gates, or by hand removal of silted deposition.

1.3 Topographical Conditions

The project area extends over an area of about 32,000 ha along the Sala River at the altitude between 80 m and 100 m above SHVP. About 87% of the project area is on the right bank and extends for about 70 km long up to Kali Kedungbanteng (or Kali Sawur) which separates the Central Java Province from the East Java Province.

The area situated on the left bank is about 4,000 ha and extends up to Kali Gawe, a tributary rising in G.Merapi. K.Dengkeng, the largest tributary on the left bank of the Sala River, flows through the central part of the area.

The project land is almost flat and sloping gently toward the Sala River in the downstream direction. Many tributaries rising from G.Lawu cut through the right bank area, while there are less number of tributaries on the left bank.

Principal roads are near the east edge of the project area. In the central part, Surakarta (Sala) city is located. The total irrigable area is about 23,600 ha out of the total area of 32,000 ha as broken down below:

	Project area	Irrigable area
Left bank area	4,000 ha	2,800 ha
Right bank area	28,000 ha	20,800 ha
Total area	32,000 ha	23,600 ha

1.4 Existing Irrigation System

Concerning water supply conditions, as shown in, DWG WI-001, the project area can be classified into four areas, namely, technical, semi-technical, non-technical and rain-fed areas.

Cumulative figures of the areas classified above were obtained from the local irrigation offices as shown in Table V-1.

These areas are supplied with water by 6-irrigation reservoirs constructed on several tributaries, 42 diversion weirs on tributaries, 28 pumps and 2 springs. Pumps are usually operated in the dry season and some of them are out of order at present.

Irrigation areas classified by each water source are given in Table V-2 to V-4.

At present, Waduk (Reservoir) Lalung is being expanded to increase the storage capacity by 2 million m^3 and thereby bring the total storage capacity to 5 million m^3. This is being done by heightening the dam by 5.5 m. By this, an area of about 3,500 ha will be supplied with water.

Present irrigation areas by each water source and seasonal water utilization in the whole area of the related local irrigation districts (Seksi) are given in Table V-5 and V-6.

As shown in Fig. V-1, most of the area on the right bank in the project area is provided with water by technical irrigation systems and only two areas totalling about 3,500 ha are rainfed in the Sragen district, because of topographic conditions.

Water distribution in this area is well managed through turnouts provided with sluice gates. Distribution canals are partly lined with stone and maintained by adjustment and repairing. In particular, canals from WD.Mulur and WD.Lalung are well maintained.

In the left bank area, there are three irrigation systems. But the area served by them is narrow, except the area served by Pencit weir on Kali Dengkeng (at present, the main part of the weir is broken and most of the area is rainfed.)

The present irrigation system is fully utilized in the wet season but more than 60% of the system is not used in the dry season.

1.5 Drainage and Farm Roads

1.5.1 Drainage

The project area generally inclines with a slope of 1/200 to 1/1,000 towards the Sala River. On the slope, there are tributaries at an approximate interval of 2.5 km. The slope of the land toward every tributary is about 1/200 to 1/500.

At present, those areas in the project area at low elevations are often inundated due to backwater of the main Sala. When the water level of the Sala is low, the tributaries (about 30) function as drainage canals. A considerable number of drains exist in the farms; its density is estimated at about 10 m/ha.

1.5.2 Farm road

Existing farm roads have a width of about 2 m on an average and are in very poor condition. The network density is estimated at about 20 m/ha. There are almost no farm roads passable for motor vehicles under all weather conditions.

Table V-1 Existing Land Classification

S e k s i	Irrigated Area (ha)								Rainfed area (ha)		Total (ha)	
	Technical		Semi technical		Non-technical		Sub-total					
	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%
Sragen	16,233	35.4	5,806	12.7	5,794	12.6	27,833	60.7	18,034	39.3	45,867	100
Karanganyar	17,219	48.8	6,423	18.2	8,041	22.8	31,683	89.8	3,597	10.2	35,280	100
Klaten	21,819	48.2	13,125	28.9	3,104	6.8	38,048	83.9	7,283	3.7	45,331	100
T o t a l	55,271	43.7	25,354	20.0	16,939	13.4	97,564	77.1	28,914	22.9	126,478	100

Data source: Master Plan (D.P.U. Offices)

Table V-2 Existing Reservoir Irrigation Area

No.	Name of reservoir	Location	Constructed year	Storage capacity Design	Storage capacity Present	Sediment-ation /1	Reservoir area	Catchment area	Irrigation area Rainy season	Irrigation area Dry season	Remarks
				(10^3m^3)	(10^3m^3)	(10^3m^3)	(ha)	(km^2)	(ha)	(ha)	
1.	Mulur	Seksi Karanganyar	1921	4,935.0	3,435.0	1,500.0	100.0	50.0	4,028.0	1,530.0	
2.	Lalung	Seksi Karanganyar	1944	3,000.0 (5,000.0)	3,000.0 (5,000.0)	0	65.0	27.0	2,183.0 (5,677.0)	1,643.0	under extension
3.	Tewel	Seksi Sragen	1912	79.5	4.5	75.0	3.4	6.1	275.0	71.0	
4.	Kebangan	Seksi Sragen	1939	500.0	350.0	150.0	13.0	7.3	1,947.0	1,235.0	
5.	Gebyar	Seksi Sragen	1942	701.3	601.3	100.0	10.0	15.0	1,727.0	420.0	
6.	Brambang	Seksi Sragen	1912	103.6	93.6	10.0	4.0	6.6	709.0	185.0	
	Total								10,869.0	5,084.0	47 %

Data source: Seksi Irrigation Offices (Karanganyar, Sragen)
/1: Not actual survey (Data source: Master Plan).

Table V-3 **Existing Tributary Irrigation Area**

No.	Name of diversion weir	Name of tributary	Irrigation area (ha)		Remarks
			Rainy season	Dry season	
1.	B. Ambil-ambil	K. Ambil-ambil	223	0	
2.	B. Geneng	K. Jlantah	760	219	
3.	B. Pepen	K. Jlantah	4,028	1,530	WD. Mulur
4.	B. Langsur	K. Nglangsur	(374)	(50)	
5.	B. Dari	K. Kumet	331	30	
6.	B. Kaliduren	K. Bening	570	170	
7.	B. Gembong	K. Gembong	2,137	990	
8.	B. Trani	K. Samin			
9.	B. Pancuran	K. Cabak	34	0	
10.	B. Karanng	K. Cabak			
11.	B. Palur	K. Bibis	45	45	
12.	B. Jumek	K. Gandu	225	144	
13.	B. Dukuh	K. Gandu	283	184	
14.	B. Kalongan	K. Wulun	1,427	1,316	
15.	B. Jongkang	K. Gabahan	583	284	
16.	B. Kebak	Afvur Siwawh	210	129	
17.	B. Lungge	Afvur Siwawh	177	145	
18.	B. Pengin	K. Tempuran	891	482	
19.	B. Ledok	K. Grompol	204	64	
20.	B. Banjarsari	K. Grompol	460	187	
21.	B. Craken	K. Craken	208	67	
22.	B. Kedunggatot	K. Karang	2,033	599	
23.	B. Kedunggawe	K. Jambangan			
24.	B. Knhil	Afvur Prampalan			
25.	B. Gebang	K. Mungkung	459	162	
26.	B. Bonggo	K. Tempuran	488	163	
27.	B. Sepreh	K. Sragen	253	80	
28.	B. Karas	K. Sragen	124	31	
29.	B. Krapyak	K. Sragen	314	103	
30.	B. Randu	K. Ngrandu	256	121	
31.	B. Maron	K. Ngrandu	74	27	
32.	B. Ngarum	K. Ngarum	603	218	
33.	B. Klenteng	K. Ngampanan	938	311	
34.	B. Kedungsong	K. Bojuz	212	53	
35.	B. Nangsri	K. Karang	1,344	361	
36.	B. Kedungduren	K. Sawar	758	145	
37.	B. Winong	K. Sawar			
38.	B. Piji	K. Sawar	1,739	599	
	Sub-total		18,313	7,429	
1.	B. Garotan	K. Paijinan	319	0	
2.	B. Jatimalang	K. Dawung	235	0	
3.	B. Pencit	K. Dengkeng	250	0	
	Sub-total		804	0	
	Total		19,117	7,429	39 %

paddy 4,265 (22 %)
sugar cane 3,164 (17 %)

Data source: Seksi Irrigation Office.

Table V-4 Existing Pump Irrigation Area

No.	Name of pumps	Water source	Capacity (m^3/sec)	Power (P.S)	Irrigation area (ha)
1.	Mlale	Bengawan Solo	0.040	16	50
2.	Kalibening	Kali Bening	0.015	30	--
3.	Plosorejo	Plesorejo	0.030	16	90
4.	Kauman	K. Jlamprang	0.010	8	20
5.	Sogo	K. Sogo	0.010	8	25
6.	Murong I	K. Kenatan	0.030	16	--
7.	Murong II	K. Kenatan	0.025	15	200
8.	Kaponan I	K. Gebang	0.023	16	40
9.	Kaponan II	K. Gebang	0.035	20	50
10.	Ngagol I	B. Solo	0.016	8	25
11.	Ngagol II	B. Solo	0.016	8	25
12.	Tenggak	B. Solo	0.040	16	50
13.	Glonggong	Bend. Craken	0.045	16	25
14.	Sribit	B. Solo	0.035	16	60
15.	Gebang I	K. Jlamprang	0.015	16	25
16.	Gebang II	K. Jlamprang	0.020	20	30
17.	Bedoro	K. Kenatan	0.020	7	30
	Sub-total (Sragen)	17 sites	0.425		745
18.	Parangjoho	B. Solo	0.070	27	100
19.	Kriwen	B. Solo	0.150	50	420
20.	Joho	Afyoer	0.015	1	15
21.	Waru	K. Guworejo	0.016	15	16
22.	Sidodadi	K. Grompol	0.050	47	101
23.	Kebak	Bend. Kebak	0.016	15	20
24.	Pulosari I	K. Manggis	0.015	15	20
25.	Kemiri	Sroyo	0.016	15	17
26.	Nangari	K. Banaran	0.016	15	16
27.	Pulosari II	K. Jelok	0.015	15	20
28.	Jaten	K. Bulu	0.030	30	36
	Sub-total (Karanganyar)	11 sites	0.409		761
	T o t a l	28 sites	0.834		1,506

Data source: Master plan (D.P.U. Offices)

Table V-5 Existing Irrigated Paddy Field by Each Water Source

Seksi	Total irrigation area		Tributaries weir Irrigation area		Reservoir Irrigation area		Reservoir No.	Spring Irrigation area		Spring No.	Spring Discharge (m³/s) Rainy S.	Spring Discharge (m³/s) Dry S.	Pump Irrigation area		Pump No.	Pump Discharge (m³/sec)
Sragen	27,833 ha	(100)	10,324 ha	(37.1 %)	11,238 ha	(40.0)	15	1,122 ha	(4.0 %)	232	2.08	0.99	5,149 ha	(18.5 %)	40	1.14
Karanganyar	31,683	(100)	20,670 ha	(65.3)	9,923	(31.3)	3	108	(0.3)	206	3.45	2.07	982	(3.1)	25	0.59
Klaten	38,048	(100)	33,169	(87.2)	2,562	(6.7)	1	2,089	(5.5)	127	3.6	2.95	228	(0.6)	18	0.78
Total	97,564	(100)	64,163	(65.8)	23,723	(24.3)	19	3,319	(3.4)	565			6,359	(6.5)	83	

Note: Above figures are compiled from the data in 1968 to 1970 prepared by D.P.U. Offices
Data source: Master Plan.

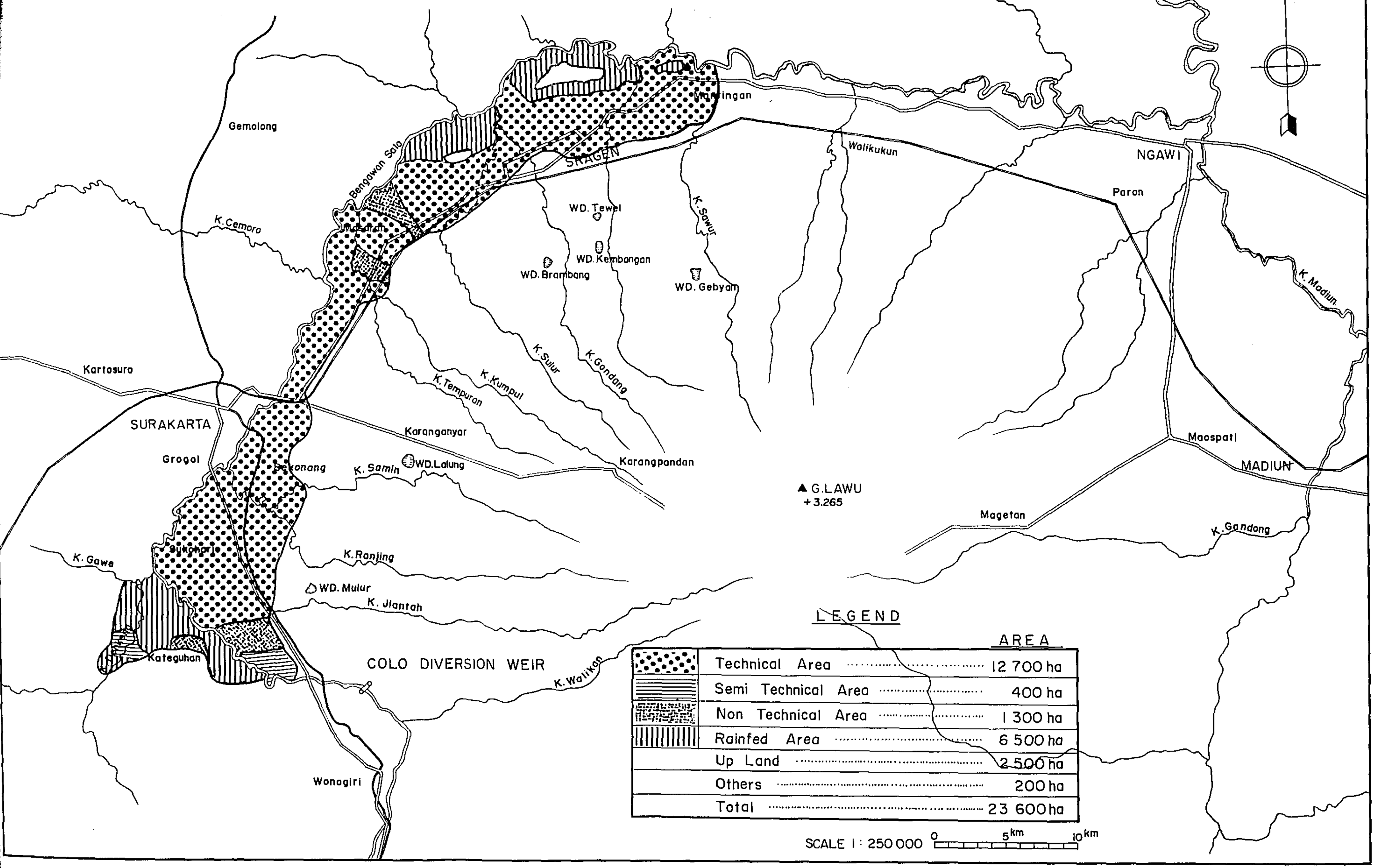
Table V-6 Existing Irrigation Water Use in Rainy and Dry Season

Seksi	Intake water Rainy season m³/s	%	Intake water Dry season m³/s	%	Intake water Total m³/s	%	Available water Rainy season m³/s	%	Available water Dry season m³/s	%	Available water Total m³/s	%	Water losses Rainy season m³/s	%	Water losses Dry season m³/s	%	Water losses Total m³/s	%
Sragen	87.65	81.1	20.42	18.9	108.07	100	58.57	84.0	11.15	16.0	69.72	100	29.08	75.8	9.27	24.2	38.35	100
Karanganyar	88.31	76.9	26.49	23.1	114.81	100	53.15	78.8	14.26	21.2	67.41	100	35.16	74.2	12.23	25.8	47.39	100
Klaten	195.55	71.0	79.84	29.0	275.39	100	187.96	72.7	70.75	27.3	258.71	100	7.59	45.5	9.09	54.5	16.68	100
Total	371.51	74.6	126.75	25.4	498.27	100	299.68	75.7	96.16	24.3	395.84	100	71.83	70.1	30.59	29.9	102.42	100

Note: (1). Above discharges show an average irrigation water in the rainy and dry seasons, estimated by using the data for three years from 1969 to 1971.
(2). Rainy season October - May
Dry season June - September.

Data source: Master Plan.

Fig. V-1 Present Irrigation Area



2. IRRIGATION PLAN

2.1 Irrigation Area

2.1.1 Proposed Irrigation Area

Main canals run on both banks along the Sala River, generally 2 to 8 km away from the river course. Proposed irrigation area will be the inner area bounded by these canals and the Sala River.

Fig. V-2 shows the administrative divisions of the proposed irrigation area; the area breakdown of each Kecamatan (township) is presented in Table V-7.

2.1.2 Land Use

The present land use in this area is given in Table V-8. Out of the present upland area of 2,500 ha and another area of 1,800 ha, 100 ha of the former and 200 ha of the latter could be turned into paddy field.

Future land use after the completion of the project is shown in Table V-9.

Among them, the lowland area of 21,200 ha and the upland area of 2,400 ha are decided as the proposed total irrigation area of 23,600 ha.

The areas situated on the left and right banks are about 2,800 ha and about 20,800 ha respectively. The total area is larger by 1,600 ha than the area proposed in the Master Plan. This increase is due to upgrading of the survey accuracy and the inclusion of an area of about 500 ha in Klaten district.

Fig. V-2 Administrative Map

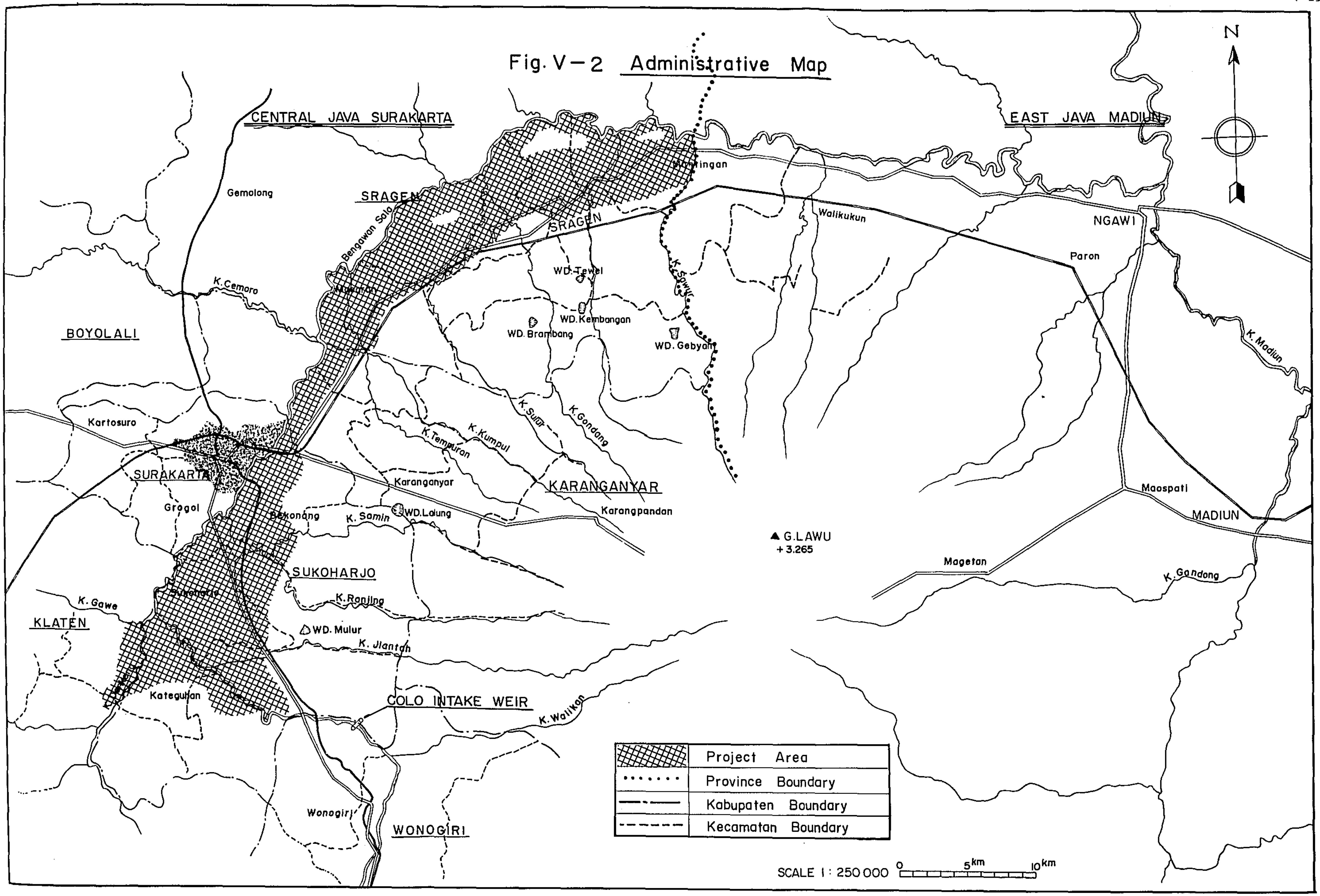


Table V-7 Irrigation Area

Kabupaten	Kecamatan	B. Sala	Irrigation Area
Sukoharjo	Nguter	Right	1,150 ha
	Sukoharjo	Right	2,450
	Bendosari	Right	860
	Polokarto	Right	430
	Grogol	Right	850
	Mojolaban		1,150
	Tawangsari		1,380
	Bulu		410
Sub-total			8,630
Karanganyar	Jaten	Right	690
	Kebakkramat	Right	990
Sub-total			1,680
Sragen	Masaran	Right	2,020
	Sidoharjo	Right	3,220
	Sragen	Right	1,840
	Ngrampal	Right	2,010
	Gondang	Right	330
	Sambungmacan	Right	2,880
Sub-total			12,300
Klaten	Karangdowo	Left	910
	Cawas	Left	80
Sub-total			990
Total			23,600

Table V-8 Present Land Use

Land category	Area (ha)
Low land	20,900
Irrigated	14,400
Rainfed	6,500
Up land	2,500
Others	1,800
Yard	6,800
Total	32,000 ha

Table V-9 Future Land Use

Land category	Area (ha)
Irrigated Low Land	21,200
Irrigated Upland	2,400
Others	1,600
Yard	6,800
Total	32,000 ha

2.2 Irrigation Water Requirement

2.2.1 General

(a) Definition

Several terms used in this section are defined as follow:

Consumptive use (U) = Evapotranspiration

Puddling requirement (PR) = Water to be required for field preparation

Water requirement (WR) = (U) + percolation + (PR)

Irrigation requirement (IR) = (WR) - Effective rainfall

Diversion requirement (DR) = (IR) x Irrigation efficiency

= (IR) + all losses (farm waste, farm ditch loss, conveyance loss, etc.)

(b) Calculation process

Firstly, consumptive use of each crop proposed and the irrigation area are calculated according to the proposed cropping pattern, and secondly, irrigation and diversion requirements for the irrigation area are calculated based on available rainfall data for the past 20 years (1953/'54 - '72/'73).

Finally, water balance calculation and frequency study of the required storage of the reservoir is worked out to determine the optimum storage capacity of the Wonogiri reservoir.

A diagram of this calculation is illustrated in Fig. V-3.

2.2.2 Consumptive Use of Crop

The most desirable way to determine the consumptive use is the actual measurement of water requirement in the field over a long period. But, since no data are available in this area at present, the Blancy-Criddle method is applied in this study.

Consumptive use obtained by this method is expressed in the following equation.

$$U = K \cdot F = Kt \cdot Kc \cdot f$$

where; U : monthly consumptive use of crops in mm

Kt: climate coefficient related to the mean air temperature
$= 0.311\ t + 0.240$

Kc: coefficient reflecting the growth stage of the crops

f : monthly consumptive use factor

$$\frac{P}{100}(45.7\ t + 813)$$

P : monthly percent of daytime hours of the year
at $7^{o} - 30'$ south latitude

t : mean monthly temperature, in ^{o}C.

In this study, mean monthly temperature is taken from the average monthly records at Panasan and Pabeland stations as shown in Table V-10.

Monthly crop coefficient of each crop is determined based on empirical data as shown in Fig. V-4 and Table V-11.

Calculation process is given in Appendix V-6 and the results are presented in Table V-12.

2.2.3 Percolation and Puddling Requirements

(a) Percolation

There are no available data of percolation measurements in this project area. Generally, the percolation rate of 1 to 3 mm/day is used for projects in Java.

Since the soil type in the project area is alluvial (60 %) and grumsol (40 %), percolation loss in the area is assumed as follows:

October - May ; 2 mm/day
June - September ; 3 mm/day

(b) Puddling requirement

Water needed for nursery puddling and field puddling is assumed to be as follows:

	Nursery	Field
Rainy season	150 mm	200 mm
Dry season	100 mm	150 mm

2.2.4 Effective Rainfall

(a) Rainfall data

Rainfall records of the past 20 years were collected from the 12 rain gauges in and around the project area.

Among them, 6 rain gauges/1 were selected as shown in Fig. V-5 for studying effective rainfall in the area by location, elevation, recorded accuracy, etc.

The average monthly rainfall in the project area in those years is presented in Table V-13. Mean annual rainfall over this area is 2,006 mm.

(b) Effective rainfall

Based on the above monthly rainfall, effective rainfall is estimated because complete daily rainfall records are not available.

Effective rainfall is presumed to be about 80 % of the total monthly rainfall, and the daily effective rainfall is calculated as shown in Table V-14. Seasonal variation of effective daily rainfall is 0.8 to 3.0 mm/day in the dry season and 5.6 to 8.4 mm/day in the rainy season.

2.2.5 Irrigation Water Requirement

(a) Cropping calendar and area

Cropping calendar adopted for the study is illustrated in

/1 See Appendix V-2.

Fig. V-6. Based on this, the monthly cropping area for the unit area of 1,000 ha for each crop is illustrated in Fig. V-7 and the total monthly irrigation area by crop is shown in Table V-15.

The nursery area in the paddy field is presumed to be 5 % of the total cropping area of paddy.
Table V-16 shows the total cropping area by crop in this project area.

Table V-16 Total Cropping Area

Crop	Area (ha)	
	Dry season	Rainy season
Paddy rice	15,800	18,500
Sugar cane	5,400	2,700
Polowijo	2,400	2,400
T o t a l	23,600 ha	

(b) Water requirements

Based on the data in the previous sections, water requirements by crops are calculated as shown in Table V-17 and V-18.

(c) Irrigation efficiency

Irrigation efficiency varies with the method of irrigation, type of crops and physical characteristics of the irrigated land.

In Java, loss rates are assumed conventionally for irrigation studies as follows.

Loss,	in	main canal	5 - 7 %
	in	secondary canal	7 - 12 %
	in	tertiary canal	30 - 60 %

Irrigation efficiency in this area is determined to be 70 % on the average, taking into consideration that the secondary and tertiary canals run through the irrigated land and reuse of water would be possible to some extent.

(d) Irrigation and diversion requirements

Based on the above water requirement of each crop, monthly irrigation requirement is calculated.

Monthly diversion requirement is then calculated by multiplying irrigation efficiency by the irrigation requirement.

Table V-19 shows the monthly diversion requirement for a period of 20 years/1. The Maximum monthly diversion requirement occurred in June, 1967/68, about 33.5 m^3/sec and the maximum annual diversion requirement was about 525 million m^3 (1961/62).

Based on the monthly requirement, the unit irrigation requirement by crop is calculated as shown in Appendix V-8.

2.2.6 Required Reservoir Storage for Irrigation Use

The water balance between the diversion requirement and the river flow at the Wonogiri dam site is calculated for a period of 20 years as shown in Appendix V-9.

Yearly deficit of water, that is the storage capacity required for the Wonogiri reservoir is presented in Table V-20. From this data, a frequency analysis of required storage for probable dry year is examined in Fig. V-8.

As shown in this figure, for the 90 % dry year (the return period of 10 years), about 400 million m^3 is required in the Wonogiri reservoir.

Besides, as the irrigation water is diverted from the Sala river after being used for power generation and then taken into canal at the Colo intake, about 13 km downstream, allowance for loss of water in this river section will be added by about 2.5 % of the required volume for conservative estimate.

Hence, the required storage capacity of Wonogiri reservoir is 410 million m^3 for irrigation use.

/1 Ref. Appendix V-7 for further details of calculation

The storage will consist of

- Storage for net irrigation requirement 400×10^6 m^3
- Allowance for loss of irrigation water 10×10^6 m^3
- Storage for water release to the downstream areas during the dry season 30×10^6 m^3 (about 2 m^3/sec)

The total storage capacity is 440×10^6 m^3.

Table V-10

Monthly Percentage of Day-time Hours and Mean Temperature

Month / Item	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
P	8.77	7.82	8.52	8.12	8.26	7.96	8.23	8.32	8.18	8.59	8.45	8.78
t	27.3	27.7	28.0	28.9	28.6	28.3	27.8	27.9	28.3	29.1	28.7	28.1

Note (P) Data Source is "Irrigation principal & Practices" by Orson W. Isnaalsen - 7° 30' south latitude.

(t) Mean value at "Panasan" and "Pabelan".

Fig.Ⅴ-3 Calculation Process

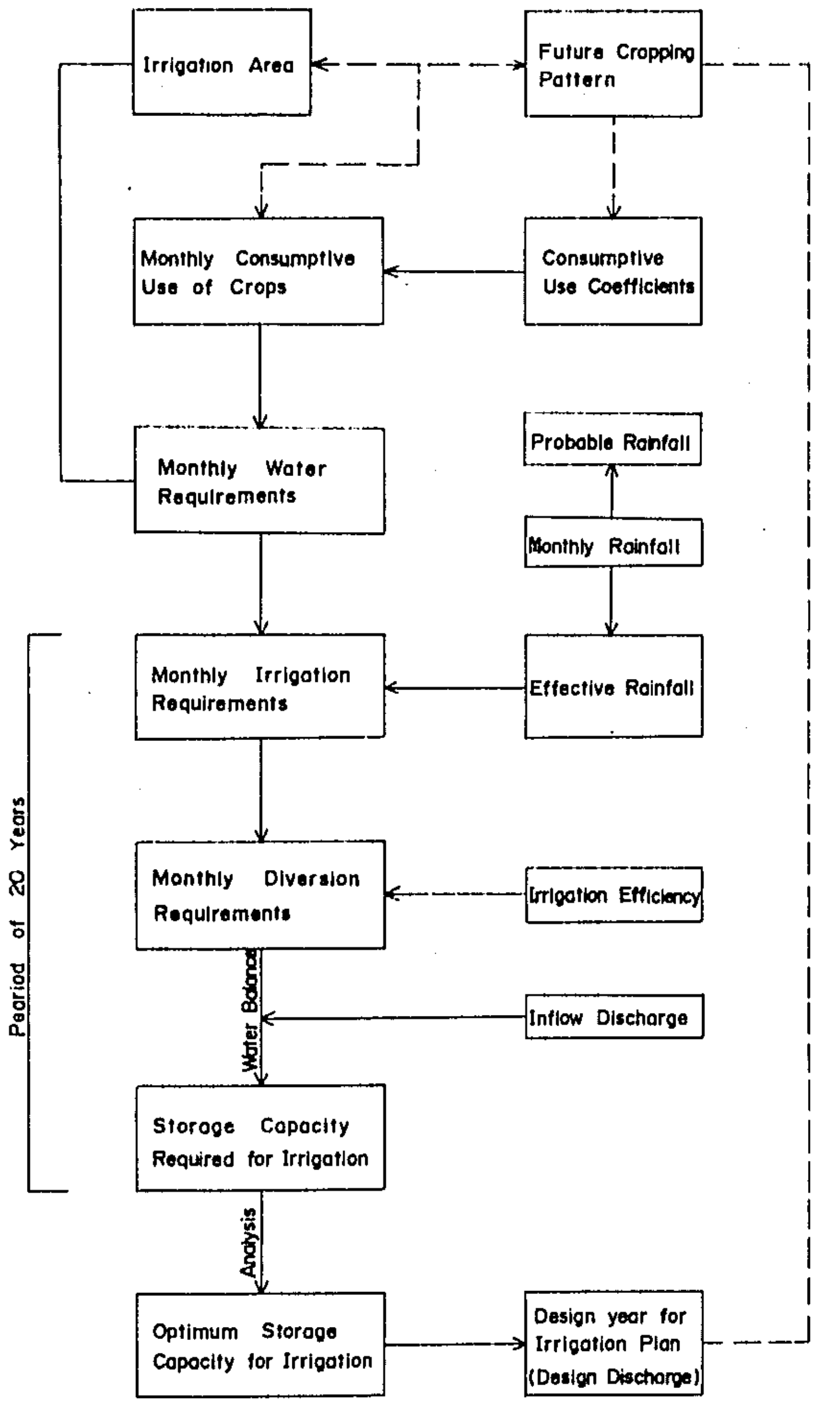


Table V-11 Consumptive Use Coefficients (Kc)

Month	Rice	Sugar cane	Polowijo
Apr.	0.91	0.65	0.6
May	1.06	0.63	0.6
June	1.31	0.55	0.6
July	1.28	0.56	0.6
Aug.	1.30	0.67	0.6
Sep.	1.50	0.75	0.6
Oct.	1.02	0.82	0.6
Nov.	0.98	0.87	0.6
Dec.	1.14	0.89	0.6
Jan.	1.11	0.90	0.6
Feb.	1.12	0.88	0.6
Mar.	1.23	0.82	0.6

Fig. V-4 Crop Coefficient Curve

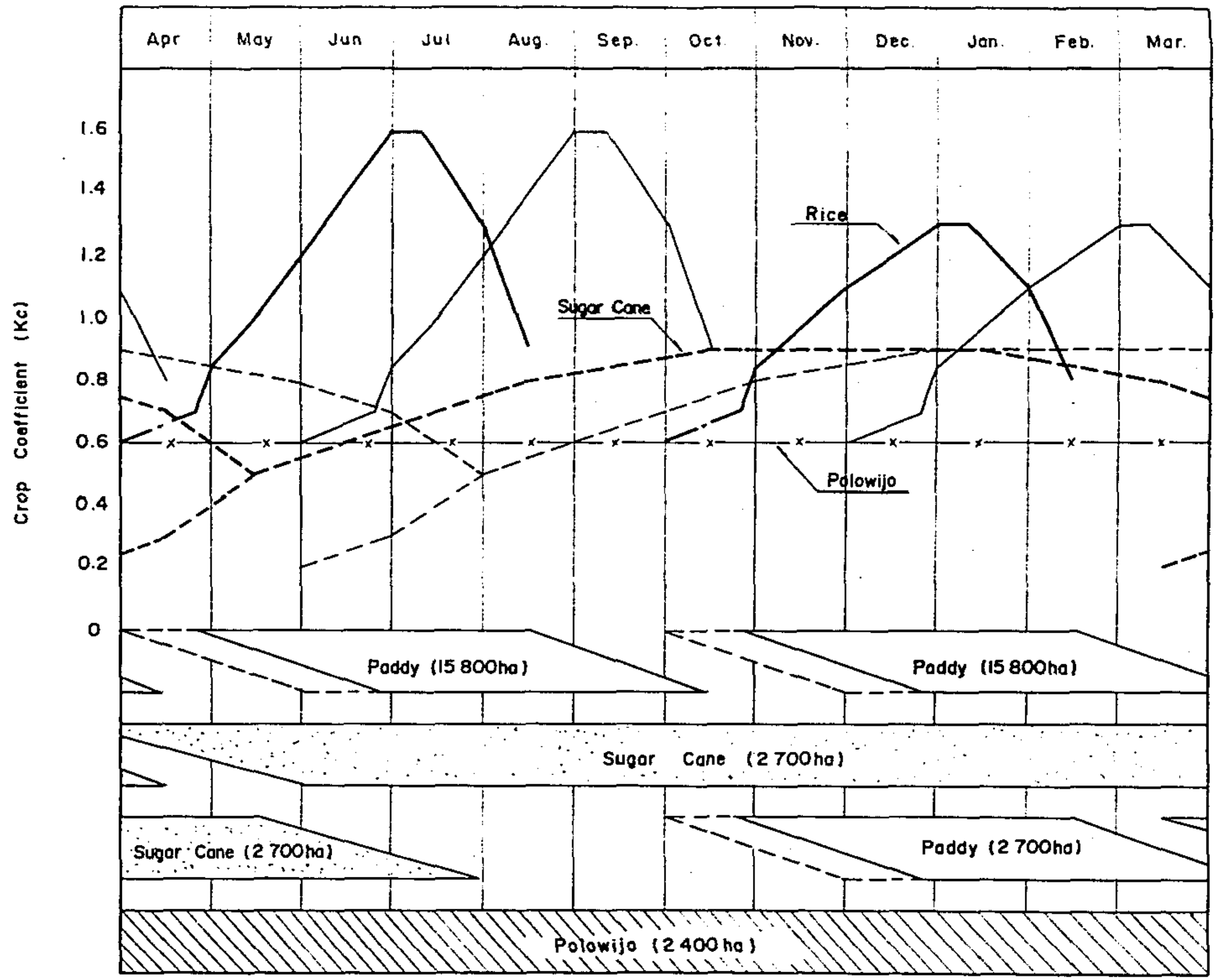


Table V-12 Consumptive Use by Crops (Unit: mm/day)

Month	Rice	Sugar cane	Polowijo
Apr.	6.0	4.3	3.9
May	6.8	4.0	3.8
June	8.2	3.5	3.7
July	7.8	3.4	3.7
Aug.	8.1	4.1	3.9
Sept.	9.6	4.8	3.8
Oct.	6.9	5.9	4.1
Nov.	6.6	5.8	4.0
Dec.	7.5	5.9	4.0
Jan.	7.1	5.7	3.8
Feb.	7.1	5.6	3.8
Mar.	7.9	5.2	3.9
Mean	7.5	4.9	3.9

Fig. V-5 Location Map of Rainfall Station

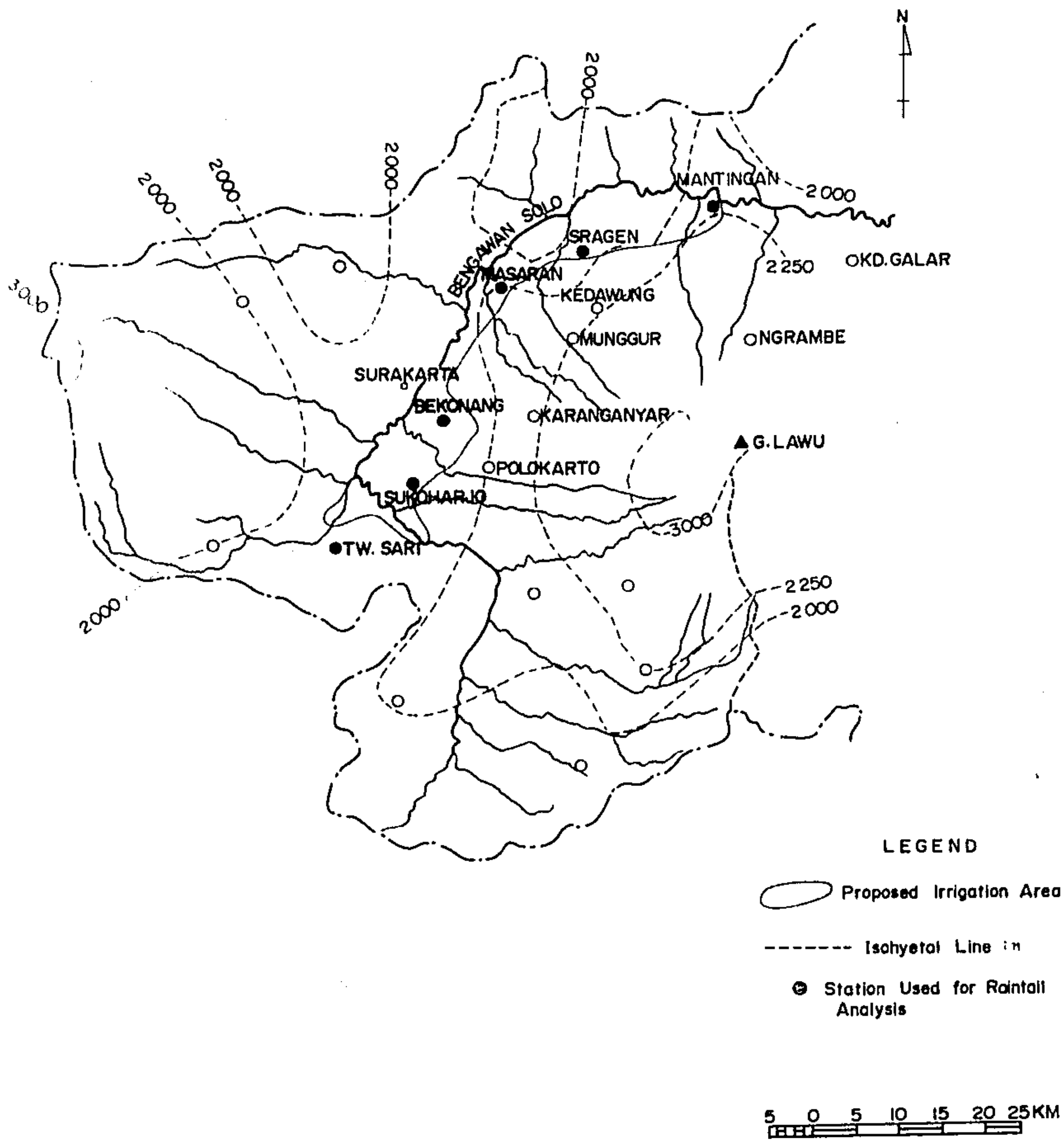


Table V-13 Average Monthly Rainfall (ave. of six rain-gauge stations)

Year	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Yearly		Dry Six Months /1	
													Total	Order	Total	Order
'53 - '54	258	181	4	32	0	0	2	235	264	392	273	183	1824	15	219	14
'54 - '55	304	256	59	94	80	69	179	337	161	290	215	301	2345	4	737	4
'55 - '56	241	38	136	230	89	39	166	286	312	443	260	167	2407	3	698	5
'56 - '57	185	142	201	111	113	91	129	151	243	197	197	311	2071	7	787	3
'57 - '58	158	46	20	154	36	4	31	193	289	233	375	409	1948	10	291	13
'58 - '59	255	205	73	169	90	101	192	211	415	296	300	356	2663	1	830	1
'59 - '60	230	147	72	75	6	33	67	205	332	235	392	189	1983	9	400	10
'60 - '61	193	195	20	20	8	19	95	419	155	253	236	243	1856	13	357	11
'61 - '62	171	107	13	11	0	2	41	209	246	389	273	294	1756	18	174	17
'62 - '63	385	89	59	89	52	11	104	223	362	277	299	295	2245	6	404	9
'63 - '64	233	18	30	0	0	0	35	129	257	172	249	279	1402	20	83	19
'64 - '65	237	207	82	31	38	56	294	135	236	328	281	364	2289	5	651	6
'65 - '66	126	53	24	42	0	3	27	273	220	311	395	381	1855	14	149	18
'66 - '67	189	61	78	0	7	21	241	202	219	446	251	188	1903	11	356	12
'67 - '68	121	21	0	0	0	8	28	180	219	324	288	402	1591	19	57	20
'68 - '69	250	200	157	159	80	63	133	350	267	274	297	266	2496	2	792	2
'69 - '70	271	42	7	0	2	0	142	171	303	239	277	330	1784	16	193	15
'70 - '71	150	216	40	33	1	62	73	249	211	235	379	396	2045	8	425	7
'71 - '72	105	154	75	30	8	33	255	177	247	225	137	330	1776	17	405	8
'72 - '73	178	160	4	0	16	0	2	188	215	391	408	327	1889	12	182	16
Mean	212	117	58	64	31	31	112	226	259	298	289	301	2006		350	

/1 : from May to Oct. or from Apr. to Sep.

Table V-14 Average Effective Rainfall (Apr. 1953 - Mar. 1973) unit: mm/day

Year	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Mean	
'53 - '54	6.9	4.7	0.1	0.8	0	0	0.1	6.3	6.8	10.1	7.5	4.7	4.0	
'54 - '55	8.1	6.6	1.6	2.4	2.1	1.8	4.6	9.0	4.2	7.5	6.1	7.8	5.1	
'55 - '56	6.4	1.0	3.6	5.9	2.3	1.0	4.3	7.6	8.1	11.4	7.4	4.3	5.3	
'56 - '57	4.9	3.7	5.4	2.9	2.9	2.4	3.3	4.0	6.3	5.1	5.4	8.0	4.5	
'57 - '58	4.2	1.2	0.5	4.0	0.9	0.1	0.8	5.1	7.5	6.0	10.7	10.6	4.3	
'58 - '59	6.8	5.3	1.9	4.4	2.3	2.7	5.0	5.6	10.7	7.6	8.6	9.2	5.8	
'59 - '60	6.1	3.8	1.9	1.9	0.2	0.9	1.7	5.5	8.6	6.1	10.8	4.9	4.3	T - 2
'60 - '61	5.1	5.0	0.5	0.5	0.2	0.5	2.5	11.2	4.0	6.5	6.7	6.3	4.1	
'61 - '62	4.6	2.8	0.3	0.3	0	0.1	1.1	5.6	6.3	10.0	7.8	7.6	3.8	T - 5
'62 - '63	10.3	2.3	1.6	2.3	1.3	0.3	2.7	5.9	9.3	7.1	8.2	7.6	4.9	
'63 - '64	6.2	0.5	0.8	0	0	0	0.9	3.4	6.6	4.4	7.1	7.2	3.1	
'64 - '65	6.3	5.3	2.2	0.8	1.0	1.5	7.6	3.6	6.1	8.5	8.0	9.4	5.0	
'65 - '66	3.4	1.4	0.6	1.1	0	0.1	0.7	7.3	5.7	8.0	10.9	9.8	4.1	
'66 - '67	5.0	1.6	2.1	0	0.2	0.6	6.2	5.4	5.7	11.5	7.2	4.9	4.2	
'67 - '68	3.2	0.5	0	0	0	0.2	0.7	4.8	5.7	8.4	8.2	10.4	3.5	T - 10
'68 - '69	6.7	5.2	4.2	4.1	2.1	1.7	3.4	9.3	6.9	7.1	8.2	6.9	5.5	
'69 - '70	7.2	1.1	0.2	0	0.1	0	3.7	4.6	7.8	6.2	7.9	8.5	3.9	
'70 - '71	4.0	5.6	1.1	0.9	0	1.7	1.9	6.6	5.4	6.1	10.8	10.2	4.5	
'71 - '72	2.8	4.0	2.0	0.8	0.2	0.9	6.6	4.7	6.4	5.8	3.9	8.5	3.9	
'72 - '73	4.7	4.1	0.1	0	0.4	0	0.1	5.0	5.5	10.1	11.5	8.4	4.1	
Mean	5.0	3.0	1.5	1.7	0.8	0.8	2.9	6.0	6.7	7.7	8.4	7.8	4.3	

Fig. V − 6 Futuve Cropping Calendar

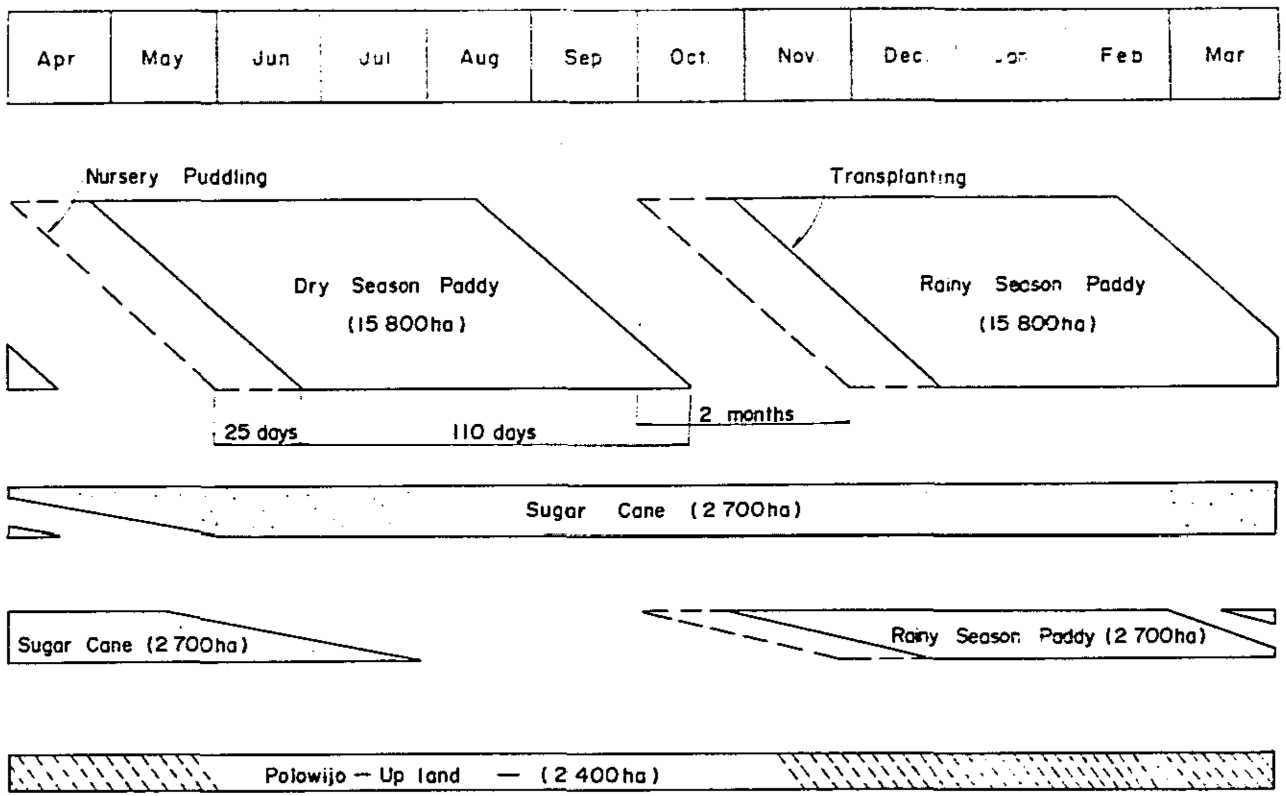


Fig. V-7 Monthly Irrigation Area by Cropping Pattern in Case of Cultivation Area of 1000 ha

	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	
	Dry Season Paddy						Wet Season Paddy						(15 800 ha)
Paddy (Nursery Puddling)	0.83∠1	0.83					0.83	0.83					
(Puddling)	2.8 ∠2	16.7	13.9				2.8	16.7	13.9				
(Growing)	81 ∠3	341	823	1 000	938	500	81	341	823	1 000	938	500	
	Sugar Cane												(2 700 ha)
Sugar Cane	400	800	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	
Paddy (Growing)	63												
	Sugar Cane						Wet Season Paddy						(2 700 ha)
Sugar Cane	1 000	950	600	200								50	
Paddy (Nursery Puddling)							0.83	0.83					
(Puddling)							2.8	16.7	13.9				
(Growing)							18	341	823	1 000	938	500	
	Polowijo												(2 400 ha)
Polowijo	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	

Note : Nursery area is equivalent to 5% of cultivation area
(1000 ha x 0.05 = 50 ha)

$\angle 1 = 50/60 = 0.83$

$\angle 2 = 1000 \times 5/60 \times 1/30 = 2.8$

$\angle 3 = 1000 \times (5/60 \times 5/30 \times 1/2 + 15/60 \times 15/30 \times 1/2) - 2.8^{\angle 2} + 14^{\angle 4} = 81$

$\angle 4$ = Nursery Area $= 50 \times 30/60 \times (25/30 \times 1/2 + 5/30) - 0.83^{\angle 1} = 14$

Table V - 15 Monthly Total Irrigation Area by Crop (Unit: ha)

Crop	Month	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Paddy	Nursery puddling	13	13					15	15				
	Puddling	44	264	220				52	309	257			
	Growing	1,450	5,388	13,003	15,800	14,820	7,900	1,328	6,309	15,226	18,500	17,353	9,250
	Total	1,507	5,665	13,223	15,800	14,820	7,900	1,395	6,633	15,483	18,500	17,353	9,250
Sugar Cane		3,180	4,725	4,320	3,240	2,700	"	"	"	"	"	"	2,835
Polowijo		2,400	"	"	"	"	"	"	"	"	"	"	"
Total		7,687	12,790	19,943	21,440	19,920	13,000	6,495	11,733	20,583	23,600	22,453	14,485

Table V-17 Calculation of Water Requirement - Paddy Rice -

Month	Puddling Requirement (1) nursery (mm)	Puddling Requirement (2) Paddy field (mm)	(3) Consumptive use (mm/day)	(4) Percolation (mm/day)	(5) (3)+(4) (mm/day)	Irrigation Area (6) Nursery puddling (ha)	Irrigation Area (7) Paddy puddling (ha)	Irrigation Area (8) Growing (ha)	Water Requirement (9) (m^3/day)	Water Requirement (10) m^3/sec
Apr	100	150	6.0	2.0	8.0	13	44	1,450	195,000	2.26
May	100	150	6.8	"	8.8	13	264	5,388	883,144	10.22
June		150	8.2	3.0	11.2		220	13,003	1,786,336	20.68
July			7.8	"	10.8			15,800	1,706,400	19.75
Aug			8.1	"	11.1			14,820	1,645,020	19.04
Sep			9.6	"	12.6			7,900	995,400	11.52
Oct	150	200	6.9	2.0	8.9	15	52	1,328	244,692	2.83
Nov	150	200	6.6	"	8.6	15	309	6,309	1,183,074	13.69
Dec		200	7.5	"	9.5		257	15,226	1,960,470	22.69
Jan			7.1	"	9.1			18,500	1,683,500	19.48
Feb			7.1	"	9.1			17,353	1,579,123	18.28
Mar			7.9	"	9.9			9,250	915,750	10.60

Note:

(9) = ((1) x (6) + (2) x (7) + (5) x (8)) x 10

Table V-18 Calculation of Water Requirement - Sugar Cane & Polowijo -

Month	Sugar Cane				Polowijo			
	(1) U	(2) I.A.	(3) Water Requirement		(1) U	(2) I.A.	(3) Water Requirement	
			m^3/day	m^3/sec			m^3/day	m^3/sec
	mm	ha			mm	ha		
Apr	4.3	3,780	162,540	1.88	3.9	2,400	93,600	1.08
May	4.0	4,725	189,000	2.19	3.8	"	91,200	1.06
June	3.5	4,320	151,200	1.75	3.7	"	88,800	1.03
July	3.4	3,240	110,160	1.28	3.7	"	88,800	1.03
Aug	4.1	2,700	110,700	1.28	3.9	"	93,600	1.08
Sept	4.8	"	129,600	1.50	3.8	"	91,200	1.06
Oct	5.9	"	159,300	1.84	4.1	"	98,400	1.14
Nov	5.8	"	156,600	1.81	4.0	"	96,000	1.11
Dec	5.9	"	159,300	1.84	4.0	"	96,000	1.11
Jan	5.7	"	153,900	1.78	3.8	"	91,200	1.06
Feb	5.6	"	151,200	1.75	3.8	"	91,200	1.06
Mar	5.2	2,835	140,400	1.63	3.9	"	93,600	1.08

Note: U = Consumptive Use I.A. = Irrigation Area

(3) = (1) x (2) x 10

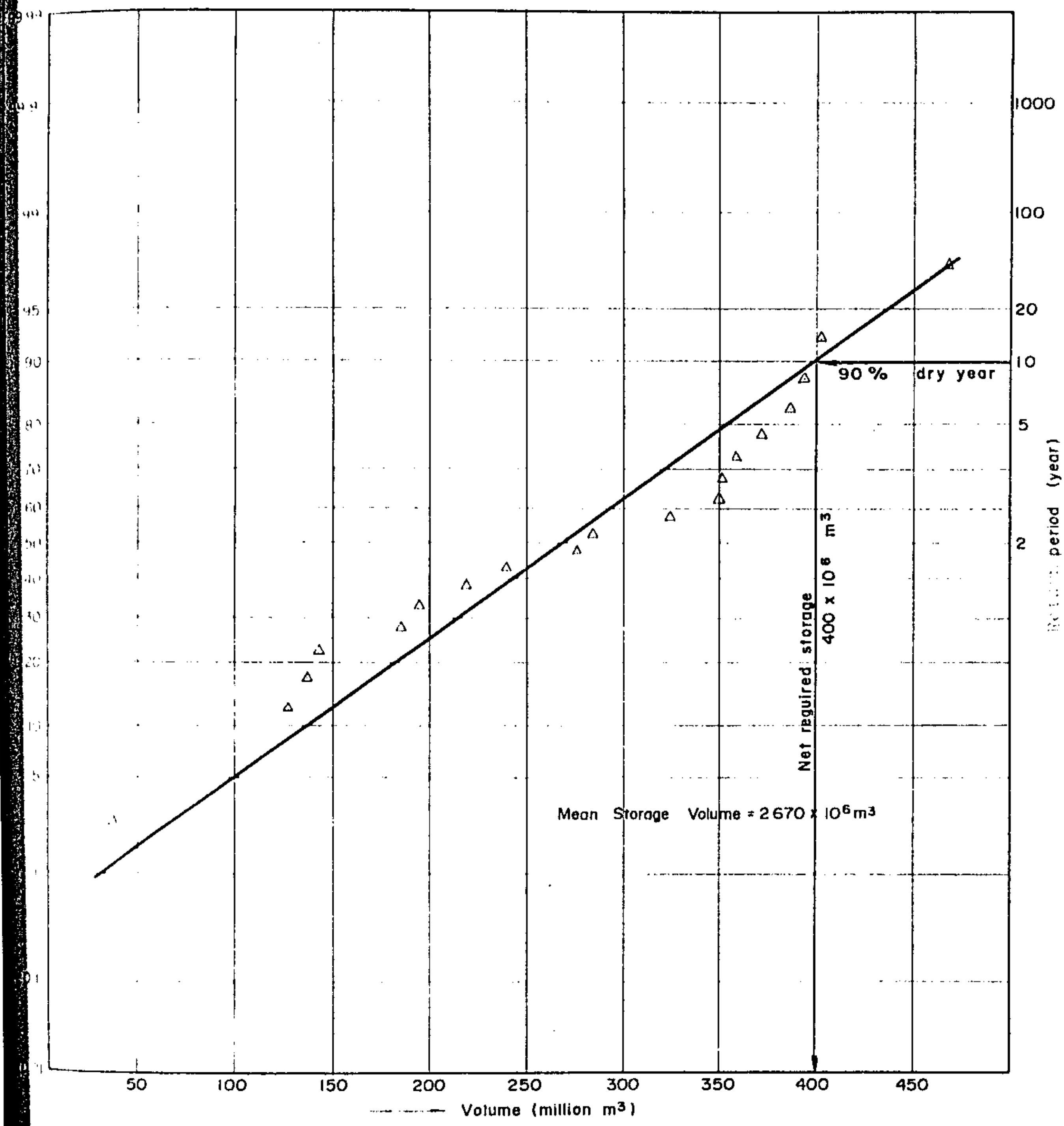
Table V-19 Monthly Diversion Requirement (Unit: m^3/sec)

Year	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Mean
1953 - 1954	1.51	10.20	33.19	28.69	30.57	20.11	8.19	12.64	15.00	0	4.60	7.96	14.39
'54 - '55	1.21	8.41	28.24	23.00	23.66	16.24	3.56	9.69	22.41	4.89	8.61	3.21	12.76
'55 - '56	1.63	17.11	21.71	12.80	22.99	17.97	3.29	11.23	11.67	0	4.89	8.89	11.18
'56 - '57	2.01	11.41	17.74	21.23	21.01	14.96	4.76	15.97	16.29	12.44	10.70	2.91	12.62
'57 - '58	2.24	16.70	31.86	17.77	27.61	19.90	7.44	14.27	13.21	9.47	0	0	13.37
'58 - '59	1.53	9.63	4.39	16.71	22.99	14.31	3.29	13.50	5.03	4.59	1.44	1.07	8.21
'59 - '60	1.71	11.20	27.24	24.79	29.91	18.19	6.49	13.66	10.40	9.17	0	7.79	13.38
'60 - '61	1.96	9.91	31.86	29.74	29.91	19.03	5.63	7.27	23.01	7.94	6.89	5.51	14.89
'61 - '62	3.10	14.76	32.80	30.74	30.57	19.94	7.20	15.34	21.13	6.41	10.44	7.00	16.62
'62 - '63	0.66	14.37	28.24	23.36	26.29	19.49	4.84	13.09	3.60	6.11	2.59	3.51	12.18
'63 - '64	2.99	18.19	30.89	31.51	30.57	20.11	7.33	17.14	15.51	14.96	5.74	4.13	16.59
'64 - '65	1.66	9.63	26.26	28.69	27.27	16.89	2.99	16.80	16.80	1.83	3.16	0.77	12.73
'65 - '66	3.14	16.27	31.53	27.61	30.57	19.90	7.56	11.56	17.91	3.36	0	0.16	14.13
'66 - '67	1.99	15.87	26.60	31.51	29.91	18.81	2.61	13.80	17.91	7.34	5.46	7.79	14.97
'67 - '68	3.39	18.19	33.51	31.51	30.57	19.94	7.56	14.74	17.91	2.13	2.59	0	15.17
'68 - '69	1.56	9.73	20.36	17.50	23.66	16.47	4.66	9.36	14.76	6.11	2.59	4.59	10.95
'69 - '70	1.43	16.91	32.84	31.51	30.24	20.11	4.31	15.04	12.44	8.86	3.44	2.14	14.94
'70 - '71	2.41	9.36	29.89	28.31	30.57	16.47	6.26	12.31	18.80	9.17	4.87	0	14.04
'71 - '72	3.90	10.86	26.91	28.69	29.91	18.19	2.51	14.89	16.03	10.09	15.69	2.14	14.98
'72 - '73	2.06	10.76	33.19	31.51	29.26	20.11	8.19	41.43	18.50	0	0	2.30	14.19
Mean	2.10	12.97	27.46	25.86	27.90	18.36	5.43	13.34	15.42	6.24	4.69	3.59	13.61

Table V-20 Storage Capacity Required

Year	m^3/sec.month	10^6 m^3
1953/54	135.0	349.9
1954/55	81.9	219.4
1955/56	42.1	112.8
1956/57	55.2	143.1
1957/58	125.2	324.5
1958/59	48.5	125.7
1959/60	106.6	276.3
1960/61	131.3	351.7
1961/62	150.5	403.1
1962/63	109.4	283.6
1963/64	174.6	467.6
1964/65	92.7	240.3
1965/66	149.2	386.7
1966/67	51.0	136.6
1967/68	152.0	394.0
1968/69	13.8	35.8
1969/70	138.0	357.7
1970/71	71.7	185.8
1971/72	75.4	195.4
1972/73	138.4	370.7
Average		268.1

Fig. V-8 Probability Calculation of Storage Capacity Required



2.3 Selection of the optimum Irrigation System

2.3.1 General

In determining the most optimum irrigation system for providing the required irrigation water to the project area, the following alternatives have been studied.

ALT. - A To build the Colo diversion weir about 13 km downstream of the Wonogiri dam and to convey water by gravity flow canals therefrom.

ALT. - B To divert water directly from the reservoir into the irrigation canal and to convey water by gravity flow canal. Two sub-alternative plans were considered in this case:

(i) to divert to both banks, and

(ii) to divert to the left bank only.

ALT. - C The main system is the same as ALT. - A, but water would be pumped up to the adjacent highland areas on the way to the main canal.

ALT. - D To divide the whole irrigation area into two blocks: one is the upstream side of the existing Afvur Siwaluh of Seksi Karanganyar and the other is the downstream area therefrom.

For the upstream area, the scheme is the same as ALT.-A, while for the downstream area, two sub-alternative plans were considered:

(i) to pump up water from the Sala River and to convey water by gravity flow canal,

(ii) to build an intake barrage across the Sala River and to convey water by gravity flow canal.

Fig. V-9 and Table V-21 show the location and figures of these alternatives.

2.3.2 Detailed description of the alternative systems

The alternative irrigation systems mentioned above are further explained in detail.

The construction cost of each system is shown in Table V-22.

(Alternative plan - A)

This is the same system as proposed in the Master Plan. Head work at Colo diverts water after using for hydropower generation into the main canals running along both banks. Since the canal has to be laid out for a longer distance with limited head, the irrigation area is rather confined.

(Alternative plan - B)

B-1 To diver to both banks

This plan increases the irrigation area by about 6,000 ha, 5,000 ha on the right and 1,000 ha on the left bank compared with ALT. A. It can save the cost of the Colo diversion weir. On the other hand, the topography calls for about 17 km of tunnel or canal construction on both banks, a 5-km tunnel on left bank and a 12-km tunnel or 10-km open canal or a deep open cut more than 15 m deep with 10 tributary crossings on the right bank.

The additional cost is estimated at about US$38.5 million; for the left bank US$8.5 million, and for the right bank US$30 million. If the cost of the downstream system is the same as in ALT. - A, the additional cost is estimated at US$35.5 million/1. (See Appendix V-1)

Besides the above, the possibility of hydro-power generation at the Wonogiri dam will be sacrificed in this case.

B-2 To divert to left bank only

If this scheme is envisaged for the left bank alone, conflict with power generation will be reduced because of the slight diversion of the discharge, max. 5.4 m^3/sec. However, this will compete with ALT. - C if the water supply is small.

/1 Total additional cost - Colo weir cost
= 38.5 - 3.0 = US$35.5 million

(Alternative plan - C)

Topography of the project area gives less possibility of extending the irrigation area by this alternative scheme within economic range. The possibility is left only for the area of 600 ha in Selogiri district north of Wonogiri on the left bank. For this area, a maximum of 0.85 m^3/sec. of water has to be pumped up by gross lift of 23 m.

Total construction cost of this area including the irrigation system is estimated at US$834,000 and the annual operation cost would be about US$64,600 (See Appendix V-1).

Comparing the schemes of direct diversion through a tunnel with pump irrigation to this left bank area, the pump irrigation has the following economic advantage:

Cost of 5-km tunnel	US$8,500,000
Cost of pump/1	US$2,126,000 x 50/20/2 = 5,315,000

(Alternative plan - D)

Bounded by the existing Afvur Siwaluh of Seksi Karanganyar, the irrigation area is divided into the upstream and the downstream areas. Water to the upstream irrigation area is diverted from the Colo weir and that to the downstream area is supplied from the Sala River at a site about 5 km downstream of the Jurug highway bridge of Surakarta.

D-1 Pump-up plan

To irrigate the divided downstream area of 12,700 ha, the maximum water of 18.0 m^3/sec has to be pumped up from the Sala River. For such a large installation, it is desirable to provide 4 to 6 units of pumps to meet the seasonal variation in water demand.

Total construction cost of this pumping facility is estimated at US$5.7 million exclusive of the canal system/1. And the annual operating expenses required will be about US$252,000/1.

/1 See Appendix V-1

/2 Life of tunnel and pump is assumed to be 50 years and 20 years respectively.

D-2 Diversion weir plan

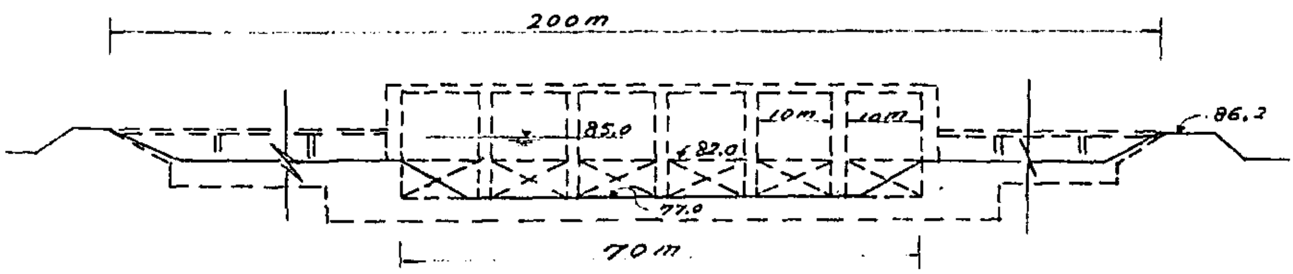
Since the Sala River widens its valley as it goes down, suitable weir site for gravity intake can hardly be found. If the water has to be led to the same area as in ALT. - A, the intake water level at the weir will have to be set at EL. 96.0 m at the lowest since the irrigation field is situated at EL. 94.0 to 95.0 m. In this case, the height of the weir comes to about 19 m above the river bed and 10 m higher than the planned formation level of the Sala level, EL. 86.2 m SHVP. Furthermore, it would submerge an area about 2 km wide and 17 km long on the upstream. Even though the levee along the Sala is raised, it will make the drainage by tributaries or sluices difficult.

In this case, the only possibility is to build a movable weir. However, manufacturing of a gate as high as 19 m or so is practically impossible. Hence, the diversion weir should be planned within practical limit combined with the river improvement scheme. Based on the present river improvement plan, the scale of the diversion weir is envisaged as follows;

Intake water level	:	EL. 82.0 m SHVP
River bed elevation	:	EL. 77.0 m
Movable section, width	:	70 m
Total length of weir	:	200 m
Gate	:	10 x 5 m @6

Sala Diversion Weir

S = 1 : 1,000



In this plan, the area irrigable by this intake weir is reduced to 7,600 ha, about 60 % of 12,700 ha. The cost of weir is estimated at US$4.5 million.

2.3.3 Operation and maintenance aspects of alternative systems

The aspects of the operation and maintenance are discussed as to ALT.-A (almost the same as B and C) and ALT.-D.

ALT. - A The main canal is 64 km long from the Colo weir to the other end with water conveyance time of about 24 hours, and it has 39 turnouts and 3 check gates on the course. Out and out water supply to the fields are indispensable to the proper operation of these facilities.

A water control organization is required, in which operation personnel make accurate gate operation and distribute water equitably to the irrigation area according to the instructions from the Central Office of Water Control (described in detail in Chapter 2.5). The personnel must always inspect the block to remove aquatic plants and dust adhering to the screens of siphons proposed at 15 sites. Also they must weed out in the canals, rectify the slopes, remove sediments (earth and sand), and so on, for maintenance to ensure good running of the water. The operation and maintenance will require US$130,000 per annum.

ALT. - D Same as in the ALT.-A, the main canal is divided into 2 sections, each length is about 30 km, but this makes the distribution time a half of the Plan A and the anticipated distribution trouble is less allowing somewhat easier water control. However, the division into two sections neither change the control method nor reduce the labor force, and the conditions in this regard are the same.

In addition to the case of ALT.-A, ALT.-D-1 requires the control of pumps and diversions.

The cost of control will be increased due to the operation of two diversions. To irrigate the same area under ALT.-A, ALT.-D must rely upon the pumping up as proposed in ALT.-D-1. In this case, the annual cost for the operation and maintenance will further increase by US$252,000 to US$382,000.

As a conclusion, ALT.-A requires more care to be taken than ALT.-D on the water control, but well trained staffs can overcome such a disadvantage. Furthermore, the cost of operation and maintenance for the ALT.-A is smaller than that for the ALT.-D.

2.3.4 Proposed irrigation system

The selection of the proposed plan from the alternative plans is made by means of the least unit cost per ha including construction cost and operation and maintenance costs.

The comparison also takes into account the operation and maintenance aspects of the irrigation systems.

As shown in Table V-22, plan A is finally selected as the most economical plan for the irrigation system. In the calculation of the unit construction cost per ha, annual operation and maintenance costs are firstly capitalized for each alternative plan by using the discount rate of 10 % with 30-year period. After calculating the total cost by adding the capitalized cost to construction cost, unit cost per ha is estimated.

Fig. V – 9 Irrigation Alternative Plan

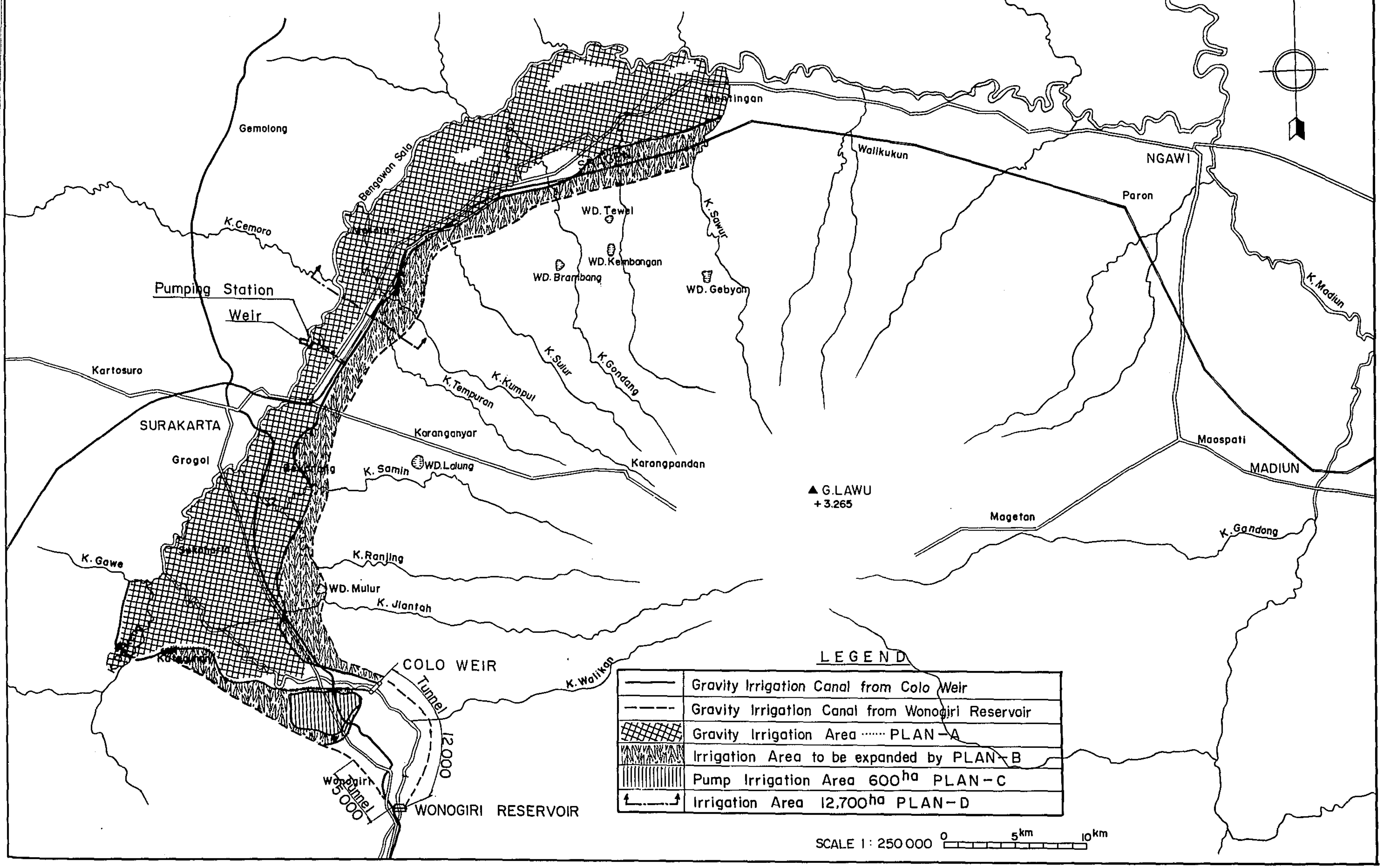


Table V-21 Summary of Comparison of the Alternatives

Item	Plan A	Plan B		Plan C	Plan D	
		1	2		1	2
Irrigation area (ha)						
Left bank	2,800	3,800	3,800	3,400	2,800	2,800
Right bank	20,800	25,800	20,800	20,800	8,100 (12,700	8,100 (7,600
Total	23,600	29,600	24,600	24,200	23,600	18,500
Main canal (km)						
Left bank	25.6	25.6	25.6	25.6	25.6	25.6
Right bank	63.9	63.9	63.9	63.9	33.0 (30.9	33.0 (30.9
Total	89.5	89.5	89.5	89.5	89.5	89.5
Tunnel (km)	-	17.0	5.0	-	-	-
Max. discharge (m^3/sec)	33.5	42.0	34.9	34.4	33.5	26.3
Colo weir	o /1	-	o	o	o	o
Surakarta weir	-	-	-	-	o	o
Pumping station	-	-	-	o	o	-
Power generation at Wonogiri	o	-	o	o	o	o

Note /1 : The item with o is required or to be installed for the plan.

V-22 Summary of Cost Comparison

(US$1,000)

Item	Plan A	Plan B		Plan C	Plan D	
		1	2		1	2
1) Construction cost	33,100	74,150	42,770	34,200	37,000	31,270
2) Annual OM cost	130	130	130	195	382	130
3) Capitalized OM cost	1,230	1,230	1,230	1,840	3,600	1,230
4) Total cost (1) + 3))	34,330	75,380	44,000	36,040	40,600	32,500
5) Unit cost per ha	1.45	2.55	1.79	1.49	1.72	1.76

2.4 Main Irrigation System

Main features of the selected irrigation system are presented in the following.

2.4.1 Headwork

For about 13 km of river length, downstream from the Wonogiri dam, several alternative sites for headwork have been studied, as shown in Fig. V-10. Selection of the proposed site was based on the following points:

(i) Keeping sufficient head at an economic cost

(ii) guaranteering structural stability at low cost

(iii) ensuring ease of construction and maintenance, as well as proximity to the irrigation area.

The study concludes that the Colo site, the lowest site, is most suitable. This site is situated near the outlet of the hilly range.

On this selected site, one concrete diversion weir having two intakes to the left and right bank canals will be constructed and will keep the water level of the Sala River up to EL.107.6 m SHVP. This intake weir will have re-regulation capacity of about 1.2 million m^3 to function as an afterbay of the Wonogiri power plant which is designed for 6-hour peak operation.

Principal features of the Colo diversion weir will be as follows.

Intake water level	106.5 m SHVP
Intake discharge, max., left	3.95 m^3/sec
right	29.55 m^3/sec
Height of weir	7.6 m
Length of weir	108.0 m
Crest elevation of weir	107.6 m SHVP
Design flood discharge (S.H.F.D.)	1,600 m^3/sec
Extraordinary flood discharge	2,000 m^3/sec

General layout of the Colo diversion weir is illustrated in Dwg. W1-003.

2.4.2 Main canal

Route of the main canal is aligned based on the available maps of 1/50,000 scale. The selected route is then surveyed to check the elevation along the route,because the presently available maps give less reliable contour elevation. Route alignment is studied from the following points of view;

(i) to select a route as straight as possible and minimize the total length,

(ii) to lay out a route to minimize crossing the settled areas and transport trunk lines.

(iii) to minimize earth work

(iv) to keep the water level in canal as high as possible.

Along the selected route, two main canals will be constructed for this irrigation area. The principal dimensions of the main canals will be as follows:

	Left	Right	Total
Irrigation area (ha)	2,800	20,800	23,600
Max. discharge (m^3/sec)	3.95	29.55	33.5
Total length (km)	25.6	63.9	89.5
Slope	1/2,500-1/3,000	1/2,500-1/6,000	
Canal density (m/ha)	9.2	3.1	3.8

As the irrigation area is narrow for about 50 km, the main canal, especially the right canal, has to cross a number of tributaries and the existing irrigation canals.

The canal will cross those tributaries by aquaducts and culverts so far as possible, and if the relative elevation makes this impossible, by syphons. The crossings of the existing canals will be replaced by turnouts and the downstream side of the existing canals will be connected to the main canal.

Most canals will be unlined excavated earth canal.

General layout and profile of the main canal route is illustrated in Fig. V-11 and Dwg. WI-002, WI-005 to WI-007.

2.4.3 Secondary canal

Secondary canals will be constructed to supply the water from the main canal to the extreme end area of 150 ha. Out of the total number of secondary canals required for this area, existing irrigation canals will be utilized for about half of them with some modification of cross section and slope. Among the existing canals, there are some which can be utilized as secondary canals with some rehabilitation.

Number and length of the secondary canals will be as follows:

	Left	Right	Total
Number	5	32	37
Total length (km)	13.1	131.8	144.9
(Length requiring only minor rehabilitation (km))	(1.0)	(31.7)	(32.7)

2.4.4 Regulating reservoir

Generally the function of the regulating reservoir is as follows.

(a) Variation in the discharge will be reduced and the cross section of the canal will be also reduced.

(b) It will enable to store and use surplus river water.

(c) Water-distribution management will be smooth and water loss will be decreased.

(d) Maintenance and repair of the canal will be easy.

(e) Canal system will be simple.

It would be desirable to provide some regulating reservoirs on the route of the main canal for controlling water distribution over such a long distance as the water has to travel about 24 hours.

However, in this project area, to provide the regulating reservoir on the main canal requires a considerable head and makes the irrigable area narrower. These reservoirs are planned, therefore, on the route of the secondary canals and are provided for three canals which will serve the area of more than 1,800 ha.

There are six existing reservoirs around this project area. If these reservoirs could be used as regulating facilities, it will be desirable for this irrigation system. But the relative elevation makes this impossible. It is, therefore, planned in this study that canals from the existing reservoirs will be connected with the main canal for effective water management.

The locations of the secondary canals and the regulating reservoirs are illustrated in Fig. V-11. The proposed irrigation system is shown in DWG. WI-002.

2.4.5 Farm network

(a) Tertiary or distribution ditches

The irrigation area of 23,600 ha will be divided into 49 blocks, the left area into 10 blocks and the right area into 39 blocks. Turnouts will be provided at each irrigation block on the main and secondary canals.

Water distribution from the turnout will be controlled by gates. The existing small irrigation canals will also be utilized as the tertiary canal on the farm. However, the density of the existing tertiary canals is only 10 m/ha or so. New tertiary canals or farm ditches will be added on the farm to an extent of 30 m/ha. Tertiary or farm ditches will be laid out every 400 m in distance on the average.

(b) Drainage

Once the Wonogiri dam is completed, inundation due to back water from the main Sala will be largely eliminated. The existing drainage canals and tributaries could fulfil their function as main drains in the area. On account of this, no additional main drainage system is planned in the study.

But on farms, as the present drains have only a density of 10 m/ha or so, additional drains will have to be provided to avoid temporary inundation by heavy rains and to quicken the drying of fields. New drainage is planned to have a density of 30 m/ha.

(c) Farm road

As stated in Chapter 1.5, the existing farm roads have a network density of 20 m/ha but are mostly impassable by motor vehicles.

Improvement of the existing farm roads to make them passable for motor vehicles and the construction of new farm roads are indispensable for improving farm management in the future.

The network density of all farm roads is designed to the level of 40 m/ha including roads provided along the irrigation canals.

Standard density of canals, drains, and farm roads on farm are shown in Fig. V-12 and the standard of each section is shown in DWG. WI-008.

Fig.V-10 Location Map of Colo Weir

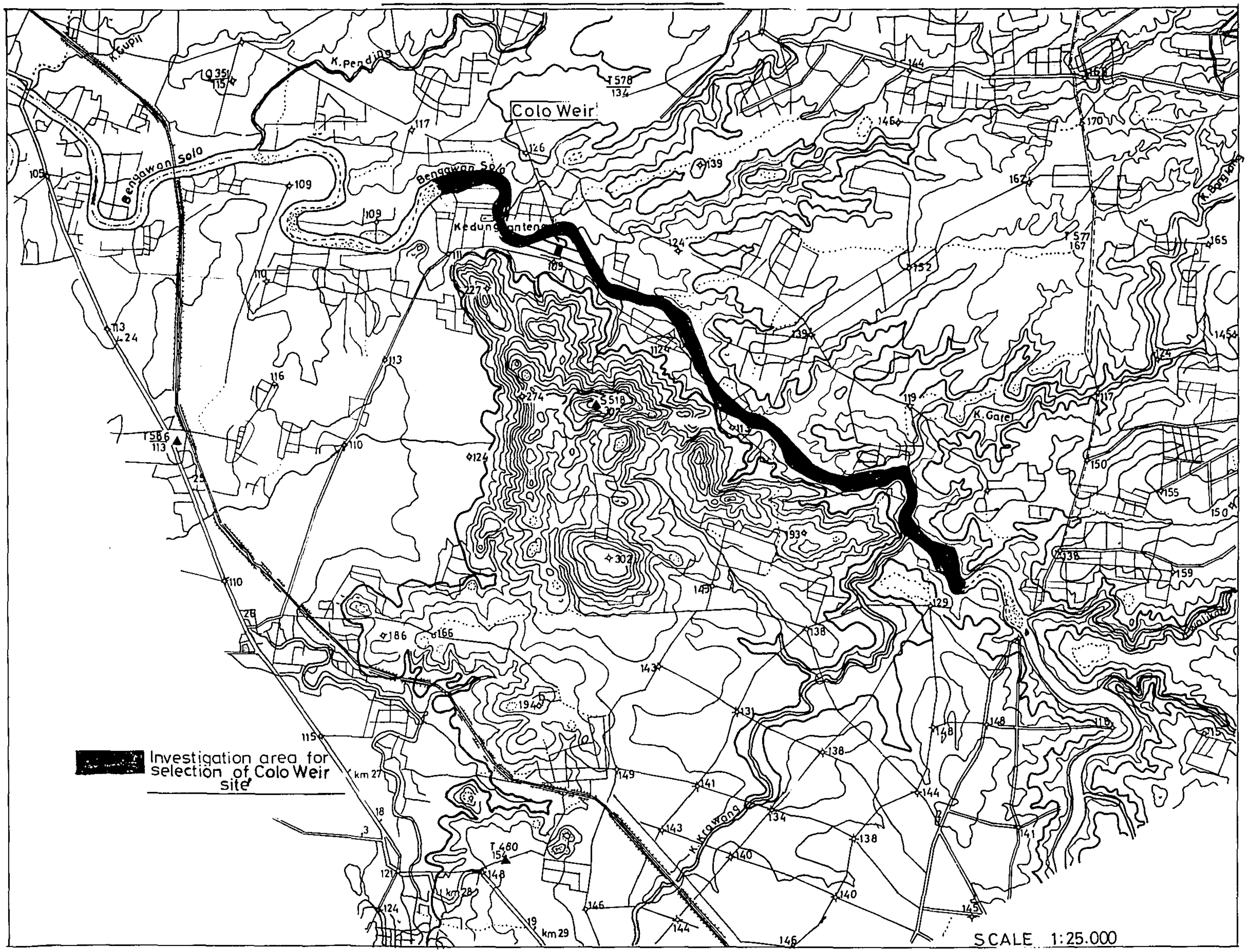


Fig. V-11 Proposed Irrigation System

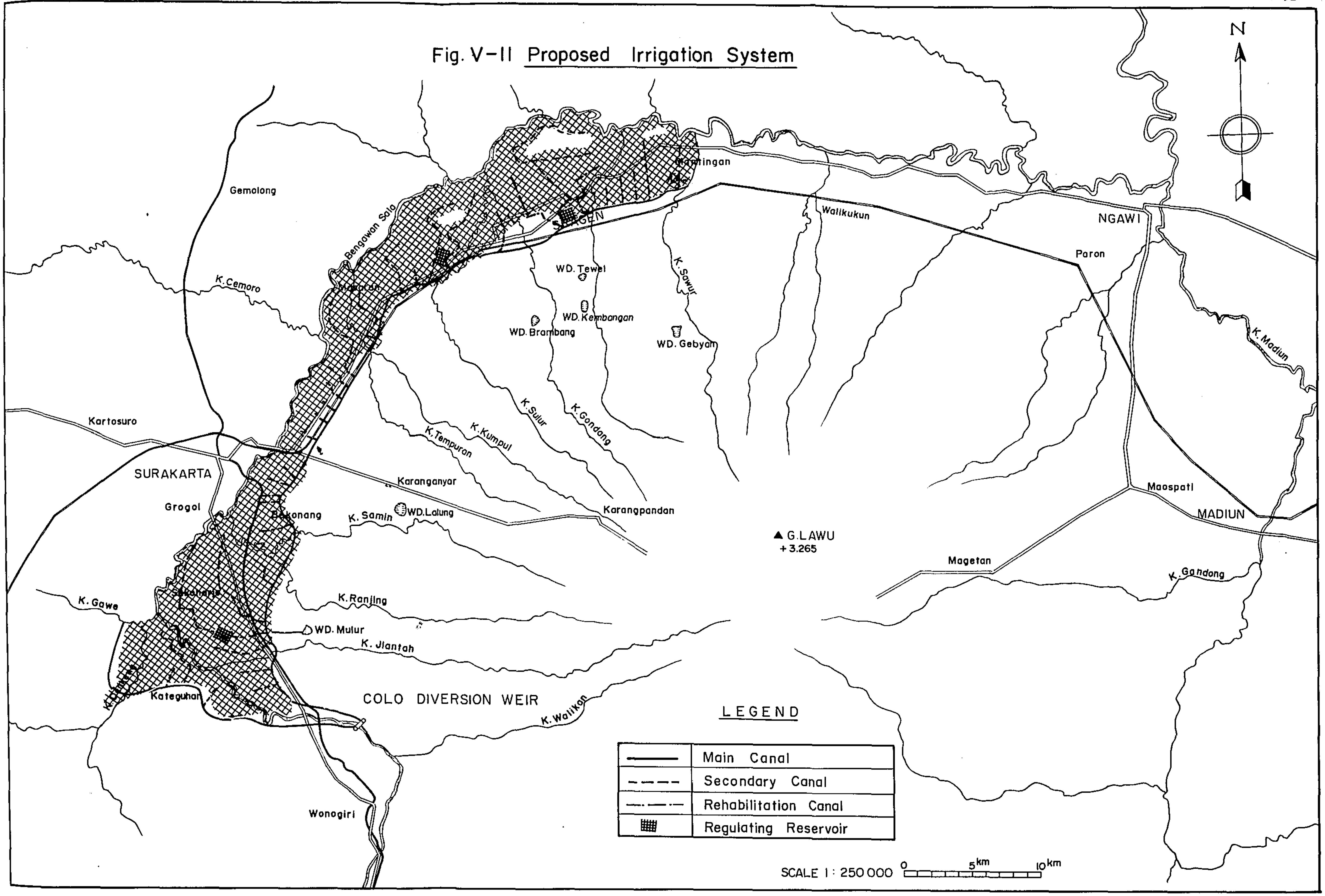
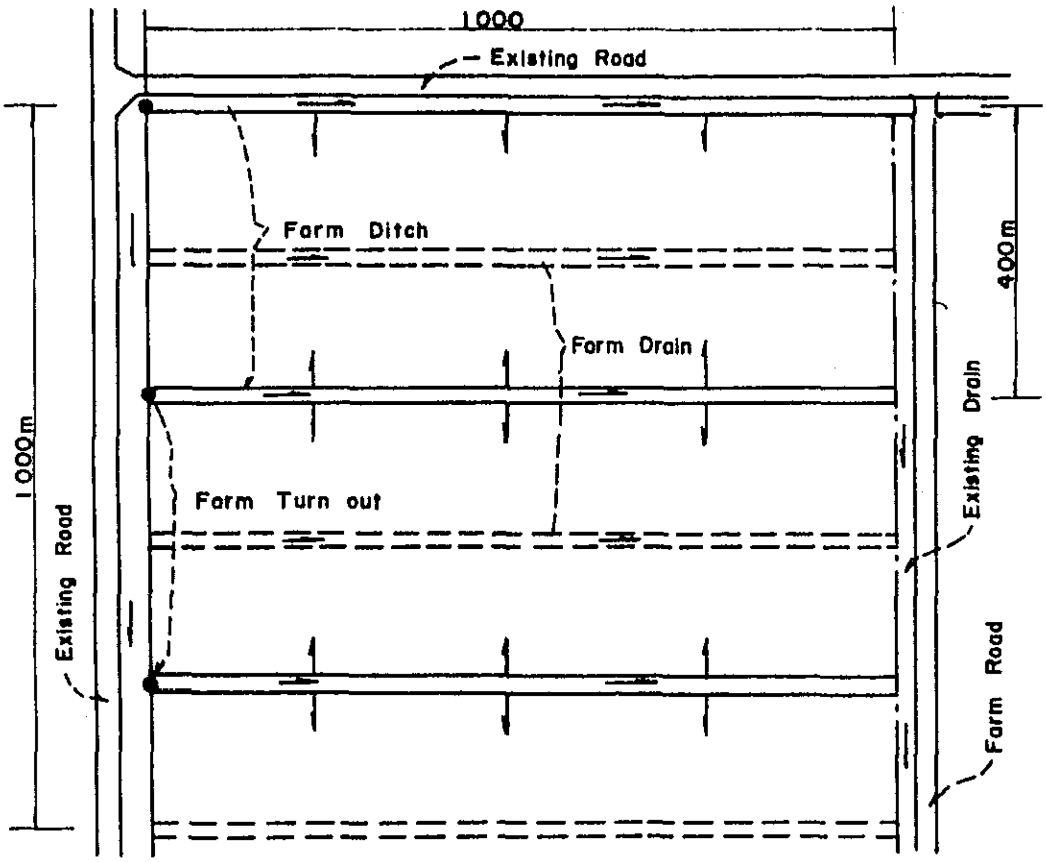


Fig. V-12 Density of Canals and Roads



Canal

Existing Canal (Tertiary) $\frac{1000m}{100ha} = 10\ ^{m}/ha$

Farm Ditch $\frac{3000m}{100ha} = 30\ ^{m}/ha$

Drain

Existing Drain $\frac{1000m}{100ha} = 10\ ^{m}/ha$

Farm Drain $\frac{3000m}{100ha} = 30\ ^{m}/ha$

Road

Existing Road $\frac{2000m}{100ha} = 20\ ^{m}/ha$

Farm Road $\frac{1000m}{100ha} = 10\ ^{m}/ha$

2.5 Operation and Maintenance

Operation and maintenance in this project is limited to the Colo weir, main and secondary canals (including appurtenant facilities), while other facilities are to be operated and maintained by means of the widely prevalent "Dharma Tirta".

2.5.1 Irrigation facilities management office

This office is to be responsible for the over-all management of water for agricultural use, supervision of facilities, inspection, maintenance, repair and cleaning. To fulfill these responsibilities the office will have to keep adequate records, undertake studies and report to higher authorities on meteorological conditions and operation, etc. The office will have a staff of about 15.

2.5.2 Colo diversion weir management office

Maintaining the staff of 2 persons, this office will have the responsibilities as follows.

(a) Water control

Keeping close and continuous contact with the Wonogiri Dam office in connection with the release of water from the dam and the intake of such water, this office will take charge of the operation of the intake gate. It is particularly important to pay careful attention to the intake gate because of the temporary increases in discharge volume for generation of power. Careful and constant supervision of the volume of intake will therefore be required.

(b) Management of gate control and operation, and maintenance of structures

Attention must be given to the scouring sluice gate on a regular and frequent basis in preparation of floods. Inspections must be made for wear and cracks in the weir, apron, etc.

(c) Management of inlet maintenance

Trash, etc. must be cleared from the screens and piers on the forward side of inlets, and accumulated silt at the forward side of inlets must occasionally be flushed by opening the scouring sluice gate.

2.5.3 Management of turnouts, check gates and regulating reservoirs

An operational staff in charge must be assigned to each turnout and check gate, and the opening and closing of the gates will be directed by the irrigation facilities management office.

3. DESIGN OF IRRIGATION FACILITIES

3.1 Colo Diversion Weir

3.1.1 Intake water level

The intake water level at the Colo weir is determined by the following conditions.

(a)	Field elevation	
	upstream end;	EL. 104 m SHVP
	downstream end;	EL. 80 m SHVP
(b)	River bed elevation at Colo;	EL. 100 m SHVP
(c)	Required water level at the end turnout;	EL. 80.5 m
(d)	Mean loss of head at every crossing structure along the canal;	0.3 m
(e)	Canal length:	64 km
	Crossings;	27 places/1
	Mean longitudinal grade;	1/4,500

From the above conditions the gross head to be secured at the Colo intake will be 22.3 m. With an allowance of about 15 % for head loss through various other devices provided in the canal, the water level at the beginning of the main canal will be set at EL. 106.0 m SHVP, at the lowest.

The intake water level of the Colo diversion weir is, therefore, set at EL. 106.5 m SHVP taking into account the loss of head in the intake structures.

Besides this, the Colo weir must function as an afterbay for the Wonogiri power plant.

The power plant is designed for peaking operation for 6 hours a day, and the maximum discharge from the reservoir through turbines is rated at 60 m^3/sec.

/1 : number of siphons and aqueducts

This peak discharge has to be re-regulated to meet the diversion requirement for irrigation day by day.

For this purpose, the regulating capacity of about 1.2 million m^3 is provided at the Colo afterbay.

The afterbay capacity is illustrated in Fig. V-13. As shown in this figure, a rise of the water level by 1.1 meter would be enough to provide the required capacity. Therefore, the crest elevation of the weir is set at EL. 107.6 m SHVP.

3.1.2 Type of weir

The weir site is selected at the river terrace on the left bank of the Sala River. The river terrace consists of fine terrace deposits of sand and clay, 20 to 25 m thick on the tuff-breccia base. The diversion weir will be the floating type on the river bed.

The overflow section of this weir has to be designed to pass safely the flood discharge of 2,000 m^3/sec, an extraordinary flood discharge at this site

Two alternatives are compared from views of back water at the time of flood, construction costs and operation and maintenance. Alternative plans are presented in Fig. V-14.

(a) Plan-A

The whole span of the weir is designed as a fixed weir except for the span of the scouring sluice. The weir comprises overflow section of 83.5 m wide and scouring sluice of 15.0 m (50 m x 3) wide. The maximum water level upstream of the weir is at EL. 112.0 m SHVP.

Construction cost of this weir is estimated as shown in Table V-22.

(b) Plan-B

The whole span of the weir is designed as the movable type and is provided with 7 gates 3.6 m high on the overflow above the crest at elevation of 104.0 m SHVP, and with the same scouring sluice as in Plan-A. In this case, with a 150 m wide scouring sluice and a 75.6 m wide flood sluice, the maximum water level upstream reaches EL. 109.3 m SHVP.

The construction cost of this weir is presented in Table V-22.

Table V-22 Comparison of Construction Cost of the Colo Weir

(Unit: US$)

Item	Plan-A (Fixed W.)	Plan-B (Movable W.)
Earth works	216,000	204,000
Foundation and cut off work	573,000	529,000
Concrete works	1,132,000	1,087,000
Revetment	127,000	127,000
Riprap	75,000	49,000
Gate	285,000	1,125,000
Others	46,000	18,000
Temporary work	20,000	20,000
Total	2,474,000	3,159,000

In the case of Plan-B, the influence of back water to the upstream reaches will be lessened than in Plan-A. However, the construction cost of Plan-B will be more expensive by US$683,000, than in Plan-A.

In the case of Plan-A, operation and maintenance will be easy, safe, and less expensive.

Therefore, Plan-A (the fixed weir type) is selected as the proposed plan. The proposed structure of Colo weir is shown in Dwg. WI-003 and Dwg. WI-004.

3.2 Canals

3.2.1 Design discharge

Network diagram and design discharge of the main and secondary canals are presented in Fig. V-15.

Fig. V-13 Storage Capacity Curve at Colo

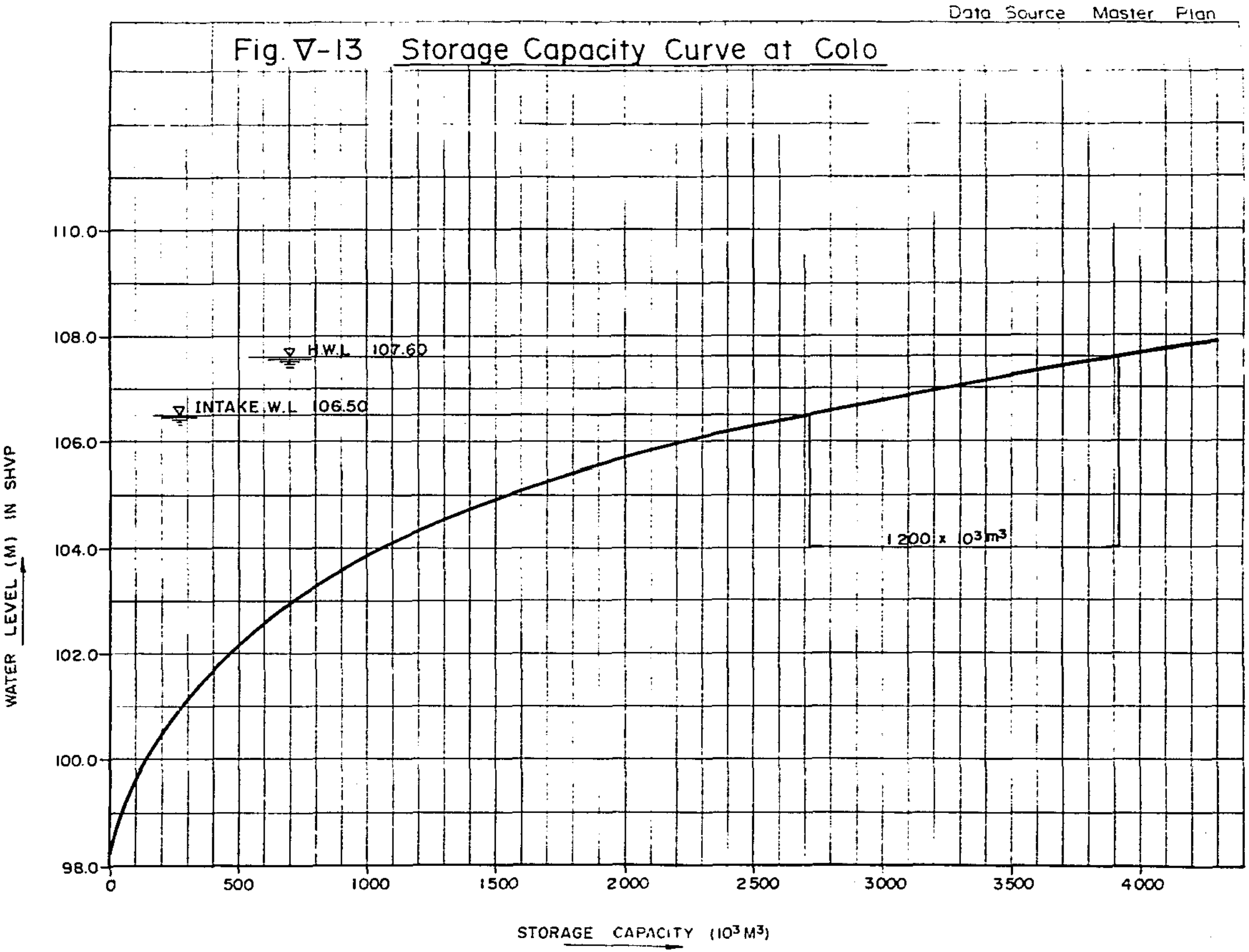
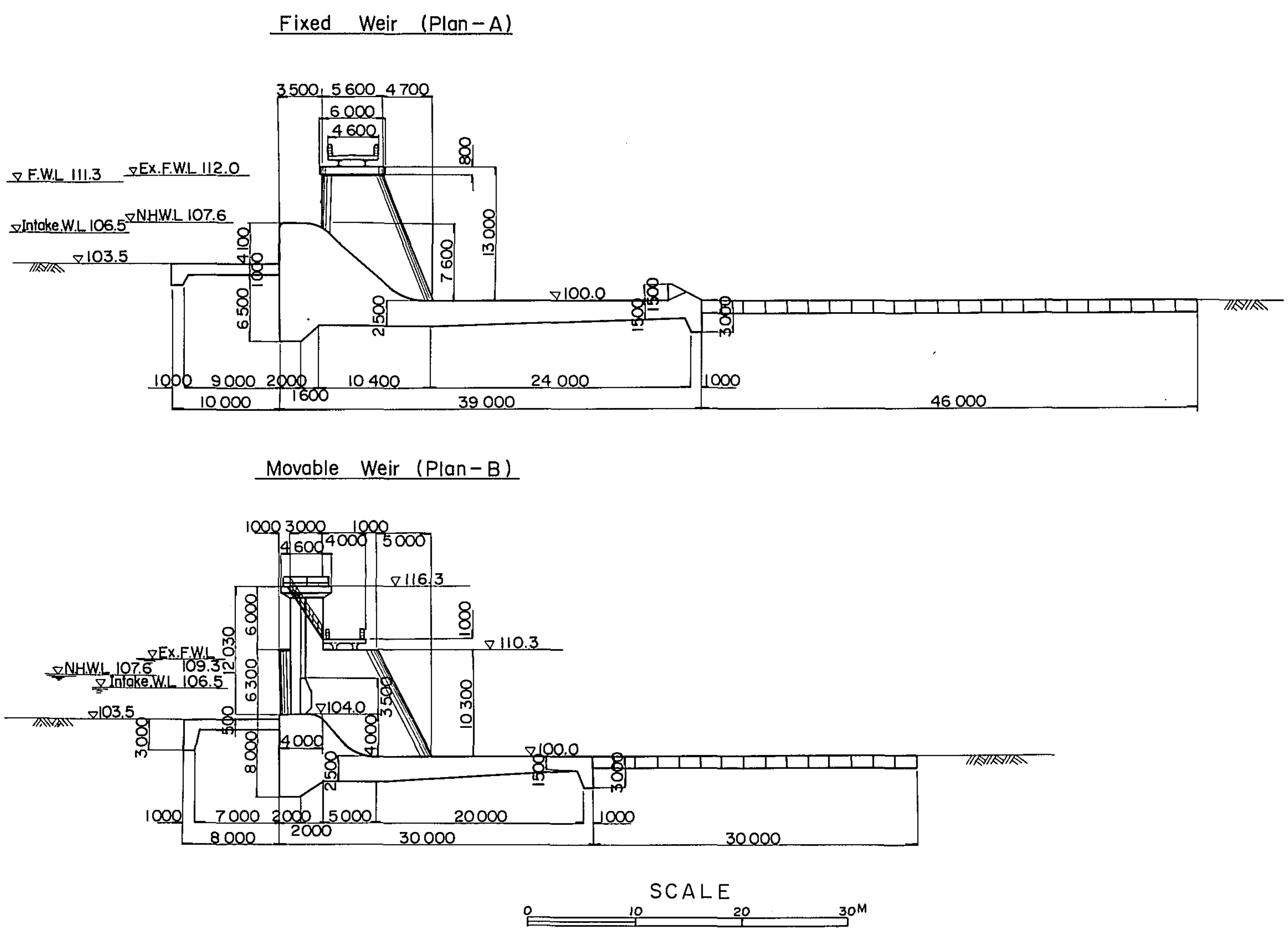


Fig. V-14 Alternatives of Colo weir



Locations of turnouts are selected at crossings of the major existing canals to connect them to the main canal and at necessary points to divert the water to newly irrigated areas. The total number of turnouts is 49, 39 on the right main canal and 10 on the left main canal.

3.2.2 Design conditions

(a) Type of canal:- Unlined earth excavated or embankment canal with trapezoidal section.

(b) Maximum velocity:- Less than 0.8 m/sec shall be kept for the safety of the unlined section.

(c) Major crossings:- Siphon and aquaduct for tributaries, and bridge and culvert for roads and railways.

(d) Longitudinal gradient:- The sectional gradient shall be arranged so as to keep enough diverting head at every turnout and to have sufficient head for every siphon to wash down sediments or drifts. It is shown in Dwg. WI-005 to Dwg. WI-007.

3.2.3 Cross section

According to the sectional discharges and distances between the turnouts, 17 types of cross section have been designed for the main canal, 12 types for the right main and 5 types for the left main canals. For the secondary canals, a total of 10 types have been designed.

Standard section of these are drawn in Dwg. WI-005 to Dwg. WI-007. And the sections and lengths of each type of the canal are presented in Table V-23 and Table V-24.

3.2.4 Crossing

The main and secondary canals cross at many places over or under the tributaries, roads and railways. Bridges, culverts, aqueducts and siphons are designed for those crossings. Number of crossings along the main canal are listed in Table V-25.

Design consideration for these crossings are as follows.

(i) Aqueduct is used where sufficient clearance can be maintained above the max. flood water level.

(ii) Siphon is used where an aqueduct cannot be adopted.

(iii) Culvert will be adopted where the tributary, canal, road or railway is higher than the main canal.

(iv) Overpass bridge will be used for road crossings where culvert is not applicable.

(v) Design velocity for siphon and aqueduct.

Q (m^3/sec)	Design Velocity (m/sec)	
	Siphon	Aqueduct
30 - 10	1.80 - 2.20	2.00 - 2.50
10 - 5	1.50 - 1.80	1.70 - 2.00
2 - 5	1.30 - 1.50	1.50 - 1.80
2	1.00 - 1.30	1.30 - 1.50

The types and the number of crossings to be used are listed in Table V-26 and the standard designs of each crossing structure are shown in Dwg. WI-009 to Dwg. WI-012.

3.2.5 Turnout

The design of turnouts is standardized to provide three types (Types A, B & C) of gate diversion works for the secondary canal for the convenience of controlling discharge and maintenance.

Romijn gate is used for type B and type C turnouts and sluice gate is for type A.

Standard design of the structure is shown in Dwg. WI-013 and Dwg. WI-014.

3.2.6 Regulating structures

For smooth distribution of water, flood water diversion, protection and maintenance of the canal, and emergency treatment, some regulating structures or devices must be provided along the canal.

(a) Waste ways and spillways

Waste way must have enough capacity to drain out water in a certain section of the canal in an emergency case.

Since many aqueducts or siphons are built on this canal, diversion structure is provided immediately upstream of those crossing structures for maintenance and clearing drifts.

Spillway to evacuate the excess flood water is also provided at this diversion structure. Standard design of the structure is shown in Dwg. WI-009 to Dwg. WI-012.

(b) Check gate

Check gates are provided downstream of the major turnouts to maintain a certain water level, to lessen rapid changes in water level, and to prevent high flow/velocity.

The check gate structure is a combination of the fixed overflow weir and manual operating gates.

Standard design of the check gate is illustrated in Dwg. WI-013.

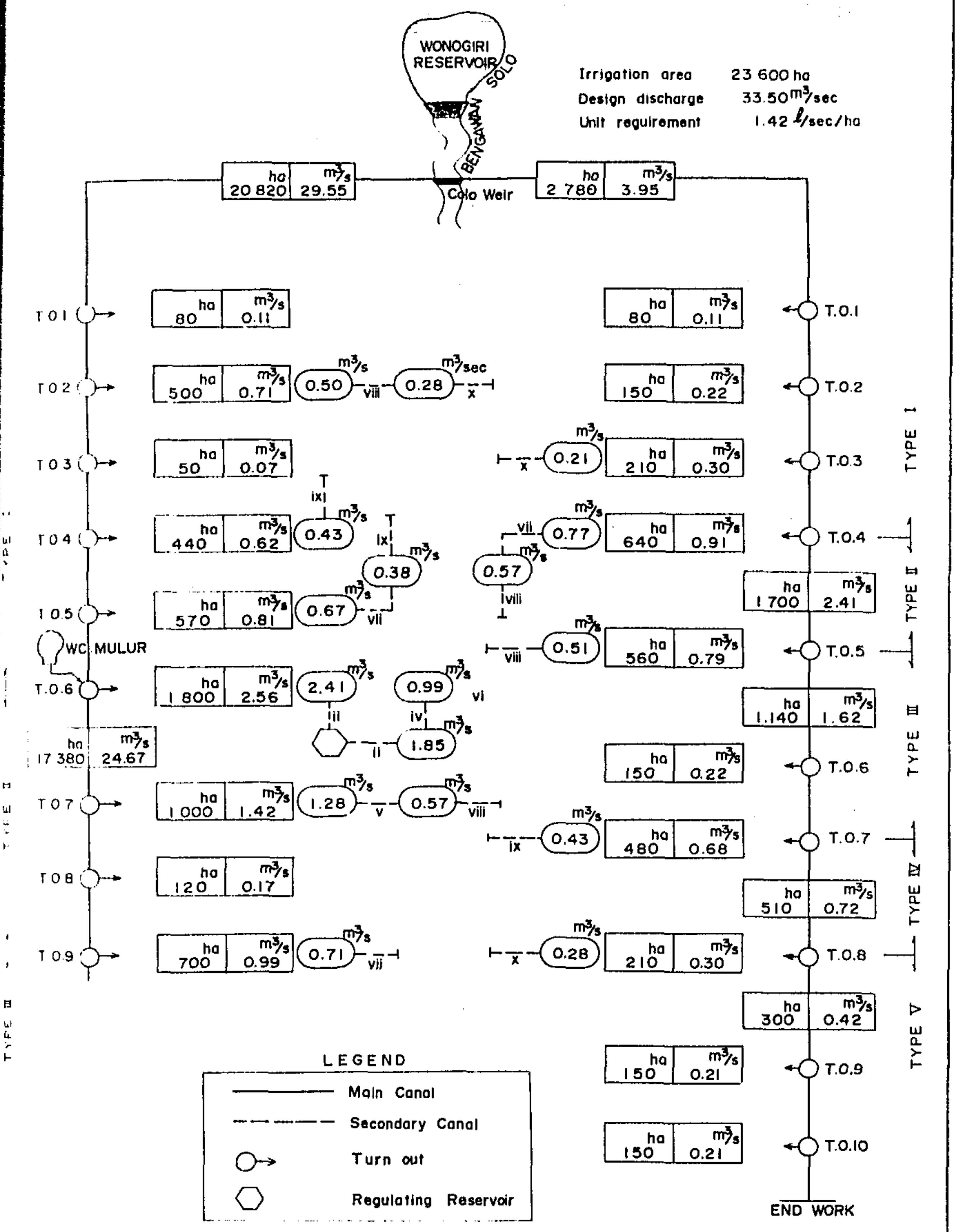
3.2.7 Regulating reservoirs

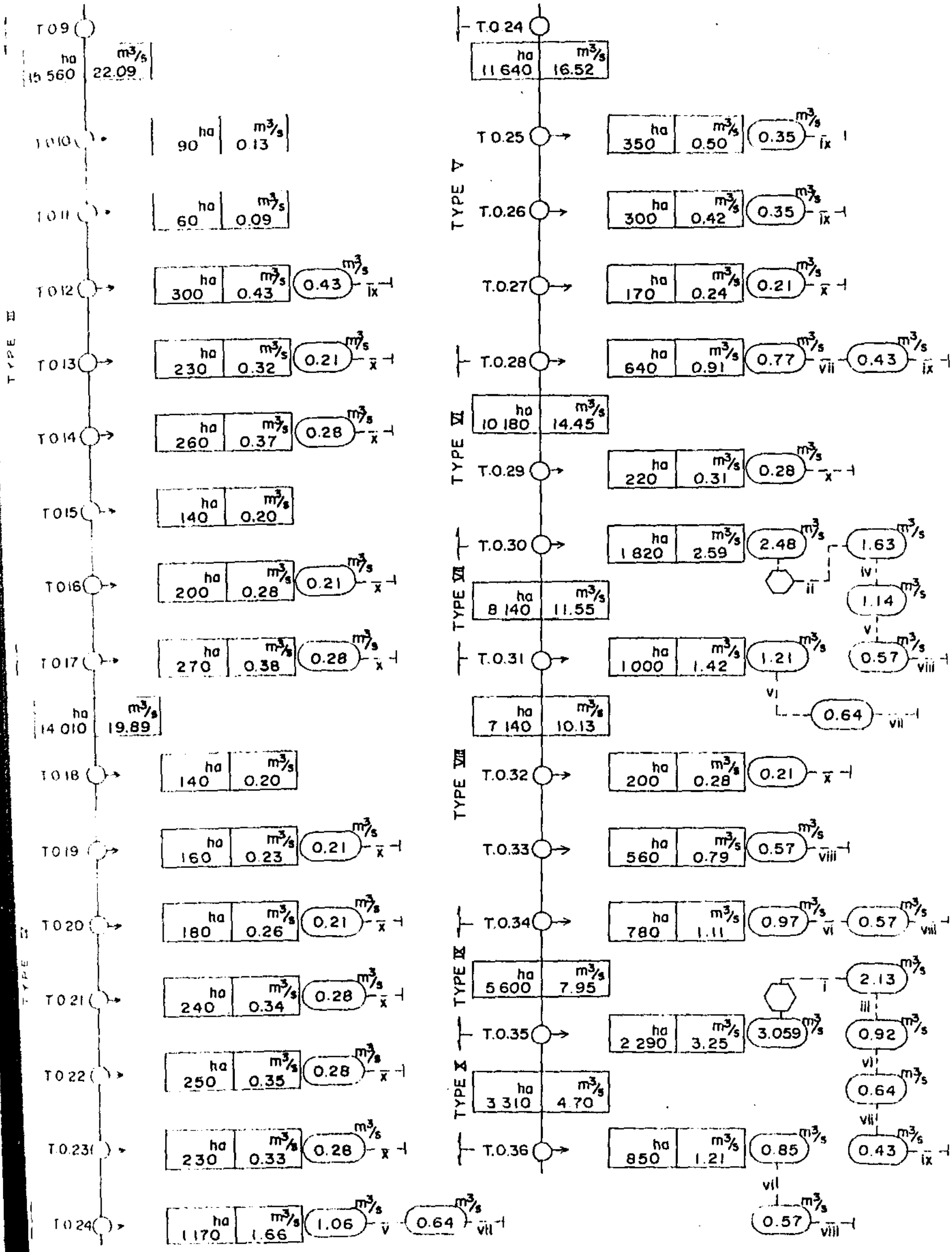
Regulating reservoirs are designed at three sites on the route of the secondary canal which serves a large area more than 1,800 ha, in order to store one-day requirement of the respective irrigation blocks.

Homogeneous earthfill dyke is designed for this by using excavated earth as much as possible.

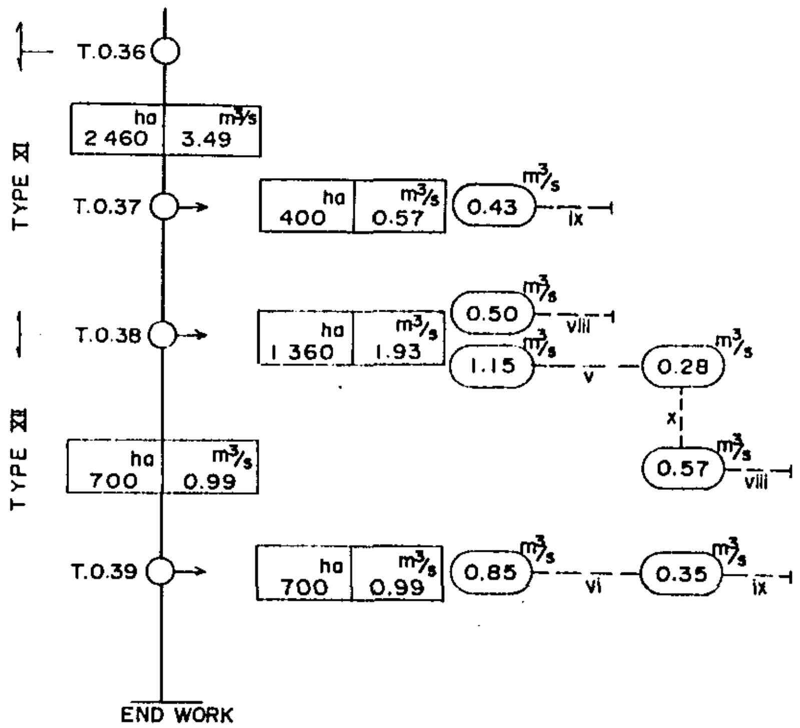
The main features of the proposed regulating reservoirs and a typical design of the structure are shown in Dwg. WI-015.

Fig. V-15 Network Diagram of Proposed Irrigation System





T O 9
ha 15 560 | m³/s 22.09
T O 10 | ha 90 | m³/s 0.13
T O 11 | ha 60 | m³/s 0.09
T O 12 | ha 300 | m³/s 0.43 | 0.43 m³/s ix
T O 13 | ha 230 | m³/s 0.32 | 0.21 m³/s x
T O 14 | ha 260 | m³/s 0.37 | 0.28 m³/s x
T O 15 | ha 140 | m³/s 0.20
T O 16 | ha 200 | m³/s 0.28 | 0.21 m³/s x
T O 17 | ha 270 | m³/s 0.38 | 0.28 m³/s x
ha 14 010 | m³/s 19.89
T O 18 | ha 140 | m³/s 0.20
T O 19 | ha 160 | m³/s 0.23 | 0.21 m³/s x
T O 20 | ha 180 | m³/s 0.26 | 0.21 m³/s x
T O 21 | ha 240 | m³/s 0.34 | 0.28 m³/s x
T O 22 | ha 250 | m³/s 0.35 | 0.28 m³/s x
T.O 23 | ha 230 | m³/s 0.33 | 0.28 m³/s x
T O 24 | ha 1 170 | m³/s 1.66 | 1.06 m³/s v | 0.64 m³/s vii
TYPE III
TYPE IV
T.O.24
ha 11 640 | m³/s 16.52
T.O.25 | ha 350 | m³/s 0.50 | 0.35 m³/s ix
T.O.26 | ha 300 | m³/s 0.42 | 0.35 m³/s ix
T.O.27 | ha 170 | m³/s 0.24 | 0.21 m³/s x
T.O.28 | ha 640 | m³/s 0.91 | 0.77 m³/s vii | 0.43 m³/s ix
TYPE V
ha 10 180 | m³/s 14.45
T.O.29 | ha 220 | m³/s 0.31 | 0.28 m³/s x
TYPE VI
T.O.30 | ha 1 820 | m³/s 2.59 | 2.48 m³/s | ii | 1.63 m³/s | iv | 1.14 m³/s | v | 0.57 m³/s viii
ha 8 140 | m³/s 11.55
TYPE VII
T.O.31 | ha 1 000 | m³/s 1.42 | 1.21 m³/s | vi | 0.64 m³/s vii
ha 7 140 | m³/s 10.13
TYPE VIII
T.O.32 | ha 200 | m³/s 0.28 | 0.21 m³/s x
T.O.33 | ha 560 | m³/s 0.79 | 0.57 m³/s viii
T.O.34 | ha 780 | m³/s 1.11 | 0.97 m³/s vi | 0.57 m³/s viii
TYPE IX
ha 5 600 | m³/s 7.95
T.O.35 | ha 2 290 | m³/s 3.25 | 3.059 m³/s | i | 2.13 m³/s | iii | 0.92 m³/s | vi | 0.64 m³/s | vii | 0.43 m³/s ix
TYPE X
ha 3 310 | m³/s 4.70
T.O.36 | ha 850 | m³/s 1.21 | 0.85 m³/s | vii | 0.57 m³/s viii



T.0.36
ha m³/s
2 460 3.49
TYPE XI
T.0.37
ha m³/s
400 0.57
0.43 m³/s
ix
T.0.38
ha m³/s
1 360 1.93
0.50 m³/s
viii
1.15 m³/s
v
0.28 m³/s
x
0.57 m³/s
viii
TYPE XII
ha m³/s
700 0.99
T.0.39
ha m³/s
700 0.99
0.85 m³/s
vi
0.35 m³/s
ix
END WORK

Table V-23 Sectional Discharge and Type of Main Canal

Turnout No.	Main Canal				Turnout	
	Irrigation Area	Discharge	Canal Type	Length	Irrigation Area	Discharge
Right Main Canal	ha	m^3/s		m	h^2	m^3/s
Intake	20,820	29.55			-	-
1	20,740	29.44			80	0.11
2	20,240	28.73			500	0.71
3	20,190	28.66	I	10,450	50	0.07
4	19,750	28.04			440	0.62
5	19,180	27.23			570	0.81
6	17,380	24.67			1,800	2.56
7	16,380	23.25			1,000	1.42
8	16,260	23.08	II	4,100	120	0.17
9	15,560	22.09			700	0.99
10	15,470	21.96			90	0.13
11	15,410	21.87			60	0.09
12	15,110	21.44			300	0.43
13	14,880	21.12	III	10,900	230	0.32
14	14,620	20.75			260	0.37
15	14,480	20.55			140	0.20
16	14,280	20.27			200	0.28
17	14,010	19.89			270	0.38
18	13,870	19.69			140	0.20
19	13,710	19.46			160	0.23
20	13,530	19.20	IV	8,900	180	0.26
21	13,290	18.86			240	0.34
22	13,040	18.51			250	0.35
23	12,810	18.18			230	0.33
24	11,640	16.52			1,170	1.66
25	11,290	16.02			350	0.50
26	10,990	15.60	V	6,950	300	0.42
27	10,820	15.36			170	0.24
28	10,180	14.45			640	0.91
29	9,960	14.14	VI	1,900	220	0.31
30	8,140	11.55			1,820	2.59

Table V-23 - Continued -

Turnout No.	Main Canal				Turnout	
	Irrigation Area	Discharge	Canal Type	Length	Irrigation Area	Discharge
			VII	1,700		
31	7,140	10.13			1,000	1.42
32	6,940	9.85			200	0.28
33	6,380	9.06	VIII	8,300	560	0.79
34	5,600	7.95			780	1.11
35	3,310	4.70	IX	1,400	2,290	3.25
36	2,460	3.49	X	1,800	850	1.21
37	2,060	2.92	XI	4,500	400	0.57
38	700	0.99			1,360	1.93
39	0	0	XII	3,000	700	0.99
Left Main Canal						
Intake	2,780	3.95				
1	2,700	3.84			80	0.11
2	2,550	3.62	I	13,900	150	0.22
3	2,340	3.32			210	0.30
4	1,700	2.41	II	2,150	640	0.91
5	1,140	1.62			560	0.79
6	990	1.40	III	4,300	150	0.22
7	510	0.72			480	0.68
8	300	0.42	IV	2,850	210	0.30
9	150	0.21			150	0.21
10	0	0	V	2,350	150	0.21

Total Length (Right) 63,900 m
(Left) 25,550 m

Table V-24 Type and Length of Secondary Canal

	Irrig. Area (ha)	Dis-charge (m^3/sec)	Length (m)	Canal Type		Irrig. Area (ha)	Dis-charge (m^3/sec)	Length (m)	Canal Type
Right bank									
T.O 2-a	350	0.50	1.500	viii	TO.30-b	1.150	1.63	1.600	iv
b	200	0.28	1.200	x	c	800	1.14	1.800	v
4-a	300	0.43	2.800	ix	d	400	0.57	1.500	viii
5-a	470	0.67	2.500	vii	31-a	850	1.27	2.800	v
b	270	0.38	3.000	ix	b	450	0.64	4.300	vii
6-a	1.700	2.41	4.000	ii	32-a	150	0.21	* 700	x
b	1.300	1.85	3.400	iv	33-a	400	0.57	*3.600	viii
c	700	0.99	5.500	vii	34-a	680	0.97	2.500	vi
7-a	900	1.28	4.700	v	b	400	0.57	*2.700	viii
b	400	0.57	3.900	viii	35-a	2.190	3.11	2.700	i
9-a	500	0.71	2.700	vii	b	1.500	2.13	3.200	iii
12-a	300	0.43	*2.500	ix	c	650	0.92	4.000	vi
13-a	150	0.21	500	x	d	450	0.64	5.000	vii
14-a	200	0.28	*1.500	x	e	300	0.43	4.000	ix
16-a	150	0.21	*1.100	x	36-a	600	0.85	*2.300	vi
17-a	200	0.28	900	x	b	400	0.57	*2.800	viii
19-a	150	0.21	700	x	37-a	300	0.43	*1.000	ix
20-a	150	0.21	1.100	x	38-a	350	0.50	*2.500	viii
21-a	200	0.28	600	x	a	810	1.15	3.000	v
22-a	200	0.28	*2.000	x	b	200	0.28	2.600	x
23-a	200	0.28	*1.500	x	c	400	0.57	*2.300	viii
24-a	750	1.04	2.800	v	39-a	600	0.85	1.800	vi
b	450	0.64	5.400	vii	b	250	0.35	3.800	ix
25-a	250	0.35	*1.500	ix	Left bank				
26-a	250	0.35	*3.000	ix	TO. 3-a	150	0.21	1.200	x
27-a	150	0.21	* 700	x	4-a	540	0.77	2.800	vii
28-a	540	0.77	2.800	vii	b	400	0.57	3.600	viii
b	300	0.43	1.000	ix	5-a	360	0.51	2.400	viii
29-a	200	0.28	900	x	7-a	300	0.43	2.100	ix
30-a	1.750	2.48	3.600	ii	8-a	200		*1.000	x

*Rehabilitation Canal

Total Length	Right:	Left:
	100,100	12,100
	* 31,700	* 1,000
	131,800 m	13,100 m

Table V-25 Number of Crossings along Main Canal

	River			Canal		Road				Railway		Village
	a(20m)	b(10m)	c(10m)	a(5m)	b(5m)	a(Main)	b(8m)	c(4m)	d(4m)	a(For Train)	b(For Truck)	
Right Main Canal												
I.	1	3	1		9	2	1	4	20	2		7
II.			1	4	10			4	3			1
III.	2	2		1	18		2	9	23			3
IV.	1		4	1	17	1		15	29		3	7
V.	1		2	4	7		4	3	4	1	1	1
VI.				2				3		1		1
VII.					2			4	1		1	-
VIII.	1	1	2	3	5			13	6	1	2	2
IX.				2	4			3	4			1
X.			1	1	5			2	6			1
XI.		2	1	4	4			5	9			2
XII.			1	3	10		1	5	4		3	2
Total	6	8	13	25	91	3	10	74	112	5	10	34
Left Main Canal												
I.		1	1	3	5	1		9	26	1		5
II.					7				2			1
III.	1		1	3				3	9			1
IV.			2	1	2			1	4			1
V.				4	6				7			1
Total	1	1	4	11	20	1		13	48	1		9
Grand Total	7	9	17	36	111	4	10	87	160	6	10	43

Table V-26 Number of Proposed Irrigation Facilities

Canal Type	Turnout			Check Gate	Siphon			Aqueduct			Culvert		Bridge	
	A	B	C		A	B	C	A	B	C	A	B	A	B
Right Main Canal														
Type I	1	3	2	1	1	3	1				2	4	2	15
II	1	1	1				1					9		6
III			8		1	1		1	1			10		22
IV	1		6		1		3			1		9	1	33
V		1	3				1	1		1	1	7		10
VI	1		1	1							1	2		3
VII	1											1		5
VIII	1	1	1				1	1	1	1	1	5		20
IX	1											4		5
X	1			1						1		3		5
XI	1	1				1			1	1		6		10
XII			1							1		8		8
Total	9	7	23	3	3	5	7	3	3	6	5	68	3	142
Left Main Canal														
Type I		1	3	1		1				1	2	5		22
II		1		1								3		1
III		1	1	1	1					1		3		8
IV			1							2		2		3
V			2									7		4
Total		3	7	3	1	1				4	2	20		38
Grand Total	9	11	29	6	4	6	7	3	3	10	7	88	3	180

4. CONSTRUCTION PLAN

4.1 Basic Considerations

Basic conditions taken into account for planning the construction method and schedule are presumed as follows:

(1)	Workable days;	180 days a year (May-Nov.)
(2)	Construction period;	5 years, except preparatory works
(3)	Division of main canal construction work;	4 sections on the right main canal and 1 section on the left main canal; The sequence of construction is shown below.

Table V-27 Division of Work and Sequence of Construction of Main Canal

Section	Main Canal Type		Length (m)	Construction Year	Related Structure: Siphon	Aqueduct	Culvert	Turnout	Bridge	Check Gate
1	Right	I	10,450	5th	5	-	6	6	17	1
2	"	II-III	15,000	3rd	3	2	19	11	28	-
3	"	IV-VII	19,400	2nd	5	3	21	14	52	1
4	"	VIII-XII	19,000	1st	2	7	27	8	48	1
5	Left	I-V	25,550	4th	2	4	22	10	38	3

Table V-28 Division of Work on Secondary Canal

Section	Length (m): Secondary canal	Rehabilitation canal	Total
1 (Right)	23,900	-	23,900
2 (")	12,700	5,100	17,800
3 (")	30,900	8,700	39,600
4 (")	32,600	17,900	50,500
5 (Left)	12,100	1,000	13,100

Note: Construction year is same as that of main canal.

(4) Manpower throughout the construction period: 5,000 man-days

(5) Allocation of construction force

Main canal, excavation and embankment:	10 % man power & 90 % mechanical
Secondary canal excavation:	100 % man power
Farm ditches and drains:	100 % man power

4.2 Colo Diversion Weir

Construction of this weir is scheduled to be started from the fourth year taking into account the availability of construction plants and equipment used for the Wonogiri Dam. After the completion of the Wonogiri dam, the river flow could be decreased considerably and this would make it possible to execute the construction work more safely.

Before starting the main work at the beginning of the fourth dry season, necessary preparatory work such as access roads, construction quarters, power and water supply systems, etc. will be completed.

The main work is divided into two construction stages. In the first stage, foundation work and coffering along the river side will be commenced first, and concreting of the weir body will follow. Meanwhile, riprap and bank revetment up- and downstream of the weir will be put in. Metal work and other auxiliary work for the weir will be executed in the succeeding rainy season or the next dry season.

In the second stage, approach channel and outlet channel will be excavated in parallel with the removal of the coffering, and the river flow will be diverted into the new approach channel. The old river channel will be backfilled with soil disposed of at the site.

4.3 Canal

Construction will be started at any place which has easy access. All excavated soil will be used for the road dyke embankments.

Materials for the canal embankments will be hauled from borrow areas selected near the construction site.

Construction of the crossing structures over or under the tributaries shall be scheduled for completion in the dry season to avoid the risk of unexpected high flood.

The downstream end of each canal under construction has to be connected to the nearby tributaries or drainage channel to keep the canal dry even in the rainy season.

Hauling the embankment material, and spreading and tamping, if necessary, will be partly carried out for the secondary canal by machines.

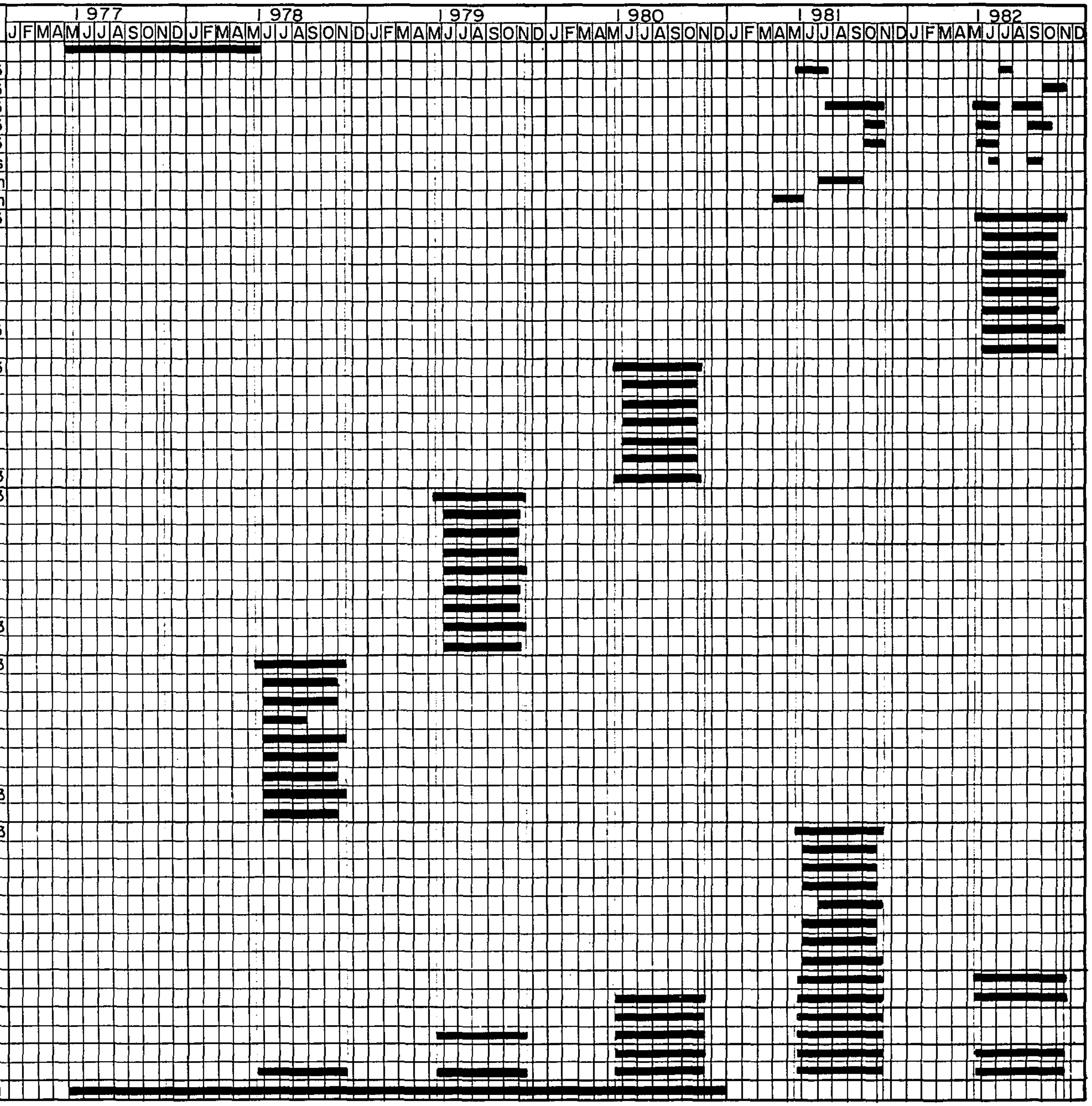
The outer slope and the shoulder at both sides of the canal dyke will be protected by sod facing.

4.4 Construction Schedule

Overall construction time schedule is presented in Fig. V-16 in the form of bar-chart.

Fig. V-16 Proposed Construction Schedule

WORK	ITEM	Q.TY
PREPARATORY WORKS	Camp House	
COLO DIVERSION WEIR	Excavation	262.000 m3
	Embankement	123.000 m3
	Concrete Structue	23.000 m3
	Revetment	10.500 m3
	Riprap	5.000 m3
	Gates	7 nos
	Foundation Works	1 sum
	Temporay Works	1 sum
SECTION 1 (RIGHT)	Main Canals L=10.450m	721.000 m3
	Siphon	5
	Culvert	6
	Turnout	6
	Bridge	17
	Check Gate	1
	Secondary Canals L=23.900m	99.000 m3
	Regulating Reservoir	1
SECTION 2 (RIGHT)	Main Canals L=15.000m	864.000 m3
	Siphon	3
	Culvert	19
	Aqueduct	2
	Turnout	11
	Bridge	28
	Secondary Canals L=17.800m	55.000 m3
SECTION 3 (RIGHT)	Main Canals L=19.400m	1 052.000 m3
	Siphon	5
	Aqueduct	3
	Culvert	21
	Turnout	14
	Bridge	52
	Check Gate	1
	Secondary Canals L=39.600m	130.000 m3
	Regulating Reservoir	1
SECTION 4 (RIGHT)	Main Canals L=19.000m	829.000 m3
	Siphon	2
	Aqueduct	7
	Culvert	27
	Turnout	8
	Bridge	48
	Check Gate	1
	Secondary Canals L=50.500m	142.000 m3
	Regulating Reservoir	1
SECTION 5 (LEFT)	Main Canals L=25.560m	628.000 m3
	Siphon	2
	Aqueduct	4
	Culvert	22
	Turnout	10
	Bridge	38
	Check Gate	3
	Secondary Canals L=13.100m	49.000 m
FARM DITCH	Rehabilitation Ditch	236.000 m
	Farm Ditch	708.000 m
DRAINAGE	Rehabilitation Drain	236.000 m
	Farm Drain	708.000 m
FARM ROAD	Rehabilitation Road	472.000 m
	Farm Road	236.000 m
LAND ACQUISITION		597 ha



5. COST ESTIMATE

The total construction cost of the irrigation project is estimated at US$33,100,000. This comprises the foreign exchange equivalent of US$16,770,000 and local currency of Rp.6,777 million (equivalent to US$16,330,000), as broken down in Table V-29. The estimated budgetary requirement is given in Table V-30.

Annual operation and maintenance costs of the irrigation system are estimated at US$130,000 as shown in Table V-31.

Table V-29 Cost Estimate for Irrigation

(Unit: US$1000)

Item	Foreign	Local	Total
I Civil Works	13,540	13,142	26,682
Preparatory Works	-	187	187
Colo Diversion Weir	2,086	881	2,967
Main Canal	6,245	4,570	10,815
Secondary Canal (incl. regulating reservoir)	972	1,224	2,196
Farm Ditch	-	1,115	1,115
Drainage	-	1,299	1,299
Farm Road	-	3,718	3,718
Construction Machinery	4,237	148	4,385
II Land Acquisition	-	800	800
III Contingency (15%)	2,030	2,088	4,118
IV Engineering & Administrative Expenses	1,200	300	1,500
Total	16,770	16,330	33,100

Table V-30 Yearly Budgetary Schedule

(Unit: US$1000)

Work Item	Construction Cost			1977		1978		1979		1980		1981		1982	
	Total	L.C.	F.C.	L.C	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C	F.C
I. Civil Works	26,682	13,142	13,540	289	-	1,529	2,244	1,788	2,244	2,680	2,243	3,682	3,386	3,174	3,423
II. Land Acquisition	800	800	-	200	-	200	-	200	-	200	-	-	-	-	-
III. Contingency	4,118	2,088	2,030	71	-	261	336	302	326	430	337	548	514	476	517
IV. Engineering & Admin. Exp.	1,500	300	1,200	60	260	40	170	50	190	50	190	50	190	50	200
Total	33,100	16,330	16,770	620	260	2,030	2,750	2,340	2,760	3,360	2,770	4,280	4,090	3,700	4,140
		33,100		880		4,780		5,100		6,130		8,370		7,840	

L.C; Local Currency

F.C; Foreign Currency

Table V-31 Estimate of Operation and Maintenance Cost

(Unit: US$)

1.	Irrigation office		
	Personnel expenses	15 x 1,200 $/year	18,000
	Others		30,000
		Sub total	48,000
2.	Colo weir office		
	Personnel expenses	2 x 1,200 $/year	2,400
	Others		1,600
		Sub total	4,000
3.	Turnout and check gate, regulating reservoir		
	Personnel expenses	50 x 960 $/year	48,000
4.	Operation and maintenance cost of canal		30,000
	Total		130,000

A P P E N D I X E S

Appendix V-1 Comparative Study of Irrigation Plan

1.1 Additional and Reduced Cost of ALT-B-1

	Right bank	Left bank
Tunnel section (horseshoe standard section)	2R=5.0 m	2R=2.5 m
Length of tunnel	12,000 m	5,000 m
Additional irrigation area	5,000 ha	1,000 ha
Additional cost	U.S.$30,000,000 /1	U.S.$8,500,000 /2
Total additional cost	U.S.$38,500,000	
Reduced cost (Colo weir)	U.S.$3,000,000	

1.2 Additional and Reduced Cost of ALT-B-2

Additional cost (same cost as left bank tunnel of ALT-B-1)	U.S.$8,500,000
Reduced cost (Colo weir)	U.S.$200,000

/1 : 2,500 U.S.$/m x 12,000 m
/2 : 1,700 U.S.$/m x 5,000 m

1.3 Additional Cost of ALT-C

Scheme of pump

Type:	Centrifugal pump
Discharge:	40 m^3/min
Bore:	600 mm
Total head:	23 m
Motor:	250 kW
Number installed:	2 sets

Cost

Construction cost	(Unit: U.S.$)
pumps and other apparatus	457,000
pump station	167,000
canal (unlined)	117,000
other works	83,000
Total	834,000

Operation and maintenance cost (annual)		(Unit: U.S.$)
personnel expenses	@300 $/month	3,600
electric charge /1	1,187,500 kWh x	59,000
repair and others		21,000
Total		64,000

Grand total cost (20 years) /2

834,000 + 64,600 x 20 = U.S.$2,126,000

/1 : quantity of consumption = 19,000 m^3/ha/year x 600 ha + 2,400 m^3/hr x 250 kW

/2 : durable period of pump is 20 years.

1.4 Additional and Reduced

Additional cost

Scheme of pump:

Type;	centrifugal pump
Discharge;	270 m^3/min.
Bore;	1,500 mm
Total head;	22 m
Engine;	1,900 PS
Number installed;	4 sets

Cost

Construction cost (Unit: U.S.$)

pump and other apparatus	2,500,000
pump station	500,000
diversion weir (movable)	1,500,000
canal (L=3,000 m)	1,200,000
Total	5,700,000

Operation and maintenance cost (annual) (Unit: U.S.$)

personnel expenses @500 $/month	6,000
fuel charge 5,660,100 /1 ℓ x 0.04$	226,000
repair and others	2,000
Total	

Grand total cost (20 years)/2

5,700,000 + 252,000 x 20 =U.S.$10,740,000

Reduced cost (Unit: U.S.$)

Colo weir			100,000
Main canal			
Earth works			940,000
Related structures			
Siphon	7	@60,000	420,000
Culvert	2	@15,000	30,000
Bridge	3	@20,000	60,000
" (Farm)	76	@ 5,000	380,000
Aqueduct	3	@60,000	180,000
Check gate	1	@10,000	10,000
Sub total			2,120,000
General expenses (20%)			420,000
Total			2,540,000

/1 : 19,000 m^3/ha/year x 12,700 ha + 16,200 m^3/hr x (0.2 l x 1,900 PS)
/2 : durable period of pump is 20 years.

1.5 Additional and Reduced Cost of ALT-D-2

Additional cost (Unit: U.S.$)

Surakarta weir			
Earth works			250,000
Concrete works			1,100,000
Form			100,000
Revetment & Riprap			200,000
Gates (8 sets)			1,700,000
Foundation works			400,000
Others			90,000
General expenses			660,000
		Total	4,500,000

Reduced cost (Unit: U.S.$)

Colo weir			400,000
Main canal			
Earth works			1,450,000
Related structures			
Siphon	7	@60,000	420,000
	3	@30,000	90,000
Culvert	2	@15,000	30,000
	3	@10,000	30,000
Bridge	3	@20,000	60,000
" (Farm)	76	@ 5,000	380,000
" (")	66	@ 2,000	132,000
Aqueduct	3	@60,000	180,000
	9	@40,000	360,000
Check gate	3	@10,000	30,000
Secondary canal			
Earth works			155,000
Turnout	30	@ 3,000	90,000
Bridge (Farm)	30	@ 5,000	150,000
Regulating reservoir			50,000
Rehabilitation canal			3,000
Farm ditch			200,000
Drainage			240,000
Farm road			670,000
		Sub total	5,120,000
General expenses (20%)			1,020,000
		Total	6,140,000

1.6 Summary of the Estimated Cost of Alternative Plans

(Unit: U.S.$ 10^6)

ALT-A

Colo weir	3.0
Other civil works	23.7
Others	6.4
Total	33.1 /1

ALT-B-1

33.1 - 3.0 + 38.5 + 5.55 /2 = 74.15

ALT-B-2

33.1 + 8.3 + 1.37 /2 = 42.77

ALT-C

33.1 + 0.8 + 0.3 /2 = 34.2

ALT-D-1

33.1 + 5.7 - 2.5 + 0.7 /2 = 37.0

ALT-D-2

33.1 + 4.5 - 6.14 - 0.19 /2 = 31.27

/1 : see Table V-29.

/2 : Cost increase or Reduce of land acquisition, engineering and administrative expenses resulting from change in the direct construction cost.

Appendix V-2-1 Monthly Rainfall

Station Name: Tawang Sari

Unit: mm

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	Mean
1952	213	176	243	182	140	13	-	102	6	76	152	327	1,630	136
1953	157	194	351	203	124	-	17	-	-	-	252	272	1,570	131
1954	334	206	152	233	156	66	60	80	13	149	384	127	1,960	163
1955	360	288	386	369	28	126	107	100	19	192	196	241	2,412	201
1956						151	257	200	24	87	209	275	1,203	
1957	225	245	207	-	73	2	177	82	-	26	166	323	1,536	128
1958	192	286	243	247	157	124	171	88	68	113	176	406	2,271	189
1959	326	200	386	97	102	106	121	3	3	47	180	292	1,863	155
1960	234	342	215	221	289	17	5	45	22	46	268	138	1,842	154
1961	226	246	213	267	119	-	40	-	-	69	176	304	1,660	138
1962	373	283	320	313	23	67	33	55	9	55	261	283	2,075	173
1963	324	436	130	148	7	-	-	-	-					
1964		287	272	214	144	62	7	9	65	268	123	324		
1965	219	230	226	112	107	6	27	-	15	-	338	125	1,405	117
1966	229	415	495	134	18	22	-	-	4	207	286	338	2,148	179
1967	219	334	211	145	17	-	-	-	-	39	244	438	1,647	137
1968	336	184	540	161	225	196	54	110	122	133	282	177	2,525	210
1969	169	260	182	324	10	7	-	-	-	126	169	275	1,522	127
1970	218	211	355	252	219	54	25	-	32	47	257	270	1,940	162
1971	198	251	382	77	89	5	16	-	-	136	45	186	1,385	115
1972	208	122	326	158	337	-	-	-	-	-	132	260	1,543	129
1973	461	385	404	104	444	50	5		76	88	94	238	2,349	196
Mean	249	254	284	180	129	46	51	42	22	91	209	268		

Appendix V-2-2 Monthly Rainfall

Station Name: Sukoharjo
Unit: mm

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	Mean
1952														
1953														
1954														
1955														
1956	301	282	92	166	244	299	135	82	35	135	135	272	2,178	182
1957	252	217	250	122	47	26	164	62	-	12	164	224	1,540	128
1958	294	475	318	237	198	131	199	178	71	167	192	458	2,918	243
1959	360	192	282	193	49	76	72	-	7	32	223	268	1,754	146
1960	189	191	141	198	224	-	11	-	21	41	329	107	1,452	121
1961	186	329	244	244	101	15	4	-	-	70	272	361	1,826	152
1962	472	272	320	397	397	12	39	36	6	57	150	523	2,681	223
1963	319	319	327	239	19	13	-	-	-	-	205	378	1,819	152
1964			320	192	185	101	-	79	47	136	135	179		
1965	266	395		78	54	-	-	-	-	27	286	220		
1966	252	330	571	173	39	69	-	3	28	221	211	231	2,128	
1967	266	202	137	199	11	-	-	-	-	-	269	179	1,263	177
1968	355	298	348	379	198	136	135	56	102	127	155	210	2,499	105
1969	186	232	256	225	20	5	-	-	-	187	102	152	1,365	208
1970	262	237	463	117	180	-	4	3	34	39	333	255	1,927	114
1971	128	226	341	58	117	116	33	30	28	150	287	317	1,831	161
1972	312	104	278	216	102	-	-	4	-	-	137	317	1,470	153
1973	535	362	229	356	194	131	101	31	205	115	107	276	2,642	123
Mean	290	274	289	211	132	63	50	31	32	84	205	274		

Appendix V-2-3 Monthly Rainfall

Station Name: Bekonang
Unit: mm

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	Mean
1952	287	362	214	130	123	-	1	86	56	150	272	169	1,850	154
1953	222	499	333	326	139	2	36	-	-	-	165	182	1,904	159
1954	405	232	139	255	292	46	40	63	96	233	325	189	2,315	193
1955	220	142	216	113	48	145	352	78	59	140	376	383	2,272	189
1956					124	277	98	111	68	48	119	156		
1957	120	184	319	182	45	24	78	30	-	17	196	333	1,528	127
1958	164	328	438	273	292	20	177	32	162	160	144	320	2,510	209
1959	292	297	424	199	99	76	47	2	65	69	213	301	2,084	174
1960	214	420	169	181	155	43	-	-	20	79	340	124	1,797	150
1961	240	280	138	183	49	2	12	-	-	50	181	249	1,384	115
1962	353	305	312	359	-	122	37	62	18	105	230	575	2,478	207
1963	282	191	296	294	66	12	-	-	-	20	52	293	1,506	126
1964	77	179	436	227	205	65	-	27	38	340	191	314	2,099	175
1965	476	321	338	182	34	20	7	-	-	32	170	219	1,799	150
1966	296	623	433	234	55	104	-	-	23	221	177	257	2,423	202
1967	476	321	103		-	-	-	-	25	14	175	96		
1968	221	238	295	264	119	119	184	75	87	153	308	305	2,368	197
1969	127	322	257	389	95	14	-	-	-	104	76	203	1,587	132
1970	381	143	232	118	210	16	23	-	64	81				
1971			476		140	81	54	-	55					
1972	195	80	390	165	104	-	-	20	-	-	174	142	1,270	106
1973	365	290	330	240	182	152	50	33	105	87	140	284	2,258	188
Mean	258	277	285	216	123	61	54	28	43	100	201	255	1,902	159

Appendix V-2-4 Monthly Rainfall

Station Name: Masaran

Unit: mm

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	Mean
1952														
1953														
1954														
1955														
1956	490	322	86	339	134	178	138	136	176	172	91	368	2,630	219
1957	175	190	487	246	26	10	164	3	-	81	254	274	1,910	159
1958	366	327	492	336	210	41	164	72	164	243	269	423	3,107	259
1959	255	274	357	204	192	25	78	14	22	85	217	345	2,068	172
1960	262	507	203	205	167	26	12	1	5	117	446	147	2,098	175
1961	285	156	303	130	195	41	2	-	7	17	322	237	1,695	141
1962	449	279	232	555	9	123	181	44	12	119	214	218	2,435	203
1963	224	324	282	270	5	40	-	-	-	88	70	222	1,525	127
1964	238	399	200	249	230	105	19	19	26	218	79	241	2,023	169
1965	306	208	424	130	91	78	42	-	-	6	175	168	1,628	136
1966	399	288	239	226	91	121	-	-	43	326	204	140	2,077	173
1967	608	206	303	59	54	-	-	-	-	42	114	217	1,603	133
1968	338	355	455	342	157	232	341	109	31	193	424	264	3,241	270
1969	473	376	322	260	46	-	-	14	-	171	212	500	2,374	197
1970	175	462	234	158	278	43	51	-	104	164	170	155	1,994	166
1971	322	495	389	151	165	107	28	8	57	242	154	305	2,423	202
1972	159	188	337	193	74	-	-	54	-	5	232	164	1,406	117
1973	321	444	333	289	269	100	96	102	198	92	189	333	2,766	230
Mean	380	322	298	241	133	70	73	47	47	132	213	262.2		

Appendix V-2-5 Monthly Rainfall

Station Name: Sragen
Unit: mm

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	Mean
1952														
1953														
1954														
1955														
1956	488	245	217	130	116	133	26	77	110	122	88	225	1,977	165
1957	211	147	290	242	41	39	187	2	18	18	186	282	1,663	139
1958	219	328	605	241	201	34	153	98	74	315	215	501	2,769	231
1959	339	339	291	370	236	106	47	-	29	54	224	414	2,449	204
1960	174	349	231	187	146	15	52	-	7	126	640	173	2,100	175
1961	275	242	355	114	146	20	6	-	-	22	213	189	1,582	132
1962	412	207	299	371	9	37	152	25	-	95	282	320	2,209	184
1963	157	226	343	268	-	17	-	-	-	23	75	134	1,243	104
1964	225	195	236	264	246	137	69	56	36	303	114	221	2,102	175
1965	263	149	435	122	16	39	4	-	-	15	295	203	1,541	128
1966	376	344	270	228	69	79	-	-	8	198	210	171	1,953	163
1967	531	146	183	91	6	-	-	-	24	38	140	154	1,313	109
1968	386	399	453	220	255	193	142	36	-	147	467	280	2,978	248
1969	387	326	301	138	40	12	-	-	-	70	124	353	1,751	146
1970	157	332	365	104	192	88	60	-	76	34	236	163	1,807	151
1971	290	542	391	134	260	68	18	-	25	492	222	179	2,621	218
1972	250	190	319	157	181	19	-	-	-	3	263	191	1,573	131
1973	271	557	340	178	233	51	105	44	196	117	318	345	2,765	230
Mean	301	292	329	298	133	60	57	19	34	122	240	250		

Appendix V-2-6 Monthly Rainfall

Station Name: Mantingan

Unit: mm

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	Mean
1952	460	453	458	94	39	19	-	222	-	205	195	300	2,445	203.7
1953	328	424	255	245	280	10	43	-	-	7	289	338	2,219	184.9
1954	438	380	259	423	319	66	181	96	99	156	302	168	2,887	240.5
1955														
1956	494	190	271	104	94	170	13	74	131	208	266	162	2,177	181.4
1957														
1958	161	507	355	194	171	89	147	74	68	153	270	383	2,572	214.3
1959	204	497	398	317	205	44	84	14	72	114	172	373	2,494	207.8
1960	337	492	175	163	191	19	39	3	40	160	490	238	2,347	195.5
1961	307	164	204	88	33	7	1	-	3	17	89	138	1,051	87.5
1962	272	293	281	315	12	68	99	91	18	192	203	253	2,097	174.7
1963	355	295	392	176	8	98	-	-	2	42	241	260	1,869	155.7
1964	147	187	212	275	229	22	93	44	126	496	168	137	2,136	178
1965	439	384	396	134	13	1	173	-	3	79	374	383	2,379	198.2
1966	313	367	277	136	91	75	-	38	17	273	124	175	1,886	157.1
1967	578	297	192	113	17	-	-	-	-	32	137	230	1,596	133
1968	305	249	319	135	248	65	95	91	37	46	476	366	2,432	202.6
1969	299	267	277	288	38	2	-	-	-	194	343	333	2,041	170
1970														
1971														
1972														
1973														
Mean	339.8	453.8	295	200	124	48	60.5	46.6	38.5	148.3	258.6	264.8		

Appendix V-3-1 Average Monthly Evaporation

Unit: mm/day

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
Pabelan	1.5	1.4	1.5	1.7	1.5	2.3	3.2	3.4	4.3	2.9	2.4	2.0	2.4
Madiun	4.1	4.2	4.5	4.6	4.9	5.0	4.7	5.6	6.7	6.6	4.8	4.8	5.0
Mean	2.8	2.8	3.0	3.2	3.2	3.7	4.0	4.5	5.5	4.8	3.6	3.4	3.7

Appendix V-3-2 Average Monthly Temperature (at 9 O'clock)

Unit: °C

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
Panasan	27.3	27.4	27.8	28.3	28.5	28.0	27.5	28.0	29.1	29.6	28.8	28.1	28.2
Pabelan	27.3	27.9	28.2	29.4	28.6	28.5	28.1	27.8	27.4	28.5	28.6	28.1	28.2
Mean	27.3	27.7	28.0	28.9	28.6	28.3	27.8	27.9	28.3	29.1	28.7	28.1	

Appendix V-3-3 Average Maximum Monthly Temperature

Unit: °C

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
Panasan	-	-	-	-	-	-	-	-	-	-	-	-	-
Pabelan	30.4	31.2	31.4	32.8	32.2	32.4	31.6	32.6	31.9	32.3	30.9	30.5	31.7

Appendix V-3-4 Average Minimum Monthly Temperature

Unit: °C

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
Panasan	-	-	-	-	-	-	-	-	-	-	-	-	-
Pabelan	23.5	23.7	23.7	24.8	24.7	23.1	23.6	23.2	22.8	23.5	23.9	23.0	23.6

Appendix V-3-5 Average Monthly Relative Humidity

Unit: %

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
Panasan	75.8	76.9	76.4	72.0	69.4	66.6	62.7	69.4	59.5	60.8	70.5	74.0	68
Pabelan	-	-	-	-	-	-	-	-	-	-	-	-	-

Appendix V-3-6 Average Monthly Sunshine Hour

Unit: %

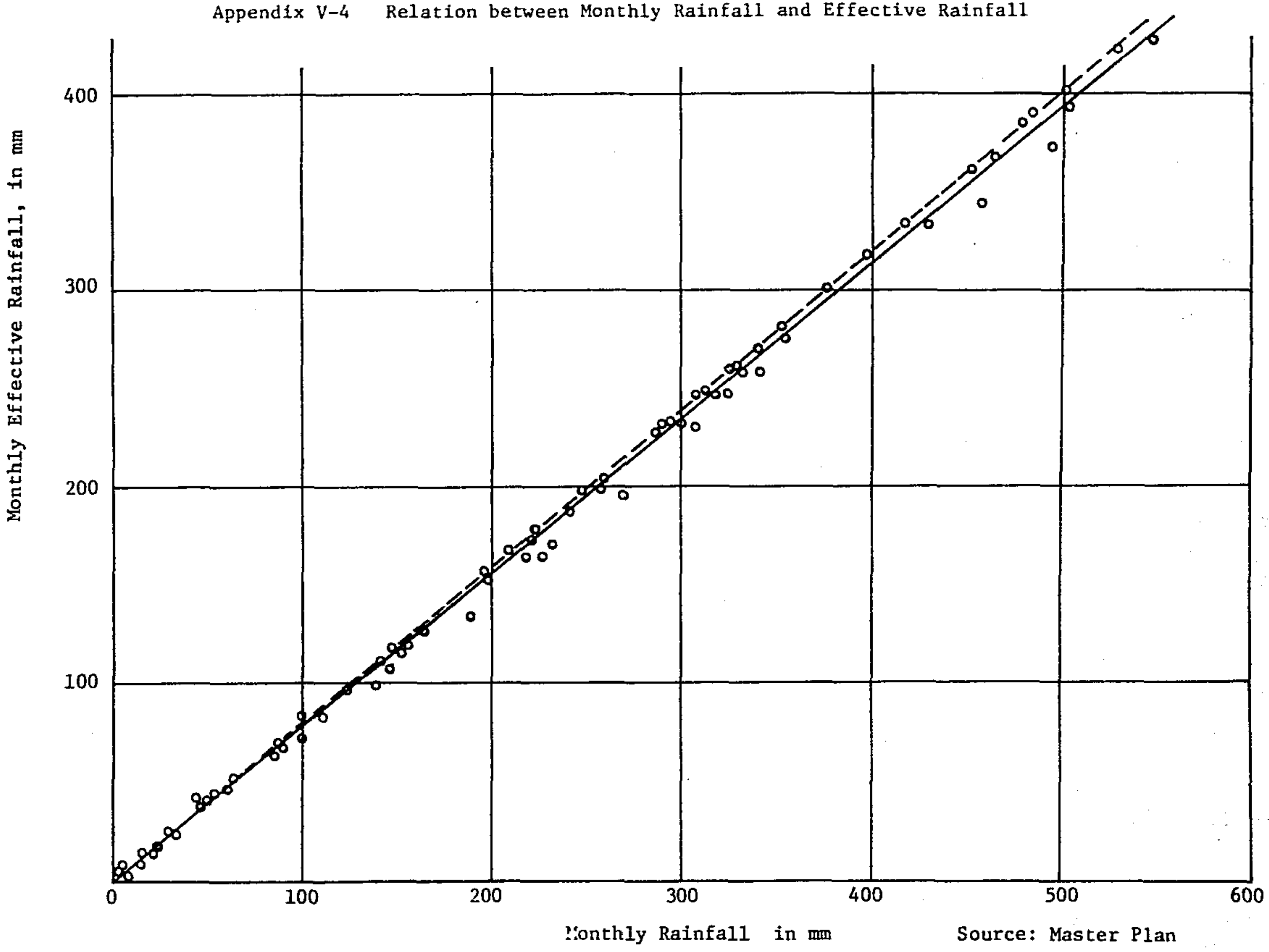
Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
Panasan	30.0	31.1	36.6	45.6	51.1	63.3	70.0	72.5	75.0	52.5	48.8	33.8	49.7

Appendix V-3-7 Average Monthly Wind Velocity

Unit: m/sec

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
Panasan	1.4	1.3	1.6	1.4	1.6	1.9	1.8	2.3	2.9	2.4	2.2	1.8	1.9
Pabelan	1.8	1.0	1.5	1.3	1.3	1.5	2.2	1.9	2.1	2.0	2.6	1.8	1.7

Appendix V-4 Relation between Monthly Rainfall and Effective Rainfall



Source: Master Plan

Appendix V-5 Effective Daily Rainfall

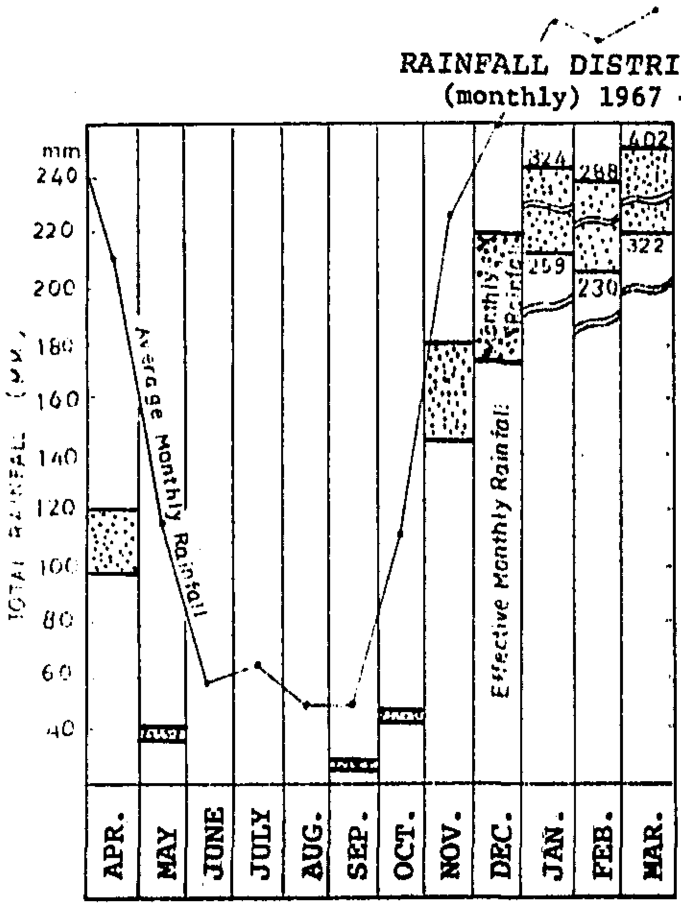
April 1967 - March 1968 (T - 10) Unit: mm

	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total
Monthly	121	21	0	0	0	8	28	180	219	324	288	402	1,591
Effective R.	97	17	0	0	0	6	22	144	175	259	230	322	1,272
E.Daily R.	3.2	0.5	0	0	0	0.2	0.7	4.8	5.6	8.4	8.2	10.4	

April 1961 - March 1962 (T - 5) Unit: mm

	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total
Monthly	171	107	13	11	0	2	41	209	246	389	273	294	1,756
Effective R.	137	86	10	9	0	2	33	167	197	311	218	235	1,405
E.Daily R.	4.4	2.8	0.3	0.3	0	0.1	1.1	5.6	6.4	10.0	7.8	7.6	

RAINFALL DISTRIBUTION
(monthly) 1967 - 1968



Appendix V-6-1 Monthly Consumptive Use by Rice

	$f = \frac{p}{100}(45.7\ t + 813)$			K = Kt · Kc			U	
Month	t°	p	f	Kt	Kc	K	(f·K) mm	U' mm/day
Apr.	28.9	8.12	173.3	1.14	0.91	1.04	180.2	6.0
May	28.6	8.26	175.1	1.13	1.06	1.20	210.1	6.8
June	28.3	7.96	167.7	1.12	1.31	1.47	246.5	8.2
July	27.8	8.23	171.5	1.10	1.28	1.41	241.8	7.8
Aug.	27.9	8.32	173.7	1.11	1.30	1.44	250.1	8.1
Sep.	28.3	8.18	172.3	1.12	1.50	1.68	289.5	9.6
Oct.	29.1	8.59	184.1	1.15	1.02	1.17	215.4	6.9
Nov.	28.7	8.45	177.2	1.13	0.98	1.11	196.7	6.6
Dec.	28.1	8.78	184.1	1.11	1.14	1.27	233.8	7.5
Jan.	27.3	8.77	180.7	1.09	1.11	1.21	218.6	7.1
Feb.	27.7	7.82	162.6	1.10	1.12	1.23	200.0	7.1
Mar.	28.0	8.52	178.3	1.11	1.23	1.37	244.3	7.9

Note: Kt = 0.0311 t° + 0.240

Appendix V-6-2   Monthly Consumptive Use by Sugar Cane

Month	f	K = Kt · Kc Kt	 Kc	 K	U (f·K) mm	U' mm/day
Apr.	173.3	1.14	0.65	0.74	128.2	4.3
May	175.1	1.13	0.63	0.71	124.3	4.0
June	167.7	1.12	0.55	0.62	104.0	3.5
July	171.5	1.10	0.56	0.62	106.3	3.4
Aug.	173.7	1.11	0.67	0.74	128.5	4.1
Sep.	172.3	1.12	0.75	0.84	144.7	4.8
Oct.	184.1	1.15	0.82	0.94	173.1	5.9
Nov.	177.2	1.13	0.87	0.98	173.7	5.8
Dec.	184.1	1.11	0.89	0.99	182.3	5.9
Jan.	180.7	1.09	0.90	0.98	177.1	5.7
Feb.	162.6	1.10	0.88	0.97	157.7	5.6
Mar.	178.3	1.11	0.82	0.91	162.3	5.2

Appendix V-6-3 Monthly Consumptive Use by Polowijo

Month	f	Kt	Kc	K	U mm	U' mm/day
Apr.	173.3	1.14	0.60	0.68	117.8	3.9
May	175.1	1.13	"	0.68	119.1	3.8
June	167.7	1.12	"	0.67	112.4	3.7
July	171.5	1.10	"	0.66	113.2	3.7
Aug.	173.7	1.11	"	0.67	116.4	3.9
Sep.	172.3	1.12	"	0.67	115.4	3.8
Oct.	184.1	1.15	"	0.69	127.0	4.1
Nov.	177.2	1.13	"	0.68	120.5	4.0
Dec.	184.1	1.11	"	0.67	123.3	4.0
Jan.	180.7	1.09	"	0.65	117.5	3.8
Feb.	162.6	1.10	"	0.66	107.5	3.8
Mar.	178.3	1.11	"	0.67	119.5	3.9

Appendix V-7-1 Calculation of Monthly Irrigation Requirement and Diversion Requirement

Year: 1953/54

Month	(1) Water Requirement			(2) Effective Rainfall	(3) Irrigation Area			(4) Irrigation Requirement				(5) Diversion Requirement
	Rice	Sugar Cane	Polowijo		Rice	Sugar Cane	Polowijo	Rice	Sugar Cane	Polowijo	Total	
	m^3/sec	m^3/sec	m^3/sec	mm/day	ha	ha	ha	m^3/sec	m^3/sec	m^3/sec	m^3/sec	m^3/sec
Apr.	2.26	1.88	1.08	6.9	1,507	3,780	2,400	1.06	0	0	1.06	1.51
May	10.22	2.19	1.06	4.7	5,665	4,725	"	7.14	0	0	7.14	10.20
June	20.68	1.75	1.03	0.1	13,223	4,320	"	20.53	1.70	1.00	23.23	33.19
July	19.75	1.28	1.03	0.8	15,800	3,240	"	18.29	0.98	0.81	20.08	28.69
Aug.	19.04	1.28	1.08	0	14,820	2,700	"	19.04	1.28	1.08	21.40	30.57
Sep.	11.52	1.50	1.06	0	7,900	"	"	11.52	1.50	1.06	14.08	20.11
Oct.	2.83	1.84	1.14	0.1	1,395	"	"	2.81	1.81	1.11	5.73	8.19
Nov.	13.69	1.81	1.11	6.3	6,633	"	"	8.85	0	0	8.85	12.64
Dec.	22.69	1.84	1.11	6.8	15,483	"	"	10.50	0	0	10.50	15.00
Jan.	19.48	1.78	1.06	10.1	18,500	"	"	0	0	0	0	0
Feb.	18.28	1.75	1.06	7.5	17,353	"	"	3.22	0	0	3.22	4.60
Mar.	10.60	1.63	1.08	4.7	9,250	2,835	"	5.57	0	0	5.57	7.96

Note: (4) = (1) - (2) x (3) x 10/86,400

(5) = Irrigation Requirement/Irrigation Efficiency = (4)/0.70

Appendix V-7-2 Calculation of Monthly Irrigation Requirement and Diversion Requirement

Year: 1954/55

Month	(1) Water Requirement			(2) Effective Rainfall	(3) Irrigation Area			(4) Irrigation Requirement				(5) Diversion Requirement
	Rice	Sugar Cane	Polowijo		Rice	Sugar Cane	Polowijo	Rice	Sugar Cane	Polowijo	Total	
	m^3/sec	m^3/sec	m^3/sec	mm/day	ha	ha	ha	m^3/sec	m^3/sec	m^3/sec	m^3/sec	m^3/sec
Apr.	2.26	1.88	1.08	8.1	1,507	3,780	2,400	0.85	0	0	0.85	1.21
May	10.22	2.19	1.06	6.6	5,665	4,725	"	5.89	0	0	5.89	8.41
June	20.68	1.75	1.03	1.6	13,223	4,320	"	18.23	0.95	0.59	19.77	28.24
July	19.75	1.28	1.03	2.4	15,800	3,240	"	15.36	0.38	0.36	16.10	23.00
Aug.	19.04	1.28	1.08	2.1	14,820	2,700	"	15.44	0.62	0.50	16.56	23.66
Sep.	11.52	1.50	1.06	1.8	7,900	"	"	9.87	0.94	0.56	11.37	16.24
Oct.	2.83	1.84	1.14	4.6	1,395	"	"	2.09	0.40	0	2.49	3.56
Nov.	13.69	1.81	1.11	9.0	6,633	"	"	6.78	0	0	6.78	9.69
Dec.	22.69	1.84	1.11	4.2	15,483	"	"	15.16	0.53	0	15.69	22.41
Jan.	19.48	1.78	1.06	7.5	18,500	"	"	3.42	0	0	3.42	4.89
Feb.	18.28	1.75	1.06	6.1	17,353	"	"	6.03	0	0	6.03	8.61
Mar.	10.60	1.63	1.08	7.8	9,250	2,835	"	2.25	0	0	2.25	3.21

Note: (4) = (1) - (2) x (3) x 10/86,400

(5) = Irrigation Requirement/Irrigation Efficiency = (4)/0.70

Appendix V-7-3 Calculation of Monthly Irrigation Requirement and Diversion Requirement

Year: 1955/56

Month	(1) Water Requirement			(2) Effective Rainfall	(3) Irrigation Area			(4) Irrigation Requirement				(5) Diversion Requirement
	Rice	Sugar Cane	Polowijo		Rice	Sugar Cane	Polowijo	Rice	Sugar Cane	Polowijo	Total	
	m^3/sec	m^3/sec	m^3/sec	mm/day	ha	ha	ha	m^3/sec	m^3/sec	m^3/sec	m^3/sec	m^3/sec
Apr.	2.26	1.88	1.08	6.4	1,507	3,780	2,400	1.14	0	0	1.14	1.63
May	10.22	2.19	1.06	1.0	5,665	4,725	"	9.56	1.64	0.78	11.98	17.11
June	20.68	1.75	1.03	3.6	13,223	4,320	"	15.17	0	0.03	15.20	21.71
July	19.75	1.28	1.03	5.9	15,800	3,240	"	8.96	0	0	8.96	12.80
Aug.	19.04	1.28	1.08	2.3	14,820	2,700	"	15.09	0.56	0.44	16.09	22.99
Sep.	11.52	1.50	1.06	1.0	7,900	"	"	10.61	1.19	0.78	12.58	17.97
Oct.	2.83	1.84	1.14	4.3	1,395	"	"	2.14	0.16	0	2.30	3.29
Nov.	13.69	1.81	1.11	7.6	6,633	"	"	7.86	0	0	7.86	11.23
Dec.	22.69	1.84	1.11	8.1	15,483	"	"	8.17	0	0	8.17	11.67
Jan.	19.48	1.78	1.06	11.4	18,500	"	"	0	0	0	0	0
Feb.	18.28	1.75	1.06	7.4	17,353	"	"	3.42	0	0	3.42	4.89
Mar.	10.60	1.63	1.08	4.3	9,250	2,835	"	6.00	0.22	0	6.22	8.89

Note: (4) = (1) - (2) x (3) x 10/86,400

(5) = Irrigation Requirement/Irrigation Efficiency = (4)/0.70

Appendix V-7-4 Calculation of Monthly Irrigation Requirement and Diversion Requirement

Year: 1956/57

Month	(1) Water Requirement			(2) Effective Rainfall	(3) Irrigation Area			(4) Irrigation Requirement				(5) Diversion Requirement
	Rice	Sugar Cane	Polowijo		Rice	Sugar Cane	Polowijo	Rice	Sugar Cane	Polowijo	Total	
	m^3/sec	m^3/sec	m^3/sec	mm/day	ha	ha	ha	m^3/sec	m^3/sec	m^3/sec	m^3/sec	m^3/sec
Apr.	2.26	1.88	1.08	4.9	1,507	3,780	2,400	1.41	0	0	1.41	2.01
May	10.22	2.19	1.06	3.7	5,665	4,725	"	7.79	0.17	0.03	7.99	11.41
June	20.68	1.75	1.03	5.4	13,223	4,320	"	12.42	0	0	12.42	17.74
July	19.75	1.28	1.03	2.9	15,800	3,240	"	14.45	0.19	0.22	14.86	21.23
Aug.	19.04	1.28	1.08	2.9	14,820	2,700	"	14.07	0.37	0.27	14.71	21.01
Sep.	11.52	1.50	1.06	2.4	7,900	"	"	9.33	0.75	0.39	10.47	14.96
Oct.	2.83	1.84	1.14	3.3	1,395	"	"	2.30	0.81	0.22	3.33	4.76
Nov.	13.69	1.81	1.11	4.0	6,633	"	"	10.62	0.56	0	11.18	15.97
Dec.	22.69	1.84	1.11	6.3	15,483	"	"	11.40	0	0	11.40	16.29
Jan.	19.48	1.78	1.06	5.1	18,500	"	"	8.56	0.15	0	8.71	12.44
Feb.	18.28	1.75	1.06	5.4	17,353	"	"	7.43	0.06	0	7.49	10.70
Mar.	10.60	1.63	1.08	8.0	9,250	2,835	"	2.04	0	0	2.04	2.91

Note: (4) = (1) - (2) x (3) x 10/86,400

(5) = Irrigation Requirement/Irrigation Efficiency = (4)/0.70

Appendix V-7-5 Calculation of Monthly Irrigation Requirement and Diversion Requirement

Year: 1957/58

Month	(1) Water Requirement			(2) Effective Rainfall	(3) Irrigation Area			(4) Irrigation Requirement				(5) Diversion Requirement
	Rice	Sugar Cane	Polowijo		Rice	Sugar Cane	Polowijo	Rice	Sugar Cane	Polowijo	Total	
	m^3/sec	m^3/sec	m^3/sec	mm/day	ha	ha	ha	m^3/sec	m^3/sec	m^3/sec	m^3/sec	m^3/sec
Apr.	2.26	1.88	1.08	4.2	1,507	3,780	2,400	1.53	0.04	0	1.57	2.24
May	10.22	2.19	1.06	1.2	5,665	4,725	"	9.43	1.53	0.73	11.69	16.70
June	20.68	1.75	1.03	0.5	13,223	4,320	"	19.91	1.50	0.89	22.30	31.86
July	19.75	1.28	1.03	4.0	15,800	3,240	"	12.44	0	0	12.44	17.77
Aug.	19.04	1.28	1.08	0.9	14,820	2,700	"	17.50	1.00	0.83	19.33	27.61
Sep.	11.52	1.50	1.06	0.1	7,900	"	"	11.43	1.47	1.03	13.93	19.90
Oct.	2.83	1.84	1.14	0.8	1,395	"	"	2.70	1.59	0.92	5.21	7.44
Nov.	13.69	1.81	1.11	5.1	6,633	"	"	9.77	0.22	0	9.99	14.27
Dec.	22.69	1.84	1.11	7.5	15,483	"	"	9.25	0	0	9.25	13.21
Jan.	19.48	1.78	1.06	6.0	18,500	"	"	6.63	0	0	6.63	9.47
Feb.	18.28	1.75	1.06	10.7	17,353	"	"	0	0	0	0	0
Mar.	10.60	1.63	1.08	10.6	9,250	2,835	"	0	0	0	0	0

Note: (4) = (1) - (2) x (3) x 10/86,400

(5) = Irrigation Requirement/Irrigation Efficiency = (4)/0.70

Appendix V-7-6 Calculation of Monthly Irrigation Requirement and Diversion Requirement

Year: 1958/59

Month	(1) Water Requirement			(2) Effective Rainfall	(3) Irrigation Area			(4) Irrigation Requirement				(5) Diversion Requirement
	Rice	Sugar Cane	Polowijo		Rice	Sugar Cane	Polowijo	Rice	Sugar Cane	Polowijo	Total	
	m^3/sec	m^3/sec	m^3/sec	mm/day	ha	ha	ha	m^3/sec	m^3/sec	m^3/sec	m^3/sec	m^3/sec
Apr.	2.26	1.88	1.08	6.8	1,507	3,780	2,400	1.07	0	0	1.07	1.53
May	10.22	2.19	1.06	5.3	5,665	4,725	"	6.74	0	0	6.74	9.63
June	20.68	1.75	1.03	1.9	13,223	4,320	"	17.77	0.80	0.50	3.07	4.39
July	19.75	1.28	1.03	4.4	15,800	3,240	"	11.70	0	0	11.71	16.71
Aug.	19.04	1.28	1.08	2.3	14,820	2,700	"	15.09	0.56	0.44	16.09	22.99
Sep.	11.52	1.50	1.06	2.7	7,900	"	"	9.05	0.66	0.31	10.02	14.31
Oct.	2.83	1.84	1.14	5.0	1,395	"	"	2.02	0.28	0	2.30	3.29
Nov.	13.69	1.81	1.11	5.6	6,633	"	"	9.39	0.06	0	9.45	13.50
Dec.	22.69	1.84	1.11	10.7	15,483	"	"	3.52	0	0	3.52	5.03
Jan.	19.48	1.78	1.06	7.6	18,500	"	"	3.21	0	0	3.21	4.59
Feb.	18.28	1.75	1.06	8.6	17,353	"	"	1.01	0	0	1.01	1.44
Mar.	10.60	1.63	1.08	9.2	9,250	2,835	"	0.75	0	0	0.75	1.07

Note: (4) = (1) - (2) x (3) x 10/86,400

(5) = Irrigation Requirement/Irrigation Efficiency = (4)/0.70

Appendix V-7-7 Calculation of Monthly Irrigation Requirement and Diversion Requirement

Year: 1959/60

Month	(1) Water Requirement			(2) Effective Rainfall	(3) Irrigation Area			(4) Irrigation Requirement				(5) Diversion Requirement
	Rice	Sugar Cane	Polowijo		Rice	Sugar Cane	Polowijo	Rice	Sugar Cane	Polowijo	Total	
	m^3/sec	m^3/sec	m^3/sec	mm/day	ha	ha	ha	m^3/sec	m^3/sec	m^3/sec	m^3/sec	m^3/sec
Apr.	2.26	1.88	1.08	6.1	1,507	3,780	2,400	1.20	0	0	1.20	1.71
May	10.22	2.19	1.06	3.8	5,665	4,725	"	7.73	0.11	0	7.84	11.20
June	20.68	1.75	1.03	1.9	13,223	4,320	"	17.77	0.80	0.50	19.07	27.24
July	19.75	1.28	1.03	1.9	15,800	3,240	"	16.28	0.57	0.50	17.35	24.79
Aug.	19.04	1.28	1.08	0.2	14,820	2,700	"	18.70	1.22	1.02	20.94	29.91
Sep.	11.52	1.50	1.06	0.9	7,900	"	"	10.70	1.22	0.81	12.73	18.19
Oct.	2.83	1.84	1.14	1.7	1,395	"	"	2.56	1.31	0.67	4.54	6.49
Nov.	13.69	1.81	1.11	5.5	6,633	"	"	9.47	0.09	0	9.56	13.66
Dec.	22.69	1.84	1.11	8.6	15,483	"	"	7.28	0	0	7.28	10.40
Jan.	19.48	1.78	1.06	6.1	18,500	"	"	6.42	0	0	6.42	9.17
Feb.	18.28	1.75	1.06	10.8	17,353	"	"	0	0	0	0	0
Mar.	10.60	1.63	1.08	4.9	9,250	2,835	"	5.35	0.10	0	5.45	7.79

Note: (4) = (1) - (2) x (3) x 10/86,400

(5) = Irrigation Requirement/Irrigation Efficiency = (4)/0.70

Appendix V-7-8 Calculation of Monthly Irrigation Requirement and Diversion Requirement

Year: 1960/61

Month	(1) Water Requirement			(2) Effective Rainfall	(3) Irrigation Area			(4) Irrigation Requirement				(5) Diversion Requirement
	Rice	Sugar Cane	Polowijo		Rice	Sugar Cane	Polowijo	Rice	Sugar Cane	Polowijo	Total	
	m^3/sec	m^3/sec	m^3/sec	mm/day	ha	ha	ha	m^3/sec	m^3/sec	m^3/sec	m^3/sec	m^3/sec
Apr.	2.26	1.88	1.08	5.1	1,507	3,780	2,400	1.37	0	0	1.37	1.96
May	10.22	2.19	1.06	5.0	5,665	4,725	"	6.94	0	0	6.94	9.91
June	20.68	1.75	1.03	0.5	13,223	4,320	"	19.91	1.50	0.89	22.30	31.86
July	19.75	1.28	1.03	0.5	15,800	3,240	"	18.84	1.09	0.89	20.82	29.74
Aug.	19.04	1.28	1.08	0.2	14,820	2,700	"	18.70	1.22	1.02	20.94	29.91
Sep.	11.52	1.50	1.06	0.5	7,900	"	"	11.06	1.34	0.92	13.32	19.03
Oct.	2.83	1.84	1.14	2.5	1,395	"	"	2.43	1.06	0.45	3.94	5.63
Nov.	13.69	1.81	1.11	11.2	6,633	"	"	5.09	0	0	5.09	7.27
Dec.	22.69	1.84	1.11	4.0	15,483	"	"	15.52	0.59	0	16.11	23.01
Jan.	19.48	1.78	1.06	6.5	18,500	"	"	5.56	0	0	5.56	7.94
Feb.	18.28	1.75	1.06	6.7	17,353	"	"	4.82	0	0	4.82	6.89
Mar.	10.60	1.63	1.08	6.3	9,250	2,835	"	3.86	0	0	3.86	5.51

Note: (4) = (1) - (2) x (3) x 10/86,400

(5) = Irrigation Requirement/Irrigation Efficiency = (4)/0.70

Appendix V-7-9 Calculation of Monthly Irrigation Requirement and Diversion Requirement

Year: 1961/62

Month	(1) Water Requirement			(2) Effective Rainfall	(3) Irrigation Area			(4) Irrigation Requirement				(5) Diversion Requirement
	Rice	Sugar Cane	Polowijo		Rice	Sugar Cane	Polowijo	Rice	Sugar Cane	Polowijo	Total	
	m^3/sec	m^3/sec	m^3/sec	mm/day	ha	ha	ha	m^3/sec	m^3/sec	m^3/sec	m^3/sec	m^3/sec
Apr.	2.26	1.88	1.08	4.6	1,507	3,780	2,400	1.70	0.47	0	2.17	3.10
May	10.22	2.19	1.06	2.8	5,665	4,725	"	8.93	1.12	0.28	10.33	14.76
June	20.68	1.75	1.03	0.3	13,223	4,320	"	20.36	1.65	0.95	22.96	32.80
July	19.75	1.28	1.03	0.3	15,800	3,240	"	19.37	1.20	0.95	21.52	30.74
Aug.	19.04	1.28	1.08	0	14,820	2,700	"	19.04	1.28	1.08	21.40	30.57
Sep.	11.52	1.50	1.06	0.1	7,900	"	"	11.46	1.47	1.03	13.96	19.94
Oct.	2.83	1.84	1.14	1.1	1,395	"	"	2.71	1.50	0.83	5.04	7.20
Nov.	13.69	1.81	1.11	5.6	6,633	"	"	10.68	0.06	0	10.74	15.34
Dec.	22.69	1.84	1.11	6.3	15,483	"	"	14.79	0	0	14.79	21.13
Jan.	19.48	1.78	1.06	10.0	18,500	"	"	4.49	0	0	4.49	6.41
Feb.	18.28	1.75	1.06	7.8	17,353	"	"	7.31	0	0	7.31	10.44
Mar.	10.60	1.63	1.08	7.6	9,250	2,835	"	4.90	0	0	4.90	7.00

Note: (4) = (1) - (2) x (3) x 10/86,400

(5) = Irrigation Requirement/Irrigation Efficiency = (4)/0.70

Appendix V-7-10 Calculation of Monthly Irrigation Requirement and Diversion Requirement

Year: 1962/63

Month	(1) Water Requirement			(2) Effective Rainfall	(3) Irrigation Area			(4) Irrigation Requirement				(5) Diversion Requirement
	Rice	Sugar Cane	Polowijo		Rice	Sugar Cane	Polowijo	Rice	Sugar Cane	Polowijo	Total	
	m^3/sec	m^3/sec	m^3/sec	mm/day	ha	ha	ha	m^3/sec	m^3/sec	m^3/sec	m^3/sec	m^3/sec
Apr.	2.26	1.88	1.08	10.3	1,507	3,780	2,400	0.46	0	0	0.46	0.66
May	10.22	2.19	1.06	2.3	5,665	4,725	"	8.71	0.93	0.42	10.06	14.37
June	20.68	1.75	1.03	1.6	13,223	4,320	"	18.23	0.95	0.59	19.77	28.24
July	19.75	1.28	1.03	2.3	15,800	3,240	"	15.54	0.42	0.39	16.35	23.36
Aug.	19.04	1.28	1.08	1.3	14,820	2,700	"	16.81	0.87	0.72	18.40	26.29
Sep.	11.52	1.50	1.06	0.3	7,900	"	"	11.25	1.41	0.98	13.64	19.49
Oct.	2.83	1.84	1.14	2.7	1,395	"	"	2.39	1.00	0	3.39	4.84
Nov.	13.69	1.81	1.11	5.9	6,633	"	"	9.16	0	0	9.16	13.09
Dec.	22.69	1.84	1.11	9.3	15,483	"	"	6.02	0	0	6.02	8.60
Jan.	19.48	1.78	1.06	7.1	18,500	"	"	4.28	0	0	4.28	6.11
Feb.	18.28	1.75	1.06	8.2	17,353	"	"	1.81	0	0	1.81	2.59
Mar.	10.60	1.63	1.08	7.6	9,250	2,835	"	2.46	0	0	2.46	3.51

Note: (4) = (1) - (2) x (3) x 10/86,400

(5) = Irrigation Requirement/Irrigation Efficiency = (4)/0.70

Appendix V-7-11 *Calculation of Monthly Irrigation Requirement* **and Diversion Requirement**

Year: 1963/64

Month	(1) Water Requirement			(2) Effective	(3) Irrigation Area			(4) Irrigation Requirement				(5) Diversion
	Rice	Sugar Cane	Polowijo	Rainfall	Rice	Sugar Cane	Polowijo	Rice	Sugar Cane	Polowijo	Total	Requirement
	m^3/sec	m^3/sec	m^3/sec	mm/day	ha	ha	ha	m^3/sec	m^3/sec	m^3/sec	m^3/sec	m^3/sec
Apr.	2.26	1.88	1.08	6.2	1,507	3,780	2,400	2.09	0	0	2.09	2.99
May	10.22	2.19	1.06	0.5	5,665	4,725	"	9.89	1.92	0.92	12.73	18.19
June	20.68	1.75	1.03	0.8	13,223	4,320	"	19.46	1.35	0.81	21.62	30.89
July	19.75	1.28	1.03	0	15,800	3,240	"	19.75	1.28	1.03	22.06	31.51
Aug.	19.04	1.28	1.08	0	14,820	2,700	"	19.04	1.28	1.08	21.40	30.57
Sep.	11.52	1.50	1.06	0	7,900	"	"	11.52	1.50	1.06	14.08	20.11
Oct.	2.83	1.84	1.14	0.9	1,395	"	"	2.68	1.56	0.89	5.13	7.33
Nov.	13.69	1.81	1.11	3.4	6,633	"	"	11.08	0.75	0.17	12.00	17.14
Dec.	22.69	1.84	1.11	6.6	15,483	"	"	10.86	0	0	10.86	15.51
Jan.	19.48	1.78	1.06	4.4	18,500	"	"	10.06	0.41	0	10.47	14.96
Feb.	18.28	1.75	1.06	7.1	17,353	"	"	4.02	0	0	4.02	5.74
Mar.	10.60	1.63	1.08	7.2	9,250	2,835	"	2.89	0	0	2.89	4.13

Note: (4) = (1) - (2) x (3) x 10/86,400

(5) = Irrigation Requirement/Irrigation Efficiency = (4)/0.70

Appendix V-7-12 Calculation of Monthly Irrigation Requirement and Diversion Requirement

Year: 1964/65

Month	(1) Water Requirement			(2) Effective Rainfall	(3) Irrigation Area			(4) Irrigation Requirement				(5) Diversion Requirement
	Rice	Sugar Cane	Polowijo		Rice	Sugar Cane	Polowijo	Rice	Sugar Cane	Polowijo	Total	
	m^3/sec	m^3/sec	m^3/sec	mm/day	ha	ha	ha	m^3/sec	m^3/sec	m^3/sec	m^3/sec	m^3/sec
Apr.	2.26	1.88	1.08	6.3	1,507	3,780	2,400	1.16	0	0	1.16	1.66
May	10.22	2.19	1.06	5.3	5,665	4,725	"	6.74	0	0	6.74	9.63
June	20.68	1.75	1.03	2.2	13,223	4,320	"	17.31	0.65	0.42	18.38	26.26
July	19.75	1.28	1.03	0.8	15,800	3,240	"	18.29	0.98	0.81	20.08	28.69
Aug.	19.04	1.28	1.08	1.0	14,820	2,700	"	17.32	0.97	0.80	19.09	27.27
Sep.	11.52	1.50	1.06	1.5	7,900	"	"	10.15	1.03	0.64	11.82	16.89
Oct.	2.83	1.84	1.14	7.6	1,395	"	"	1.60	0	0	1.60	2.29
Nov.	13.69	1.81	1.11	3.6	6,633	"	"	10.93	0.72	0.11	11.76	16.80
Dec.	22.69	1.84	1.11	6.1	15,483	"	"	11.76	0	0	11.76	16.80
Jan.	19.48	1.78	1.06	8.5	18,500	"	"	1.28	0	0	1.28	1.83
Feb.	18.28	1.75	1.06	8.0	17,353	"	"	2.21	0	0	2.21	3.16
Mar.	10.60	1.63	1.08	9.4	9,250	2,835	"	0.54	0	0	0.54	0.77

Note: (4) = (1) - (2) x (3) x 10/86,400

(5) = Irrigation Requirement/Irrigation Efficiency = (4)/0.70

Appendix V-7-13 Calculation of Monthly Irrigation Requirement and Diversion Requirement

Year: 1965/66

Month	(1) Water Requirement Rice	Sugar Cane	Polowijo	(2) Effective Rainfall	(3) Irrigation Area Rice	Sugar Cane	Polowijo	(4) Irrigation Requirement Rice	Sugar Cane	Polowijo	Total	(5) Diversion Requirement
	m^3/sec	m^3/sec	m^3/sec	mm/day	ha	ha	ha	m^3/sec	m^3/sec	m^3/sec	m^3/sec	m^3/sec
Apr.	2.26	1.88	1.08	3.4	1,507	3,780	2,400	1.67	0.39	0.14	2.20	3.14
May	10.22	2.19	1.06	1.4	5,665	4,725	"	9.30	1.42	0.67	11.39	16.27
June	20.68	1.75	1.03	0.6	13,223	4,320	"	19.76	1.45	0.86	22.07	31.53
July	19.75	1.28	1.03	1.1	15,800	3,240	"	17.74	0.87	0.72	19.33	27.61
Aug.	19.04	1.28	1.08	0	14,820	2,700	"	19.04	1.28	1.08	21.40	30.57
Sep.	11.52	1.50	1.06	0.1	7,900	"	"	11.43	1.47	1.03	13.93	19.90
Oct.	2.83	1.84	1.14	0.7	1,395	"	"	2.72	1.62	0.95	5.29	7.56
Nov.	13.69	1.81	1.11	7.3	6,633	"	"	8.09	0	0	8.09	11.56
Dec.	22.69	1.84	1.11	5.7	15,483	"	"	12.48	0.06	0	12.54	17.91
Jan.	19.48	1.78	1.06	8.0	18,500	"	"	2.35	0	0	2.35	3.36
Feb.	18.28	1.75	1.06	10.9	17,353	"	"	0	0	0	0	0
Mar.	10.60	1.63	1.08	9.8	9,250	2,835	"	0.11	0	0	0.11	0.16

Note: (4) = (1) - (2) x (3) x 10/86,400

(5) = Irrigation Requirement/Irrigation Efficiency = (4)/0.70

Appendix V-7-14 Calculation of Monthly Irrigation Requirement and Diversion Requirement

Year: 1966/67

Month	(1) Water Requirement			(2) Effective Rainfall	(3) Irrigation Area			(4) Irrigation Requirement				(5) Diversion Requirement
	Rice	Sugar Cane	Polowijo		Rice	Sugar Cane	Polowijo	Rice	Sugar Cane	Polowijo	Total	
	m^3/sec	m^3/sec	m^3/sec	mm/day	ha	ha	ha	m^3/sec	m^3/sec	m^3/sec	m^3/sec	m^3/sec
Apr.	2.26	1.88	1.08	5.0	1,507	3,780	2,400	1.39	0	0	1.39	1.99
May	10.22	2.19	1.06	1.6	5,665	4,725	"	9.17	1.32	0.62	11.11	15.87
June	20.68	1.75	1.03	2.1	13,223	4,320	"	17.47	0.70	0.45	18.62	26.60
July	19.75	1.28	1.03	0	15,800	3,240	"	19.75	1.28	1.03	22.06	31.51
Aug.	19.04	1.28	1.08	0.2	14,820	2,700	"	18.70	1.22	1.02	20.94	29.91
Sep.	11.52	1.50	1.06	0.6	7,900	"	"	10.97	1.31	0.89	13.17	18.81
Oct.	2.83	1.84	1.14	6.2	1,395	"	"	1.83	0	0	1.83	2.61
Nov.	13.69	1.81	1.11	5.4	6,633	"	"	9.54	0.12	0	9.66	13.80
Dec.	22.69	1.84	1.11	5.7	15,483	"	"	12.48	0.06	0	12.54	17.91
Jan.	19.48	1.78	1.06	11.5	18,500	"	"	5.14	0	0	5.14	7.34
Feb.	18.28	1.75	1.06	7.2	17,353	"	"	3.82	0	0	3.82	5.46
Mar.	10.60	1.63	1.08	4.9	9,250	2,835	"	5.35	0.10	0	5.45	7.79

Note: (4) = (1) - (2) x (3) x 10/86,400

(5) = Irrigation Requirement/Irrigation Efficiency = (4)/0.70

Appendix V-7-15 Calculation of Monthly Irrigation Requirement and Diversion Requirement

Year: 1967/68

Month	(1) Water Requirement			(2) Effective Rainfall	(3) Irrigation Area			(4) Irrigation Requirement				(5) Diversion Requirement
	Rice	Sugar Cane	Polowijo		Rice	Sugar Cane	Polowijo	Rice	Sugar Cane	Polowijo	Total	
	m^3/sec	m^3/sec	m^3/sec	mm/day	ha	ha	ha	m^3/sec	m^3/sec	m^3/sec	m^3/sec	m^3/sec
Apr.	2.26	1.88	1.08	3.2	1,507	3,780	2,400	1.70	0.48	0.19	2.37	3.39
May	10.22	2.19	1.06	0.5	5,665	4,725	"	9.89	1.92	0.92	12.73	18.19
June	20.68	1.75	1.03	0	13,223	4,320	"	20.68	1.75	1.03	23.46	33.51
July	19.75	1.28	1.03	0	15,800	3,240	"	19.75	1.28	1.03	22.06	31.51
Aug.	19.04	1.28	1.08	0	14,820	2,700	"	19.04	1.28	1.08	21.40	30.57
Sep.	11.52	1.50	1.06	0.2	7,900	"	"	11.52	1.44	1.00	13.96	19.94
Oct.	2.83	1.84	1.14	0.7	1,395	"	"	2.72	1.62	0.95	5.29	7.56
Nov.	13.69	1.81	1.11	4.8	6,633	"	"	10.01	0.31	0	10.32	14.74
Dec.	22.69	1.84	1.11	5.7	15,483	"	"	12.48	0.06	0	12.54	17.91
Jan.	19.48	1.78	1.06	8.4	18,500	"	"	1.49	0	0	1.49	2.13
Feb.	18.28	1.75	1.06	8.2	17,353	"	"	1.81	0	0	1.81	2.59
Mar.	10.60	1.63	1.08	10.4	9,250	2,835	"	0	0	0	0	0

Note: (4) = (1) - (2) x (3) x 10/86,400

(5) = Irrigation Requirement/Irrigation Efficiency = (4)/0.70

Appendix V-7-16 Calculation of Monthly Irrigation Requirement and Diversion Requirement

Year: 1968/69

Month	(1) Water Requirement			(2) Effective Rainfall	(3) Irrigation Area			(4) Irrigation Requirement				(5) Diversion Requirement
	Rice	Sugar Cane	Polowijo		Rice	Sugar Cane	Polowijo	Rice	Sugar Cane	Polowijo	Total	
	m^3/sec	m^3/sec	m^3/sec	mm/day	ha	ha	ha	m^3/sec	m^3/sec	m^3/sec	m^3/sec	m^3/sec
Apr.	2.26	1.88	1.08	6.7	1,507	3,780	2,400	1.09	0	0	1.09	1.56
May	10.22	2.19	1.06	5.2	5,665	4,725	"	6.81	0	0	6.81	9.73
June	20.68	1.75	1.03	4.2	13,223	4,320	"	14.25	0	0	14.25	20.36
July	19.75	1.28	1.03	4.1	15,800	3,240	"	12.25	0	0	12.25	17.50
Aug.	19.04	1.28	1.08	2.1	14,820	2,700	"	15.44	0.62	0.50	16.56	23.66
Sep.	11.52	1.50	1.06	1.7	7,900	"	"	9.97	0.97	0.59	11.53	16.47
Oct.	2.83	1.84	1.14	3.4	1,395	"	"	2.28	0.78	0.20	3.26	4.66
Nov.	13.69	1.81	1.11	9.3	6,633	"	"	6.55	0	0	6.55	9.36
Dec.	22.69	1.84	1.11	6.9	15,483	"	"	10.33	0	0	10.33	14.76
Jan.	19.48	1.78	1.06	7.1	18,500	"	"	4.28	0	0	4.28	6.11
Feb.	18.28	1.75	1.06	8.2	17,353	"	"	1.81	0	0	1.81	2.59
Mar.	10.60	1.63	1.08	6.9	9,250	2,835	"	3.21	0	0	3.21	4.59

Note: (4) = (1) - (2) x (3) x 10/86,400

(5) = Irrigation Requirement/Irrigation Efficiency = (4)/0.70

Appendix V-7-17 Calculation of Monthly Irrigation Requirement and Diversion Requirement

Year: 1969/70

Month	(1) Water Requirement			(2) Effective Rainfall	(3) Irrigation Area			(4) Irrigation Requirement				(5) Diversion Requirement
	Rice	Sugar Cane	Polowijo		Rice	Sugar Cane	Polowijo	Rice	Sugar Cane	Polowijo	Total	
	m^3/sec	m^3/sec	m^3/sec	mm/day	ha	ha	ha	m^3/sec	m^3/sec	m^3/sec	m^3/sec	m^3/sec
Apr.	2.26	1.88	1.08	7.2	1,507	3,780	2,400	1.00	0	0	1.00	1.43
May	10.22	2.19	1.06	1.1	5,665	4,725	"	9.50	1.59	0.75	11.84	16.91
June	20.68	1.75	1.03	0.2	13,223	4,320	"	20.37	1.65	0.97	22.99	32.84
July	19.75	1.28	1.03	0	15,800	3,240	"	19.75	1.28	1.03	22.06	31.51
Aug.	19.04	1.28	1.08	0.1	14,820	2,700	"	18.87	1.25	1.05	21.17	30.24
Sep.	11.52	1.50	1.06	0	7,900	"	"	11.52	1.50	1.06	14.08	20.11
Oct.	2.83	1.84	1.14	3.7	1,395	"	"	2.23	0.68	0.11	3.02	4.31
Nov.	13.69	1.81	1.11	4.6	6,633	"	"	10.16	0.37	0	10.53	15.04
Dec.	22.69	1.84	1.11	7.8	15,483	"	"	8.71	0	0	8.71	12.44
Jan.	19.48	1.78	1.06	6.2	18,500	"	"	6.20	0	0	6.20	8.86
Feb.	18.28	1.75	1.06	7.9	17,353	"	"	2.41	0	0	2.41	3.44
Mar.	10.60	1.63	1.08	8.5	9,250	2,835	"	1.50	0	0	1.50	2.14

Note: (4) = (1) - (2) x (3) x 10/86,400

(5) = Irrigation Requirement/Irrigation Efficiency = (4)/0.70

Appendix V-7-18 Calculation of Monthly Irrigation Requirement and Diversion Requirement

Year: 1970/71

Month	(1) Water Requirement			(2) Effective Rainfall	(3) Irrigation Area			(4) Irrigation Requirement				(5) Diversion Requirement
	Rice	Sugar Cane	Polowijo		Rice	Sugar Cane	Polowijo	Rice	Sugar Cane	Polowijo	Total	
	m^3/sec	m^3/sec	m^3/sec	mm/day	ha	ha	ha	m^3/sec	m^3/sec	m^3/sec	m^3/sec	m^3/sec
Apr.	2.26	1.88	1.08	4.0	1,507	3,780	2,400	1.56	0.13	0	1.69	2.41
May	10.22	2.19	1.06	5.6	5,665	4,725	"	6.55	0	0	6.55	9.36
June	20.68	1.75	1.03	1.1	13,223	4,320	"	19.00	1.20	0.72	20.92	29.89
July	19.75	1.28	1.03	0.9	15,800	3,240	"	18.10	0.94	0.78	19.82	28.31
Aug.	19.04	1.28	1.08	0	14,820	2,700	"	19.04	1.28	1.08	21.40	30.57
Sep.	11.52	1.50	1.06	1.7	7,900	"	"	9.97	0.97	0.59	11.53	16.47
Oct.	2.83	1.84	1.14	1.9	1,395	"	"	2.52	1.25	0.61	4.38	6.26
Nov.	13.69	1.81	1.11	6.6	6,633	"	"	8.62	0	0	8.62	12.31
Dec.	22.69	1.84	1.11	5.4	15,483	"	"	13.01	0.15	0	13.16	18.80
Jan.	19.48	1.78	1.06	6.1	18,500	"	"	6.42	0	0	6.42	9.17
Feb.	18.28	1.75	1.06	10.8	17,353	"	"	3.41	0	0	3.41	4.87
Mar.	10.60	1.63	1.08	10.2	9,250	2,835	"	0	0	0	0	0

Note: (4) = (1) - (2) x (3) x 10/86,400

(5) = Irrigation Requirement/Irrigation Efficiency = (4)/0.70

Appendix V-7-19 Calculation of Monthly Irrigation Requirement and Diversion Requirement

Year: 1971/72

Month	(1) Water Requirement			(2) Effective Rainfall	(3) Irrigation Area			(4) Irrigation Requirement				(5) Diversion Requirement
	Rice	Sugar Cane	Polowijo		Rice	Sugar Cane	Polowijo	Rice	Sugar Cane	Polowijo	Total	
	m^3/sec	m^3/sec	m^3/sec	mm/day	ha	ha	ha	m^3/sec	m^3/sec	m^3/sec	m^3/sec	m^3/sec
Apr.	2.26	1.88	1.08	2.8	1,507	3,780	2,400	1.77	0.66	0.30	2.73	3.90
May	10.22	2.19	1.06	4.0	5,665	4,725	"	7.60	0	0	7.60	10.86
June	20.68	1.75	1.03	2.0	13,223	4,320	"	17.62	0.75	0.47	18.84	26.91
July	19.75	1.28	1.03	0.8	15,800	3,240	"	18.29	0.98	0.81	20.08	28.69
Aug.	19.04	1.28	1.08	0.2	14,820	2,700	"	18.70	1.22	1.02	20.94	29.91
Sep.	11.52	1.50	1.06	0.9	7,900	"	"	10.70	1.22	0.81	12.73	18.19
Oct.	2.83	1.84	1.14	6.6	1,395	"	"	1.76	0	0	1.76	2.51
Nov.	13.69	1.81	1.11	4.7	6,633	"	"	10.08	0.34	0	10.42	14.89
Dec.	22.69	1.84	1.11	6.4	15,483	"	"	11.22	0	0	11.22	16.03
Jan.	19.48	1.78	1.06	5.8	18,500	"	"	7.06	0	0	7.06	10.09
Feb.	18.28	1.75	1.06	3.9	17,353	"	"	10.45	0.53	0	10.98	15.69
Mar.	10.60	1.63	1.08	8.5	9,250	2,835	"	1.50	0	0	1.50	2.14

Note: (4) = (1) - (2) x (3) x 10/86,400

(5) = Irrigation Requirement/Irrigation Efficiency = (4)/0.70

Appendix V-7-20 Calculation of Monthly Irrigation Requirement and Diversion Requirement

Year: 1972/73

Month	(1) Water Requirement			(2) Effective Rainfall	(3) Irrigation Area			(4) Irrigation Requirement				(5) Diversion Requirement
	Rice	Sugar Cane	Polowijo		Rice	Sugar Cane	Polowijo	Rice	Sugar Cane	Polowijo	Total	
	m^3/sec	m^3/sec	m^3/sec	mm/day	ha	ha	ha	m^3/sec	m^3/sec	m^3/sec	m^3/sec	m^3/sec
Apr.	2.26	1.88	1.08	4.7	1,507	3,780	2,400	1.44	0	0	1.44	2.06
May	10.22	2.19	1.06	4.1	5,665	4,725	"	7.53	0	0	7.53	10.76
June	20.68	1.75	1.03	0.1	13,223	4,320	"	20.53	1.70	1.00	23.23	33.19
July	19.75	1.28	1.03	0	15,800	3,240	"	19.75	1.28	1.03	22.06	31.51
Aug.	19.04	1.28	1.08	0.4	14,820	2,700	"	18.35	1.16	0.97	20.48	29.26
Sep.	11.52	1.50	1.06	0	7,900	"	"	11.52	1.50	1.06	14.08	20.11
Oct.	2.83	1.84	1.14	0.1	1,395	"	"	2.81	1.81	1.11	5.73	8.19
Nov.	13.69	1.81	1.11	5.0	6,633	"	"	9.85	0.25	0	10.10	14.43
Dec.	22.69	1.84	1.11	5.5	15,483	"	"	12.83	0.12	0	12.95	18.50
Jan.	19.48	1.78	1.06	10.4	18,500	"	"	0	0	0	0	0
Feb.	18.28	1.75	1.06	11.7	17,353	"	"	0	0	0	0	0
Mar.	10.60	1.63	1.08	8.4	9,250	2,835	"	1.61	0	0	1.61	2.30

Note: (4) = (1) - (2) x (3) x 10/86,400

(5) = Irrigation Requirement/Irrigation Efficiency = (4)/0.70

Appendix V-8-1 Unit Irrigation Requirement (Paddy Rice)

Unit: mm/day

	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Mean May-Oct.	Mean Nov.-Apr.
1953-1954	0.5	3.9	11.2	10.0	10.4	6.3	1.5	4.1	4.9	0	1.5	2.6	7.2	2.3
'54- '55	0.4	3.2	10.0	8.4	8.4	5.4	1.1	3.2	7.1	1.6	2.8	1.1	6.1	2.7
'55- '56	0.5	5.2	8.3	4.9	8.3	5.8	1.2	3.7	3.8	0	1.6	2.8	5.6	2.1
'56- '57	0.7	4.3	6.8	7.9	7.7	5.1	1.3	5.0	5.3	4.0	3.5	1.0	5.5	3.3
'57- '58	0.7	5.2	10.9	6.8	9.6	6.3	1.5	4.6	4.3	3.1	0	0	6.7	2.1
'58- '59	0.5	3.7	9.7	6.4	8.3	4.9	1.1	4.4	1.6	1.5	0.5	0.4	5.7	1.5
'59- '60	0.6	4.2	9.7	8.9	10.2	5.9	1.4	4.4	3.4	3.0	0	2.5	6.7	2.3
'60- '61	0.6	3.8	10.9	10.3	10.2	6.0	1.3	2.4	7.2	2.6	2.3	1.8	7.1	2.8
'61- '62	0.8	4.9	11.1	10.6	10.4	6.3	1.5	5.0	6.9	2.1	3.4	2.3	7.5	3.4
'62- '63	0.2	4.8	10.0	8.5	9.2	6.2	1.3	4.3	2.8	2.0	0.8	1.1	6.7	1.9
'63- '64	1.0	5.4	10.6	10.8	10.4	6.3	1.5	5.2	5.1	4.7	1.9	1.3	7.5	3.2
'64- '65	0.5	3.7	9.5	10.0	9.5	5.6	0.9	5.1	5.5	0.6	1.0	0.3	6.5	2.2
'65- '66	0.8	5.1	10.8	9.7	10.4	6.3	1.5	3.8	5.8	1.1	0	0.1	7.3	1.9
'66- '67	0.6	5.0	9.6	10.8	10.2	6.0	1.0	4.5	5.8	2.4	1.8	2.5	7.1	2.9
'67- '68	0.8	5.4	11.3	10.8	10.4	6.3	1.5	4.7	5.8	0.7	0.8	0	7.6	2.1
'68- '69	0.5	3.7	7.8	6.7	8.4	5.5	1.2	3.1	4.8	2.0	0.8	1.5	5.6	2.1
'69- '70	0.5	5.2	11.1	10.8	10.3	6.3	1.2	4.7	4.1	2.9	1.1	0.7	7.5	2.3
'70- '71	0.7	3.6	10.4	9.9	10.4	5.5	1.4	4.0	6.1	3.0	1.6	0	6.9	2.6
'71- '72	0.8	4.2	9.6	10.0	10.2	5.9	1.0	4.7	5.2	3.3	4.9	0.7	6.8	3.3
'72- '73	0.7	4.1	11.2	10.8	10.0	6.3	1.5	4.6	6.0	0	0	0.8	7.3	2.0
Mean	0.6	4.4	10.0	9.2	9.6	5.9	1.3	4.3	5.1	2.0	1.5	1.2	6.7	2.5

Note: Cropping area - May to Oct.; 15,800 ha Nov. to Apr.; 18,500 ha

Appendix V-8-2 Unit Irrigation Requirement (Sugar Cane)

Unit: mm/day

	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Mean May-Oct.	Mean Nov.-Apr.
1953-1954	0	0	2.7	1.6	4.1	4.8	5.8	0	0	0	0	0	3.2	0
'54- '55	0	0	1.5	0.6	2.0	3.0	1.3	0	1.7	0	0	0	1.4	0.3
'55- '56	0	2.6	0	0	1.8	3.8	0.5	0	0	0	0	0.7	1.5	0.1
'56- '57	0	0.3	0	0.3	1.2	2.4	2.6	1.8	0	0.5	0.2	0	1.1	0.4
'57- '58	0.1	2.4	2.4	0	3.2	4.7	5.1	0.7	0	0	0	0	3.0	0.1
'58- '59	0	0	1.3	0	1.8	2.1	0.9	0.2	0	0	0	0	1.0	0
'59- '60	0	0.2	1.3	0.9	3.9	3.9	4.2	0.3	0	0	0	0.3	2.4	0.1
'60- '61	0	0	2.4	1.7	3.9	4.3	3.4	0	1.9	0	0	0	2.6	0.3
'61- '62	0.8	1.8	2.6	1.9	4.1	4.7	4.8	0.2	0	0	0	0	3.3	0.2
'62- '63	0	1.5	1.5	0.7	2.8	4.5	3.2	0	0	0	0	0	2.4	0.4
'63- '64	0	3.1	2.2	2.0	4.1	4.8	5.0	2.4	0	1.3	0	0	3.5	0.6
'64- '65	0	0	1.0	1.6	3.1	3.3	0	2.3	0	0	0	0	1.5	0.4
'65- '66	0.6	2.3	2.3	1.4	4.1	4.7	5.2	0	0.2	0	0	0	3.3	0.1
'66- '67	0	2.1	1.1	2.0	3.9	4.2	0	0.4	0.2	0	0	0.3	2.2	0.2
'67- '68	0.8	3.1	2.8	2.0	4.1	4.6	5.2	1.0	0.2	0	0	0	3.6	0.3
'68- '69	0	0	0	0	2.0	3.1	2.5	0	0	0	0	0	1.3	0
'69- '70	0	2.5	2.6	2.0	4.0	4.8	2.2	1.2	0	0	0	0	3.0	0.2
'70- '71	0.2	0	1.9	1.5	4.1	3.1	4.0	0	4.8	0	0	0	2.4	0.8
'71- '72	1.1	0	1.2	1.6	3.9	3.9	0	1.1	0	0	1.7	0	1.8	0.7
'72- '73	0	0	2.7	2.0	3.7	4.8	5.8	0.8	0.4	0	0	0	3.2	0.2
Mean	0.2	1.1	1.7	1.2	3.3	4.0	3.1	0.6	0.5	0.1	0.1	0.1	2.4	0.3

Note: Cropping area - May to Oct.; 5,400 ha, Nov.-Apr.; 2,700 ha

Appendix V-8-3 Unit Irrigation Requirement (Polowijo)

Unit: mm/day

	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Mean May-Oct.	Mean Nov.-Apr.
1953-1954	0	0	3.6	2.9	3.9	3.8	4.0	0	0	0	0	0	3.0	0
'54- '55	0	0	2.1	1.3	1.8	2.0	0	0	0	0	0	0	1.2	0
'55- '56	0	2.8	0.1	0	1.6	2.8	0	0	0	0	0	0	1.2	0
'56- '57	0	0.1	0	0.8	1.0	1.4	0.8	0	0	0	0	0	0.7	0
'57- '58	0	2.6	3.2	0	3.0	3.7	3.3	0	0	0	0	0	2.6	0
'58- '59	0	0	1.8	0	1.6	1.1	0	0	0	0	0	0	0.8	0
'59- '60	0	0	1.8	1.8	3.7	2.9	2.4	0	0	0	0	0	2.1	0
'60- '61	0	0	3.2	3.2	3.7	3.3	1.6	0	0	0	0	0	2.5	0
'61- '62	0	1.0	3.4	3.4	3.9	3.7	3.0	0	0	0	0	0	3.1	0
'62- '63	0	1.5	2.1	1.4	2.6	3.5	0	0	0	0	0	0	1.9	0
'63- '64	0	3.3	2.9	3.7	3.9	3.8	3.2	0.6	0	0	0	0	3.5	0.1
'64- '65	0	0	1.5	2.9	2.9	2.3	0	0.4	0	0	0	0	1.6	0.1
'65- '66	0.5	2.4	3.1	2.6	3.9	3.7	3.4	0	0	0	0	0	3.2	0.1
'66- '67	0	2.2	1.6	3.7	3.7	3.2	0	0	0	0	0	0	2.4	0
'67- '68	0.7	3.3	3.7	3.7	3.9	3.6	3.4	0	0	0	0	0	3.6	0.1
'68- '69	0	0	0	0	1.8	2.1	0.7	0	0	0	0	0	0.8	0
'69- '70	0	2.7	3.5	3.7	3.8	3.8	0.4	0	0	0	0	0	3.0	0
'70- '71	0	0	2.6	2.8	3.9	2.1	2.2	0	0	0	0	0	2.3	0
'71- '72	1.1	1.7	1.7	2.9	3.7	2.9	0	0	0	0	0	0	2.2	0.2
'72- '73	0	0	3.6	3.7	3.5	3.8	4.0	0	0	0	0	0	3.1	0
Mean	0.1	1.2	2.3	2.6	3.1	3.1	1.6	0.1	0	0	0	0	2.3	0

Note: Cropping area - 2,400 ha

Appendix V-9-1 Yearly Balance of Water

	1953/1954			1954/55			1955/56			1956/57			1957/58		
	Inflow Discharge	Outflow Discharge	Balance	In.	Out.	B.	In.	Out.	B.	In.	Out.	B.	In.	Out.	B.
Mar.	57.4	10.2	0	35.3	8.4	0	15.9	17.1	0	9.0	11.4	-2.4	5.2	16.7	-11.5
June	-0.4	33.2	-33.6	8.4	28.2	-19.8	10.8	21.7	-10.9	21.8	17.7	0	-1.0	31.9	-44.4
July	-0.1	28.7	-62.4	3.6	23.0	-39.2	17.6	12.8	-6.1	12.4	21.2	-8.8	8.7	17.8	-53.5
Aug.	-1.6	30.6	-94.6	1.4	23.7	-61.5	4.8	23.0	-24.3	4.0	21.0	-25.8	2.2	27.6	-78.9
Sep.	-1.6	20.1	-116.3	-1.1	16.2	-78.8	1.0	18.0	-41.3	0.4	15.0	-40.4	-1.4	19.9	-100.2
Oct.	-1.7	8.2	-124.5	0.5	3.6	-81.9	2.5	3.3	-42.1	1.8	4.8	-43.4	-1.5	7.4	-109.1
Nov.	3.8	12.6	-135.0	41.9	9.7	-49.7	29.0	11.2	-24.3	4.2	16.0	-55.2	-1.8	14.3	-125.2
Dec.	21.5	15.0	-128.5	31.7	22.4	40.4	19.8	11.7	-16.2	26.9	16.3	-44.6	38.7	13.2	-99.7
Jan.	49.2	0	-79.3	44.3	4.9	1.0	49.4	0	0	22.1	12.4	-34.9	11.8	9.5	-97.4
Feb.	61.1	4.6	-24.8	31.4	8.6	0	47.3	4.9	0	29.1	10.7	-16.5	62.4	0	-35.0
Mar.	41.4	8.0	0	39.6	3.2	0	27.5	8.9	0	85.8	2.9	0	56.6	0	0
Apr.	42.3	1.2	0	54.8	1.6	0	9.8	2.0	0	33.5	2.2	0	59.0	1.5	0

Outflow Discharge = Diversion Requirement

Appendix V-9-2 Yearly Balance of Water

	1958/1959			1959/60			1960/61			1961/62			1962/63		
	Inflow Discharge	Outflow Discharge	Balance	In.	Out.	B	In.	Out.	B	In.	Out.	B.	In.	Out.	B.
Mar.	24.2	9.6	0	20.1	11.2	0	42.3	9.9	0	16.9	14.8	0	13.8	14.4	-0.6
June	0.1	4.4	-4.3	10.3	27.2	-16.9	1.4	31.9	-30.5	0.1	32.8	-32.7	2.3	28.2	-26.5
July	9.3	16.7	-11.7	2.7	24.8	-39.0	0.6	29.7	-59.6	-1.1	30.7	-64.5	1.0	23.4	-48.9
Aug.	1.1	23.0	-33.6	-1.3	29.9	-70.2	-1.3	29.9	-90.8	-1.3	30.6	-96.4	-0.6	26.3	-75.8
Sep.	-0.6	14.3	-48.5	-1.0	18.2	-89.4	-1.4	19.0	-111.2	-1.4	19.9	-117.7	-1.5	19.5	-96.8
Oct.	7.5	3.3	-44.3	-1.4	6.5	-97.3	-1.4	5.6	-118.2	-1.4	7.2	-126.3	-0.9	4.8	-102.5
Nov.	7.6	13.5	-50.2	4.4	13.7	-106.6	2.3	7.3	-123.2	2.3	15.3	-139.3	6.2	13.1	-109.4
Dec.	45.2	5.0	-10.0	41.9	10.4	-75.1	14.9	23.0	-131.3	9.9	21.1	-150.5	30.3	8.6	-87.7
Jan.	64.2	4.6	0	35.6	9.2	-48.7	28.8	7.9	-110.4	58.1	6.4	-98.6	55.0	6.1	-38.8
Feb.	68.4	1.4	0	71.9	0	0	40.9	6.9	-76.4	40.1	10.4	-69.1	57.1	2.6	0
Mar.	63.1	1.1	0	54.4	7.8	0	47.9	5.5	-34.0	41.3	7.0	-34.8	74.5	3.5	0
Apr.	33.6	1.7	0	53.0	2.0	0	29.0	3.1	-8.1	78.6	0.7	0	35.3	3.0	0

Note: Inflow Discharge may include evaporation from water surface of resource.

Appendix V-9-3 Yearly Balance of Water

	1963/64			1964/65			1965/66			1966/67			1967/68		
	Inflow Discharge	Outflow Discharge	Balance	In.	Out.	B.	In.	Out.	B.	In.	Out.	B.	In.	Out.	B.
Mar.	1.4	18.2	-16.8	16.1	9.6	0	1.6	16.3	-14.7	24.1	15.9	0	8.6	18.2	-9.6
June	0.4	30.9	-47.3	9.3	26.3	-17.0	-0.5	31.5	-46.7	19.7	26.6	-6.9	1.1	33.5	-42.0
July	-1.3	31.5	-80.1	-0.5	28.7	-46.2	-0.9	27.6	-75.2	41.5	31.5	0	-0.4	31.5	-73.9
Aug.	-1.3	30.6	-112.0	-1.0	27.3	-74.5	-1.4	30.6	-107.2	0.4	29.9	-29.5	-1.2	30.6	-105.7
Sep.	-1.4	20.1	-133.5	-1.3	16.9	-92.7	-1.5	19.9	-128.6	-1.4	18.8	-49.7	-1.5	19.9	-127.1
Oct.	-1.4	7.3	-142.2	17.5	2.3	-77.5	-1.6	7.6	-137.8	1.3	2.6	-51.0	-1.6	7.6	-136.3
Nov.	-0.9	17.1	-160.2	13.3	16.8	-81.0	0.2	11.6	-149.2	13.5	13.8	-51.3	-1.0	14.7	-152.0
Dec.	4.9	15.5	-170.8	12.5	16.8	-85.3	22.5	17.9	-144.6	40.4	17.9	-28.8	19.4	17.9	-150.5
Jan.	11.2	15.0	-174.6	37.3	1.8	-49.8	31.5	3.4	-116.5	84.9	7.3	0	35.2	2.1	-117.4
Feb.	15.3	5.7	-165.0	55.4	3.2	0	52.7	0	-63.8	56.4	5.5	0	42.0	2.6	-78.0
Mar.	45.6	4.1	-123.5	50.2	0.8	0	86.4	0.2	0	41.6	7.8	0	85.2	0	0
Apr.	41.7	1.7	-83.5	33.3	3.1	0	41.5	2.0	0	45.6	3.4	0	63.8	1.7	0

Appendix V-9-4 Yearly Balance of Water

	1968/69			1969/70			1970/71			1971/72			1972/73		
	Inflow Discharge	Outflow Discharge	Balance	In.	Out.	B.	In.	Out.	B.	In.	Out.	B.	In.	Out.	B.
Mar.	48.5	9.7	0	6.6	16.9	-10.3	52.8	9.4	0	25.7	10.9	0	23.1	10.8	0
June	31.2	20.4	0	2.3	32.8	-40.8	21.5	29.9	-8.4	15.1	26.9	-11.8	1.8	33.2	-31.4
July	29.9	17.5	0	-0.1	31.5	-72.4	3.6	28.3	-33.1	6.2	28.7	-34.3	0.6	31.5	-62.3
Aug.	18.1	23.7	-5.6	-0.6	30.2	-103.2	1.3	30.6	-62.4	4.4	29.9	-59.8	0.2	29.3	-91.4
Sep.	8.3	16.5	-13.8	-1.0	20.1	-124.3	7.2	16.5	-71.7	2.6	18.2	-75.4	-0.8	20.1	-112.3
Oct.	6.3	4.7	-12.2	-1.2	4.3	-129.8	17.0	6.3	-61.0	18.3	2.5	-59.6	-0.8	8.2	-121.3
Nov.	23.6	9.4	0	6.8	15.0	-138.0	36.5	12.3	-36.8	35.9	14.9	-38.6	2.3	14.4	-133.4
Dec.	45.6	14.8	0	9.8	12.4	-140.6	64.3	18.8	0	40.5	16.0	-14.1	9.4	18.5	-138.4
Jan.	23.5	6.1	0	25.6	8.9	-123.9	50.3	9.2	0	67.6	10.1	0	48.6	0	-89.8
Feb.	76.0	2.6	0	66.6	3.4	-60.7	92.2	4.9	0	29.2	15.7	0	52.5	0	-37.3
Mar.	45.5	4.6	0	55.3	2.1	-7.5	117.7	0	0	91.8	2.1	0	114.6	2.3	0
Apr.	34.8	1.4	0	45.5	2.4	0	37.5	3.9	0	33.1	2.1	0	63.4	1.6	0

Appendix V-10 Standard Value of V, b/d, W, Fb

Q (m^3/sec)	V (m/s)	Z	b/d
0 - 0.15	0.25	1.0	1.0
0.15 - 0.30	0.30	1.0	1.0
0.30 - 0.40	0.35	1.0	1.5
0.40 - 0.50	0.40	1.0	1.5
0.50 - 0.75	0.45	1.0	2.0
0.75 - 1.50	0.50	1.0	2.0
1.50 - 3.00	0.60	1.0	2.5
3.00 - 4.50	0.65	1.5	3.0
4.50 - 6.00	0.65	1.5	3.5
6.00 - 7.50	0.65	1.5	4.0
7.50 - 9.00	0.70	1.5	4.5
9.00 - 11.00	0.70	1.5	5.0
11.00 - 15.00	0.70	1.5	6.0
15.00 - 25.00	0.75	2.0	8.0
25.00 - 40.00	0.80	2.0	10.0
40.00 - 80.00	0.80	2.0	12.0

q	n	W_1	W_2
2.0	0.025	3.00	1.00
2.0	"	4.00	1.00
5.0	"	5.00	2.5
11.0	0.0225	5.00	2.5

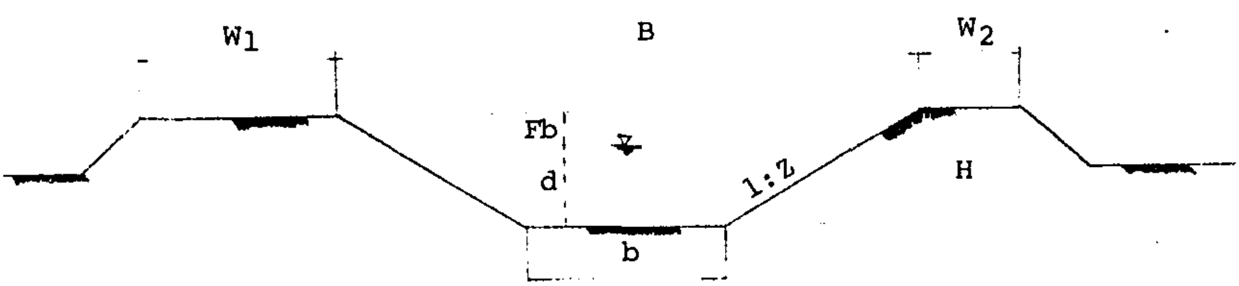
Free boad

$Q > 3.0$ m/s

$Fb = (0.30+d/4)$

$Q < 3.0$ m/s

$Fb = (0.24+d/4)$

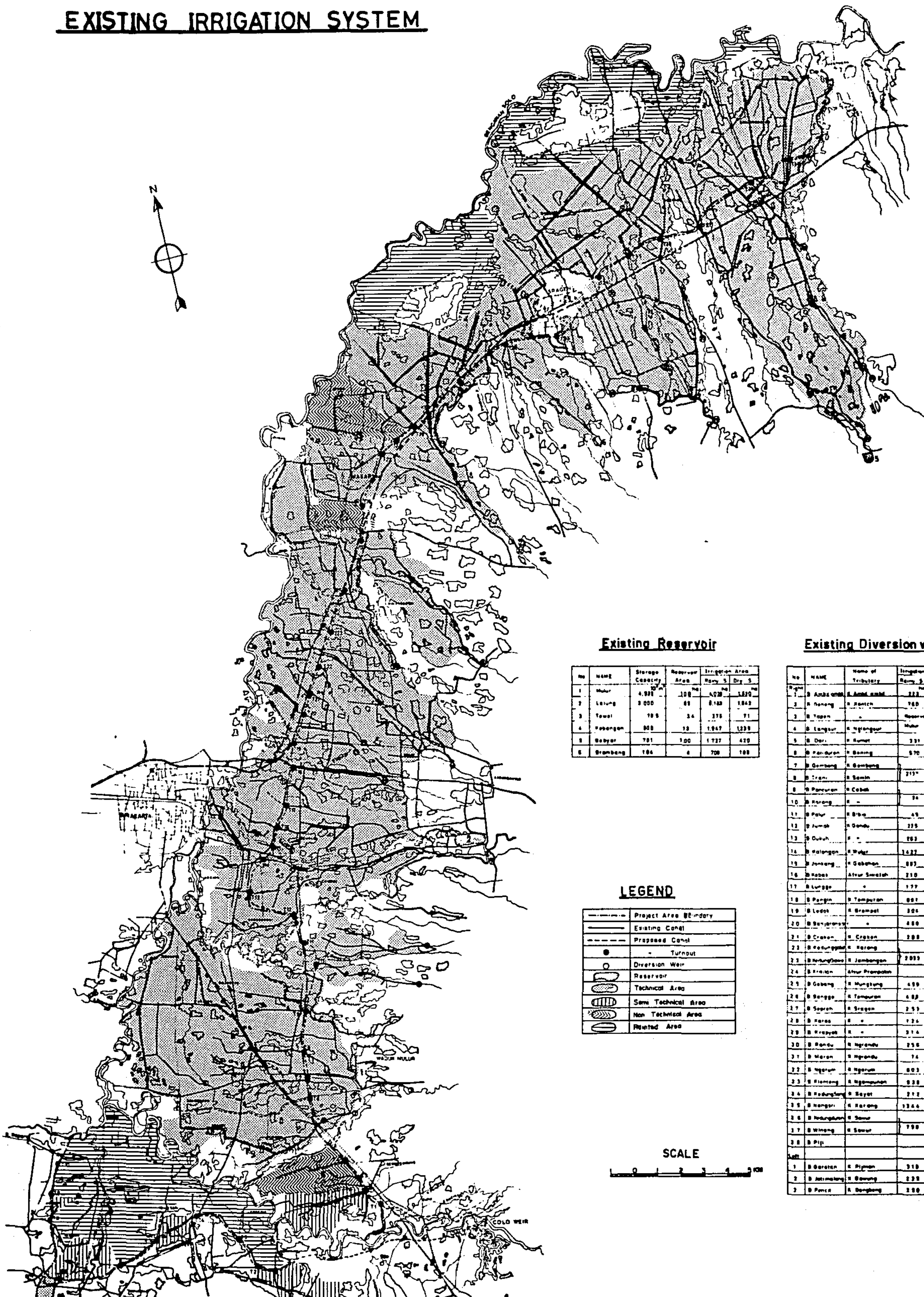


Appendix V-11 Construction Plants and Equipment for Irrigation Project

No.	Equipment	Capacity	Quantity Total	Quantity Purchased	Quantity Transfered from the dam
1.	Bulldozer	20 ton	16	16	-
2.	Crawler loader	20 m^3	5	5	-
3.	Back hoe	1.2 m^3	6	6	-
4.	Dump truck	8 ton	95	95	-
5.	Motor grader	3.7 m	3	3	-
6.	Vibration roller	5 ton	3	3	-
7.	Fuel tanker	8 ton	2	2	-
8.	Water tanker	8 ton	2	2	-
9.	Trailer truck	30 ton	1	1	-
10.	Cargo truck	6 ton	10	10	-
11.	Grease car	6 ton	5	5	-
12.	Truck crane	30 ton	1	1	-
13.	Portable concrete mixer	0.1 m^3	4	4	-
14.	Concrete plant	21 cft x 2	1	-	1
15.	Agitator truck	3.2 m^3	3	-	3
16.	Pump w/engine	4 inch	8	8	-
17.	Road roller	8 ton	2	2	-
18.	Screening plant	50 ton/hr	1	-	1
19.	Repair shop		L.S.	L.S.	-
20.	Saw mill		L.S.	L.S.	-
21.	Ripper attachment Bull.	20 ton	2	2	-
22.	Dragline attachment shovel	1.2 m^3	3	3	-
23.	Power shovel attachment	1.2 m^3	3	3	-
24.	Miscellaneous		L.S.	L.S.	

D R A W I N G

EXISTING IRRIGATION SYSTEM



Existing Reservoir

No	NAME	Storage Capacity	Reservoir Area	Irrigation Area	
				Rainy S	Dry S
		$10^3 m^3$	ha	ha	ha
1	Mulur	4,931	100	4,020	1,520
2	Lalung	3 000	65	8,183	1,842
3	Tawal	19.5	3.4	275	71
4	Pebangan	900	13	1,947	1,239
5	Gebyar	701	1.00	1 727	420
6	Brambang	164	4	709	188

Existing Diversion weir

No	NAME	Name of Tributary	Irrigation Area	
			Rainy S	Dry S
Right			ha	ha
1	B Ambi ambi	R Ambi ambi	222	8
2	B Nonong	R Kontch	760	215
3	B Topen	"	Reservoir	
4	B Langsur	R Ngolangsur	Mulur	
5	B Dari	R Kumot	331	30
6	B Pandaran	R Bening	570	170
7	B Gombang	R Gombang		
8	B Trani	R Samin	2137*	990
9	B Pancuran	R Cabak		
10	B Karang	R –	34	0
11	B Palur	R Bibis	45	45
12	B Jumok	R Gondu	225	144
13	B Duduh	R –	263	184
14	B Kalongan	R Walur	1427	1318
15	B Jonkang	R Gabahan	897	286
16	B Kabat	Afvur Swalah	210	120
17	B Lungge	"	177	145
18	B Pangin	R Tempuran	891	482
19	B Ledok	R Brampal	306	64
20	B Banjarana	"	480	107
21	B Croben	R Croben	288	87
22	B Kedunggabel	R Karang		
23	B KedungDawa	R Jambangan	2033	599
24	B Krisian	Afvur Prampalan		
25	B Gabang	R Mungkung	459	167
26	B Sanggo	R Tempuran	482	113
27	B Sopron	R Sragen	251	80
28	B Karas	R "	126	31
29	B Krapyak	R "	314	103
30	B Randu	R Ngrandu	256	121
31	B Maren	R Ngrandu	74	27
32	B Ngarum	R Ngarum	603	210
33	B Plentong	R Ngampunan	938	311
34	B Kedungsang	R Sayat	272	53
35	B Nangsri	R Karang	1344	361
36	B Kedungdawn	R Sawur		
37	B Winong	R Sawur	798	145
38	B Piji			
Left				
1	B Garatan	R Pijman	319	0
2	B Jatimalang	R Dawung	233	0
3	B Panca	R Dangbang	230	0

LEGEND

- Project Area Boundary
- Existing Canal
- Proposed Canal
- " Turnout
- Diversion Weir
- Reservoir
- Technical Area
- Semi Technical Area
- Non Technical Area
- Rainfed Area

SCALE

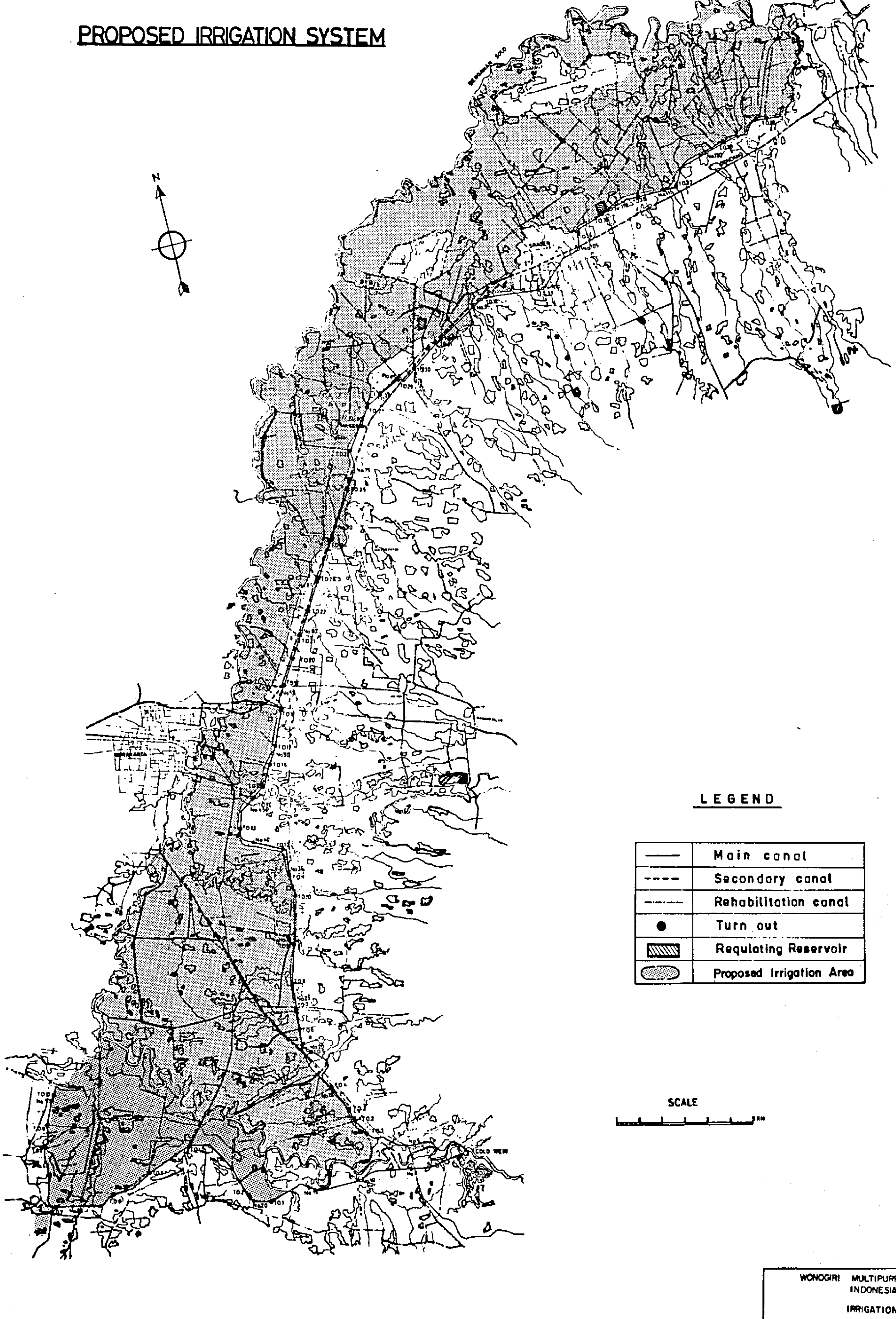
0 1 2 3 4 5 km

WONOGIRI MULTIPURPOSE DAM
INDONESIA
IRRIGATION

EXISTING IRRIGATION SYSTEM

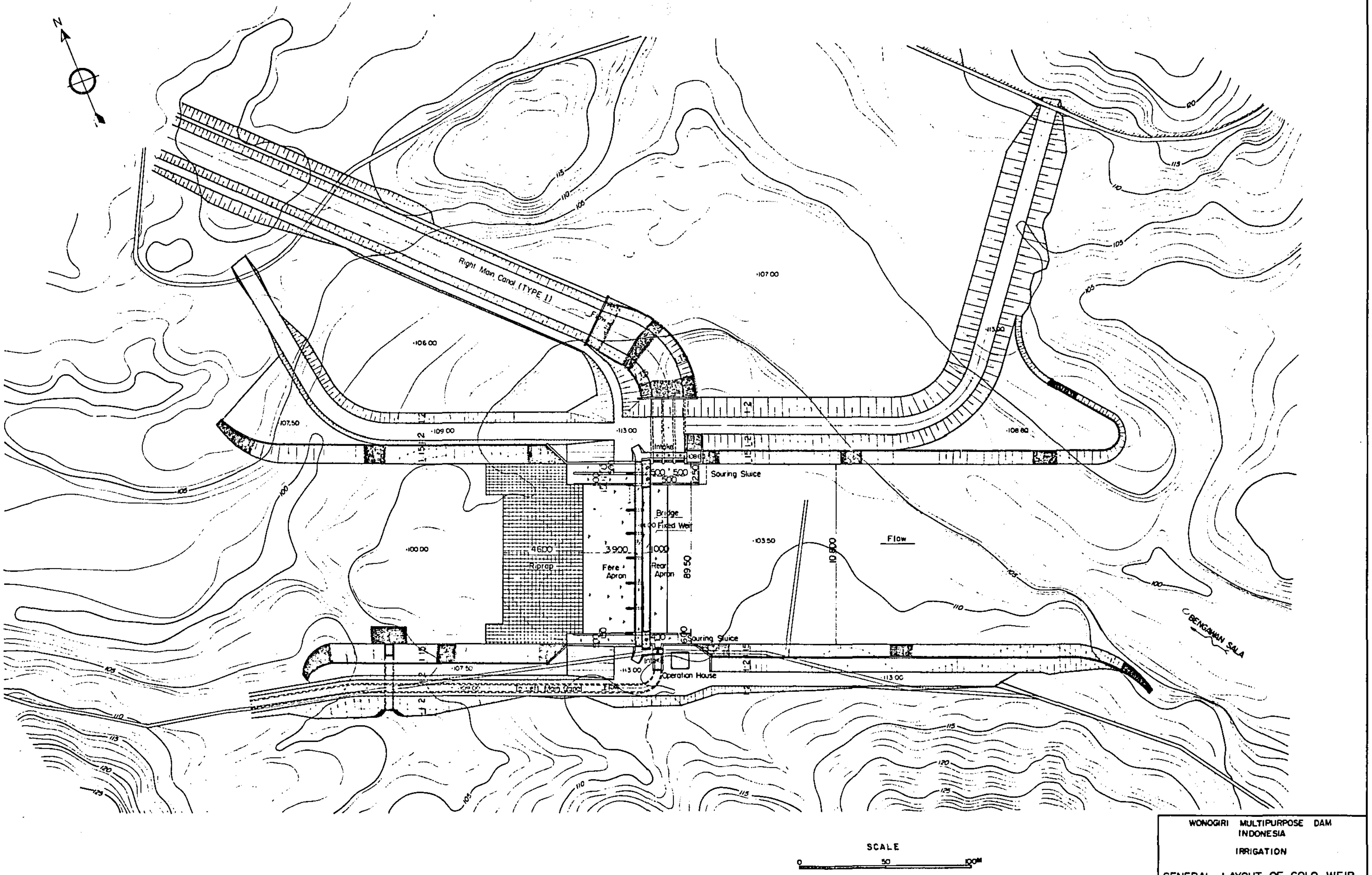
Date : July 31, 1975 | DWG NO WI - 001

PROPOSED IRRIGATION SYSTEM



WONOGIRI MULTIPURPOSE DAM INDONESIA	
IRRIGATION	
PROPOSED IRRIGATION SYSTEM	
Date : July 31, 1975	DWG NO WI-002

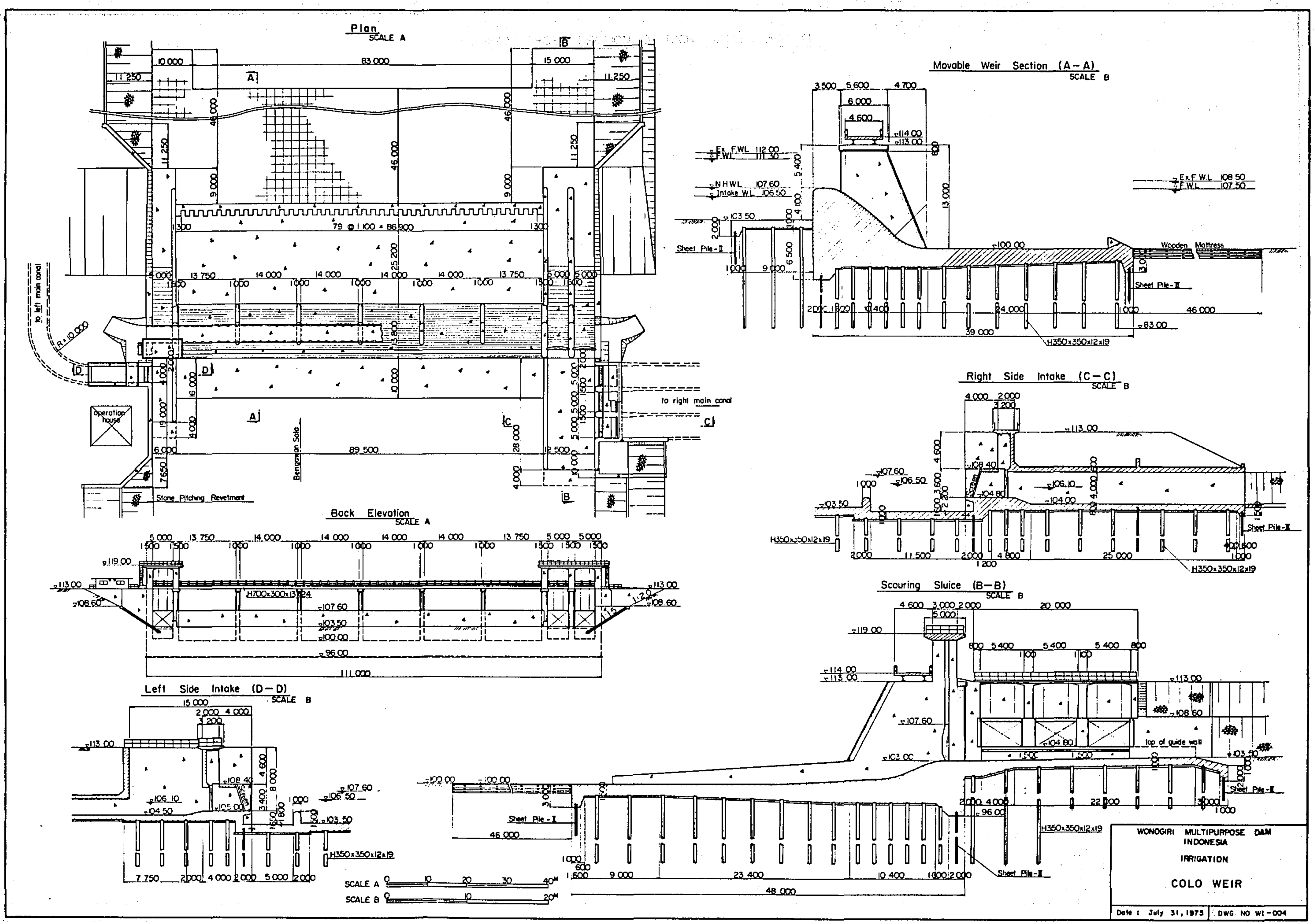
GENERAL LAYOUT OF COLO WEIR



WONOGIRI MULTIPURPOSE DAM
INDONESIA
IRRIGATION

GENERAL LAYOUT OF COLO WEIR

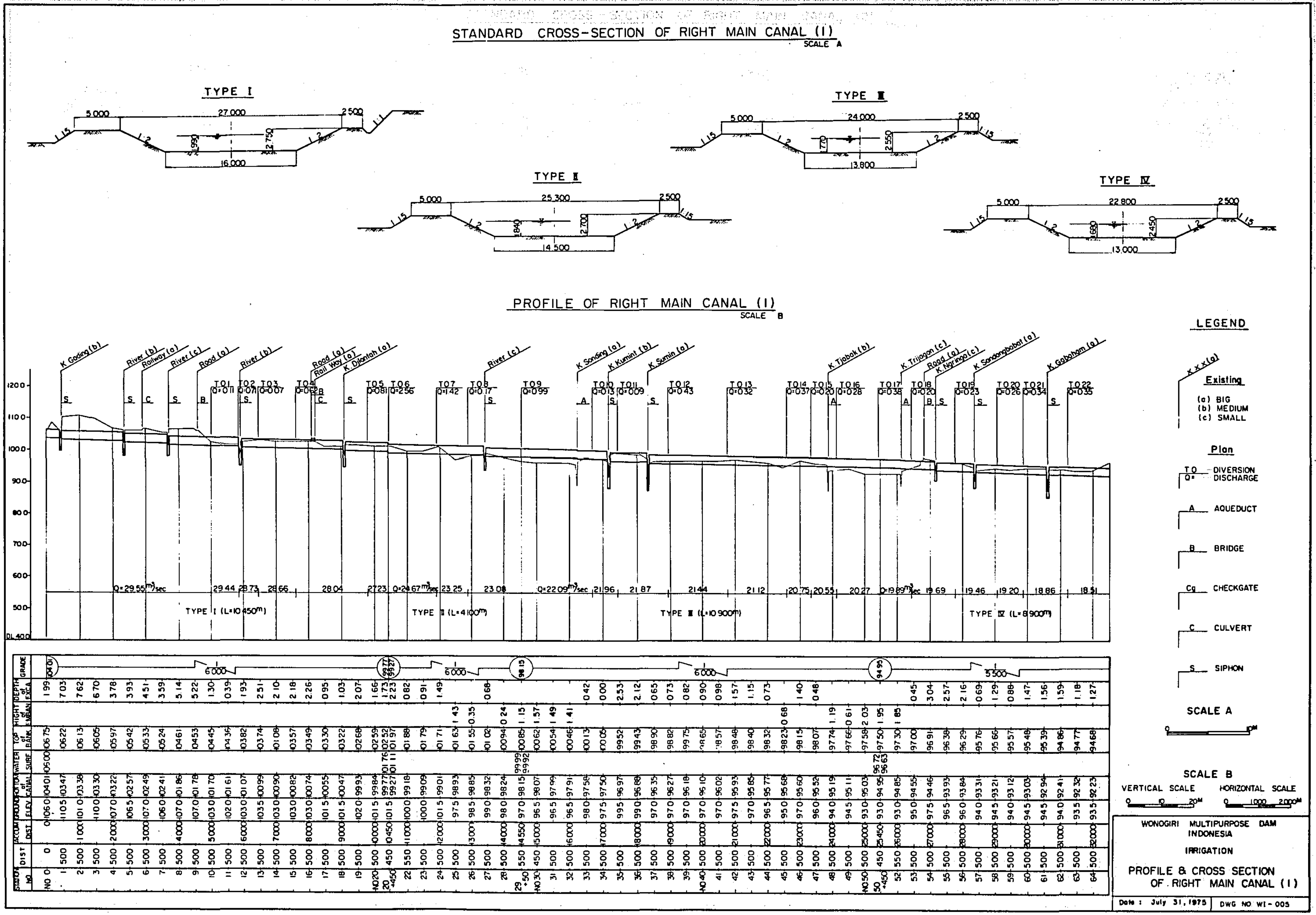
Date : July 31, 1975	DWG NO WI-003



Plan
SCALE A
Movable Weir Section (A – A)
SCALE B
Right Side Intake (C – C)
SCALE B
Scouring Sluice (B – B)
SCALE B
Back Elevation
SCALE A
Left Side Intake (D – D)
SCALE B
83 000
79 @ 1 100 = 86 900
89 500
111 000
to left main canal
to right main canal
R = 10 000
operation house
Bengawan Solo
Stone Pitching Revetment
Ex. F.W.L. 112.00
F.W.L. 111.30
N.H.W.L. 107.60
Intake W.L. 106.50
Ex.F.W.L. 108.50
F.W.L. 107.50
Wooden Mattress
Sheet Pile – I
Sheet Pile – II
H350x350x12x19
H700x300x13x24
top of guide wall
SCALE A 0 10 20 30 40M
SCALE B 0 10 20M
WONOGIRI MULTIPURPOSE DAM
INDONESIA
IRRIGATION
COLO WEIR
Date : July 31, 1975
DWG. NO WI – 004

STANDARD CROSS-SECTION OF RIGHT MAIN CANAL (I)

SCALE A



WONOGIRI MULTIPURPOSE DAM
INDONESIA

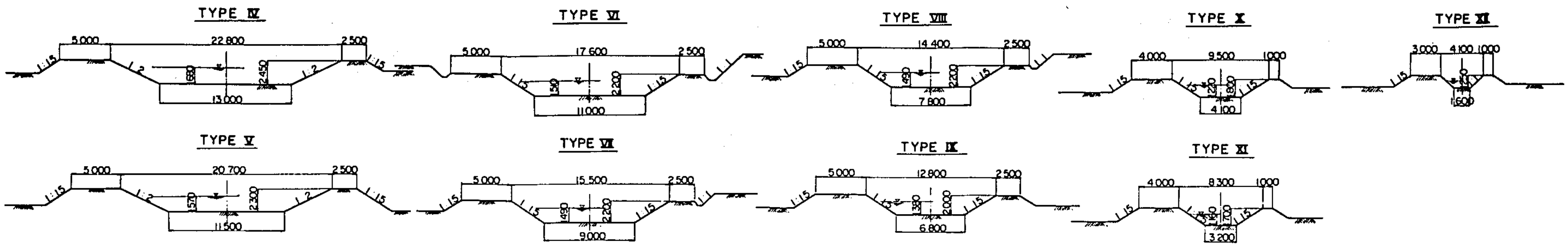
IRRIGATION

PROFILE & CROSS SECTION OF RIGHT MAIN CANAL (I)

Date: July 31, 1975 | DWG NO WI-005

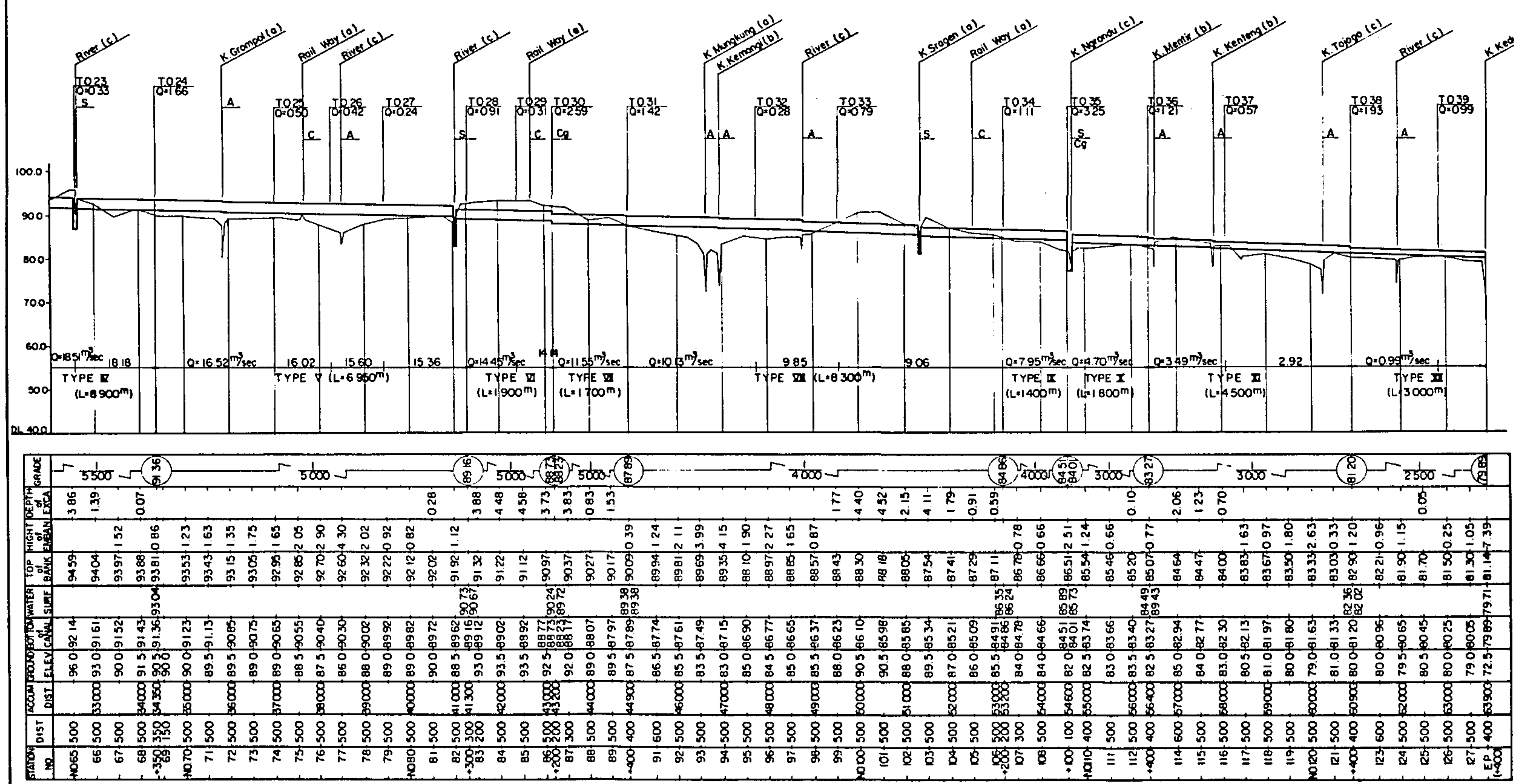
STANDARD CROSS-SECTION OF RIGHT MAIN CANAL (2)

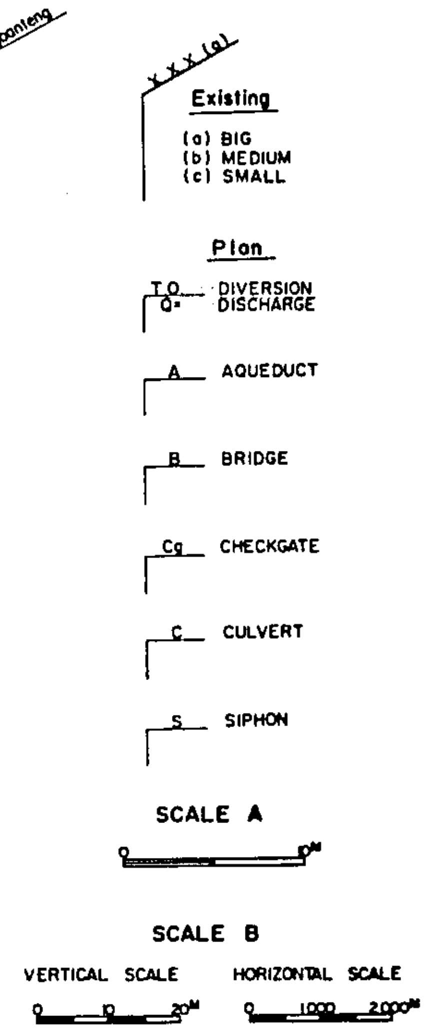
SCALE A



PROFILE OF RIGHT MAIN CANAL (2)

SCALE B





WONOGIRI MULTIPURPOSE DAM
INDONESIA

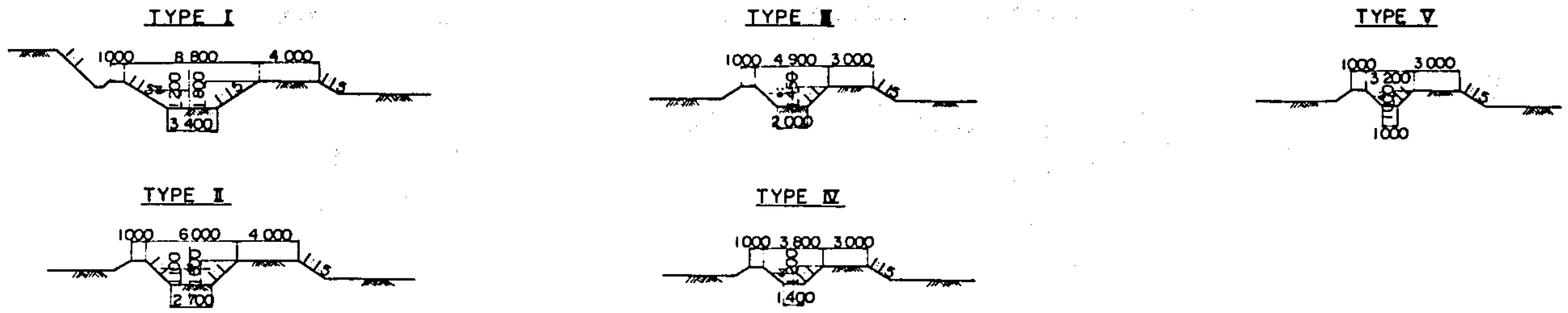
IRRIGATION

PROFILE & CROSS SECTION OF RIGHT MAIN CANAL (2)

Date : July 31, 1975 | DWG NO. WI-006

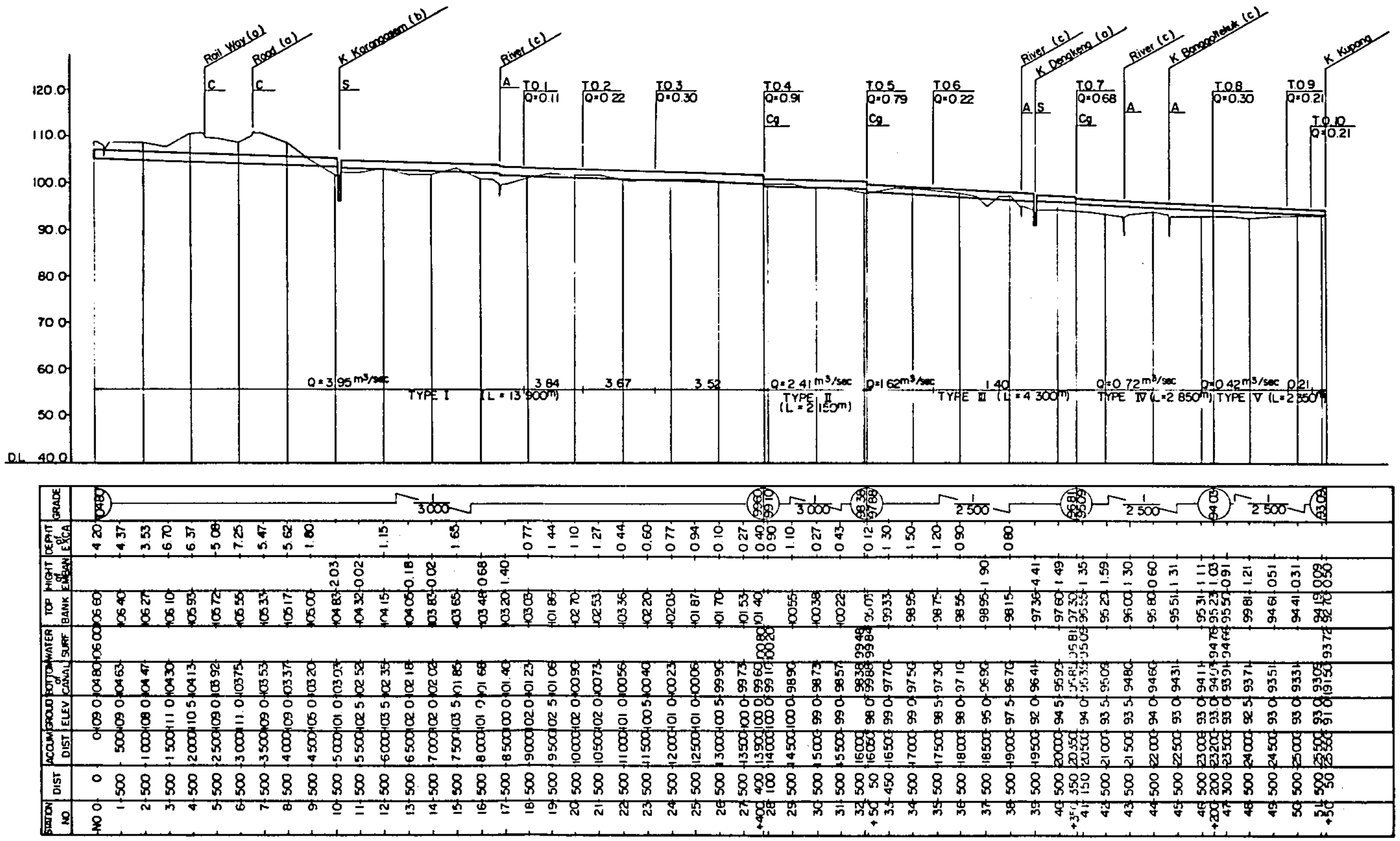
STANDARD CROSS-SECTION OF LEFT MAIN CANAL

SCALE A



PROFILE OF LEFT MAIN CANAL

SCALE B



LEGEND

x-x-x (a) Existing
(a) BIG
(b) MEDIUM
(c) SMALL

Plan

T.O. / Q — DEVERSION / DISCHARGE

A — AQUEDUCT

B — BRIDGE

Cg — CHECK GATE

C — CULVERT

S — SIPHON

SCALE A: 0 — 10M

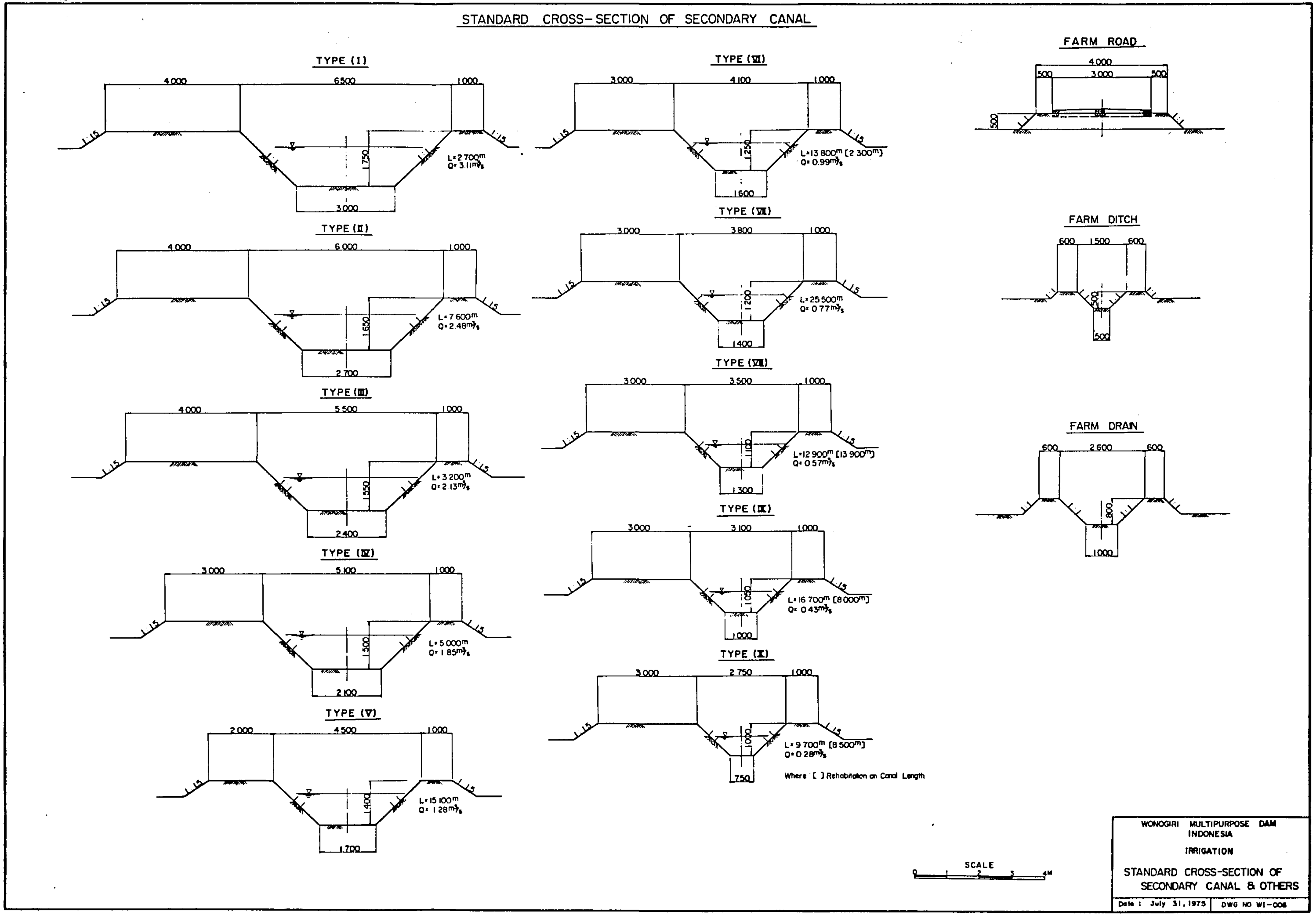
SCALE B: VERTICAL SCALE 0 10 20M; HORIZONTAL SCALE 0 1000 2000M

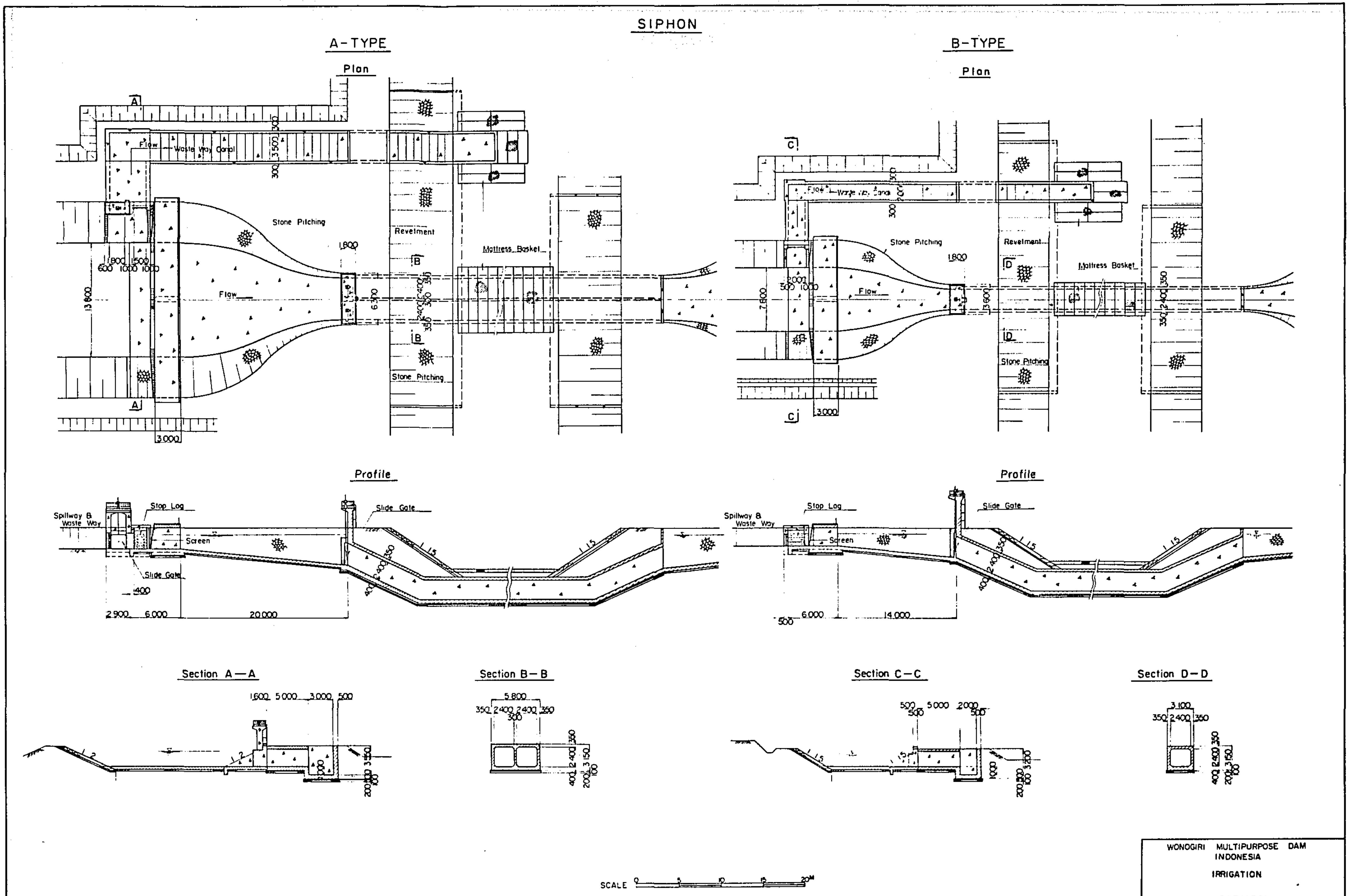
WONOGIRI MULTIPURPOSE DAM
INDONESIA

IRRIGATION

PROFILE & CROSS SECTION OF LEFT MAIN CANAL

Date: July 31, 1975 | DWG NO WI-007


STANDARD CROSS-SECTION OF SECONDARY CANAL
TYPE (I)
4.000 6.500 1.000
1:1.5
1:1
1.750
3.000
L=2.700m Q=3.11m³/s
TYPE (II)
4.000 6.000 1.000
1.650
2.700
L=7.600m Q=2.48m³/s
TYPE (III)
4.000 5.500 1.000
1.550
2.400
L=3.200m Q=2.13m³/s
TYPE (IV)
3.000 5.100 1.000
1.500
2.100
L=5.000m Q=1.85m³/s
TYPE (V)
2.000 4.500 1.000
1.400
1.700
L=15.100m Q=1.28m³/s
TYPE (VI)
3.000 4.100 1.000
1.250
1.600
L=13.800m (2.300m) Q=0.99m³/s
TYPE (VII)
3.000 3.800 1.000
1.200
1.400
L=25.500m Q=0.77m³/s
TYPE (VIII)
3.000 3.500 1.000
1.100
1.300
L=12.900m (13.900m) Q=0.57m³/s
TYPE (IX)
3.000 3.100 1.000
1.050
1.000
L=16.700m (8.000m) Q=0.43m³/s
TYPE (X)
3.000 2.750 1.000
1.000
750
L=9.700m (8.500m) Q=0.28m³/s
Where: ( ) Rehabilitation on Canal Length
FARM ROAD
4.000
500 3.000 500
500
FARM DITCH
600 1.500 600
500
500
FARM DRAIN
600 2.600 600
800
1.000
SCALE
0 1 2 3 4M
WONOGIRI MULTIPURPOSE DAM
INDONESIA
IRRIGATION
STANDARD CROSS-SECTION OF SECONDARY CANAL & OTHERS
Date: July 31, 1975
DWG NO WI-008



WONOGIRI MULTIPURPOSE DAM
INDONESIA

IRRIGATION

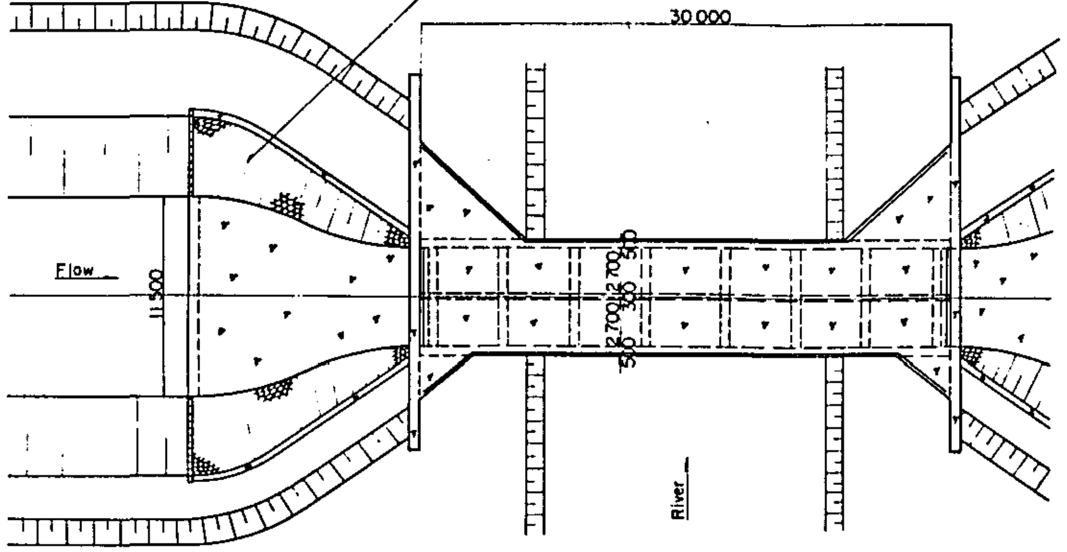
SIPHON

Date : July 31, 1975	DWG NO WI-009

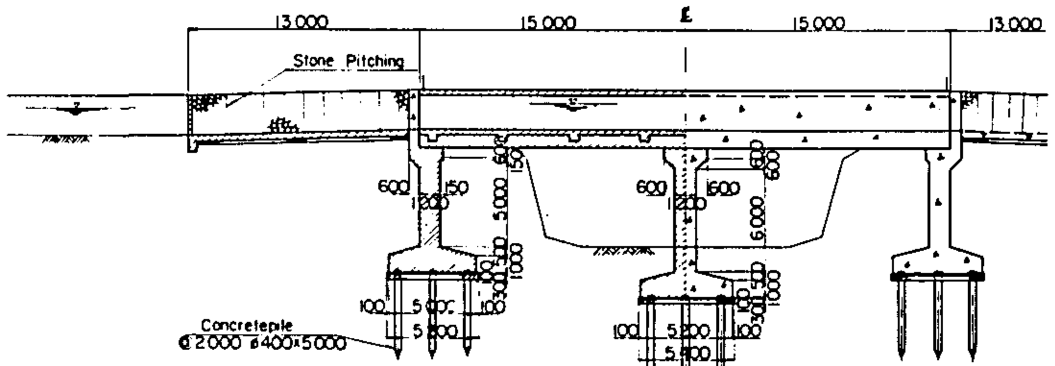
AQUEDUCT

A TYPE

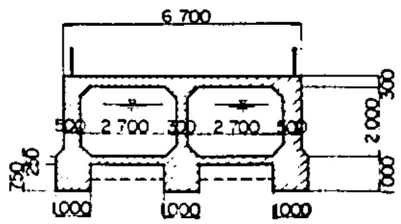
Plan
SCALE A



Profile
SCALE A

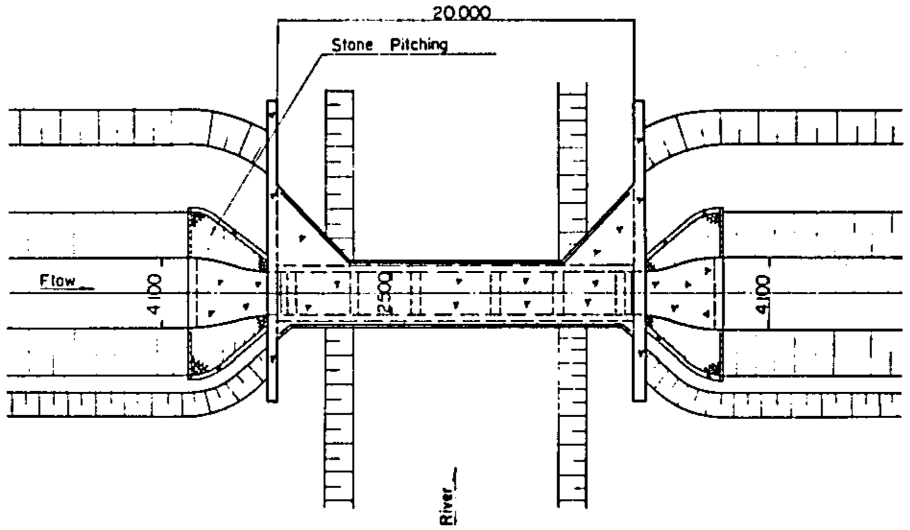


Aqueduct Section
SCALE B

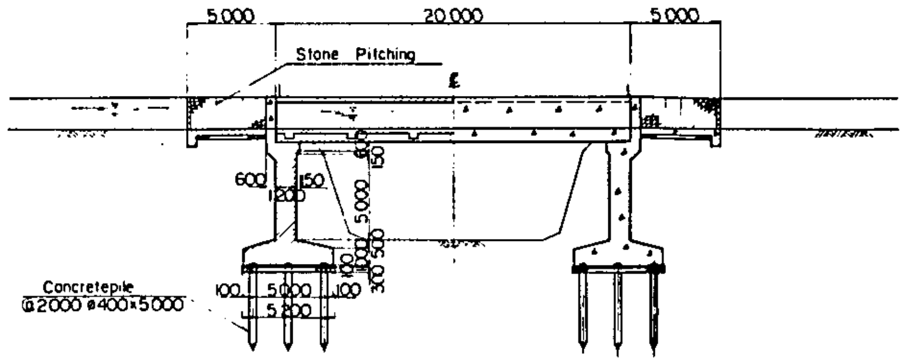


B TYPE

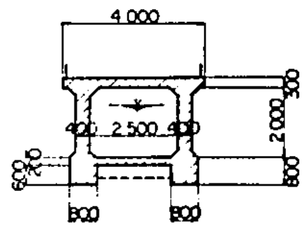
Plan
SCALE A

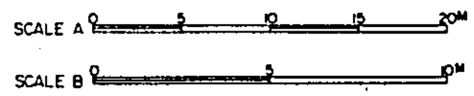


Profile
SCALE A



Aqueduct Section
SCALE B

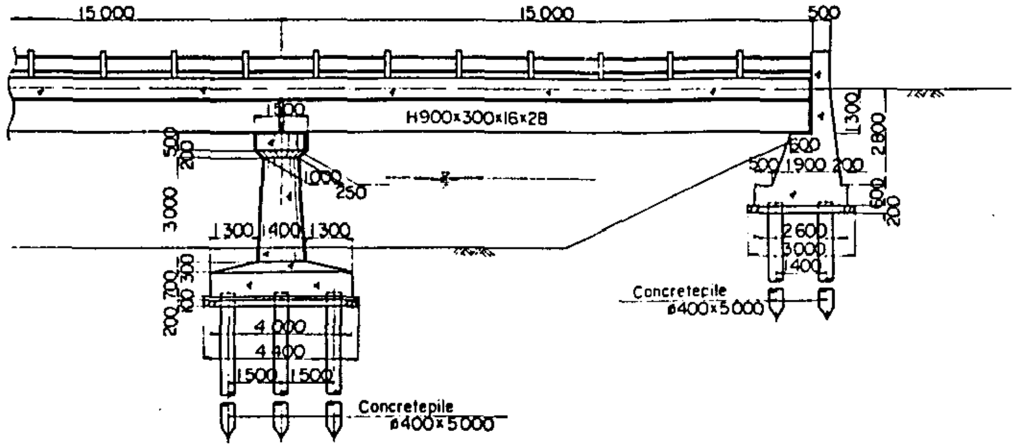




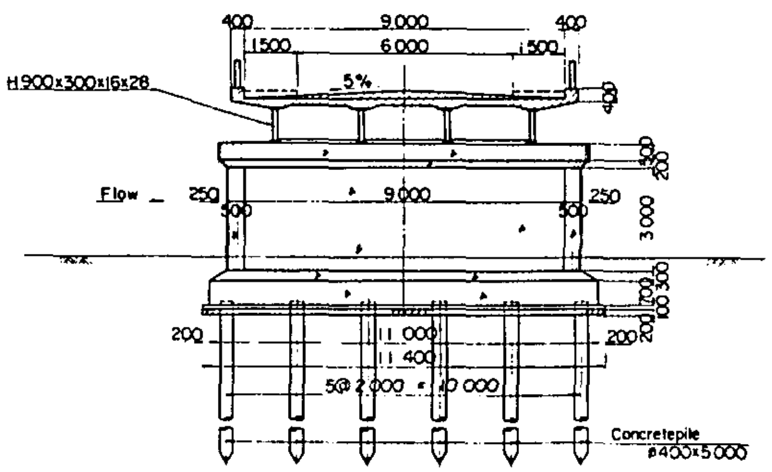
WONOGIRI MULTIPURPOSE DAM INDONESIA	
IRRIGATION	
AQUEDUCT	
Date : July 31, 1975	DWG NO WI-010

GENERAL ROAD BRIDGE (BRIDGE A TYPE)

Profile

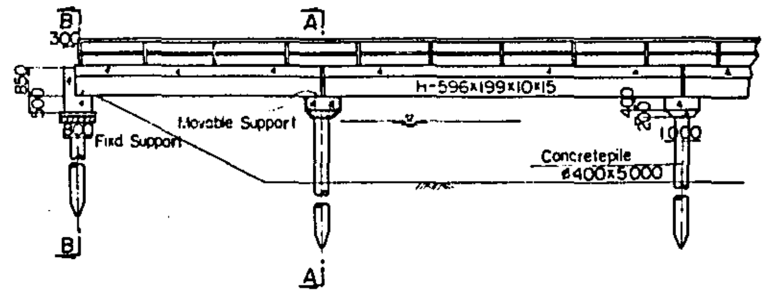


Bridge Pier

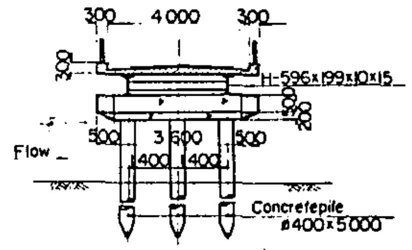


FARM-ROAD BRIDGE (BRIDGE B TYPE)

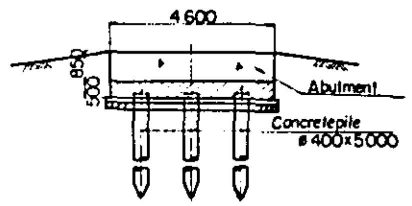
Profile



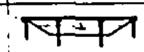
Section A-A



Section B-B



Dimension Table

Type	Span	Canal Type No	No
B-a		Main (R) Type I-IV	34
B-b		Main (R) Type V-IX	20
B-c		Main (R) X-XII " (L) I-V Secondary	126

SCALE

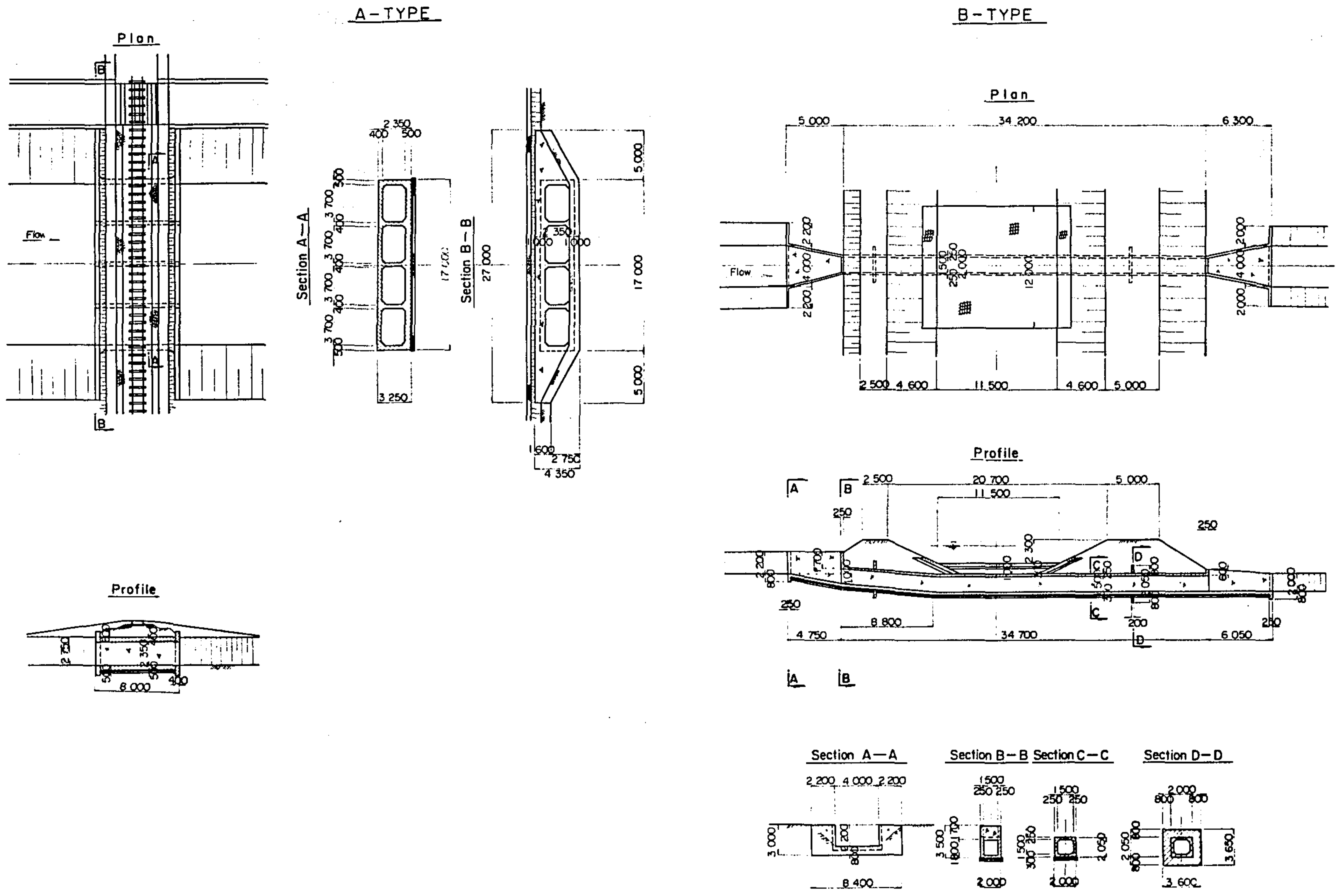
WONOGIRI MULTIPURPOSE DAM INDONESIA

IRRIGATION

BRIDGE

Date : July 31, 1975 DWG NO WI-011

CULVERT



SCALE 0 10 20M

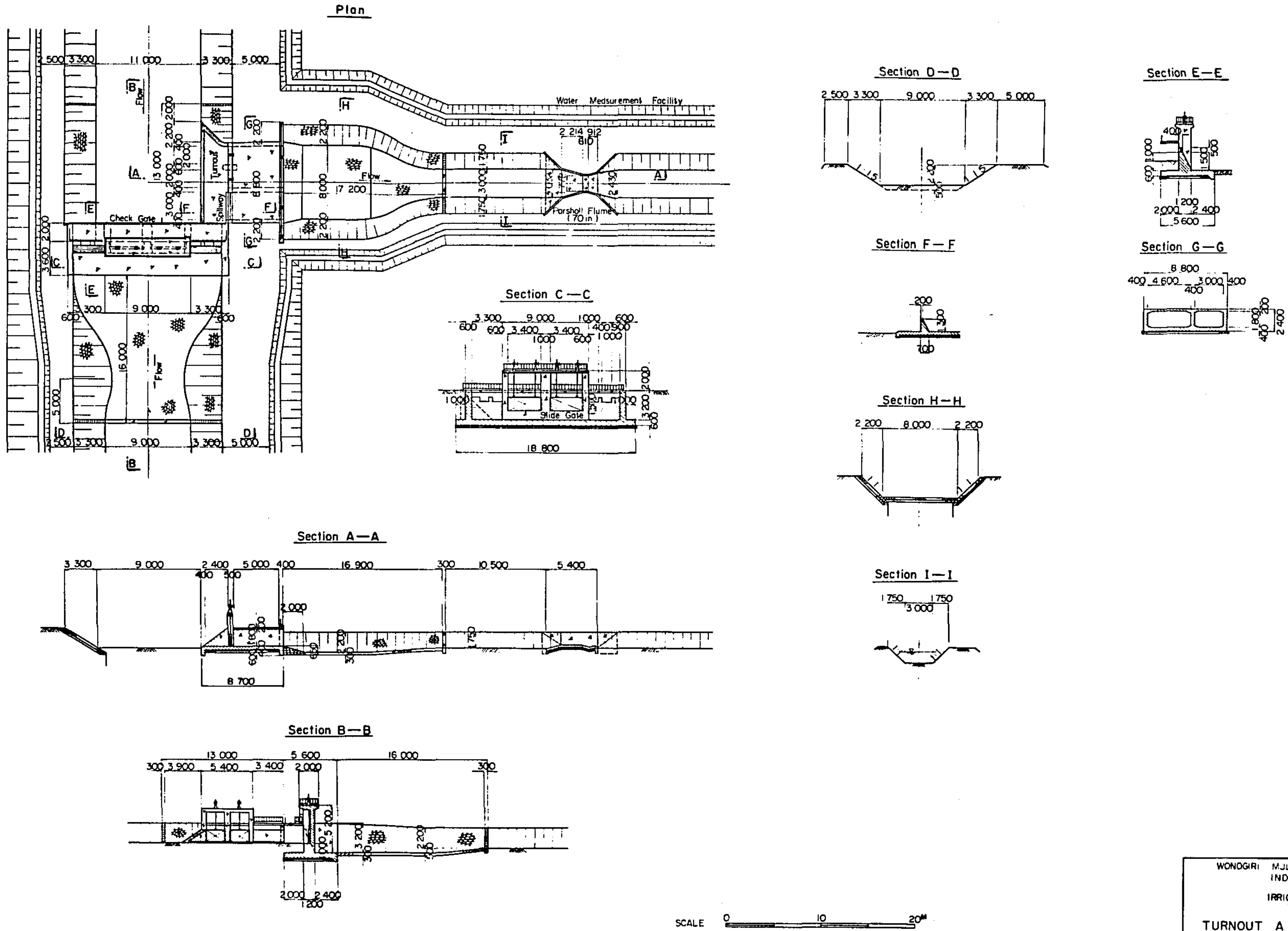
WONOGIRI MULTIPURPOSE DAM
INDONESIA

IRRIGATION

CULVERT

Date : July 31, 1975 | DWG NO WI - 012

TURNOUT A TYPE & CHECK GATE



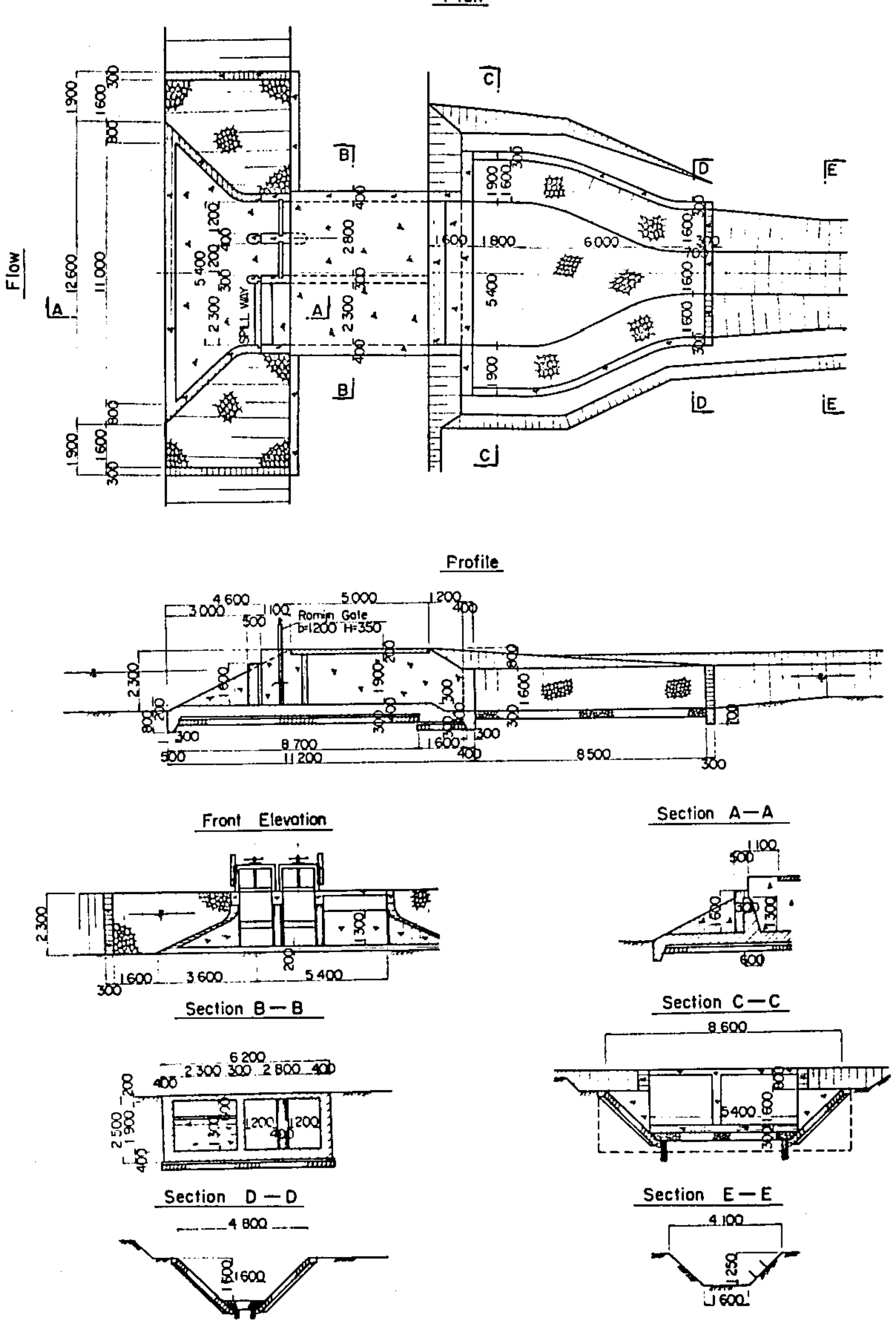
WONOGIRI MULTIPURPOSE DAM
INDONESIA

IRRIGATION

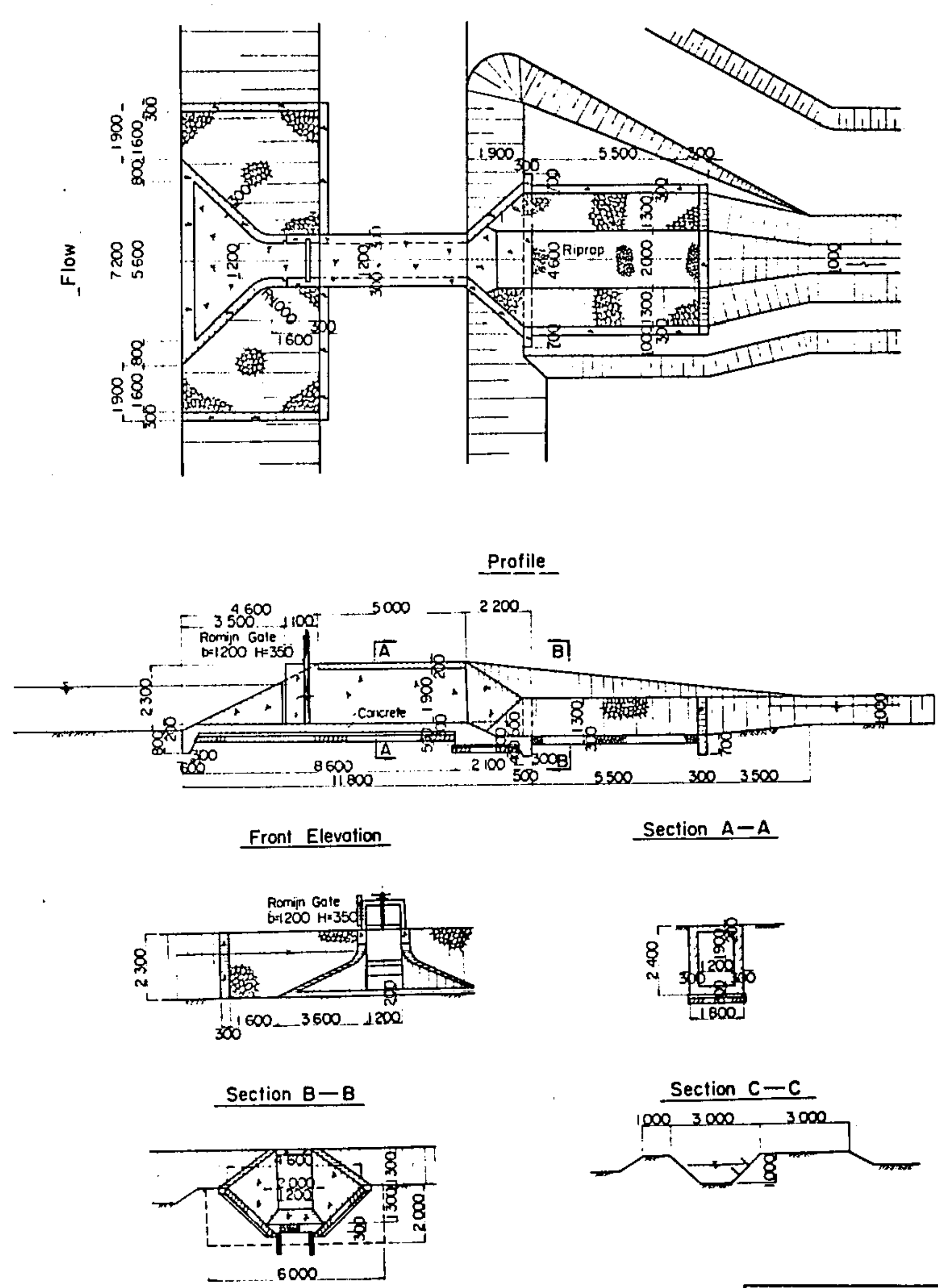
TURNOUT A & CHECK GATE

Date : July 31, 1975	DWG NO WI-013

TURNOUT B TYPE



TURNOUT C TYPE



SCALE

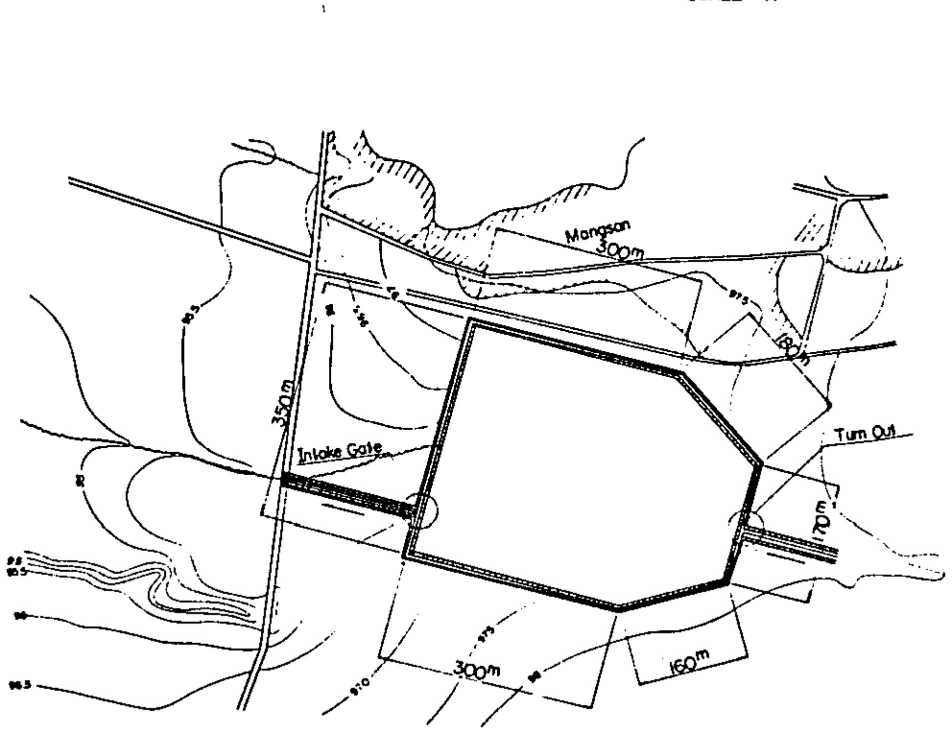
WONOGIRI MULTIPURPOSE DAM
INDONESIA

IRRIGATION

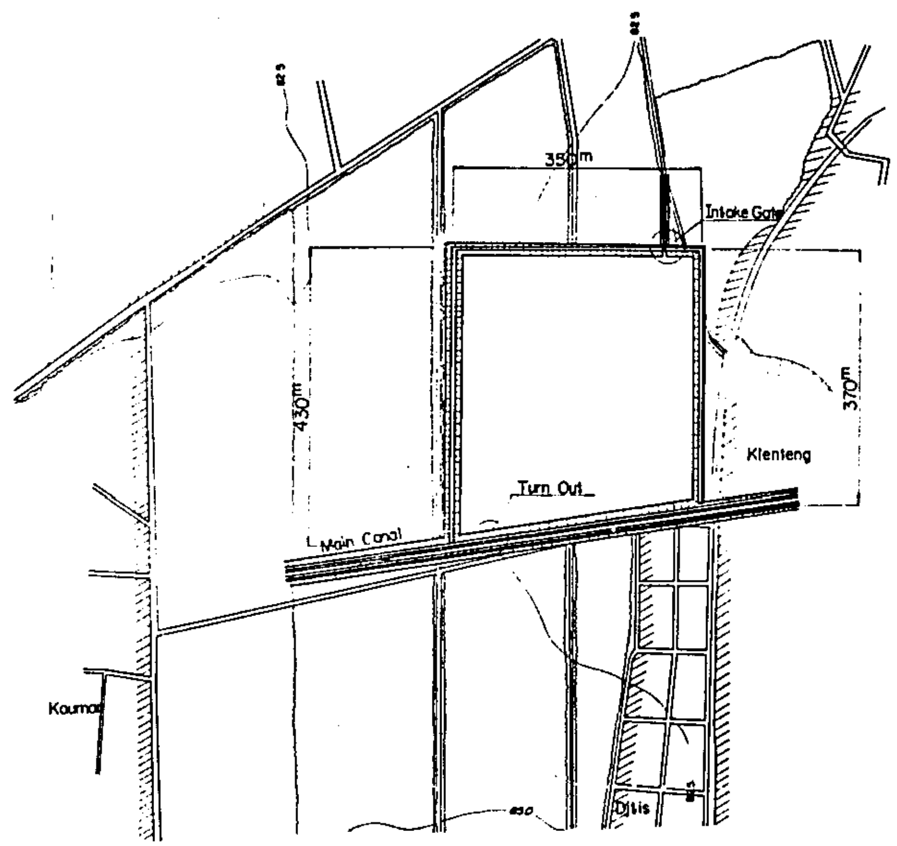
TURNOUT B&C

Date : July 31, 1975	DWG NO WI - 014

REGULATING RESERVOIR (NO. 1)
SCALE A



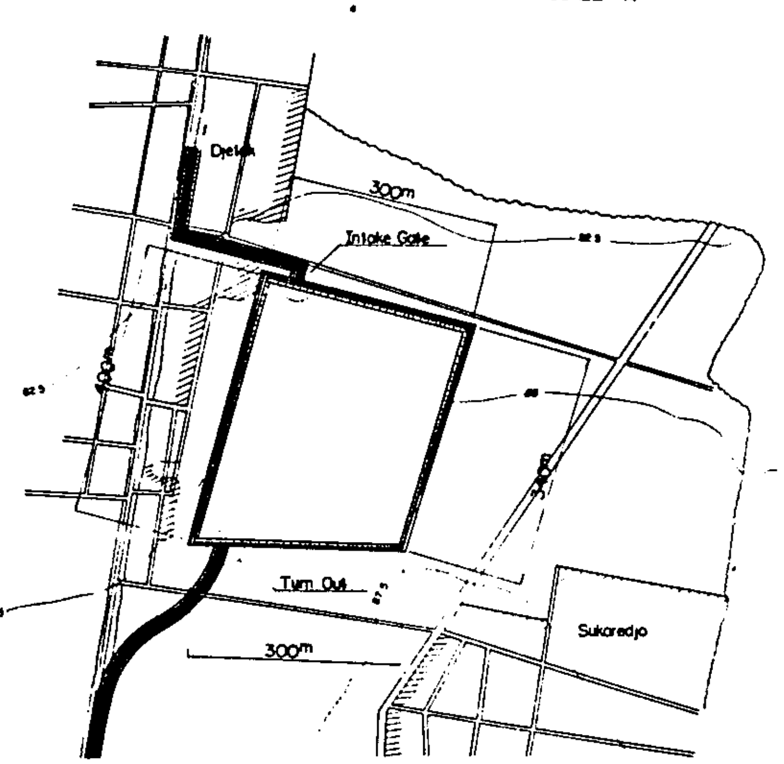
REGULATING RESERVOIR (NO. 3)
SCALE A



Main Features of The Proposed Regulating Reservoirs

REGULATING RESERVOIR NO. (Turnout NO)		NO 1 (NO 6)	NO 2 (NO 30)	NO 3 (NO 35)
Governing area	(ha)	1,800	1,820	2,290
Max discharge	(m^3/sec)	2 4	2 5	3 0
Crest of reservoir	(m)	EL98 5	EL 96 0	EL85 0
W.L of reservoir	(m)	EL97 5	EL 85 0	EL84 0
Storage capacity	(m^3)	210,000	210,000	260,000
Reservoir area	(ha)	14 4	11 0	14 2
Reservoir depth	(m)	1 5	2 0	2 0
Height of dyke	(m)	2 5	3 0	3 0
Length of dyke	(m)	1,800	1,100	1,200
EL of reservoir basin	(m)	EL96 0	EL 83 0	EL82 0

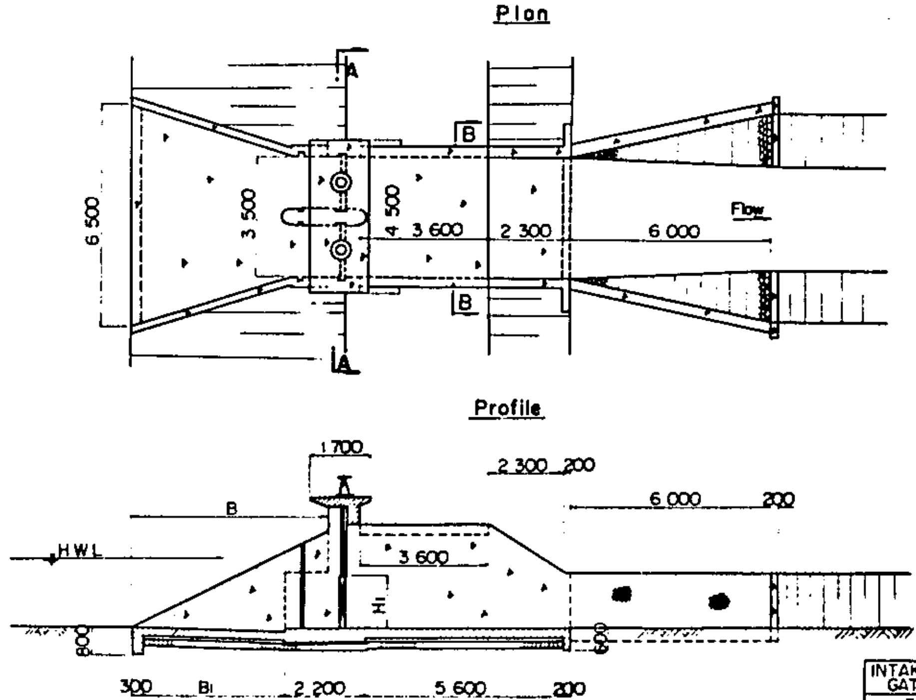
REGULATING RESERVOIR (NO. 2)
SCALE A



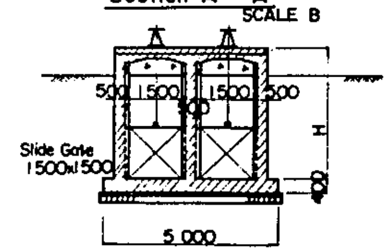
INTAKE GATE
SCALE B

Plan

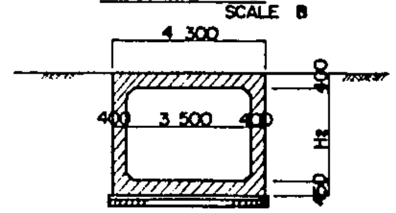
Profile



Section A — A
SCALE B



Section B — B
SCALE B



SCALE A 0 — 500M

SCALE B 0 — 5 — 10M

INTAKE GATE NO	NO 1	NO 2	NO 3
B	5 500	6 500	6 500
B_1	4 000	5 000	5 000
H	3 800	4 800	4 800
H_1	1 500	2 000	2 000
H_2	2 700	3 200	3 200

WONOGIRI MULTIPURPOSE DAM
INDONESIA

IRRIGATION

REGULATING RESERVOIR

Date : July 31, 1975 | DWG NO WI-015

社会開発協力部報告書