APPENDIX I - VII

IRRIGATION AND DRAINAGE

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IRRIGATION AND DRAINAGE

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IRRIGATION AND DRAINAGE

1. PRESENT CONDITION OF IRRIGATION AND DRAINAGE

1.1 Present Irrigated Area and Water Deficit

Current paddy field area in the Project area is 11,050ha, 9,505ha or 86 % of which is irrigated paddy and 1,545ha or 14 % rainfed paddy. Even though most of the irrigated land is covered by Communal Irrigation Systems (CIS), the area still suffers water shortages. In order to determine the irrigation water shortage, NIA carried out two kinds of surveys: one is an inventory Survey of CIS (see TABLE VII-1) carried out by PIO and the other is the land utilization study by PDD. According to the inventory survey conducted by PIO, 12% in wet season and 29% in dry season of irrigated land remains un-served. The team has resurveyed the area in cooperation with NIA counterpart based on the above survey and study.

As a result, the inventory Survey of CIS seemed to be optimistic in estimating the irrigated areas during both wet and dry seasons, and the team estimated the shortage ratio at 27% in wet season and 67% in dry season against arable land (except orchard) of 12,940ha, as shown in TABLE VII-2. The causes of water deficiencies are as follows:

i) The Magat and Matuno rivers have comparatively stable water flow except during infrequent drought years. However, there are some structural constraints limiting the area covered, such as location and elevation of intake facilities and main canals. Moreover, the common brush dam type intake weirs do not usually provide a stable water supply.

ii) In the Project area, 43 or about 57% of the CIS depend on the water resources of 16 local streams including return flow use. These streams have a small catchment area of only 10-50 km^2, and during the dry season, they are mostly dry.

iii) Existing intake facilities, main canals and related structures of CIS are mostly improperly constructed and are now obsolete. The diversion works do not properly control the flow volume, resulting in inequitable water distribution to the area. In the case of large main canal systems such as Colocol Main Canal, priority is given to upstream areas while those downstream suffer water shortage.

Approximately 226ha of rainfed paddy fields are scattered in the western foothills ranging from 240m to around 300m in elevation. Other fields, covering a total of 1,319ha are mainly located on either side of National Road No.5 in Bagabag municipality, in the northeastern portion of the Project area. At present, these areas can not be irrigated by gravity due to topographical conditions and lack of irrigation water.

Private pump irrigation systems within the Project area, 104 in all, have a total potential irrigation command area of about 1,250ha as shown below.

Municipality	Number	Irrigation Area (ha)
Bayombong	7	117.6
Solano	13	145.2
Villaverde	5	37.1
Bagabag	79	952.9
Total	104	1,252.8

Of this area 953ha or 76% is located in Bagabag municipality. These private pump irrigation systems are seldom operated, due to difficulties of operation and maintenance mainly in the form of high fuel costs and mechanical failure. Therefore, practically all farmers presently depend on rainfall for irrigation.

1.2 Condition of Existing Irrigation Facilities

1.2.1 Present Facilities

Current irrigated paddy in the Project area are mainly served by the Communal Irrigation Systems. The water resources of the same are the Magat and Matuno rivers, tributaries of the Lanog and Lamut rivers, and Apad Creek. CIS located in the Project area are tabulated in detail in TABLE VII-1, and are summarized according to water resources utilized as shown below.

Basin	Number	Area (ha)		
		Potential	Wet	Dry
Magat River 1/	31	3,285	3,102	3,102
Matuno River	2	544	544	544
Lamut River 2/	9	598	530	307
Lanog River	24	4,300	4,084	2,760
Apad Creek	9	946	764	583
Total	75	9,673	9,024	7,296
Magat River Right bank	4	517	463	463

1/ consists of 30 CIS totalling 3,258ha diverted from Colocol Main Canal and 27ha served by San Vicente CIS

2/ consists of the tributary creeks Nagalisan, Ibung and Massin.

1.2.2 Irrigation Facilities of On-going Projects

There is no National Irrigation Project in the Project area at present, but 4 Communal Irrigation Projects are planned for implementation under the Farm System Development Corporation (FSDC) as tabulated on the following page.

Name	Irrigable Area (ha)	Water Source	Stage
Gannib - Cabalitan	60	Lanog River	Under Construction
Sta Cruz-Careb	450	- do -	- do -
Nangyatan	60	- do -	- do -
Lamut	500	Lamut River	F/S completed

The first two projects involve construction of an intake weir at Gannib on the Lanog River, as well as funneling of the various western hill area tributaries and utilization of return flow from upstream to serve the downstream area. The proposed Lamut Communal Irrigation Project envisions the construction of an intake weir at Panut Dupan covering about 500ha on the right bank of the river. This scheme will be incorporated within the proposed Project.

1.2.3 Canal Conditions of Existing CIS

Main canal length and canal density of existing CIS are tabulated according to water source in the following table:

Basin	Potential Area (ha)	Length of Main Canal (km)	Canal Density (m/na)
Colocol CIS	3,301	68.53 1/	20.8
Lanog River	3,342	45.69	13.7
Lamut River	1,020	17.93	17.6
Apad Creek	805	12.20	15.2
Matuno River	502	9.38	18.7
Total	8,970	153.73	AV. 17.1

1/ includes 21km of the Colocol Main Canal

(1) Colocol Main Canal

The Colocol Main Canal receives water directly from the Magat River via San Vicente, Bayombong, one of the most suitable intake sites along the Magat River. A concrete structure and weir intake dam was constructed at the same; however, when typhoon Aring caused a devastating flood in the area, in 1980, the dam was buried under flood debris. In its place, a temporary brush dam was constructed. This brush dam must be rehabilitated and the intake structure of the canal must be excavated by bulldozer after every flood which occur 3-4 times a year. Although the intake gate has 3 sluice gates, only 2 are currently serviceable and thus regulation of water flow cannot be controlled.

Maximum flow capacity of the Colocol Main Canal is about $6.0m^3/s$ at the intake. With a total length of 21km the main canal extends from Bayombong along National Highway No.5 and passes through Solano, ending near the town of Bagabag. Some portions of the canal from upstream Bayombong to Solano, mainly those within the town and along the national highway, are lined with stone masonry, but the majority remain unlined and some curves have deteriorated. The average canal slope is 1:640.

Closer to the terminal, the canal passes through 4-5km of low area. Here it begins to meander and the flow capacity decreases. Generally, operation and maintenance of the main canal is insufficient, and most portions except along the National Highway have no inspection road.

The thirty CIS served by the Colocol Main Canal receive water via diversion works placed on the average at 700m intervals. 1 to 1.5m high weirs have been constructed for most of the CIS in Bayombong municipality to dam up the canal flow. These fixed weirs limit the flow capacity of the canal, resulting in overflow and inundation of the area especially during storms.

Downstream from Solano, most intake facilities consist of flash board weirs which control flow by stop logs. Due to lack of flow volume control in the main canal, however, many of the intake facilities' side walls have been destroyed. All intake facilities in this system regardless of irrigation area, are open type structures equipped with simple stop logs only.

The main canal joins the Apad Creek at Solano. During periods of rapid increase in flow, flow waters from an area of about 6km^2 including those from the western hills, join the Colocol Main Canal from the Apad basin. The said main canal has no waste ways resulting in inundation of downstream areas.

(2) Other CIS

The Sto. Domingo CIS, including about 500ha of irrigation land, derives its water supply from the Matuno River. The Sto. Domingo CIS is equipped with a temporary brush dam as an intake facility but the flow of the Matuno River is usually sufficient to service the CIS area. When flooding occurs however, the intake facility is washed away or buried under sediment.

Most of the other CIS are equipped with fixed type intake weirs. Several of these intake facilities were destroyed by the Aring Typhoon of 1980, due to their inferior hydraulic structure. The Uddiawan and San Juan CIS have since been rehabilitated, while others are dependant on temporary brush dams.

Intake facilities of CIS that exist in the downstream area of small rivers consist mainly of flash board weirs with simple stop logs. The canal networks of CIS are predominantly unlined main canals. CIS located at high elevations have steep decline canals, water loss in which is large due to erosion of the main canal.

The Uddiawan CIS which joins the Bintawan River commands an irrigation area of about 600ha. The canal network of the said CIS is comparatively well developed with a canal density of about 20m/ha. Intake and turn-out facilities however, are of the flash board type only. The catchment basin of Bintawan River is 17km^2 at the Uddiawan CIS intake. Consequently, although water flow of the same is usually sufficient in the wet season, during the dry season it is significantly reduced. During this period therefore, the area is divided into two irrigation blocks to be irrigated in alternate years.

1.3 History of the CIS

The Colocol Main Canal was constructed in 1876 during the Spanish era, and included the formation of the Sunday CIS and Villarama-Cafiza CIS, both of which derive water from the upper Colocol Main Canal. At that time, Borrobob Spring located in the western hills of Bayombong was also a source of irrigation water. It is assumed that both the Nagragadian and Salpad CIS were constructed in the same period, a fact which provides evidence of the early beginnings of irrigation in the area.

Many CIS connected with the Colocol Main Canal were constructed from the early 1930s until just before the beginning of World War II, representing an impressive development period. Other irrigation systems, including such systems as Uddiawan and Sanjan CIS, Bintawan River water source and other CIS, and Wacal Spring water source, relied upon small streams originating from the western hills, and were developed after 1915. This was the initial stage of foothill development. During the period between the early 1930s to pre-World War II, other irrigation systems connected to small streams were developed. In the 1970s some CIS were established which use the return flow system to obtain water from existing schemes in the area.

Throughout the history of CIS development, the socio-economic impact of the same has been apparent. However, except for those connected to the Colocol Main Canal, all CIS have developed separately and gradually upon the demand of local farmers. Hence, the command areas of the same vary from 20ha to about 600ha and have not been systematically developed. Moreover lateral or sublateral canals have not been developed in areas which suffer chronic water shortages and consequently agricultural production has been retarded in the Project area.

1.4 CIS and Related Problems

The Communal Irrigation System is the base of the irrigation system in the Philippines and is managed by the farmers themselves. The Government of the Philippines continually stresses the importance of improving and rehabilitating the existing CIS in a long term development plan.

The 75 CIS in the Project area account for over 40% of the total irrigated area covered by the 260 CIS in Nueva Viscaya. These CIS have a long history closely intertwined with the organization and development of Farmers Irrigators' Associations, and at present the two systems together form the nucleus of communities in the area. In the formation of the irrigation development plan in the area, therefore, these existing systems and their functions must be duly considered.

(1) Colocol CIS

The Colocol Main Canal involves 30 different Communal Irrigation Systems which cover about 3,000ha and benefit about 2,500 farm households. With the development of CIS facilities, the administrative irrigators' associations have also been expanded and subsequently integrated into the present federal association of San Vicente Gaddang Communal Irrigation Association. Moreover, the said canal functions as a domestic water supply for Bayombong, Solano, Bagabag and their respective vicinities.

The Colocol Main Canal and related CIS serve about 40% of the total 6,000 farm households in the Project area, while the Colocol Main Canal is also an important source of domestic water supply to the administrative center of Bayombong, and the commercial center of Solano, the principal cities in the area. These same CIS and main canals are rationally matched to local circumstances, and in this sense are the most developed in the area. Consequently, improvements planned under this Project are concentrated on those farmers who are connected with the same.

(2) Problems of the Existing CIS

Existing CIS are the core of community solidarity. The same are not however, smoothly managed, particularily in regards to the collection of water service fees, the main difficulty arising from lack of adequate irrigation water supply. The latter can be attributed to the following reasons:

i) shortage of water resources and inadequate facilities, resulting in irregular distribution of irrigation water;

ii) unsatisfactory diversion structures and water control facilities hindering balanced water distribution;

iii) superannuated canal facilities and related structures resulting in a water flow deficit;

iv) hydraulically and structurally under-designed intake wiers which are destroyed by large floods resulting in excessive rehabilitation and maintenance costs; and

v) obstruction of crop production improvement and drainage by present facilities for reuse of irrigation water located in small rivers.

The above problems should however, be solved by Project implementation. Existing small scale CIS at times actually hinder operation of the large overall irrigation system, and therefore, under the Project these are to be integrated within an overall system while at the same time maintaining their present functions.

1.5 Present Drainage Condition

(1) General

The Project area forms a sub-basin surrounded by the Matuno, Magat and Lamut rivers and the western mountain range. The Lanog River runs through the center of this sub-basin from south to north serving as the main drainage canal. In addition, the Nangalisan Creek gathers runoff from the mountains in the northwest Project area later joining the Lamut River while runoff from the east and north drains directly into the Magat River.

About 90% of the Project area is paddy. Surface drainage is fairly adequate and widely distributed with a relatively high density of about 14m/ha including drainage from each of the area's rivers, as well as from mountain streams and existing drainage canals in the western mountains.

Except in the flood channel area, the Matuno, Magat and Lamut rivers have sufficient drop in elevation to diminish the frequency of outside water level flooding along the adjacent banks in all but major floods.

Those rivers which present difficulties in drainage planning are as follows:

The Lanog River

The Lanog River joins the Lamut River in the southeast area. The basin which is about 50% paddy, has an area of 15.6km^2 and a stream length of about 30km. Except for the lowland area, the area downstream from National Highway No.4 has sufficient drop along the banks of the adjacent agricultural land to neutralize the effect of backwater from flooding of the Magat River.

Problems occur however between the confluence of the Bintawan River and intersection with National Highway No.4, where excessive meandering and shortage of cross-sectional area of flow occur. Irrigation and drainage systems are even more complicated in the district upstream of the Lanog's conjunction with Wacal Creek. The extreme narrowness of the existing cross section requires urgent rehabilitation. The agricultural land along the river has an incline of 1/3oo or greater, and gravitational drainage will accordingly be possible with rehabilitation of the channel.

Most streams and drainage canals which join the Lanog River flow through the paddy area from the relatively steep incline of the western foothills and thus have sufficient flow capacity. Some CIS, however, utilize water from these streams, as well as the Lanog River, resulting in drainage problems. It is therefore necessary to increase the drainage function of these streams in conjunction with the irrigation system plan.

The Apad Creek

The Apad Creek orginates in the mountainous area west of Bayombong and joins the Colocol Main Canal near Solano. Downstream from this conjunction, the canal's cross section is inadequate resulting in flooding of the surrounding area during a heavy rains.

Relocation of the Lanog River channel is one possible solution to this problem. Expansion of the Colocol Main Canal and construction of a new drainage canal would be preferable however, due to the large right of way required for the canal and the expense of Lanog River conservation.

Downstream Area of Colocol Main Canal Area

Barangay Tuao and its vicinity are situated on low swampy area commonly known as "Tullag Lake." This swampy area results both from low elevation coupled with poor drainage of water from the western mountain district which collects in the depression, and from excessive narrowness and meandering of the Colocol Main canal.

Drainage control for this area must therefore provide for a mountainside catch canal, a canal to the Magat River and construction of a new canal from the upper part of the Colocol Main Canal.

Others

Besides those area mentioned above, various other sections of the drainage system function only partially or inadequately. The function of these however can be satisfactorily restored by small scale conservation works.

1.6 On-farm Condition

(1) On-farm Irrigation Facilities

Irrigated paddy in the Project area are serviced by existing CIS which supply on-farm fields with irrigation water directly from the main/lateral canals or via farm ditches diverted from the main or lateral canals. This water is distributed to the fields by the plot to plot irrigation method and drained via the main drainage canal or the irrigation canals.

Canal density for the Uddiawan CIS selected as the model district in the Project area, is estimated at approximately 17m/ha. This CIS is comparatively well developed, the canal density of other CIS being either equal to or less than this standard.

Existing on-farm irrigation facilities are poorly constructed using only simple stop-logs as intake facilities for the main/lateral canals. Furthermore, although year-round irrigation is practised in those areas serviced by relatively well-supplied CIS (namely, the upper Colocol CIS, Sto. Domingo CIS, and the lower Lanog River), those areas serviced by CIS with unreliable water supply in the western hill area must practise alternate irrigation, irrigating each command area every other year during the dry season.

(2) Drainage Facilities

The plot-to-plot method is used for on-farm irrigation. Excess water is channeled from the higher to the lower plot, and then drained into the main drainage canal or the CIS main/lateral canals. Accordingly provision of on-farm drainage facilities in each field is unnecessary.

(3) Road Condition

Virtually no on-farm roads exist due to traditional on-farm irrigation practice and reliance on manpower and carabao for planting and harvesting.

(4) Scale of Farm Plot

The scale of farm plots vary with the topography. In comparatively level areas neat rectangular plots from 1,000m^2 to 4,000m^2, are common. In the relatively steep areas near the mountains, however, plots of varying size from small to large are combined within the same district.

1.7 Water Quality

Thirteen samples were collected from Bante and site B2 on the Matuno River, from Batu Bridge, Colocol intake and Baretbet on the Magat River, and near Bintawan on the Lanog River, in October and November, 1981 and April, August and November, 1982. Chemical analysis were made by NIA Laboratory as shown in TABLE VII-3. On the basis of the analysis and the US Department of Agriculture and Environmental Protection Agency Standards, water quality for irrigation has been evaluated as described below.

The quality analysis of 16 samples are shown in the classification chart, FIG.VII-1. All samples are classified into C1-S1 and C2-S1 grades, i.e. low to medium salinity hazard and low sodium hazard which is assessed by the sodium absorption ratio.

On the whole, the results indicate that all water sources of the Matuno, Magat and Lanog rivers are suitable for irrigation purposes with no cause for water quality management problems. A slightly high electrical conductivity was found among the samples from the Magat and Lanog rivers, which may adversely affect salt-sensitive crops such as kidneybeans, carrots, strawberries, etc. Although such crops generally require appropriate leaching, as a secondary crop of paddy-paddy it is considered that leaching will not be required.

2. SELECTION OF IRRIGATION AREA

Potential irrigable area in the subject area depends on natural conditions of water source, topography, vegetation, soil condition, etc., as well as on socio-economic conditions including present land use, stage of CIS development, etc.

The proposed irrigation area incorporated within the Project consists of 12,940ha of arable lowland area which, due to the surrounding Magat, Matuno and Lamut rivers and western mountain range, is rich in water resources from rivers and tributaries. About 90% of this area's arable land is currently used for paddy irrigated by relatively well-developed CIS in some parts of the province.

Anticipated elevation of the intake point on the Matuno and Magat rivers is estimated at 270-350m. Based on this elevation, the Team studied the area to determine possible extension of irrigation benefits to areas other than that of the main survey. The Magat right bank and Lamut left bank areas were accordingly studied as summarized below, and it was concluded that their incorporation within the Project irrigation area would not be economically beneficial.

(1) Magat Right Bank Area

The subject area extends from Batu down to Paitan on the right bank of the Magat River. A total 517ha of land is currently served by four CIS which use water from the Magat River, as shown in the following table.

Name of CIS	Location	Area served(ha)
Latuyot CIS	Latuyot, Bayobong	34
Magapuy CIS	Magapuy, Bayombong	53
Paitan CIS	Paitan, Bayombong	370
Celestine CIS	Prgonsino, Bagabag	60

Note: 517ha x 0.975 = 504ha

504ha of the above irrigated area in Paitan CIS and upstream is included in the present study. The altitude ranges from 260-300m, and in order to integrate the existing temporary intake weirs of these CIS, a new intake dam was proposed at Batu, a suitable site in terms of elevation.

Various alternative Magat intake facility plans were also considered as discussed in 5. DIVERSION DAM, but from an over-all view, the San Vicente site of Bayombong was selected as most suitable for the diversion dam. It will not however, be possible to irrigate the entire area of the right bank from this site for only 370ha in Paitan may be irrigated with US$ 6,700/ha of additional direct construction costs (see 5. DIVERSION DAM).

Utilization of the Matuno River water source with an inverted siphon under the Magat River from the St. Domingo Main Canal has also been studied and a preliminary plan prepared (see FIG. VII-2). The total direct construction and land adquisition costs for development amounts to US$5,700/ha.

Finally, the right bank area of the Magat River was dropped as an irrigation benefit area because of high investment cost, although this area is still considered as part of the study area to maintain existing water rights.

(2) Lamut Left Bank Area

The Lamut River, a tributary of the Magat River, forms the provincial boundary, the left bank of the river belonging to Ifgao Province and the right to the province of Nueva Vizcaya. The potential irrigation area to be incorporated into the Project is situated on both sides of National Highway No.4. The area upstream of the highway consists of the Lamut river terrace, while the area downstream consists of undulating hilly area.

Area elevation varies from 210 to 260m. The lowland areas along the upper stream of the Lamut River and its small tributaries consist of paddy. The majority of the area however is hilly upland and consists of dry fields or natural pasture. Soil of this pasture land is silty loam and clayey loam. As discussed in 1.2, the upper basin of the Lamut River presently includes the existing CIS with cover area extending to about 1,300ha. Low water flow at Sitio Panopnupan (C.A=160km^2) is estimated at 1.2 to 2.0m^3/s. Considering the irrigation water for the Panopdapan and Lawig CIS which are presently serving 420ha of land, and further including the flow from the tributary, Bonog River (C.A.=37km^2), reliable water source from the Lamut River is estimated at 1.1 to 1.2m^3/s.

The envizaged irrigation system will utilize the water resources of the Lamut River or of the Matuno and Magat rivers. In either case the irrigation area to be incorporated in the

Project will be 555ha with an elevation of 230m or less, depending on topographical conditions and water source. Direct construction costs for each case are roughly estimated at 28.8 and 32.6 million pesos respectively, equivalent to US$5,180 and 5,870. These comparatively high cost estimates are due to land reclamation costs of about 30,000 pesos per hectare.

In accordance with the above, the right bank area of the Lamut River was also eliminated as an irrigation benefit area under the proposed Project.

3. IRRIGATION PLAN

3.1 Irrigation Water Demand

3.1.1 Diverted Water Requirement

(1) General

Project irrigation requirements may be determined by addition of the water requirement of crops to be cultivated in the Project area based on the proposed cropping pattern, to the total anticipated water operation loss including that from canal seepage, etc. The basic factors determining irrigation water demand are consumptive use of crops and percolation, while the formulas generally employed to estimate required amounts are as follows:

(a) Consumptive use
(Evapotranspiration) + (Deep Percolation) + (Water Requirement for Land Soaking and Land Preparation)

(b) field water requirement
(Net Water Requirement) - (Effective Rainfall) + (Field Losses)

(c) Diverted water requirement
(Field Water Requirement) + (Conveyance Losses) + (Operation Losses)

(2) <u>Consumptive Use of Crops</u>

(a) Observed pan evaporation: Epan

Evapotranspiration can be calculated by several empirical methods using meteorological data representative of the area and vicinity. In the Project area, however, as available data is limited, the Pan Evaporation Method, widely adopted throughout the Philippines was used to calculate evapotranspiration.

The results are presented in APPENDIX-I METEOROLOGY AND HYDROLOGY. For immediate reference, however, the table presented below provides monthly evaporation in the Project area.

Unit: mm

Month	EPO	Month	EPO
JAN	111.8	JUL	175.2
FEB	140.1	AUG	177.3
MAR	194.5	SEP	162.3
APR	208.3	OCT	139.9
MAY	183.2	NOV	114.8
JUN	171.5	DEC	105.4
		TOTAL	1,884.3

(b) Reference crop evapotranspiration: ETo

ETo has been adopted in accordance with the results of experiments conducted in the field in IRRI, Los Baños.

ETo = 1.6 Eo

Where,

Eo : open water evaporation in paddy field

The relationship between Eo and Pan Evaporation is shown in the following formula.

Eo: Kp· Epan

Epan: Observed Pan Evaporation (mm)

Kp: Adaptation of 0.6 of Class A pan coefficient

(c) Crop evapotranspiration: ET crop
ET crop = Kc · ETo

Kc indicates the crop factor which varies according to the stage of crop maturation. Again no experimental results with regards to the crop factor were available in the Project area at the time of study. Therefore, experimental results from Canili and recommended figures from ECAFE in the Southeast Asian region were adopted.

Crop factors adopted in Project calculations are presented in TABLE VII-4.

(d) Deep percolation

Deep percolation in paddy during both rainy and dry seasons is estimated at 2mm/day for the entire Project area.

Observation of deep percolation was conducted from June to August. 1978 by NIA and from February to March, 1982 by the Team at the sites shown in FIG. VII-5. The results are tabulated in TABLE VII-5 as well as summarized below.

Results of Percolation Test

Unit:mm/day

	Number of Tests	Max.	Min.	Mean
NIA	15	3.108	0.364	1.130
Team	16	3.0	0.3	1.370

Deep percolation in the paddy was determined at 2.0mm/day according to the above mentioned observation results and NIA Design Guide 1/. Deep percolation is not considered to occur in the area for upland crops.

(e) Water requirement for land soaking and land preparation

Water requirements for seedbed preparation, land soaking and land preparation are provided in TABLE VII-6, a summary of which is given below:

Unit:mm

	Rainy Season	Dry Season
1st irrigation	207.5	207.5
2nd irrigation	80.5	59.5
Total	288.0	267.0

Water requirements for upland crop land preparation are:

Crops	Water Requirement (mm)
Maize	150.0
Peanut	100.0
Vegetables	200.0
Mung bean	97.5

Consumptive use of each crop according to calculation of the above conditions per month is tabulated in TABLE VII-7.

1/ - Design Guides and Criteria for Irrigation Canals, O & M Roads, Drainage Channels and Appurtenant Structures, NIA, 1979
- Manual on Canals and Canal Structure, NIA, 1982
- The Philippines Recommendation for Irrigation Water Management, U.P., NIA etc., 1978

(3) Field Water Requirement (FWR)

(a) Effective rainfall

Effective rainfall calculations are based on the amount of rain for consumptive use of crops required from total rainfall in the area. As long term meteorological records are non-existant in the Project area daily rainfall data which has been collected at nearby Salinas station since 1957 was extensively used. The station shifted to Barat in 1976. Collected data is listed in the DATA BOOK.

Calculation of effective rainfall was based on the following standards:

i) Paddy

- Daily depth of paddy field inundation follows NIA Guidelines[1/].
- Land preparation period: Inundation depth 60-150mm
- Growing period: inundation depth 20-80mm

ii) Upland field

The USDA, SCS[2/] method has been adopted to calculate effective rainfall.

(b) Field water requirement

The calculated monthly field water requirement is given in TABLE VII-8.

(4) Irrigation Water Requirement

Irrigation water requirement is calculated based on the field water requirement and irrigation efficiency rate.

(a) Irrigation efficiency rate

The loss of irrigation water has been calculated according to the following factors:

i) Field Loss

1/-- Guideline in Calculating the Dependable Service Area of an Irrigation System, NIA
-- Manual on Canals and Canal Structure, Chapter-1, NIA, 1982

2 Irrigation and Drainage Paper, No.25, FAO, 1974

ii) Conveyance Loss, Operation Loss

Field loss differs from farm to farm depending on the individual farmer's water management ability and the physical conditions of the field. In the Project area, field losses are assumed to be 30% for rainy season paddy, 25% for dry season paddy and 35% for upland crop fields. Conveyance loss consists of two different factors, namely 1) for rainy season paddy, 25% for dry season paddy and 35% for upland crop fields. Conveyance loss consists of two different factors, namely 1) physically measureable conveyance loss and 2) operation loss which cannot be quantitatively measured.

Conveyance loss results from percolation and evaporation, while operation losses are caused by inadequate water management, mis-operation at the time of torrential rain, and lack of communication and water management skills in all irrigation systems.

Generally, conveyance loss is measured by the ponding method, but no experimental record has been conducted in the Project area. Therefore, as an estimate of the same, data from the NIA Manual1/ as given below and other published experimental studies were superimposed.

Water Losses	Paddy		Diversified field
	Wet	Dry	Both seasons
Field Loss	30	25	35
Conveyance loss	20	20	25
Operation loss	15	10	15

Under these assumptions, the total irrigation efficiency ratio was calculated at 48% for rainy season paddy, 54% for dry season paddy, and 41% for both rainy and dry season upland crops.

1/ Draft Manual on Canals and Canal Structure, NIA, April 1982

Seepage loss was calculated based on A.N. Kostiakov's Formula and Moriz' Equation by the procedure shown in TABLE VII-9. Results of the formulas were 19.63% and 11.65% respectively and thus a 20% seepage loss ratio was adopted by the Team to allow for a safety margin.

(b) Irrigation water requirement

On the basis of the above assumptions, the irrigation water requirement was calculated as shown in TABLE VII-10.

3.1.2 Unit Design Irrigation Water Requirement

(1) Unit Water Requirement for Field Ditches

The calculation of design irrigation volume for main farm ditches and supplemental farm ditches situated at the tail end of the irrigation system, are in accordance with the following criteria:

i) Standard command area of the turnout device from the lateral or sub-lateral canal to the main field ditch is 50ha. This command area forms a Rotation Block, with a Rotation Unit of 10ha.

ii) Diversion from main field ditches to supplemental farm ditches is by a simultaneous irrigation system. Diversion from supplmental farm ditches to each field is by a rotational irrigation system.

iii) The cross section of supplemental farm ditches controlling 10ha of rotation unit is uniform with a design flow amount of 16.93ℓ/s[1/].

iv) The cross section area of the main farm ditch differs depending on the number of rotation units which range from a maximum design flow amount of 84.65ℓ/s[2/] to a minimum of 16.93ℓ/s.

1/ 256mm x 10ha x 10,000 x 1,000/1,000 x 25 days x 86,400 x 0.70 = 16.93ℓ/s

2/ 16.93ℓ/s x 5 = 84.65ℓ/s

The above criteria are based on the following assumptions:

i) Water Requirement for Land preparation (25 days duration)
- Rainy season: 256mm
- Dry season: 243mm

ii) Field Loss
- Rainy Season: 30%
- Dry season: 20%

(2) Unit Water Requirement for Main and Lateral Canals

Under the proposed cropping pattern for the Project area, rainy season crops are paddy (11,280ha) and corn (1,400ha). Under these conditions, maximum irrigation water is required on the last day of land preparation in June with a maximum unit water volume of 1.92 m^3/s as calculated below.

Maximum land preparation water requirement

= (Land soaking water + standing water)/60 + 59(KC·EP + deep percolation)/60

= (97.5 + 60)/60 + 59(1.0 x 5.75 x 0.60 + 2.00)/60 = 7.98mm

q = 7.98 x 10,000 x 1000/1000 x 86400 x 0.48 = 1.92 l/s/ha

Design capacity of the facilities assumes the inclusion of domestic water requirements and total capacity is thus 2.00 $m^3/s/ha$.

3.2 Irrigation System

3.2.1 Basic Concept

The basic concept of the planned irrigation system, with due consideration given to existing Communal Irrigation Systems, is delineated as follows:

i) to design intake facilities for both the Magat and Matuno rivers to supply stable irrigation water;

ii) to simplify water management by connecting the main canal systems with existing intake facilities, and integrating existing small scale CIS into the new irrigation system within limits not prejudiciary to current functions and organization; and,

iii) to optimize the drainage function of small streams by integrating intake facilities thereby overcoming present drainage problems.

3.2.2 Alternative Plans for Irrigation System

For the 12,680ha of irrigation area under the Project, alternative plans for irrigation systems were studied and evaluated for various water resources as described in APPENDIX I-VI, WATER RESOURCES DEVELOPMENT. Finally, the proposed irrigation system was determined as described under 3.3 below.

As shown in FIG. VII-6, irrigation water will be mostly dependant on the Magat River. The Magat Diversion Dam at San Vicente where the existing Colocol intake weir is located, will be equipped with a water intake at EL. 273.6m above sea level.

The main canal systems are composed of the existing Colocol main canal and the recently constructed Moutainside main canal following the western foothills to the right bank of the Lamut River and ranging from 270 to 240m in elevation. The service area of these main canals is 11,590ha. The remaining 1,090ha of irrigable land with an elevation range of 350 -295m will be served by a main canal constructed along the western foothills which will divert irrigation water from the new Manamtam Diversion Dam on the Matuno River.

FIG.VII-7 and VII-8 show the two other alternative irrigation system plans considered.

3.3 Proposed Irrigation Systems

The proposed irrigation systems designated by source of irrigation water are presented below.

(1) Magat River Source

11,590ha of the irrigation area will be served by the newly constructed Magat Diversion Dam at San Vicente in Bayombong municipality which is located 6km downstream from Batu Bridge.

Intake water level is 273.6m above sea level. The main canal alignment plan is divided into two different canal systems; a rehabilitated Colocol Main Canal System, and another newly constructed Mountain-side Main Canal System. The latter will be aligned with the western foothills and have an elevation ranging from 270m to 240m above sea level.

Most of the service area of the existing Uddiawan CIS which covers 580ha of irrigable land will be included in the Mountain-side Main Canal System. As 180ha of the area with an elevation above 270m in the same CIS can not be irrigated by the System, the intake facility on the Bintauan River, the main canal system of this area, will be rehabilitated.

(2) Matuno River Source

The area of 1,090ha with an elevation range of 310 to 295m above sea level around Sto. Domingo and La Torre will be served by a newly constructed diversion dam at Manamtan site on the Matuno River through a main canal along the foothill. The main canal will partially involve the rehabilitation of the existing main canal of Sto. Domingo CIS. This main canal system will serve the Manamtan area, and the upper Magat left bank and La Torre area.

As an alternative to the said main canal system, the following plan was also studied. As shown in FIG.VII-9, a relatively lower portion of the 1,090ha is to be irrigated by the rehabilitated Sto. Domingo Main canal, while the higher area around La Torre is to be irrigated through a pumping station to be constructed at the end of the Sto. Domingo Main Canal near barangay Magsaysay. On the basis of roughly estimated construction costs for each plan as shown on the following page, the former plan was selected over the alternative plan for economic reasons.

Item	Cost(1,000 Pesos)	Remarks
Original Plan		
-Main cana	115,514	
Alternative Plan		Discharge: 0.5 m^3/s
-Pump and Motor	3,830	Total head: 20.0m
-Pumping Station	3,830	350 m/m volute pump
-Main Canal	12,256	with 75kW motor
Total	19,906	2 sets

(3) Lanog River Source

The northeastern portion of the Project area lies within Murong and Sta. Lucia of Bagabag municipality with an elevation range of 210 to 225m. This area, consisting of 2,745 ha, has the most deficient irrigation supply in the Project area. For the area, construction of a diversion dam on the Lanog river is proposed to utilize the local flow from the western hills as well as to utilize the return flow of the upstream area served by the proposed Magat Diversion Dam. In addition, further water shortage is to be supplemented by the proposed Mountain Side Main Canal through the Bintawan River. Rehabilitation of canal networks of both existing Sta. Cruz Careb and Gannib Caharitan CIS, and new canal construction are proposed for the two main canals, Left and Right Main Canal, and for lateral canals.

As an alternative to the said Lang Diversion Dam, the following plan was also studied. Instead of utilizing return flow from the upstream area of the Lanog River, the required water will be diverted from the Mountain Side Main Canal after passing the Bintawan River. Diversion canal irrigation water will be supplied to the Lanog Left Main Canal, and further through an inverted siphon to the Lanog Right Main Canal. On the basis of estimated construction cost tabled on the following page, the original plan with a diversion dam was selected over the alternative plan for economic reasons.

Item	Cost (1,000 pesos)	Remarks
Original Plan		
-Lanog Diversion Dam	5,420	
Alternative Plan		
-Enlargement of Mountain Side Main Canal	2,270	1.4m3/s increase in M1-M3 main canal
-Diversion Canal	5,975	Capacity: 5.49m3/s Length : 4.5km Excludes land acquisition cost
-Inverted Siphon	403	Capacity: 3.008m3/s
Total	8,648	Length : 40m

(4) Lateral Canal Network

The lateral canal network plan is based on the following:

i) The function and location of existing CIS irrigation blocks are to be changed or interfered with as little as possible.

ii) Considering the topographical conditions, etc., small scale existing CIS will be integrated into new lateral canal networks.

iii) The existing canal networks will be effectively utilized to minimize the amount of unusable land to be created by newly constructed canals.

The distribution of lateral canals was planned on the basis of the above mentioned factors, topographical conditions, and distribution of small streams which will be used as main or lateral drainage canals, as shown in FIG. VII-10. The length of these proposed main and lateral canals are presented on the following page.

Unit: m

Main canal system	Main canal length	Lateral canal length
Mountain Main Canal	26,050	78,100
Colocol Main Canal	21,100	37,350
Lanog Main Canal	22,000	17,850
Sto. Domingo Main Canal	21,200	60,100
Total	90,350	193,400

3.4 Improvement Plan of Existing CIS

The physical and institutional functions of existing CIS will be improved and strengthened with the mutual agreement of both the executing agency and the concerned farmers. Presentation of the plan to farmers is discussed in the MAIN TEXT CHAPTER VII.

3.4.1 Present Problems Within CIS

About 90% of the paddy land in the Project area currently belongs to the command area of existing CIS. Improvement of existing CIS is thus one of the most important factors of the Project plan. Some problems which need to be resolved to improve the effeciency of existing irrigation systems are summarized below:

(1) Water Resources

Due to improper functioning of present intake facilities, water supply from large rivers is not constant. Small local flows, each having a small catchment basin, extend from the hillside. Most of these rivers dry up, particularly in the dry season.

(2) Water Management

(a) CIS connecting the Colocol main canal

Water does not flow smoothly through the Main Canal due to sedimentation and canal deterioration. Diversion works without measurement structure are constructed at approximately 700m intervals and hence, during low flow periods in the upper stream, water is supplied preferentially. Furthermore, since there are no waste ways, flooding occurs during heavy rains. Equalization of water distribution through the main canal is thus difficult at present.

(b) Other CIS

Many individual CIS scattered within the Project area use return flow from local streams and drainage canals. Since these are all individual systems, they are not coordinated by the federal water management system and thus the CIS located upstream benefit more than those downstream during low flow periods. Most of these CIS are small scale systems equipped inadequately for larger scale operation, thus resulting in operation losses.

(3) Operation and Maintenance of Facilities

The average size of existing CIS in the area is 136ha. There are 9 large CIS covering areas greater than 300ha, 31 medium CIS covering areas from 300 to 100ha, and 35 small CIS of less than 100ha. The latter share about 47% of the total service area. The management, regardless of its scale, is composed of the Communal Irrigators' Association (CIA), and the administrative body of the CIS, consisting of a President, Vice-president, Secretary, Treasurer, Auditor and a Board of Directors. This system of organization and the great number of CIS necessitates a large regular operation and maintenance cost for the entire Project area. Additional repairs and rehabilitation work to remedy damage caused by natural disasters, often raises the cost for the municipal and provincial goverments still further in terms of input materials and fuel. For example, after typhoon Aring in 1980, the rehabilitation cost of the Colocol intake weir and Uddiawan intake weir amounted to 150,000 Pesos supplied by the local government and 300,000 Pesos by the social sectors for input materials and machine fuel, while labor was provided by farmer volunteers.

(4) Losses due to Non-uniform Farming

The cropping pattern, the varieties of crops, and the type of field operation works in each CIS command area are not uniform due to different physical and socio-economic backgrounds.

This lack of uniformity makes the flow system more complex resulting in inefficient operation of the system and water losses.

3.4.2 CIS Improvement Plan

In recent years, the NIA, following the suggestion of the National Economic and Development Authority (NEDA), has launched a policy of delegating responsibility for management and operation of national irrigation projects to Communal Irrigators' Associations. The CIS improvement plan, in accordance with the above policy, is proposed as follows:

(1) Stable Water Resources

To simplify the main canal systems and ensure stable water supply, the Magat and Matuno Rivers were chosen as the main water sources. Existing intake systems from small streams and drainage canals are to be abolished, and these flows to be integrated into the Lanog River. Downstream the Lanog River, these integrated flows and return flows will become the source of irrigation water.

(2) Improvement and Strengthening of the Water Management System

Major points emphasized in this plan are the integration of existing CIS and improvement of their facilities.

(a) CIS integration program

The following table shows the results of the CIS integration plan for each main canal system.

Main canal	Existing CIS (A) (Nos.)	Proposed system (B) (Nos.)	B/A (%)
Mountain Side M.C	33	14	42
Colocol M.C	32	14	44
Lanog M.C	5	2	40
Sto. Domingo M.C	5	1	20
Total	75	31	41

The detailed integration plan for existing CIS and a comparison of the main canal systems are shown in FIG.VII-11 and TABLE VII-11.

(b) Utilization and improvement of existing facilities

Each CIS has its own irrigation system in accordance with the recommendation of the Provincial Irrigation Office and NIA Region II. Under the new system, the existing main canal will be joined to the proposed lateral canal. Thus the following water management systems will be improved:

i) Present canal density of 17/m/ha will be extended to 22m/ha.

ii) Present main canals of each CIS will become lateral canals or main farm ditches under the Project. Existing canals will be used as much as possible to avoid the destruction of arable land. In general existing canals are aligned with steep inclines and the structures of turnout facilities are inadeqate. Under the Project plan, the incline will be regulated, and the cross section of the canal will be expanded and stabilized. As well, the turnout facility will be installed with a water regulator.

iii) Inspection roads along the canals are planned.

iv) A farm level water management system will procede from the customary system of plot to plot irrigation for a preliminary period. To keep up with the implementation of main and lateral canal systems, farm irrigation systems will be modernized.

3.4.3 Improvement Program for Proposed Main Canals

(1) Mountain Side Main Canal

At present most of the existing CIS pertaining to this water system are diverted directly from local flows or utilize return flow at a mid way point or downstream. under the Project all of these CIS will be served by 22 lateral canals diverted from the mountain side canal. Hence, present intake facilities of the CIS will no longer be necessary. On the other hand, existing canal systems can be effectively used as lateral canals, sub-lateral canals, tertiary and main farm ditches. The present downstream return flow irrigation system on small streams will be integrated into a new lateral canal system.

Present intake facilities in small rivers will be removed to improve the drainage capacity and to increase the intensity of cropping and agricultural production.

All CIS under the command area of this canal system will be modified to the same water source, the Magat River, while present small-scale CIS will be integrated into the larger system to increase farming stability, simplify water management and reduce the O & M cost. Local flows and return flows which presently serve the area will be amalgamated into the Lanog Main Canal systems through the Lanog River.

(2) Colocol Main Canal System

The Colocol main canal system has the longest history in this area, the institutional system of which was established by beneficiaries of the federal association. Since maintenance of facilities and water management for equal water distribution no longer function properly, the canal itself and other facilities have become obsolete. The following points are therefore essential for the establishment of a more modern and effective system:

(a) To increase the flow capacity, all sections of the main canal will be lined with dry masonry, and inspection roads within the existing canal area, will be constructed.

(b) Small CIS and their intake facilities will be integrated. For constant distribution of water, intake facilities will be installed with a water regulator.

(c) About 4 km of the tail end portion of the existing canal passes through lowland area and is not clearly aligned. This portion should be realigned and rehabilitated while drainage facilities must be fully equipped.

(d) The Colocol main canal joins the Apad Creek near the town of Solano, where sewage water flows directy into the canal. Very often this causes flooding in the lowland area, damaging the canal and related facilities. To resolve these problems, 3 wasteways will be constructed.

(e) Currently, some areas such as Agubb CIS and the area along the Apad Creek are dependant on overflow water from the Colocol main canal. The irrigation service of these areas will be expanded by changing the water source to the other main canal system.

(3) Lanog Main Canal System

The existing intake weir of this water system constructed at the Gannib site of the Lanog River, needs rehabilitation. The upper Bintawan River and other small streams including the return flow will be used to serve the existing CIS as well as the present rainfed paddy land in the Murong and Santa Lucia areas. During low water periods, water will be supplied from the mountainside main canal through the Bintawan River and the existing CIS will thus recieve stable water supply from the new main canal system.

(4) Sto. Domingo Main Canal

Presently, both Manamtam and Sto. Domingo CIS recieve water directly from the Matuno River. These 2 CIS, which irrigate 80ha and 500ha respectively, have temporary brush dams which have very poor resistance to flood conditions. There are a few CIS which depend on the Borobob Spring and other small streams to the west of Bayombong as an irrigation source. The Borobob Spring supplies drinking water to the Bayombong and Solano areas. According to the plan, an intake weir is to be constructed at Manamtam, with the main canal running along the foot hills to serve 1,090ha of land. A portion of the proposed Santo Domingo Main Canal will be a rehabilitated existing main canal. Rehabilitation and installation of diversion works, other canal related structures, and construction of roads are also proposed.

3.4.4 Improvement Plan for O&M System

The institutional aspects of operation and maintenance for the irrigation system will be discussed in a later section. Existing small-scale CIS will be integrated into the larger CIS system. In the new irrigation development area, some new organizations will be formed.

Using the Colocol federation as a model, federal irrigation associations may be organized.

3.5 On-Farm Development

On-farm facilities are the basis of the farming practices of benefited farmers. Most of the irrigated paddy fields in this Project area are operated by the CIS. On-farm fields are provided with field canals to a certain extent. However, it is necessry to improve on-farm irrigation, drainage and road facilities so that modern water management and farming practices can be introduced to the farmers concerned.

(1) Precondition for Planning

According to the irrigation system under the Project, an Irrigators' Association will be organized for each lateral canal, and on-farm water management will be handled by an organization established with a rotation area of about 50 ha.

Therefore, all on-farm irrigation and drainage facilities and farm roads will be managed and maintained in cooperation. As to the irrigation method, water will be supplied for each rotation block as scheduled.

(2) Rotation Area

In consideration of the topographical conditions, present irrigating conditions, farming practices and proposed water management, organization for a rotation area irrigated by a turnout will be 50ha and a rotation unit will be 10ha.

(a) Farm block

It is impossible to organize the entire area into farm block divisions with one based pattern on topographical conditions. Therefore, the Irrigators' Association on lateral canal units will organize farm practice groups.

Basically, appropriate and easy management is required for the irrigation and drainage of on-farm fields. The farm blocks will be divided so that necessary farming takes advantage of the farmland at a high density as previously mentioned. Definite plans are as follows:

i) To arrange branch roads for on-farm fields connected to the main and lateral roads.

ii) To separate existing irrigation and drainage, and provide farm blocks with on-farm irrigation and drainage canals under irrigation rotation. (Farm block scale depends on topographical conditions.)

iii) To improve water management efficiency by instruction in agricultural techniques and standardization of cropping patterns for each season. To also improve effective use of agricultural machinery and make the scale as uniform as possible in consideration of the above conditions.

(b) On-farm canal plan

The proposed typical layout of on-farm facilities is shown in FIG. VII-12. Basic criteria for the planning of the layout are described as follows.

i) Arrangement of Main Irrigation and Drainage Canal (M.F.D.).

The command areas of the existing CIS are divided by a stream or drainage canal. Accordingly, the present main and lateral irrigation canals generally cross the contour line and are located on a higher portion of the irrigation area. The interval of the lateral canal under the Project is planned at about 500m and the existing irrigation and drainage canals are to be used wherever possible. The main farm ditches will therefore be mostly arranged parallel to the contour line. For the steep sloping mountain side area, (average above 1/100) most of the ditches will, on the other hand, cross the contour line. The main farm ditches will be extended to 500m to 1,200m in length.

ii) On-farm Flow Division System

As a standard, rotation areas will be controlled by a turnout on the Main Farm Ditch (M.F.D.). From the Main Farm Ditch to each rotation unit, the flow will be diverted to the supplemental farm ditch (S.F.D.) and distributed to each field.
The M.F.D. is to be a simultaneous irrigation system and the S.F.D. is to be a rotation irrigation system in accordance with the NIA Standard.1/

4. DRAINAGE PLAN

4.1 Basic Concept

The basic concept of the drainage plan is as follows:

i) Present drainage systems in the area will remain basically unchanged, although for some portions newly constructed drainage systems are proposed in due consideration of the proposed irrigation system.

1/ Design Guides and Criteria for Irrigation Canals, O&M Roads, Drainage Canals & Appurtenant Structures, NIA, Jan. 1979

ii) With regard to existing drainage canals and rivers, to reduce the neck portion of the drainage function, the cross section will be expanded. Especially for the Lanog River, which is utilized as the most important drainage canal under the Project, much attention to rehabilitation will be paid.

iii) In order to improve drainage conditions existing intake facilities in creeks and rivers will be removed and the water source changed to other main canal systems.

4.1.1 Drainage Plan for Flat Areas

In flat areas, the average command area of drainage canals and rivers, including the new drainage canal system, is about 190ha. These rivers, and drainage canals compose the designed drainage block areas.

The inclination of the area varies from 1:300 to 1:60. At present, the tail end plot has no perfect drainage canal and irrigation; water instead flows from higher to lower elevation in plot to plot and then into the river. According to the plan, drainage systems at the plot level will be established, while drainage water will flow from each plot to a farm drainage canal. The amount of flow will be controlled by efficient storage in the paddy field.

4.1.2 Drainage from Mountains

The flows from the western hill and the mountain area drain into the Magat River via 19 small streams. These streams all have catchment areas below $40km^2$ with good vegetation coverage while the inclination of the riverbed is comparatively steep at 1:100. Therefore, the peak flow during heavy rain causes sedimentation, and sometimes accumulation of sediment in the transitional part or flat areas. This trend in the Project area is comparatively stable. However, in the plan the drainage capacity of these rivers will require partial improvement.

4.2 Design Drainage

4.2.1 Rainfall Data for Drainage Study

(1) Design Rainfall

Average basin rainfall data was adopted for analysis of the amount of flow from the proposed drainage network. Data was collected from meteorological stations within the Project area and vicinity as mentioned in APPENDIX I-I.

Observed and probable maximum continuous rainfall in 1-day, 2-day and 3-day period is provided in TABLE VII-12.

(2) Rainfall Intensity Curve

Although to calculate the distribution of estimated rainfall the area rainfall intensity curve should be used, in the study area, sufficient hourly rainfall data was not available. Therefore, Talbot rainfall intensity was applied. The following data was used to calculate rainfall distribution and thereby analyze the probable flood pattern in the Project area.

$$R(6\ hr)/R(24\ hr) = 0.58$$

$$r = \frac{1.32 \times R_{24}^{T}}{7.64 + t}$$

r: Rainfall Intensity (mm/hr)

R_{24}^{T}: T-year probable daily depth of rainfall (mm)

t: Duration of rainfall (hr)

Over a 5-year period the estimated yearly rainfall intensity curve will be:

$$r = \frac{148.58}{7.64 + t}$$

(3) Rainfall Distribution

The calculation of flow discharged from the paddy field has been calculated based on 3-day continuous probable rainfall. The distributed rainfall for the 1st, 2nd and 3rd day is 28.3mm, 112.7mm, and 30.4mm, respectively (total: 171.4mm) .

4.2.2 Unit Discharge in Lowland Area

Lowland area of the Project area is mostly paddy. Therefore, the calculation of unit discharge has been estimated according to the TODA and the plot to plot method which are generally used in paddy area. The TODA method is used to determine the unit discharge pattern in the consolidated farm land area, while paddy drainage areas are calculated by the plot to plot method.

The result of analysis in both cases is given below:

TODA Method: 7.47ℓ/s/ha > Plot to plot method 4.83ℓ/s/ha

With the implementation of this Project consolidation of farm land will commence, and thus present plot to plot drainage fields will be upgraded to the system which is applied in the TODA Method.

Therefore, it can be assumed that the unit discharge in lowland area will be 7.47ℓ/s/ha. The calculation procedures are as follows:

(1) TODA Method Analysis

The TODA Method runoff pattern is shown in FIG. VII-13. In this method drainage flow consists of the following 3 steps:

i) rainfall in the paddy plot flows from plot outlet to farm drain;

ii) drainage water from each plot is integrated and flows downstream; and,

iii) water flows into a lateral drainage system from the tail end of farm drains.

In this process of drainage, the most insufficient part of flow capacity is the limited total discharge amount.

Consequently, in this method, the following conditions are to be fulfilled:

i) uniform water level in paddy plot will be maintained;

ii) amount of flow from plot outlet is not controlled by farm drain water level;

iii) flow within farm drain is uniform; and

iv) flow from farm drain into lateral drain is not controlled by the water level of the lateral drain.

From the present status of the Project area and the proposed on-farm layout a model was prepared and the flow capacity for each runoff process given in FIG. VII-14.

According to the above mentioned assumptions and formula, the discharge amount was calculated as shown in FIG. VII-15.

The relationship between rainfall and runoff from the plot outlet was calculated by the following formula:

$$R - Q = \frac{ds}{dt}$$

where,

$Q = C \cdot B \cdot H^{1.5}$

R: Rainfall Intensity

Q: Runoff from plot outlet

S: Plot storage

C: Coefficient characteristic of flow condition over the weir

B: Plot outlet width

H: Overflow depth

(2) Analyses with Plot to Plot Method

The plot to plot method assumes the runoff pattern illustrated in FIG. VII-16. Rainfall will runoff the farm plot into lower plots from the outlet and finally reach the farm drainage system.

In this method, the following conditions are to be met:

i) runoff from the plot outlet will not be affected by the water level of the lower plot;

ii) runoff from the final tail end plot outlet will not be affected by water level of the farm drainage system; and,

iii) the farm drainage system will have sufficient drainage capacity.

The results were arrived at according to the following formula, as shown in FIG. VII-17.

$$\text{(plot 1)} \quad R - q_1 = \frac{dS_1}{dt}$$

$$\text{(plot 2)} \quad R + q_1 - q_2 = \frac{dS_2}{dt}$$

$$\vdots$$

$$\text{(plot i)} \quad R + q_{i-1} - q_i = \frac{dS_1}{di}$$

$$\vdots$$

$$\text{(plot n)} \quad R + q_{n-1} - q_n = \frac{dS_n}{dt}$$

where,

$qi = C \times B \times hi^{1.5}$

R : Rainfall intensity

qi: Runoff from plot outlet

Si: Plot storage

C : coefficient of discharge (≒ 0.6)

B : Plot outlet width

hi: Overflow depth

4.2.3 Hill Area Unit Discharge

Water level and discharge of small rivers in the Project area are not recorded in the observation data. The calculation of the peak discharge of the Bintawan River was made by the Rational formula adaptable to small rivers with less than 50km^2 catchment area, and whose specific discharge is applied to other rivers.

The dimensions of the Bintawan River are listed below.

- River length: 13,000m
- Catchment area: 38.01km^2
- Watershed slope length: 1,500m (Area/2 x L)
- Flood runoff time

$$t_1 = \ell/0.3 = 1500/0.3 = 1.389 \text{ hr}$$

- Flood flowing time (Rzuha's formula)

$$t_2 = L/72(\frac{H}{L})^{0.6} = 13.1/72(\frac{0.8-0.25}{13.1})^{0.6} = 1.219 \text{ hr}$$

- Flood arriving time

$$t_p = t_1 + t_2 = 2.6 \text{ hr}$$

The Rational formula is represented by the following:

$$Q_p = \frac{1}{360} \cdot f \cdot r \cdot A$$

Q_p: peak runoff (m^3/s)
f: runoff coefficient
r: average rainfall intensity within arriving time (mm/hr)
A: catchment basin (ha)

To determine the discharge amount per unit area, A = 1.0 (ha). The "r" is calculated by the rainfall intensity formula and arriving time. The runoff coefficient (f) is designated as 0.6 as a general numerical value in the tertiary mountains.

Therefore, the Rational formula is:

$$Qp = \frac{1}{360} \times 0.6 \times (\frac{148.58}{7.64 + 2.6})$$
$$= 0.02417 m^3/s/ha = 24.17 \ \ell/s/ha$$

The unit discharge of the hill area is thus determined at 24.17ℓ/s/ha.

5. DIVERSION DAM

5.1 General

As demonstrated in APPENDIX I-VI, WATER RESOURCES DEVELOPMENT, the irrigation plan with the main diversion dam on the Magat River was selected as the most appropriate plan. The planning approach for the Magat Diversion Dam, Manamtam Diversion Dam, and Lanog Diversion Dam is discussed in this chapter. The main features for the three diversion dams are tabulated on the following page.

	River	B (m)	H (m)	Irrigable Area (ha)	
Magat Diversion Dam	Magat	305	1.6	11,590	
Manamtam Diversion Dam	Matuno	127	2.5	1,090	
Lanog Diversion Dam	Lanog	35	1.8	2,745	(return flow)

The locations of the three diversion dams are illustrated in FIG. VII-10.

5.2 Magat Diversion Dam

5.2.1 Location

In due consideration of river engineering and topography, the following four candidate sites were proposed for the main diversion dam.

- Manamtam, Matuno River — Downstream of the Matuno River
- Batu bridge, Magat River — Upstream of the Magat River
- Busilak, Magat River — 2km downstream of Batu bridge
- Bayombong, Magat River — 6km downstream of Batu bridge

The last three alternative sites on the Magat River are illustrated in FIG. VII-18. After the alternative study, Bayombong appears as the most appropriate site for the diversion dam for the reasons summarized on the following page.

Site	Riverbed Width (m)	Irrigable Area (ha) Main Diversion Dam	Manamtam Diversion Dam
Manamtam	127	12,680	-
Batu bridge	400	12,100	580
Busilak	500	12,100	580
Bayombong	305	11,590	1,090

(1) Manamtam

This plan envisions the construction of a diversion dam at Manamtam on the Matuno River serving an area of 12,680 ha.

As discussed in APPENDIX I-VI, WATER RESOURCES DEVELOPMENT, the plan, however, is not feasible as a multipurpose development plan because it suppresses hydropower generation potential. In addition, the water source is not sufficient for the irrigation of the entire potential irrigable area. This diversion dam would serve only 1,090 ha of Manamtam, Sto. Domingo and La Torre area.

(2) Batu Bridge

Since the width of the riverbed is not exceedingly wide at the Batu site, the same would be a competitive site if the existing bridge were reconstructed together with the proposed diversion dam.

After investigation, however, the Team judged that reconstruction of the bridge is not urgently needed because the recent scoring problem which frequently occurs around the abutment on the left bank is not serious even during high water. This scoring portion can even be minimized during unusually severe floods, by the provision of such appropriate protection works as large precast concrete blocks.

As is easily recognized from the results of the comparative study discussed in APPENDIX I-VI, only hydropower development along the Matuno River is applicable under this plan, which is less beneficial in comparison with the diversion plan for hydropower development.

Consequently, the Batu Bridge was excluded as a possible site for the proposed diversion works.

(3) Busilak

This site was also judged as unfavorable due to the long weir and tunnel required, even though the plan has the advantage of irrigation of the Paitan area on the right bank of the Magat River.

The potential irrigable area in Paitan is 370 ha. The necessary length for the fixed weir required for this scheme would be approximately 500m, while, for example, that which would be required at Bayombang is only 305m. Furthermore, to irrigate Paitan, a tunnel with a diameter of 3.2m or a deep excavated canal would be necessary. The direct construction costs for these works are estimated at approximately 2.5 million.

The additional development for Paitan area (370 ha) is equivalent to about US$6,700/ha. Hence the Busilak site was eliminated from possible development plans together with the irrigation plan of Paitan area.

(4) Bayombong

This site was judged most favorable for the proposed diversion dam mainly due to the following advantages:

i) Investment is comparatively minimal (US$2.4 million less than the Busilak site),

ii) Land acquisition for the main canal is similarily minimal; and,

iii) Intake to the canal is the same as the existing Colocol CIS, consequently agreement for construction of the diversion dam can be easily obtained.

5.2.2 River Condition and Dam Axis

(1) River Condition

According to the cadastral map prepared in 1928, the width of the Magat River along the site is about 300m at almost all sections. At that time, the intake for Colocol CIS was located about 3km upstream from the present site. Moreover, since that time, frequent reconstruction of the brush dam and intake canal after floods led to streamlining of the left bank, and subsequently a portion of the farm land on this bank disappeared. This tendency gradually extended to the lower portion, until finally a protection dike between Bayombong and Andesite Hill was constructed to limit erosion.

Construction of the protection dike caused a shift in scoring to the right bank, while the left bank become an area for sediment deposits. Accordingly, about 30ha of irrigated land in Paitan has been scored, and it is assumed that this will continue for the foreseeable future if countermeasures are not carried out.

The present features of the riverbed are as follows:

Site	Width (m)	Slope
Protection dike	about 300	Av. 1/270
Upstream	900 - 1200	1/200
Downstream	about 450	1/337

(2) Dam Axis

Axis of the proposed diversion dam has been determined as rectanglar to the river flow during floods. The left bank abutment has been planned at the Andesite Hill area. After the construction of the diversion dam, the upstream bed slope of the Magat riverbed will be about 1/400 as opposed to the present 1/200. This decreased slope will cause a raise in the surface water level upstream of the diversion dam as well as in back-water by the diversion dam.

In due consideration of this fact, a flood embankment is planned on the right bank of the Magat River to protect the Paitan area from scoring.

5.2.3 Intake Water Level

The intake water level of the diversion dam was determined at EL. 273.5m after careful study discussed hereinafter. As summarized in APPENDIX I-VI, Manamtam Diversion Dam irrigates an estimated 1,090ha of elevated area including La Torre. Accordingly, Magat Diversion Dam is planned to irrigate 11,590 ha of the area. The required water level at the beginning of the main canal is determined at EL 273.0m, and intake water level at EL. 273.50m considering an intake loss of 0.50m.

5.2.4 Preliminary Design

(1) Sill Elevation

Sill elevation of the Dam has been determined at EL. 272.0m which is 30cm above the present lowest riverbed.

(2) Flood Discharge

Flood discharges of the Magat River at the Dam site are as follows:

- 20-year return period	5200m^3/s
- 50-year "	5870 "
-100-year "	6300 "

In the diversion dam design, a 20-year return period design flood was adopted for proportioning of weir on the basis of the design of similar structures in the Philippines. On the other hand, a 50-year return period flood was applied to determine the dimensions of riverbed protection and backwater protection banks, and a 100-year return period flood for the height of the pier.

(3) Proportioning of Gate and Fixed Weir

Gates consisting of scouring sluice and spillway gates have been determined on the basis of a flood discharge of 500 m^3/s which occurs at least a few times during each rainy season. Floods exceeding 500m^3/s will be discharged through both the gate portion and the fixed weir. Accordingly, a stable low water channel or major floodway will gradually form in the upper steam.

(4) Gate Portion

The scouring sluice structure was designed based on the following conditions:

i) Supercritical flow adopted during discharge of bed materials;
ii) Design discharge of 20m^3/s; and,
iii) Bed material (D_{90}): 100mm.

The scouring sluice gate selected is as follows:

- Type	Fixed wheel (1 no)
- Span	13m
- Height	1.95m

Alternative studies of fixed wheel, steel flap and rubber type spillway gates were made. From an economic viewpoint, the rubber type is superior to the other types both in initial investment and maintenance cost. However, this type has not been used at the site selected mainly due to coarse bed material which would prevent the rubber dam from raising.

Since either the fixed wheel or steel flap are technically feasible for the site, the fixed wheel has been choosen due to economic considerations.

Selected spillway gate is as follows:

- Type	Steel flap (2 nos)
- Span	30m
- Height	1.6m

(5) Fixed Weir Portion

The fixed weir portion has been designed as follows:

- Type	Concrete overflow
- Span	228m
- Height	1.6m
- Crest elevation	EL. 273.6m

(6) Intake Structure

Design intake discharge was calculated on the basis of diversion water at 21.4m^3/s. The intake structure will be located on the left side of the river.

Major dimensions are as follows:

- Intake gate	Fixed wheel
- Span	3.85m x 4
- Height	1.5m
- Intake sill elevation	EL. 272.65m

(7) Settling Basin

A settling basin has not been planned, however, since the transition section provided right after the intake structure can be expected to function as a settling basin.

(8) Embankment

In order to protect the outside area of the river from backwater, an embankment has been designed to be provided along both sides of the river. The same criteria as established in APPENDIX I-VIII, FLOOD CONTROL have been adopted for designing the embankment.

(9) Head Diversion Structure

At the existing intake structure of the Colocol CIS, the head diversion structure has been designed to divert water equally to both the Mountain Side Main Canal and the Colocol Main Canal.

Major dimensions are as follows:

- Mountain Side Main Canal

Gate	Fixed Wheel
Span	4.31m
Height	2.5m

- Colocol Main Canal

Gate	Fixed Wheel
Span	4.31m
Height	1.9m

5.3 Other Diversion Dams

5.3.1 Manamtam Diversion Dam

(1) Location and River Condition

Planned location of the proposed Manamtam Diversion Dam for the Manamtam CIS is about 100m downstream from the existing brush dam.

Present riverbed width is approximately 50m for ordinary and 110m for flood discharge. The riverbed has a 1/120 slope and is generally stable at the proposed site. The heights of both the right and left bank are about 10m higher than the riverbed.

(2) Preliminary Design

A concrete fixed weir type dam was adopted for the provisional design, since no harmful effects are considered to result from the same, due to the sufficiently higher bank which protects the upstream area from backwater. The design flood is 2,700m^3/s with a 100-year return period. Major dimensions of the structure are as follows:

- Diversion Dam

Type	Concrete Fixed Weir
Crest Length	118m

Height	2.5m for right side 72m 2.0m for left side 40m
Sill Elevation	EL 352m
- Scouring Sluice	
Gate	Fixed Wheel
Span	5m x 1 no
Height	2.5m
- Intake Structure	
Intake Water Level	EL 353.9m
Design Discharge	2.18m^3/s
Gate	slide gate
Span	2.0m x 1 no
Height	1.5m

In order to lead the main stream to the left bank, crest height of the left portion of the fixed weir (40m out of total 72m) has been designed 50cm lower than the other major sections.

5.3.2 Lanog Diversion Dam

(1) Location and River Condition

A diversion dam exists 100m downstream from the confluence of the Lanog and Bintawan rivers. Rehabilitation of the diversion dam is proposed as part of the Project's drainage improvement plan.

Under the plan, the improved river condition is 35m of bottom width, 1/500 of river slope, and 4m of bank height for the design flood discharge determined at 223m^3/s.

(2) Preliminary Design

Since the proposed site is situated in a lowland area, the introduction of a fixed weir causes backwater and subsequent reduction in effect of drainage improvement. Accordingly, a rubber dam was adopted considering both economic and technical conditions. Major dimensions of the structure are presented on the following page.

- Diversion Dam

Crest Length	38.6 m
Height	1.8m
Sill Elevation	EL. 228.5 for upstream EL. 227.7 for downstream

- Intake Structure

Intake Water Level	EL. 230.3m
Design Discharge	1.61m^3/s for left bank main canal 3.88m^3/s for right bank main canal
Gate Type	slide gates
Dimension of Gate	1.5 x 0.8 x 2 no for left bank 2.0 x 1.0 x 2 no for right bank

6. PHYSICAL PLAN OF IRRIGATION CANALS AND RELATED STRUCTURES

6.1 Irrigation Canal

6.1.1 Canal System Planning

(1) General

With regards to the basic concept of the irrigation system plan, canal alignment scale was designated as 1:10,000 based on topographical maps, with maximum irrigable land and utilization of existing canal systems.

After calculation of the irrigation water requirement, unit design irrigation water requirement was determined at 2.0ℓ/s/ha in section 3.1.2. The design discharge for each portion of the main canal was determined based on the irrigable area multiplied by the unit design irrigation water requirement as illustrated in FIG. VII-19. The dimensions of each canal were determined on the basis of the above design discharge.

(2) Improvement of Colocol Main Canal

The improvement plan for the Colocol main canal has been proposed in due consideration of the location of existing turnout as shown in FIG. VII-20. This plan envisions the improvement of the integrated function of the canal and abolition of intake facilities thereby improving the radical system within the existing water utilization network.

(a) Canal system

In principal, the main canal alignment will not be changed. The canal dimensions such as cross section, longitudinal slope etc. will be determined on the basis of the design discharge. Part of the main canal's cross section is considered unnecessarily large as shown in FIG. VII-21, and, as a result, reduced water velocity and sedimentation occur. Therefore, these sections will be improved according to the designed cross section. The canal will be lined with dry masonry to stabilize the flow, since the canal passes through a town area. Lateral canal systems will fully utilize the existing facilities as much as possible.

(b) Hydraulic structure

As shown in FIG. VII-20, existing intake facilities are equipped with a sill. Under the planned integration program of intake facilities, some existing facilities will be replaced with a drop structure, while other facilities will be reconstructed in consideration of the existing water level.

(c) Countermeasure for Apad Creek inflow

Inflow of water from Apad Creek located in the southern section of Solano will not be changed under the proposed plan. Thus, it is necessary to release inflowing water as early as possible with a wasteway. The wasteway will be constructed just above the C-L6 intake facility. Cross section of the main canal from the meeting point of Apad Creek down to the wasteway point, about 700m, will be expanded to accomodate the capacity of inflow at peak periods.

6.1.2 Design Criteria

(1) Mean Velocity Formula

Manning's Formula was used to determine the canal cross section, as presented below.

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

$$Q = A \cdot V$$

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

where,

V : Mean velocity (m/s)

n : Roughness coefficient

R : Hydraulic radius (m)

I : Surface slope

Q : Discharge (m^3/s)

A : Cross sectional area (m^2)

Where it is assumed that a steady and uniform flow is a given factor, the water surface slope is equal to the canal bed slope.

(2) Roughness Coefficient

Roughness coefficient (n) of the Manning Formula is mostly affected by configuration of the canal and its material. The general "n" value adopted for planning is given in the table presented below.

Roughness Coefficient

Facility	"n" value
Main Lateral Earth Canal	0.025
Plain Riprap Lined	0.025
Concrete Pipe and Culvert	0.015
Farm Ditch	0.030

(3) <u>Allowable Velocity</u>

Water velocity should be within the minimum velocity of anti-hydrophyte to growth and maximum velocity which will not cause erosion nor an un-stable flow. Factors to identify minimum velocity are quite indefinite, but generally they are assumed to be in the range of 0.25-0.45m/s. Maximum velocity can be determined by Kennedy's Formula provided below which is designed to prevent erosion:

$$Va = C \cdot D^{0.64}$$

where, Va: allowable maximum velocity (m/s)

D : water depth (m)

C : coefficient by different nature of soil; in this plan 0.546 of the general value for sandy loam is adopted.

(4) <u>Canal Cross Section</u>

Cross section of the canal has been planned as a trapezoid type, and the design criteria of the same are as follows:

(a) Base-depth ratio

When taking the smallest B/d ratio into consideration for the earth canal, seepage losses can be controlled with reduced wetted perimeter. However, this approach is not convenient for operation and maintenance. Moreover, a large variation flux effects the variation of water level resultant in diversion. On the other hand, the large B/d ratio requires an extensive land area and is thus usually not economical. In the case of a gradually decreasing cross sectional area with reduced flow in the lower reaches of a long canal system, rapid change of water depth is not desirable. Therefore, the B/d ratio should be small in accordance with the reduced canal section.

Considering the above, the B/d ratio was classified by size of canal and in line with the design criteria of NIA.

Base-depth Ratio by Different Discharge

Discharge (m^3/s)	B/d ratio
- 4.0	2.0
4.0 - 9.0	2.5
9.0 -	3.0

(b) Inside slope

To maintain a stable inside canal face, the inside slope is determined by the nature of the soil. The standard slope for different soils differs slightly with the cutting and mounting approach applied. However, as a standard value for sandy clay, the inside slope was decided at 1:1.5.

(c) Outside slope

The outside slope was considered in light of dike saturation and stability of the embankment. After the study, the outside slope of the canal was determined at 1:1.5. The following points were given due consideration in planning embankment above 5m:

i) compacted material will be carefully selected;

ii) toe drains, etc. for slope drainage will be provided;

iii) anti-seepage will be ensured by compaction, etc.; and,

iv) outside slope of the embankment will be more gradual than the standard value 1:1.5.

(d) Bank top width

In principal, one side of the canal bank is planned as a service road, and the other side as an inspection path. The scale of these roads depends on the design discharge of the canal as is presented on the following page.

Item	Design Discharge m^3 (m)	Service Road (m)	Inspection Path (m)
Main Canal	10.0 - 30.0	6.0	4.0
Main and Lateral Canal	5.0 - 10.0	4.0	2.5
	3.0 - 5.0	4.0	2.0
	1.0 - 3.0	4.0	1.5
	0.3 - 1.0	4.0	1.0
Lateral Canal	- 0.3	3.0	1.0

(e) Freeboard

Water level in a canal always has the potential to rise above the designed water level. Some of the major reasons for this are:

i) un-expected roughness coefficient caused by improper construction;

ii) structural defects;

iii) waving by wind; and

iv) increase in rainfall.

Accordingly, freeboard has been designed as follows with due consideration of the above points:

$$Fb = 0.25\ d + 0.3 \quad (d \leqq 2.0)$$

$$Fb = 0.4\ d \quad (d > 2.0)$$

Fb : Freeboard (m)(should not be below 0.3m)

d : water depth for design discharge (m)

The criteria appears appropriate and in accordance with NIA criteria, such as Design Guides and Criteria for Irrigation Canals, O & M Roads Design Channels & Appurtenant Structures.

(5) Bed Gradient

Bed gradient should be determined on the condition of allowable water velocity as mentioned above. FIG. VII-22 shows the relationship of bed gradient and velocity based on roughness coefficient and canal cross sectional configuration. The figures indicate that the allowable velocity and the economical cross section has a slope range of 1/4,000 above $4.0m^3/s$ and 1/3,000 below $4.0m^3/s$.

There are cases of determining the bed gradient by the condition of canal alignment. The main canal longitudinal profile is shown in VOLUME 4 DRAWINGS.

(6) Canal Alignment

Each canal length under the plan is tabulated in TABLE VII-13.

(7) Canal Lining

In principal, all canals will be earth-lined except Colocol Main Canal which will be lined with dry masonry. A detail plan of masonry lining is shown in VOLUME 4 DRAWINGS.

6.1.3 Canal Related Structures

(1) Diversion and Measurement Structures

Diversion and water measurement structures have been designed as double orifice. Diversion of water above $1.0m^3/s$ from the main to lateral canal however, will be by a head gate and parshall frume. Diversion from lateral to sub-lateral canals has been designed to maintain a fixed rate using fixed proportional diversion.

(2) Check Gate

Behind the diversion facilities, a check gate is planned to be constructed to maintain a fixed water level for cases in which the discharge amount is below the designed value. However, depending on the interval of diversion facilities, sometimes it may be unnecessary to use the check gate.

(3) Drop

A drop structure will be constructed to maintain the designed bed slope. The vertical drop is a simple structure well suited for small discharge, but not for a large discharge and drop. Therefore, for a discharge greater than $2.0m^3/s$ and/or a drop larger than 0.9m the chute type structure will be adopted.

(4) Wasteway and Spillway

In principal, wherever a change occurs in the main canal cross section a wasteway has been planned. The wasteway incorporates a spillway to automatically drain overflow water.

The river or drainage canal for each irrigation canal is tabulated on the following page.

Irrigation Canal	Drainage System
M-1	A-2
M-2	W
M-3	B-3
M-4	N-L3
M-5	Lamut River
C-1	M13
C-2	M11
C-3	M8
C-4	M3-2
LL-1	N-L1
LL-2	Lamut River
LR-1	L-L4
LR-2	M3-L2
LR-3	M1
S-1	S6
S-2	A-2
S-3	W

(5) Crossing Facilities

An inverted siphon has been planned for drainage canals in consideration of the relationship between water level in the canal and probable water level in crossing the drainage canal, and in comparison of the flow amount in the irrigation canal and estimated flood in the drainage canal.

Although, it is economical to construct the irrigation siphon when the estimated flood amount in drainage is distinguishably larger than the flow amount in the irrigation canal, when a small drainage canal crosses an irrigation canal, a drainage culvert will be advantageous.

(6) Road Crossing Facilities

Where the irrigation canal crosses the existing road, a bridge has been planned. As shown in DRAWINGS the general structural design of the bridges to be constructed is the prestressed concrete type.

When the flow amount is below $3.0m^3/s$, a road cross pipe will be constructed in light of the economics of this approach.

(7) Drain Inlet

When drainage flow is small a drain inlet to lead drainage water into the irrigation canal is planned rather than a drainage culvert. In such a case, the drain inlet amount will not exceed 10 % of the irrigation water flow. General model design is presented in the DRAWINGS.

Each of the structures discussed above and planned quantities of the same have been based on the results of field investigations, and desk studies of the 1/10,000 scale topographical-maps as TABLE VII-14 shows.

6.2 Drainage Canal

6.2.1 Canal System Planning

The basic concept of the designed drainage system is maximum utilization of existing drainage facilities with improvement of the same where necessary.

(1) Alignment of Drainage Canal Networks

(a) New construction

In the areas with current insufficient drainage canal systems, new drainage networks are planned for construction. Locations of the newly proposed drainage canals are provided in FIG. VII-23, and the total length is 22,250m.

(b) Canal improvement

Generally, most drainage canals have sufficient capacity for the design drainage discharge in terms of cross sectional area as evaluated in TABLE VII-15. However, the field study demonstrated that some sections in these canals require rehabilitation of narrow sections and increased bed elevation. Total length of the sections to be rehabilitated is 19,900m or more than 10% of the existing drainage canal length.

(2) Lanog River Rehabilitation

During the study, chronic flooding caused by shortage in drainage capacity mid-stream of the Lanog River was noted. About 10km of this river will be rehabilitated with emphasis on the following points:

i) narrow sections will be expanded;
ii) extreme meandering will be improved;
iii) cross section will be improved to 1:1 of the side slope;
iv) design water depth will be 3.0m;
v) freeboard will be 1.0m;
vi) roughness coefficient will be assumed at 0.03;

vii) allowable mean velocity at the time of flooding will be assumed at 2.0m/s;

viii) design riverbed slope will be eased from the present slope of 1/500 to 1/1,000; and

ix) consolidation work will be carried out at 5 locations on the riverbed.

Cross sections of the rehabilitation plan are shown in FIG. VII-24, while the longitudinal section of the plan is shown in FIG. VII-25.

(3) Design Drainage Discharge

The scope of each drainage canal is calculated with a drainage area multiplied by the following unit area drainage discharge.

Description	Unit Discharge (ℓ/s/ha)
Runoff from paddy field	7.47
Runoff from mountain	24.17

Schematic diagram of the proposed drainage system is presented in FIG. VII-26.

6.2.2 Design Criteria

(1) Mean Velocity Formula

The mean velocity was determined by adoption of the Manning Formula with a roughness coefficient "n" of 0.03.

(2) Allowable Velocity

Allowable velocity was determined according to Kennedy's Formula which considers scouring as shown on the following page.

$$Va = 0.546 \cdot D^{0.64}$$

Va : allowable velocity (m/s)
D : water depth (m)

For the drainage canal design, the maximum Va was fixed at 1.0m/s.

(3) Canal Cross Section

The dimensions for various types of drainage canals are presented in FIG. VII-27. Criteria for the drainage canal cross section are given below:

(a) Bed-depth ratio

Although a large bed-depth ratio helps stabilize the discharge flow, it is not usually economically viable due to increased construction work and land requirements. Accordingly the trapezoid cross section, which has maximum hydraulic radius per unit cross-sectional area, was adopted as the most effective drainage system and the following formula was used.

$$B = 2H\ (\ 1 + m^2 - m)$$

B : bed width (m)
H : water depth (m)
m : side slope

When m = 1.0, B is 0.828H.

(b) Drainage canal side slope

The side slope of the drainage canal should be stable to prevent landsliding and scouring. Generally, the side slope is determined by the soil conditions. As soils in the Project area are mainly composed of clay and sandy-loam, the side slope has been designated as 1:1.

(c) Freeboard

Design criteria for freeboard corresponds to the following formula used for designing irrigation canals:

$$Fb = 0.25\ H + 0.3 \qquad (H \leq 2.0m)$$
$$\quad = 0.4\ H \qquad (H \quad 2.0m)$$

Fb : freeboard (m)
H : water depth (m)

(4) Proposed Canal Length

Proposed canal length is tabulated in TABLE VII-16. This includes the entire downstream portion of the river within the Project area.

6.2.3 Canal Related Structures

(1) Drop

The average land slope within the Project area exceeds 1/300. The proposed average bed slope for drainage canals has been planned at 1/1,000 to prevent scouring. Consequently, numerous drops are required. The proposed drop pattern is shown in the DRAWINGS, with a standard drop of 1.0m selected due to economical factors and drainage discharge.

(2) Canal Crossing Structure

The canal crossing structure is discussed under the irrigation canal structure section.

(3) Road Crossing Structure

Existing canal systems will use only existing road crossing facilities. Construction of new road crossing structures is planned at major road crossings for all proposed canals. Type of structure is dependant on scale of drainage canal and road width.

(4) Number of Drainage Structures

The location and number of drainage structures to be constructed were determined on the basis of a 1/10,000 topographical-map. The number of drops in the rehabilitation plan was estimated according to the difference between the existing and design bed slope, and in the new construction plan, the difference of land slope and design bed slope was also estimated.

Crossing structures for irrigation canals have been considered as irrigation canal structures. The number of such structures required in drainage canal networks is given in the following table.

Structure	Numbers
Drop	208
Culvert	3

6.3 Inspection Roads

Gravel paved roads for operation and maintenance of canals are planned along the main and lateral irrigation canals. Road width was determined on the basis of canal scales presented in the table below.

unit: m

Canal	Road Width	Pavement Width
Main Canal (10 - 30m^3/s)	6.0	4.5
Main/Lateral Canal (0.3 - 10m^3/s)	4.0	3.0
Lateral Canal (0 - 0.3m^3/s)	3.0	2.0

All canals to be newly constructed are designed with inspection roads for convenience and in consideration of existing roads. Construction of new bridges are envisioned wherever an irrigation canal crosses a drainage canal by means of a siphone. Where feasible however, an existing bridge in the vicinity or detours may be used.

The length of the proposed inspection road is tabulated in TABLE VII-17.

6.4 On-Farm Facilities

On the basis of the typical on-farm layout discussed in the section 3.5, the following facilities are proposed.

(1) Turn-out

For diversion to the main farm ditch from the lateral canal or directly from the main canal, a double orifice turnout has been planned. The service area per turnout facility is generally 50ha due to topographical conditions and present irrigation traditions, while design capacity is calculated at 2.0ℓ/s/ha based on water requirement during land preparation including reasonable losses.

Proposed orifice size is 0.35m x 0.60m with either ø18" or ø12" R.C pipe.

(2) Main Farm Ditches

Assuming adoption of simultaneous irrigation, the longitudinal canal section has been designed to maintain a minimum water level of more than 10cm above land surface during the crop maintenance stage.

Top bank elevation will be determined according to the maximum water level during land preparation with an additional 20cm of freeboard. This will allow distribution of water to supplementary farm ditches. The side slope and bank top width is designed at 1:0.5 and 0.4m, respectively while planned minimum and maximum allowable velocity will be 0.2m/s and 0.65m/s, respectively. The canal bed slope was decided in consideration of the minimum and maximum allowable velocity, and design cross section determined by the Manning method with a roughness coefficient of 0.03.

(3) Supplementary Farm Ditches

Design water level for canals is the same as that for the main farm ditch. Top bank elevation was determined with 15cm freeboard according to the maximum expected water level obtained during crop maintenance with assumed adoption of the rotational system. The proposed irrigation cross section for each supplementary farm ditch is fixed and uniform. Side slope is 1:0.5 and bank top width, 0.35m. Minimum and maximum allowable velocity is the same as that for the main farm ditch.

(4) Farm Drains

Farm drains will be arranged parallel to farm ditches to drain surplus water from the open portion of farm drains in the upper plot into lateral drainage canals, creeks and rivers. The design cross section was fixed according to the Manning method, with a 0.03 roughness coefficient.

(5) Farm Roads

Construction of 2m wide farm roads are planned. Such roads will follow alongside every other supplementary farm ditch.

(6) Diversion Boxes

Diversion boxes are planned at the origin of each supplementary farm ditch. Structural design of the same, presented in the DRAWINGS, consists of 2 precast leaf wall type checks to be installed in both sides of the SFD and MFD.

(7) End Checks

The end check will be installed at the tail end of each SFD to prevent runoff water from flowing into the farm drain. Design structure is precast leaf wall.

(8) Farm Road Crossings

Pipe crossings have been planned wherever a farm road crosses a MFD. The proposed scale of these pipes is ø18", using R.C. pipe.

Existing Communal Irrigation System in the Project Area

River Basin of Water Resource	No.	Name of CIS	Municipality	Area (ha) potential	Area (ha) wet	Area (ha) dry	Water supply (l/sec) wet	Water supply (l/sec) dry	Water supply unit 3/	Canal discharge (l/s) wet	Canal discharge (l/s) dry	Canal Length (km)	Completed Year	No. of families
1. Colocol main canal	1	Danao (L)1/	Bayombong	66	66	66	165	132	W.2.5 D.2.0	4,739 10-8-73	3,015 4/5-30-74	1.18	1932	50
	2	Sunday (L)	-do-	117	117	117	290	234	W.2.47 D.2.0	4,544 "	3,712 5-20-74	1.32	during spanish regime	110
	3	Pablo Ramos (R)2/	-do-	140	140	140	360	280	W.2.57 D.2.0	4,614 "	3,916 "	2.52	1932	107
	4	Ramirez (R)	-do-	350	350	350	800	700	W.2.28 D.2.0	3,614 "	3,916 "	2.52	1932	332
	5	Villarama-Cafisa (L)	-do-	197	197	197	470	394	W.2.38 D.2.0	3,458 "	2,196 5-17-74	2.70	during spanish regime	183
	6	Damaso (R)	-do-	101	90	90	225	180	W.2.5 D.2.0	3,160 "	2.010 "	1.26	1932	70
	7	Macapulay (L)	-do-	35 5/ exp (80)	35	35	290	570	W.8.281 D.16281	4,005 10-2-73	2,910 5-30-74	0.89	1948	28
	8	Moton (L)	-do-	107	107	107	295	214	W.2.75 D.2.0	3,037 10-8-73	2,481 5-31-74	2.00	1932	120
	9	Bawang-Lactawan (L)	Solano	343	343	343	514.5	514.5	W.1.5 D.1.5	2,662 11-26-73	2,401 4-10-74	5.20	1973	291

Note:
1/: (L) indicates left bank of main canal
2/: (R) indicates right bank of main canal
3/: water supply (ℓ/sec) per hectare
4/: date of measurement by PIO
5/: proposed expansion area

River Basin of Water Resource	No.	Name of CIS	Municipality	Area (ha) potential	Area (ha) wet	Area (ha) dry	Water supply (l/sec) wet	Water supply (l/sec) dry	Water supply (l/sec) unit3/	Canal discharge (l/s) wet	Canal discharge (l/s) dry	Canal Length (km)	Completed Year	No. of families
Colocol main canal	10	Magarang (R)	-do-	70	55	55	582.5	282.5	W.10.59 D.5.13	1,736 11-27-73	1,514 5-27-74	1.22	1932	55
	11	Mamangcad (L)	-do-	44	44	44	446	366	W.10.591 D.8.31	2,147 11-27-73	1,911 5-21-74	1.22	1932	33
	12	Cutug (L)	-do-	97	36	36	54	54	W.1.5 D.1.5	2,039 11-26-73	1,884 5-21-74	1.18	pre-war	35
	13	Silap (L)	-do-	100	100	100	650	250	W.6.5 D.2.5	1,892 11-29-73	1,685 5-24-74	1.50	1932	77
	14	Curifang Dadap (R)	-do-	85	85	85						1.80		71
	15	Lacar (L)	Bayombong	48	48	48	672	372	W.14.0 D.7.75	1,632 11-27-73	1,218 5-21-74	1.00	1932	40
	16	Labog (L)	Solano	69	69	69	303.5	103.5	W.4.40 D.1.5	1,558 11-27-73	1,162 5-21-74	0.66	pre-war	73
	17	Ramos (L)	-do-	25	25	25	37.5	27.5	W.1.5 D.1.1	1,461 11-28-73	1,138 5-23-74	0.80	1932	27
	18	Baquiran (R)	-do-	35	32	32	4.6	46	W.1.43 D.1.43	2,326 11-26-73	2,004 4-10-74	1.12	1932	31
	19	Acacia (R)	-do-	31	31	31	65	46	W.2.10 D.1.48	1,338 11-26-73	1,105 5-24-74	1.22	1932	21
	20	Tanap (L)	-do-	97	97	97	546	W.5.63 246	1,292 D.2.53	905 11-23-73	5-22-74	1.94	1932	85
	21	Malatupa (L)	-do-	48	48	48	572	W.11.92 272	1,784 D.5.67	1,583 11-27-73	6-21-74	1.40	1932	42
	22	Arusip (R)	-do-	70	65	65	380	W.5.85 197	1,145 D.2.98	921 11-26-73	5-24-74	1.96	1932	60
	23	Sico (R)	-do-	97	66	66	499	W.7.56 299	1.033 D.4.53	980 11-29-73	5-24-74	1.80	1932	78
	24	Nakumbentuan (R)	-do-	70	68	68	510	W.7.5 202	892 D.2.97	701 11-28-73	5-23-74	1.22	1932	65

River Basin of Water Resource	No.	Name of CIS	Municipality	Area (ha) potential	wet	dry	Water supply (1/sec) wet	dry	unit3/	Canal discharge (1/s) wet	dry	Canal Length (km)	Completed Year	No. of families
Colocol main canal	25	Bagabag (R)	Bagabag	258	258	258	420	387	W.1.63 693 D.1.5	469 11-21-73	4-21-74	3.12	1972	205
	26	Baretbet (R)	-do-	103	50	50	340	85	W.6.8 D.1.7	187 11-19-73	116 5-16-74	1.24	1973	60
	27	Tullag (L)	-do-	160	160	160	276	240	W.1.73 D.1.5	867 11-6-73	415 5-20-74	2.22	pre-war	269
	28	Tullag (R)	-do-	200	200	200	344	300	W.1.72 D.1.5					
	29	Tabban	-do-	58	58	58						1.32	1974	42
	30	Namnama	Solano	37	37	37								28
Total	30		including expansion area	3,258 (3,338)	3,077	3,077						47.53		2,688
2. Lanog River Basin Wacal creek	1	Casat	Bayombong	160	160	80	330	160	W.2.06 D.2.0	357 2-5-73	328 5-24-74	1.84	pre-war	116
Wasala Spring	2	Ubbog	Solano	170	170	85	255	127	W.1.5 D.1.49	200 6-6-75	160 2-5-76	2.18	1915	157
Wacal Creek	3	Mongcal	-do-	162	162	81								124
Tributaly	4	Damotes	-do-	29	29	15						0.50		24
"	5	Caldaan	-do-	102	102	75	210	150	W.2.05 D.2.0	204 2-5-73	181 5-24-74	1.10	1947	86
Mabaina creek	6	Bangaan	-do-	168	140	70	780	205	W.5.57 D.2.93	363 11-30-73	214 4-29-74	1.40	1915	108
"	7	Cabaruan	-do-	36	36	18								28

River Basin of Water Resource	No.	Name of CIS	Municipality	Area (ha) potential	Area (ha) wet	Area (ha) dry	Water supply (l/sec) wet	Water supply (l/sec) dry	Water supply (l/sec) unit3/	Canal discharge (l/s) wet	Canal discharge (l/s) dry	Canal Length (km)	Completed Year	No. of families
Bintawan River	8	Uddiawan	-do-	582	568	280	852	420	W.1.5 D.1.5			7.50	1915	270
"	9	San Juan	-do-	300	300	150	450	225	W.1.5 D.1.5			2.00	1915	115
"	10	Belacuit	Villaverde	46	46	25	369	138	W.8.02 D.5.52				1915	34
"	11	Bintawan San Juan	Solano	200	200	100								76
	12	Bintawan	Villaverde	60	32	32	448	160	W.14.0 D.5.0			2.00	1976	50
Tributary of Wacal Creek	13	Coupligan	Solano	60	60	30	90	45	W.1.5 D.1.5			1.50	1978	48
Lanog River	14	Adduan	Bayombong	400	400	400	1036	800	W.2.59 D.2.0	3,011 12-4-73	2,446 5-8-74	3.95	1969	360
Pauangan creek	15	Cob cob	Solano	31	31	31								24
Nampayacan creek down stream of pauangan creek	16	Nampayacan	-do-	62	62	62								48
Gaud creek (down stream of Nampayacan creek)	17	Gaud	-do-	21	21	21								16
Lanog River	18	Tucal	-do-	185	150	150	225	225	W.1.5 D.1.5	3,021 12-4-73	2,446 5-8-74	1.22	1932	145
-do-	19	Nangyatan	-do-	60	60	60								43
Bawang creek	20	Aggub	"	170	159	159	800	230	W.5.03 D.1.45			4.50	1932	199
Lanog River	21	Gannib/Cabaritan	Bagabag	170	170	50						6.00	1977	113

River Basin of Water Resource	No.	Name of CIS	Municipality	Area (ha) potential	Area (ha) wet	Area (ha) dry	Water supply (1/sec) wet	Water supply (1/sec) dry	Water supply (1/sec) unit3/	Canal discharge (1/s) wet	Canal discharge (1/s) dry	Canal Length (km)	Completed Year	No. of families
	22	Sta Cruz/Careb	"	340	340	100								261
	23	Dapat	Bagabag	400	300	300	600	450	W.2.0 D.1.5			6.5	1969	250
	24	Magaad	"	386	386	386	950	597	W.2.48 D.1.55	3,132 11-20-73	2,310 5-2-74	3.5	1933	300
Total	24			4,300	4,084	2,760						45.69		2,995
3. Lamut River Basin														
Nangalisan River	1	Omoc	Villaverde	40	40	20	60	30	W.1.5 D.1.5				pre-war	42
-do-	2	Nagbitin	-do-	130 exp (37)	100	55	150	83	W.1.5 D.1.51	319 11-8-73	151 4-18-74	2.25	pre-war	95
-do-	3	Cabulalaan	-do-	107 exp (59)	80	40	320	160	W.4.0 D.4.0	261 11-7-73	61 4-26-74	3.08	pre-war	96
-do-	4	Ibung	-do-	36 exp(117)	36	25	54	38	W.1.5 D.1.52	274 11-6-73	37 4-26-74	2.76	pre-war	33
Ibung creek	5	Pieza Ibung	-do-	36 exp (39)	36	4	154	6	W.4.27 D.1.5	121 11-7-73	32 4-18-74	2.04	1972	24
Maasin creek	6	Pieza Nangalisan	-do-	30 exp (83)	30	6	745	190	W.24.83 D.31.67	269 11-6-73	30 4-18-74	1.01	pre-war	20
	7	Maasin	-do-	41 exp (54)	41	20	61.5	30	W.1.5 D.1.5	284 11-6-73	43 4-25-74	2.52	pre-war	38
	8	Bakir	Bagabag	117 exp (73)	117	117	940	275	W.8.03 D.2.35	200 11-19-73	119 4-26-74	3.08	1979	85
	9	Banutan	Villaverde	61	50	20	475	130	W.7.5 D.6.5	146 11-5-73	83 4-25-74	1.186	1915	42
Total	9		including expansion area	598 (1,060)	530	307						17.93		475

River Basin of Water Resource	No.	Name of CIS	Municipality	Area (ha) potential	wet	dry	Water supply (l/sec) wet	dry	unit3/	Canal discharge (l/s) wet	dry	Canal Length (km)	Completed Year	No. of families
4. Apad Creek Basin														
Borrabob creek	1	Nagragadian	Bayombong	227	150	70	340	140	W.2.27 D.2.0	900 12-8-75	451 3-23-76	2.8	during spanish regime	105
Bayombong creek	2	Bayag	-do-	156	156	75	250	113	W.1.60 D.1.5	1,256 12-8-75	425 2-15-76	2.78	1947	128
Barrobob creek	3	Salpad	-do-	145	55	55	130	110	W.2.36 D.2.0	806 12-7-75	298 3-28-76	1.92	during spanish regime	66
Bayombong creek	4	Candillas	-do-	25	10	10	25	20	W.2.5 D.2.0	1,204 12-7-75	321 2-5-76	1.05		20
Paone creek	5	Paone	-do-	56	56	56	138	112	W.2.5 D.2.0	840 3-18-74	656 5-14-75	1.148	1962	25
Apad creek	6	Apad	-do-	55	55	55	141	110	W.2.56 D.2.0				1933	47
Downstream of Apad creek	7	Cam-cam	Solano	196	196	196						2.50		163
"	8	Cayong-gayong	-do-	46	46	46								35
Ipil creek	9	Ipil	Bayombong	40	40	20								30
Total	9			946	764	583						12.20		619

River Basin of Water Resource	No.	Name of CIS	Municipality	Area (ha) potential	Area (ha) wet	Area (ha) dry	Water supply (1/sec) wet	Water supply (1/sec) dry	unit3/	Canal discharge (1/s) wet	Canal discharge (1/s) dry	Canal Length (km)	Completed Year	No. of families
5. Magat River Basin														
Matuno River	1	Manamtam	Bambang	69 exp (22)	69	69	9.800	6.800	W.142.82 D.98.55					30
"	2	Sto. Domingo	-do-	475	475	475	9,800	8,500	W.20.63 D.17.89	2,213 12-20-73	2,100 4-26-74	8.12		350
Magat River	3	San Vicente	Bayombong	27	25	25	2.460	800	W.98.4 D.32.0	4,313 2-5-73	4,178 5-24-74	1.26		20
Total	3			571 (593)	569	569						9.38		4.00
Grand Total	75		including expansion area	9,673 (10,237)	9,024	7,296						132,73		7,177

Sammary

	Number (place)	Area (ha) potential	Area (ha) wet	Area (ha) dry	Number of families
Oclcol Main Canal	30	3,258 (3,338)	3,077	3,077	2,688
Lanog River	24	4,300	4,084	2,760	2,995
Lamut River	9	598 (1,060)	530	307	475
Apad Creek	9	946	764	583	619
Magat River	3	571 (593)	569	569	400

Note: ( ) includes proposed expansion area

Existing Communal Irrigation Systems in Magat River Right Bank

River Basin of Water Resource	No.	Name of CIS	Municipality	Area (ha) potential	Area (ha) wet	Area (ha) dry	Water supply (l/sec) wet	Water supply (l/sec) dry	Water supply (l/sec) unit3/	Canal discharge (l/s) wet	Canal discharge (l/s) dry	Canal Length (km)	Completed Year	No. of families
6. Magat Right Bank	1	Latuyot	Bayombong	34	34	34						1.74		
"	2	Magapuy	-do-	53	53	53						1.96		
"	3	Paitan	-do-	370	316	316								
"	4	Celestino	Bagabag	60	60	60						2.3		
Total	4			517	463	463								

PRESENT IRRIGATED AREA (JICA SURVEY)

Land Use	Area (ha)[1/]	Irrigation Rate[1/] (%) Wet	Dry	Irrigation Area (ha) Wet	Dry	Shortage Area (ha) Wet	Dry
Pr	1,545	0[2/]	0	0	0	1,545	1,545
Pr I (1)	2,060	100[3/]	0	2,060	0	0	2,060
Pr I (A)	2,750	100	25[4/]	2,750	688	0	2,062
Pr I (2)	4,695	100	75[5/]	4,695	3,521	0	1,174
Diversified	1,890	0[2/]	0	0	0	1,890	1,890
Total	12,940			9,505	4,209	3,435	8,731
(Proportion %)	(100)			(73)	(33)	(27)	(67)

(EXISTING CIS INVENTORY SURVEY)

	Potential Area (ha)	Irrigated Area (ha) Wet	Dry	Shortage Area (ha) Wet	Dry
	10,237	9,024	7,296	1,213	2,941
(Proportion %)	(100)	(88)	(71)	(12)	(29)

Note:

1/ Estimated based on site investigation of entire area in February and Aug. 1983

2/ Rainfed area with no irrigation facility

3/ Alternate irrigation with minor irrigation facilities

4/ Insufficient water source and irrigation facilities

5/ Sufficient water source and insufficient water management and on-farm facilities

RESULTS OF CHEMICAL ANALYSES OF RIVER WATER

No.	Sample Information	pH	$EC_{25}\times10^6$ (μU/cm)	Cations (meq./l) Na^+	K^+	Ca^{2+}	Mg^{2+}	Anions (meq./l) Cl^-	SO_4^{2-}	CO_3^{2-}	(HCO_3^-)	* ca	* an	* ion	(meq./l) $Ca^{2+}+Mg^{2+}$	SAR	ADJ SAR	R.S.C.
1.	Matuno River (B1 Site) Q=54m3/s Aug. 26 '81	8.2	200	0.33	0.01	1.15	0.55	0.05	0.32	-	1.70	2.04	2.07	4.11	1.70	0.36	0.47	-
2.	Matuno River (B1 Site) Nov. 23 '82	8.5	241	0.40	0	1.40	0.70	0.25	0.25	-	1.70	2.50	2.20	4.70	2.10	0.39	0.55	0.40
3.	Matuno River (B2 Site) Aug. 10 '82	8.2	200	0.33	0.01	1.15	0.55	0.05	0.32	0	1.70	2.04	2.07	4.11	1.70	0.36	0.47	0
4.	Matuno River (Bante) Oct. 23 '81	7.9	226	0.25	0	1.39	0.59	0.10	0.46	-	2.05	2.23	2.61	4.84	1.98	0.25	0.38	0.07
5.	Matuno River (Bante) Oct. 29 '81	7.9	209	0.26	0	1.24	0.54	0.10	0.20	-	2.05	2.04	2.35	4.39	1.78	0.28	0.42	0.27
6.	Matuno River (Bante) Nov. 11 '81	7.9	174	0.21	0	0.88	0.61	0.05	0.33	-	1.70	1.70	2.08	3.78	1.49	0.24	0.34	0.21
7.	Matuno River (Bante) Q=54m3/s Apr. 20 '82	7.8	233	0.40	0.02	1.40	0.40	0.15	0.30	-	2.00	2.22	2.45	4.67	1.80	0.42	0.63	0.20
8.	Matuno River (Bante) Apr. 26 '82	7.6	215	0.36	0.012	-	-	0.09	0.36	-	1.62	2.06	2.07	4.13	1.68	0.39	0.51	-0.06
9.	Magat River (Batu Ferry Bridge) Apr. 26 '82	8.2	329	0.60	0.03	1.90	0.55	0.50	0.29	-	2.53	3.08	3.32	6.40	2.45	0.54	0.92	0.08
10.	Magat River (Batu Ferry Bridge) Nov. 23 '82	8.4	293	0.49	0.01	1.70	0.85	0.35	0.25	-	1.90	3.05	2.50	5.55	2.55	0.43	0.69	-0.65
11.	Magat River (Colocol Intake) Aug. 10 '82	8.2	259	0.41	0.02	1.55	0.55	0.15	0.34	0	2.05	2.53	2.54	5.07	2.10	0.40	0.60	-0.05
12.	Magat River (Baretbet) Aug. 11 '82	8.3	280	0.44	0.02	1.45	0.85	0.20	0.50	0.1	2.15	2.76	2.95	5.71	2.30	0.41	0.66	-0.05
13.	Lanog River Aug. 11 '82	8.3	508	0.58	0.04	3.10	1.10	0.20	0.45	0.5	4.10	4.82	5.25	10.07	4.20	0.40	0.88	0.45

Note:

$EC_{25}\times10^6$: Electrical Conductivity at 25°C (micromhos/cm)

SAR : Sodium Adsorption Ratio = $Na/\sqrt{\frac{Ca^{2+}+Mg^{2+}}{2}}$

ADJ SAR : Adjusted SAR = SAR x $(1 + 8.4 - pHc^2)$

$pHc = (pK_2' - pKc') + p(Ca^{2+} + Mg^{2+}) + p(HCO_3^- + CO_3^{2-})$

R.S.C. : Residual Sodium Carbonate (meq./l) $= (HCO_3^- + CO_3^{2-}) - (Ca^{2+} + Mg^{2+})$

* ca : Cations

* an : Anions

* ion : Cations + Anions

CROP COEFFICIENT

Rice

Growing Stage	Coefficient
1st	0.86
2nd	0.85
3rd	0.88
4th	0.95
5th	0.99
6th	1.00
7th	0.98
8th	0.92
9th	0.85

Diversified Crop

Growing Stage	Coefficient			
	Corn	G.Nuts	Mung Bean	Vegetables
1st	0.23	0.20	0.30	0.72
2nd	0.38	0.28	0.62	0.72
3rd	0.54	0.40	0.85	0.72
4th	0.71	0.56	0.90	0.72
5th	0.85	0.70	0.80	0.72
6th	0.92	0.78	0.60	0.72
7th	0.93	0.81		0.72
8th	0.90	0.81		0.72
9th	0.85	0.74		0.72
10th	0.78	0.57		0.72

RESULTS OF DEEP PERCOLATION TEST

Test Site No.	Location	Land Class	Land Use	Soil Texture (Surface & Underlying) (cm)	Percolation Date (mm per day)
1.	Brgy. Sto. Domingo, Bambang	1R(2)	Pr1(2)	(0-75)L/(75-100)CL	0.3
2.	- do -	1R(2)	Pr1(2)	- do -	0.3
3.	Brgy. La Torre, Bayombong	1R	Pr1(A)	(0-16)L/(16-43)CL/(43-85)SCL	-
4.	- do -	1R	Pr1(A)	- do -	-
5.	Brgy, Wacal, Solano	1R	Pr1(2)	(0-20)L/(20-100)C	-
6.	- do -	1R	Pr1(2)	- do -	-
7.	Brgy. Uddiawan, Solano	2R	Pr1(A)	(0-20)CL/(20-77)C	3.0
8.	Sitio Mongcol, Solano	1R	Pr1(A)	(0-11)CL/(11-33)C/(33-120)SL	0.3
9.	Brgy, Lactawan, Solano	1R	Pr1(2)	(0-12)CL/(12-101)C	3.5
10.	Sitio Bon al East, Bayombong	1R(2)	Pr1(2)	(0-16)SICL/(16-28)SIL/(45-89)S	0.4
11.	Brgy. Curi ang, Solano	1R	Pr1(2)	(0-18)CL/(18-74)C	8.0
12.	Brgy. San Juan, Solano	1R	Pr1(1)	(0-9)SIL/(9-29)CL/(29-80)C	2.6
13.	Brgy. Poblacion, Villaverde	1R	pr1(1)	(0-44)CL/(44-83)C	1.2
14.	Brgy. Baretbet, bagabag	1R	Pr1(A)	(0-20)CL/(20-88)C	0.8
15.	Brgy. Nangalisan, Bagabag	1R (1)	Pr1(1)	(0-23)CL/(23-117)SCL	1.0
16.	Brgy. Bakur, Bagabag	1R (2)	Pr1(A)	(0-18)L/(18-114)CL	1.2
	Total				21.8
	Average				1.36

Note: Observed by JICA Team measured by quick percolation measuring apparatus conducted from July to August, 1982.

RESULTS OF DEEP PERCOLATION TEST

Test Site No.	Location	Number of Hours Observed	Land Class	Land Use	Soil Texture (Surface & Underlying) (cm)	Percolation Date (mm per day)
1.	Brgy. Sto. Domingo, Bambang	45.50	Dual	Pr	(0-30)VFSCL/(30-50)SCL	2.031
2.	Brgy. Vistahill, Baombong	24.25	1R	Pr	(0-30)SIL/(30-60)SICL	0.494
3.	Brgy. Masok, Bayombong	27.50	1R	Pr	(0-30)FSCL/(30-65)C	3.108
4.	Bayombong	27.50	1R	Pr	(0-14)C/(15-70)C	0.314
5.	Brgy. Polloc, Solano	45.75	1R	Pr	(0-10)SICL/(10-50)C	0.666
6.	Brgy. Lactawan, Solano	47.25	1R	Pr	(0-20)SICL/(20-50)C	0.676
7.	Sitio Calawagan, Wacal, Solano	47.75	1R	Pr	(0-20)SICL/(20-90)SIC	1.645
8.	Brgy. Udjawan, Solano	28.00	1R	Pr	(0-40)C/(40-60)SIC	0.839
9.	Brgy. Bintawan, Villaverde	43.50	1R	Pr	(0-30)C/(30-70)C	0.589
10.	Brgy. Ibong, Villaverde	51.00	1R	Pr	(0-20)SICL/(20-70)SIC	0.544
11.	Sitio Labunan, Ibong, Villaverde	53.50	1R	Pr	(0-10)C/(10-70)SIC	0.364
12.	Brgy. Nangalisan, Bagabag	47.00	1R	Pr	(0-15)SICL/(15-75)SICL	1.238
13.	Brgy. Morong, Bagabag	43.50	1R	Pr1	(0-25)FSCL/(25-60)SIC	1.472
14.	Brgy. baretbet, Bagabag	45.25	1R	Pr	(0-25)C/(25-60)SIC	0.584
15.	Brgy. Pogonsino, Solano	47.75	1R	Pr	(0-20)SIL/(20-80)FSL	2.382
	Total					16.946
	Average					1.130

Note: Conducted by National Irrigation Administration (July 30 - August 28,1978)

WATER REQUIREMENT FOR LAND SOAKING AND LAND PREPARATION

1. Wet season (May - July) 25 days

1) First irrigation	:		207.5
Top soil saturation 300mm depth, porosity 50% (silty clay loam), dryness 65%	:	300mm x 0.5 x 0.65	97.5
Percolation (2mm/day)	:	2mm x 25 days	50.0
Standing water	:		60.0
2) Second and third irrigation	:		48.2
Evaporation in 14 days	:	5.74mm x 0.6 x 14 days	48.2
T O T A L		255.7 =	256

2. Dry season (September - December)

1) First irrigation	:		207.5
Top soil saturation 300mm depth, porosity 50%, dryness 65%	:	300mm x 0.5 x 0.65	97.5
Percolation (2mm/day)	:	2mm x 25 days	50.0
Standing water	:		60.0
2) Second and third irrigation	:		35.5
Evaporation in 14 days	:	4.23mm x 0.6 x 14 days	35.5
T O T A L			243

TABLE VII-7

CONSUMPTIVE USE OF CROPS

Unit: mm/day

Month	Rice (Wet)	Rice (Dry)	Mung Bean	Corn (Wet)	Vegetable	Peanuts	Corn (Dry)
Jan.		4.4			2.4	1.2	1.5
Feb.		2.3	2.4		3.6	2.4	3.1
Mar.		0.1	4.5		4.3	4.4	5.0
Apr.			4.5		4.8	5.1	5.5
May	3.0		2.2		4.1	2.1	1.1
Jun.	6.2		0.2	2.1	2.3		
Jul.	6.8			5.5			
Aug.	7.0			2.4			
Sep.	4.0	1.1		3.9			
Oct.	0.7	4.1		3.7			
Nov.		5.4		2.2			
Dec.		5.1			7.3	4.1	5.7

Note: During land preparation and harvesting, area factor is considered.

FIELD WATER REQUIREMENT

(Unit: mm)

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1957 CROP	1	-	-	-	-	72.99	87.68	83.02	152.90	58.64	9.80	-	-
	2	136.17	65.61	2.34	-	-	-	-	-	-	104.40	121.37	141.64
	3	-	66.65	80.03	49.43	-	-	-	-	-	-	-	-
	4	-	-	-	-	-	63.09	50.64	-	-	4.46	-	-
	5	57.03	100.22	75.87	58.25	26.44	-	-	-	-	-	-	216.70
	6	19.96	68.21	77.74	68.24	26.47	-	-	-	-	-	-	116.70
	7	27.22	87.70	96.40	78.24	25.33	-	-	-	-	-	-	166.70
1958 CROP	1	-	-	-	-	25.17	97.55	116.35	71.20	50.09	10.80	-	-
	2	136.17	60.58	1.36	-	-	-	-	-	-	107.59	101.35	147.74
	3	-	55.59	125.13	73.76	-	-	-	-	-	-	-	-
	4	-	-	-	-	-	60.87	100.96	-	-	-	5.11	-
	5	61.94	89.17	120.97	82.58	7.73	-	-	-	-	-	-	220.04
	6	24.88	57.15	122.83	92.58	10.22	-	-	-	-	-	-	120.04
	7	32.13	76.64	141.49	102.57	-	-	-	-	-	-	-	170.04
1959 CROP	1	-	-	-	-	26.37	90.42	36.05	143.84	56.34	14.40	-	-
	2	136.17	58.82	0.78	-	-	-	-	-	-	125.27	79.24	81.06
	3	-	56.84	69.39	89.01	-	3.41	-	-	-	-	-	-
	4	-	-	-	-	-	39.89	51.52	-	2.85	36.42	-	-
	5	64.19	90.41	65.23	97.83	-	3.07	-	-	-	-	-	210.38
	6	27.12	58.40	67.10	107.83	-	-	-	-	-	-	-	110.38
	7	34.37	77.89	85.76	117.82	0.99	-	-	-	-	-	-	160.38
1960 CROP	1	-	-	-	-	41.58	12.14	69.97	69.99	59.87	10.80	-	-
	2	136.17	42.31	2.34	-	-	-	-	-	-	99.31	148.98	142.44
	3	-	-	135.34	16.91	-	-	-	-	-	-	-	-
	4	-	-	-	-	-	-	43.01	-	-	-	59.52	-
	5	67.61	-	131.18	25.74	-	-	-	-	-	-	-	221.63
	6	30.55	-	133.05	35.73	-	-	-	-	-	-	-	121.63
	7	37.80	-	151.71	45.72	10.41	-	-	-	-	-	-	171.63
1961 CROP	1	-	-	-	-	41.10	70.03	26.67	165.10	101.27	8.40	-	-
	2	136.17	65.61	1.56	-	-	-	-	-	-	78.67	86.05	28.04
	3	-	66.65	35.56	49.65	-	-	-	-	-	-	-	-
	4	-	-	-	-	-	-	10.05	-	66.67	-	-	-
	5	73.40	100.22	31.40	58.47	34.39	-	-	-	-	-	-	145.51
	6	36.34	68.21	33.27	68.47	-	-	-	-	-	-	-	45.51
	7	43.59	87.70	51.93	78.46	17.06	-	-	-	-	-	-	95.51
1962 CROP	1	-	-	-	-	53.22	94.84	56.80	118.80	70.04	18.00	-	-
	2	136.17	65.61	0.78	-	-	-	-	-	-	127.53	114.58	135.54
	3	-	66.65	79.12	44.55	4.86	-	-	-	-	-	-	-
	4	-	-	-	-	-	32.70	10.05	-	-	98.32	34.93	-
	5	66.91	100.22	74.96	53.38	64.66	9.51	-	-	-	-	-	225.56
	6	29.85	68.21	76.83	63.37	36.36	-	-	-	-	-	-	126.56
	7	37.10	87.70	95.49	73.36	18.53	-	-	-	-	-	-	176.56
1963 CROP	1	-	-	-	-	49.36	60.47	28.15	127.70	61.84	18.00	-	-
	2	136.17	51.72	2.34	-	-	-	-	-	-	108.01	134.78	59.04
	3	-	55.01	87.54	135.08	1.92	-	-	-	-	-	-	-
	4	-	-	-	-	-	12.71	10.05	-	-	95.55	61.69	-
	5	64.75	88.58	83.38	143.91	61.72	-	-	-	-	-	-	166.28
	6	27.68	56.56	85.24	153.90	8.72	-	-	-	-	-	-	66.28
	7	34.93	76.05	103.90	163.90	-	-	-	-	-	-	-	116.28
1964 CROP	1	-	-	-	-	36.45	32.46	79.55	93.14	54.58	8.40	-	-
	2	136.17	63.81	1.56	-	-	-	-	-	-	127.18	9.99	17.64
	3	-	65.31	128.58	107.98	-	-	-	-	-	-	-	-
	4	-	-	-	-	-	34.38	77.04	-	-	-	-	-
	5	71.66	98.89	124.42	116.80	-	-	-	-	-	-	-	141.74
	6	34.60	66.87	126.29	126.79	-	-	-	-	-	-	-	41.74
	7	41.85	86.36	144.95	136.79	-	-	-	-	-	-	-	91.74
1965 CROP	1	-	-	-	-	29.19	123.64	84.49	176.50	71.54	8.80	-	-
	2	136.17	59.08	0.78	-	-	-	-	-	-	127.53	61.12	123.84
	3	-	59.51	106.11	53.16	-	-	-	-	-	-	-	-
	4	-	-	-	-	-	61.66	13.57	-	-	37.43	-	-
	5	56.29	93.08	101.95	61.98	38.86	21.93	-	-	-	-	-	203.12
	6	19.23	61.07	103.82	71.98	-	-	-	-	-	-	-	103.12
	7	26.48	80.56	122.48	81.97	-	-	-	-	-	-	-	153.12
1966 CROP	1	-	-	-	-	40.28	104.25	87.99	72.70	79.81	16.80	-	-
	2	136.17	65.61	2.34	-	-	-	-	-	17.82	65.59	33.02	109.24
	3	-	66.65	95.54	54.50	-	-	-	-	-	-	-	-
	4	-	-	-	-	-	54.60	67.98	-	57.12	55.05	-	-
	5	63.77	100.22	91.38	63.33	-	-	-	-	-	-	-	211.77
	6	26.70	68.21	93.24	73.32	-	-	-	-	-	-	-	111.77
	7	33.95	87.70	111.90	83.32	-	-	-	-	-	-	-	161.77

CROP: 1: Wet Paddy 2: Dry Paddy 3: Mung Bean 4. Wet Corn
5: Vegetable 6: Peanut 7: Dry Corn

FIELD WATER REQUIREMENT

(Unit: mm)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1967 CROP 1	-	-	-	-	25.57	25.14	10.25	111.95	35.79	3.00	-	-
2	132.69	51.28	2.04	-	-	-	-	-	-	127.53	-	-
3	-	55.67	126.17	43.84	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	38.32	-	-	-	-	-
5	50.03	89.24	122.01	52.66	-	-	-	-	-	-	-	129.12
6	12.97	57.22	123.87	62.65	-	-	-	-	-	-	-	29.12
7	20.22	76.71	142.53	72.65	-	-	-	-	-	-	-	79.12
1968 CROP 1	-	-	-	-	1.20	122.65	93.41	53.00	67.86	8.40	-	-
2	136.17	65.61	2.34	-	-	-	-	-	-	102.86	132.88	143.14
3	-	66.65	138.51	3.07	-	-	-	-	-	-	-	-
4	-	-	-	-	-	63.09	73.86	-	11.71	63.35	65.12	-
5	52.98	100.22	134.35	11.89	40.63	20.88	-	-	-	-	-	216.84
6	15.91	68.21	136.21	21.89	0.02	-	-	-	-	-	-	116.84
7	23.17	87.70	154.87	31.88	-	-	-	-	-	-	-	166.84
1969 CROP 1	-	-	-	-	28.17	153.24	0.00	199.00	94.69	10.80	-	-
2	136.17	64.71	2.34	-	-	-	-	-	2.82	63.18	111.28	117.34
3	-	65.98	118.82	102.49	-	-	-	-	-	-	-	-
4	-	-	-	-	-	57.93	10.05	-	62.24	31.54	31.61	-
5	74.80	99.55	114.66	111.32	56.39	44.39	-	-	-	-	-	198.59
6	37.74	67.54	116.52	121.31	-	-	-	-	-	-	-	98.59
7	44.99	87.03	135.18	131.30	-	-	-	-	-	-	-	148.59
1970 CROP 1	-	-	-	-	38.47	43.46	67.05	119.67	79.83	6.00	-	-
2	136.17	61.08	0.78	-	-	-	-	-	8.02	47.75	25.14	-
3	-	56.40	80.11	69.68	-	-	-	-	-	-	-	-
4	-	-	-	-	-	60.87	69.31	-	-	-	-	-
5	52.54	89.97	75.95	78.50	30.35	-	-	-	-	-	-	170.18
6	15.47	57.96	77.82	88.49	15.45	-	-	-	-	-	-	70.18
7	22.72	77.44	96.48	98.49	19.92	-	-	-	-	-	-	120.18
1971 CROP 1	-	-	-	-	34.22	100.44	33.17	193.30	75.84	10.80	-	-
2	136.17	58.82	2.34	-	-	-	-	-	-	127.53	55.21	54.14
3	-	31.62	104.04	126.98	-	-	-	-	-	-	-	-
4	-	-	-	-	-	49.07	16.98	7.16	-	-	-	-
5	44.35	65.19	99.88	135.80	-	18.05	-	-	-	-	-	164.31
6	7.29	33.17	101.75	145.79	-	-	-	-	-	-	-	64.31
7	14.54	52.66	120.41	155.79	-	-	-	-	-	-	-	114.31
1972 CROP 1	-	-	-	-	52.39	129.14	0.00	199.36	83.82	19.20	-	-
2	136.17	63.35	2.34	-	-	-	-	-	-	127.53	73.36	150.44
3	-	64.64	118.18	7.60	11.89	-	-	-	-	-	-	-
4	-	-	-	-	-	49.83	10.05	-	3.77	105.89	-	-
5	32.48	98.22	114.02	16.42	71.69	38.94	-	-	-	-	-	221.91
6	-	66.20	115.88	26.42	23.54	-	-	-	-	-	-	121.91
7	2.67	85.69	134.54	36.41	18.60	-	-	-	-	-	-	171.91
1973 CROP 1	-	-	-	-	58.33	114.94	153.45	133.20	99.79	9.60	-	-
2	136.17	65.61	2.34	-	-	-	-	-	14.72	75.82	82.85	157.14
3	-	66.65	138.51	116.57	33.52	-	-	-	-	-	-	-
4	-	-	-	-	-	41.48	127.59	-	56.38	-	2.64	-
5	74.80	100.22	134.35	125.39	93.32	31.84	-	-	-	-	-	226.56
6	37.74	68.21	136.21	135.38	30.95	-	-	-	-	-	-	126.56
7	44.99	87.70	154.87	145.38	13.81	-	-	-	-	-	-	176.56
1974 CROP 1	-	-	-	-	29.69	109.02	94.83	184.40	111.76	12.00	-	-
2	136.17	62.95	2.34	-	-	-	-	-	16.02	55.27	49.31	82.04
3	-	64.64	134.09	96.56	-	-	-	-	-	-	-	-
4	-	-	-	-	-	58.81	72.62	8.82	98.89	-	-	-
5	68.59	98.22	129.93	105.38	53.48	6.15	-	-	-	-	-	191.05
6	31.52	66.20	131.79	115.38	13.28	-	-	-	-	-	-	91.05
7	38.78	85.69	150.45	125.37	3.53	-	-	-	-	-	-	141.05
1975 CROP 1	-	-	-	-	40.38	145.55	148.85	124.50	92.90	15.30	-	-
2	136.17	63.51	2.34	-	-	-	-	-	9.32	84.27	76.55	45.54
3	-	65.09	127.60	61.55	-	-	-	-	-	-	-	-
4	-	-	-	-	-	63.09	124.09	-	53.45	32.13	-	-
5	74.80	98.66	123.45	70.38	35.51	31.15	-	-	-	-	-	160.32
6	37.74	66.65	125.31	80.37	7.60	-	-	-	-	-	-	60.32
7	44.99	86.13	143.97	90.36	-	-	-	-	-	-	-	110.32
1976 CROP 1	-	-	-	-	85.69	75.55	77.24	131.57	87.81	13.20	-	-
2	136.17	65.61	2.34	-	-	-	-	-	-	81.83	115.68	135.44
3	-	66.65	86.10	127.75	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	64.09	-	22.62	27.98	34.48	-
5	18.13	100.22	81.94	136.58	-	-	-	-	-	-	-	226.56
6	-	68.21	83.80	146.57	-	-	-	-	-	-	-	126.56
7	-	87.70	102.46	156.56	35.62	-	-	-	-	-	-	176.56

CROP: 1: Wet Paddy 2: Dry Paddy 3: Mung Bean 4. Wet Corn
5: Vegetable 6: Peanut 7: Dry Corn

CALCULATION OF SEEPAGE LOSS RATIO

1. Kostiakov's Equation

Canal	Section	Length(L) (km)	Discharge(Q) (m^3/s)	A	m	s (%)	S (m^3/s)	Ratio (%)
Mountain Side	A	2.35	14.32	1.90	0.40	0.655	0.22	1.54
Main Canal	B	5.65	11.93	1.90	0.40	0.705	0.48	4.02
	C	6.50	10.56	1.90	0.40	0.740	0.50	4.73
	D	7.65	3.78	0.70	0.30	0.470	0.14	3.70
	E	0.45	1.44	0.70	0.30	0.627	0.01	0.69
Sub total								14.68
Lateral Canal	M - L20	6.90	1.01	0.70	0.30	0.698	0.05	4.95
Total								19.63

2. Moriz's Equation

Canal	Section	Length(L) (km)	Discharg(Q) (m^3/s)	Velocity(V) (m/s)	S ($m^3/s/km$)	Amount S (m/s)	Ratio (%)
Mountain Side	A	2.35	14.32	0.55	0.026	0.06	0.43
	B	5.65	11.93	0.68	0.021	0.12	1.01
	C	6.50	10.56	0.60	0.021	0.14	1.33
	D	7.65	3.78	0.53	0.013	0.16	4.23
	E	0.45	1.44	0.41	0.009	0.01	0.69
Sub total							7.69
Lateral Canal	M - L20	6.90	1.01	0.66	0.006	0.04	3.96
Total							11.65

TABLE VII-10
(1 of 2)

IRRIGATION WATER REQUIREMENT

Unit: m^3/s

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1957	CROP1	0.0	0.0	0.0	0.0	6.01	7.46	6.83	12.58	4.99	1.47	0.0	0.0
	2	9.54	4.91	1.69	0.0	0.0	0.0	0.0	0.0	0.0	8.23	8.78	9.92
	3	0.0	2.34	2.62	1.67	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4	0.0	0.0	0.0	0.0	0.0	4.16	0.65	0.0	0.0	0.06	0.0	0.0
	5	0.21	0.39	0.28	0.22	0.10	0.0	0.0	0.0	0.0	0.0	0.0	1.17
	6	0.18	0.66	0.71	0.64	0.32	0.0	0.0	0.0	0.0	0.0	0.0	1.57
	7	0.11	0.38	0.40	0.33	0.25	0.0	0.0	0.0	0.0	0.0	0.0	1.01
	TOTAL	10.04	8.68	5.70	2.86	6.68	11.62	7.48	12.58	4.99	9.76	8.78	13.67
1958	CROP1	0.0	0.0	0.0	0.0	2.07	8.30	9.58	5.86	4.26	1.62	0.0	0.0
	2	9.54	4.54	0.98	0.0	0.0	0.0	0.0	0.0	0.0	8.48	7.33	10.35
	3	0.0	1.95	4.10	2.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4	0.0	0.0	0.0	0.0	0.0	4.01	1.29	0.0	0.0	0.0	0.08	0.0
	5	0.23	0.35	0.44	0.31	0.03	0.0	0.0	0.0	0.0	0.0	0.0	1.18
	6	0.23	0.56	1.12	0.87	0.13	0.0	0.0	0.0	0.0	0.0	0.0	1.61
	7	0.13	0.34	0.58	0.43	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.03
	TOTAL	10.13	7.74	7.22	4.11	2.23	12.31	10.87	5.86	4.26	10.10	7.41	14.17
1959	CROP1	0.0	0.0	0.0	0.0	2.17	7.69	2.97	11.84	4.79	2.16	0.0	0.0
	2	9.54	4.40	0.56	0.0	0.0	0.0	0.0	0.0	0.0	9.95	5.74	5.68
	3	0.0	1.99	2.27	3.02	0.0	0.25	0.0	0.0	0.0	0.0	0.0	0.0
	4	0.0	0.0	0.0	0.0	0.0	2.63	0.66	0.0	0.04	0.46	0.0	0.0
	5	0.23	0.35	0.24	0.37	0.0	0.01	0.0	0.0	0.0	0.0	0.0	1.13
	6	0.25	0.57	0.61	1.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.48
	7	0.14	0.34	0.35	0.50	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.97
	TOTAL	10.16	7.65	4.03	4.90	2.18	10.58	3.63	11.84	4.83	12.57	5.74	9.26
1960	CROP1	0.0	0.0	0.0	0.0	3.42	1.03	5.76	5.76	5.09	1.62	0.0	0.0
	2	9.54	3.17	1.69	0.0	0.0	0.0	0.0	0.0	0.0	7.83	10.78	9.98
	3	0.0	0.0	4.44	0.57	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4	0.0	0.0	0.0	0.0	0.0	0.0	0.55	0.0	0.0	0.0	0.90	0.0
	5	0.25	0.0	0.48	0.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.19
	6	0.28	0.0	1.21	0.34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.64
	7	0.15	0.0	0.62	0.19	0.10	0.0	0.0	0.0	0.0	0.0	0.0	1.04
	TOTAL	10.22	3.17	8.44	1.20	3.52	1.03	6.31	5.76	5.09	9.45	11.68	13.85
1961	CROP1	0.0	0.0	0.0	0.0	3.38	5.96	2.20	13.59	8.61	1.26	0.0	0.0
	2	9.54	4.91	1.13	0.0	0.0	0.0	0.0	0.0	0.0	6.20	6.23	1.96
	3	0.0	2.34	1.17	1.68	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4	0.0	0.0	0.0	0.0	0.0	0.0	0.13	0.0	0.88	0.0	0.0	0.0
	5	0.27	0.39	0.11	0.22	0.13	0.0	0.0	0.0	0.0	0.0	0.0	0.78
	6	0.33	0.66	0.30	0.64	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.61
	7	0.18	0.38	0.21	0.33	0.17	0.0	0.0	0.0	0.0	0.0	0.0	0.58
	TOTAL	10.32	8.68	2.92	2.87	3.68	5.96	2.33	13.59	9.49	7.46	6.23	3.93
1962	CROP1	0.0	0.0	0.0	0.0	4.38	8.06	4.67	9.78	5.96	2.70	0.0	0.0
	2	9.54	4.91	0.56	0.0	0.0	0.0	0.0	0.0	0.0	10.05	8.29	9.49
	3	0.0	2.34	2.59	1.51	0.16	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4	0.0	0.0	0.0	0.0	0.0	2.15	0.13	0.0	0.0	1.25	0.53	0.0
	5	0.24	0.39	0.27	0.20	0.24	0.04	0.0	0.0	0.0	0.0	0.0	1.22
	6	0.27	0.66	0.70	0.60	0.45	0.0	0.0	0.0	0.0	0.0	0.0	1.70
	7	0.15	0.38	0.39	0.31	0.18	0.0	0.0	0.0	0.0	0.0	0.0	1.07
	TOTAL	10.20	8.68	4.51	2.62	5.41	10.25	4.80	9.78	5.96	14.00	8.82	13.48
1963	CROP1	0.0	0.0	0.0	0.0	4.06	5.14	2.32	10.51	5.26	2.70	0.0	0.0
	2	9.54	3.87	1.69	0.0	0.0	0.0	0.0	0.0	0.0	8.51	9.75	4.13
	3	0.0	1.93	2.87	4.58	0.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4	0.0	0.0	0.0	0.0	0.0	0.84	0.13	0.0	0.0	1.22	0.94	0.0
	5	0.24	0.34	0.30	0.54	0.22	0.0	0.0	0.0	0.0	0.0	0.0	0.89
	6	0.25	0.55	0.78	1.45	0.11	0.0	0.0	0.0	0.0	0.0	0.0	0.89
	7	0.14	0.33	0.43	0.69	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.70
	TOTAL	10.17	7.02	6.07	7.26	4.45	5.98	2.45	10.51	5.26	12.43	10.69	6.61
1964	CROP1	0.0	0.0	0.0	0.0	3.00	2.76	6.55	7.66	4.64	1.26	0.0	0.0
	2	9.54	4.78	1.13	0.0	0.0	0.0	0.0	0.0	0.0	10.02	0.72	1.24
	3	0.0	2.29	4.22	3.66	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4	0.0	0.0	0.0	0.0	0.0	2.26	0.98	0.0	0.0	0.0	0.0	0.0
	5	0.26	0.39	0.45	0.44	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.76
	6	0.32	0.65	1.15	1.19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.56
	7	0.17	0.38	0.59	0.58	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.55
	TOTAL	10.29	8.49	7.54	5.87	3.00	5.02	7.53	7.66	4.64	11.28	0.72	3.11
1965	CROP1	0.0	0.0	0.0	0.0	2.40	10.51	6.95	14.53	6.08	1.32	0.0	0.0
	2	9.54	4.42	0.56	0.0	0.0	0.0	0.0	0.0	0.0	10.05	4.42	8.67
	3	0.0	2.09	3.48	1.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4	0.0	0.0	0.0	0.0	0.0	4.06	0.17	0.0	0.0	0.48	0.0	0.0
	5	0.21	0.36	0.37	0.23	0.14	0.09	0.0	0.0	0.0	0.0	0.0	1.09
	6	0.18	0.59	0.95	0.68	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.39
	7	0.11	0.35	0.50	0.35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.93
	TOTAL	10.04	7.81	5.86	3.06	2.54	14.66	7.12	14.53	6.08	11.85	4.42	12.08
1966	CROP1	0.0	0.0	0.0	0.0	3.31	8.87	7.24	5.98	6.79	2.52	0.0	0.0
	2	9.54	4.91	1.69	0.0	0.0	0.0	0.0	0.0	2.90	5.17	2.39	7.65
	3	0.0	2.34	3.13	1.85	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4	0.0	0.0	0.0	0.0	0.0	3.60	0.87	0.0	0.75	0.70	0.0	0.0
	5	0.23	0.39	0.33	0.24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.14
	6	0.24	0.66	0.85	0.69	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.50
	7	0.14	0.38	0.46	0.35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.98
	TOTAL	10.15	8.68	6.46	3.13	3.31	12.47	8.11	5.98	10.44	8.39	2.39	11.27

CROP: 1: Wet Paddy 2: Dry Paddy 3: Mung Bean 4: Wet Corn
5: Vegetable 6: Peanut 7: Dry Corn

IRRIGATION WATER REQUIREMENT

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1967	CROP1	0.0	0.0	0.0	0.0	2.10	2.14	0.84	9.21	3.04	0.45	0.0	0.0
	2	9.29	3.84	1.47	0.0	0.0	0.0	0.0	0.0	0.0	10.05	0.0	0.0
	3	0.0	1.95	4.14	1.48	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4	0.0	0.0	0.0	0.0	0.0	0.0	0.49	0.0	0.0	0.0	0.0	0.0
	5	0.18	0.35	0.44	0.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.69
	6	0.12	0.56	1.13	0.59	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.39
	7	0.08	0.34	0.58	0.31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.48
	TOTAL	9.67	7.04	7.76	2.58	2.10	2.14	1.33	9.21	3.04	10.50	0.0	1.56
1968	CROP1	0.0	0.0	0.0	0.0	0.10	10.43	7.69	4.36	5.77	1.26	0.0	0.0
	2	9.54	4.91	1.69	0.0	0.0	0.0	0.0	0.0	0.0	8.10	9.62	10.03
	3	0.0	2.34	4.54	0.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4	0.0	0.0	0.0	0.0	0.0	4.16	0.94	0.0	0.15	0.81	0.99	0.0
	5	0.19	0.39	0.49	0.04	0.15	0.09	0.0	0.0	0.0	0.0	0.0	1.17
	6	0.14	0.66	1.24	0.21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.57
	7	0.09	0.38	0.63	0.13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.01
	TOTAL	9.96	8.68	8.59	0.48	0.25	14.68	8.63	4.36	5.92	10.17	10.61	13.78
1969	CROP1	0.0	0.0	0.0	0.0	2.32	13.03	0.0	16.38	8.05	1.62	0.0	0.0
	2	9.54	4.84	1.69	0.0	0.0	0.0	0.0	0.0	0.46	4.98	8.05	8.22
	3	0.0	2.31	3.90	3.47	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4	0.0	0.0	0.0	0.0	0.0	3.82	0.13	0.0	0.82	0.40	0.48	0.0
	5	0.27	0.39	0.42	0.42	0.21	0.19	0.0	0.0	0.0	0.0	0.0	1.07
	6	0.34	0.66	1.06	1.14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.33
	7	0.18	0.38	0.55	0.56	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.90
	TOTAL	10.33	8.58	7.62	5.59	2.53	17.04	0.13	16.38	9.33	7.00	8.53	11.52
1970	CROP1	0.0	0.0	0.0	0.0	3.17	3.70	5.52	9.85	6.79	0.90	0.0	0.0
	2	9.54	4.57	0.56	0.0	0.0	0.0	0.0	0.0	1.31	3.76	1.82	0.0
	3	0.0	1.98	2.63	2.36	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4	0.0	0.0	0.0	0.0	0.0	4.01	0.88	0.0	0.0	0.0	0.0	0.0
	5	0.19	0.35	0.28	0.30	0.11	0.0	0.0	0.0	0.0	0.0	0.0	0.92
	6	0.14	0.56	0.71	0.83	0.19	0.0	0.0	0.0	0.0	0.0	0.0	0.94
	7	0.09	0.34	0.40	0.42	0.19	0.0	0.0	0.0	0.0	0.0	0.0	0.73
	TOTAL	9.96	7.80	4.58	3.91	3.66	7.71	6.40	9.85	8.10	4.66	1.82	2.59
1971	CROP1	0.0	0.0	0.0	0.0	2.82	8.54	2.73	15.91	6.45	1.62	0.0	0.0
	2	9.54	4.40	1.69	0.0	0.0	0.0	0.0	0.0	0.0	10.05	4.00	3.79
	3	0.0	1.11	3.41	4.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4	0.0	0.0	0.0	0.0	0.0	3.23	0.22	0.09	0.0	0.0	0.0	0.0
	5	0.16	0.25	0.36	0.51	0.0	0.08	0.0	0.0	0.0	0.0	0.0	0.88
	6	0.07	0.32	0.93	1.37	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.86
	7	0.06	0.23	0.49	0.66	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.69
	TOTAL	9.83	6.31	6.88	6.84	2.82	11.85	2.95	16.00	6.45	11.67	4.00	6.22
1972	CROP1	0.0	0.0	0.0	0.0	4.31	10.98	0.0	16.41	7.13	2.88	0.0	0.0
	2	9.54	4.74	1.69	0.0	0.0	0.0	0.0	0.0	0.0	10.05	5.31	10.54
	3	0.0	2.27	3.87	0.26	0.39	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4	0.0	0.0	0.0	0.0	0.0	3.28	0.13	0.0	0.05	1.35	0.0	0.0
	5	0.12	0.38	0.42	0.06	0.26	0.16	0.0	0.0	0.0	0.0	0.0	1.19
	6	0.0	0.64	1.06	0.25	0.29	0.0	0.0	0.0	0.0	0.0	0.0	1.64
	7	0.01	0.38	0.55	0.15	0.18	0.0	0.0	0.0	0.0	0.0	0.0	1.04
	TOTAL	9.67	8.41	7.59	0.72	5.43	14.42	0.13	16.41	7.18	14.28	5.31	14.41
1973	CROP1	0.0	0.0	0.0	0.0	4.80	9.77	12.63	10.96	8.49	1.44	0.0	0.0
	2	9.54	4.91	1.69	0.0	0.0	0.0	0.0	0.0	2.40	5.97	6.00	11.01
	3	0.0	2.34	4.54	3.95	1.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4	0.0	0.0	0.0	0.0	0.0	2.73	1.63	0.0	0.74	0.0	0.04	0.0
	5	0.27	0.39	0.49	0.47	0.34	0.13	0.0	0.0	0.0	0.0	0.0	1.22
	6	0.34	0.66	1.24	1.27	0.38	0.0	0.0	0.0	0.0	0.0	0.0	1.70
	7	0.18	0.38	0.63	0.62	0.13	0.0	0.0	0.0	0.0	0.0	0.0	1.07
	TOTAL	10.33	8.68	8.59	6.31	6.75	12.63	14.26	10.96	11.63	7.41	6.04	15.00
1974	CROP1	0.0	0.0	0.0	0.0	2.44	9.27	7.80	15.18	9.50	1.80	0.0	0.0
	2	9.54	4.71	1.69	0.0	0.0	0.0	0.0	0.0	2.61	4.36	3.57	5.75
	3	0.0	2.27	4.40	3.27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4	0.0	0.0	0.0	0.0	0.0	3.87	0.93	0.11	1.30	0.0	0.0	0.0
	5	0.25	0.38	0.47	0.40	0.19	0.03	0.0	0.0	0.0	0.0	0.0	1.03
	6	0.29	0.64	1.20	1.09	0.16	0.0	0.0	0.0	0.0	0.0	0.0	1.22
	7	0.16	0.38	0.62	0.53	0.03	0.0	0.0	0.0	0.0	0.0	0.0	0.85
	TOTAL	10.24	8.38	8.38	5.29	2.82	13.17	8.73	15.29	13.41	6.16	3.57	8.85
1975	CROP1	0.0	0.0	0.0	0.0	3.31	12.38	12.25	10.25	7.90	2.30	0.0	0.0
	2	9.54	4.75	1.69	0.0	0.0	0.0	0.0	0.0	1.52	6.64	5.54	3.19
	3	0.0	2.28	4.18	2.09	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4	0.0	0.0	0.0	0.0	0.0	4.16	1.58	0.0	0.70	0.41	0.0	0.0
	5	0.27	0.38	0.45	0.26	0.13	0.13	0.0	0.0	0.0	0.0	0.0	0.86
	6	0.34	0.65	1.14	0.76	0.09	0.0	0.0	0.0	0.0	0.0	0.0	0.81
	7	0.18	0.38	0.59	0.38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.67
	TOTAL	10.33	8.44	8.05	3.49	3.53	16.67	13.83	10.25	10.12	9.35	5.54	5.53
1976	CROP1	0.0	0.0	0.0	0.0	7.05	6.42	6.36	10.83	7.47	1.98	0.0	0.0
	2	9.54	4.91	1.69	0.0	0.0	0.0	0.0	0.0	0.0	6.45	8.37	9.49
	3	0.0	2.34	2.82	4.33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4	0.0	0.0	0.0	0.0	0.0	0.0	0.82	0.0	0.30	0.36	0.52	0.0
	5	0.07	0.39	0.30	0.51	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.22
	6	0.0	0.66	0.76	1.38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.70
	7	0.0	0.38	0.42	0.66	0.35	0.0	0.0	0.0	0.0	0.0	0.0	1.07
	TOTAL	9.61	8.68	5.99	6.88	7.40	6.42	7.18	10.83	7.77	8.79	8.89	13.48

CROP: 1: Wet Paddy 2: Dry Paddy 3: Mung Bean 4: Wet Corn
5: Vegetable 6: Peanut 7: Dry Corn

INTEGRATION PLAN OF EXISTING CIS

Canal Name	Irrigable Area (ha)	CIS Name	Irrigable Area (ha)
1. Colocol Main Canal			
C-L_1	36	San. Vincent	27
C-L_2	203	Danao	66
		Sunday	117
		Villaramo Catisa	197
		Macapulay	115
Sub-total (1)	239		522
C-L_3	553	Ramirez	350
		Pablo-Ramos	140
		Magarang	70
C-L_4	100	Domaso	101
		Maton	107
Sub-total (2)	653		768
C-L_5	343	Bawang-Laotawan	343
		Aggub	170
C-L_6	67	Mamangend	44
C-L_7	266	Cuting	97
		Silap	100
		Gonzales	
C-L_8	150	Lacar	48
		Labog	69
		Ramos	25
Sub-total (3)	826		896
C-L_9	317	Curifang Dodao	85
		Baquiran	35
		Acasia	31
C-L_{11}	80	Arasip	70
C-L_{12}	125	Sico	97
		Nakumbentuan	70
		Namnama	37
Sub-total (4)	522		425
C-L10	125	Tanop	97
C-L_{13}	144	Tullag (L)	160
		Malatupa	48
SUB-total (5)	269		305
C-L_{14}	261	Bagabog	258
C-L-15	445	Tullag (R)	200
		Baretbet	103
		Tabban	58
Sub-total (6)	706		619
Total	3,220		3,535

Canal Name	Irrigable Area (ha)	CIS Name	Irrigable Area (ha)
2. Mountain Side Main Canal			
M-L_1	76	Paoac	56
M-L_2	1,118	Adduan	400
		Nampayacan	62
		Cob-Cob	31
		Apad	55
		Cam-Cam	196
		Gaud	21
		Gayong-Gayong	46
M-L_3	159	Salpad	145
Sub-total (1)	1,353		1.037
M-L_4	301	Casat	160
M-L_5	259	Ubbog	170
		Domotis	29
		Caldaan	102
M-L_6	110	Banguaan	168
Sub-total (2)	670		791
M-L_7	124	Uddowan	394 (582)
M-L_8	110		
M-L_9	160		
M-L_{10}	458	(Uddiawan)	
		Cabaruan	36
		Tucal	185
M-L_{11}	210	San Juan 300	
		Coupligor	60
M-L_{12}	235	Bintawan San Juan	200
		Bintawan	60
		Nangyatan	
Sub-total	1,297		1,242 (1,423)
M-L_{13}	101	Non CIS	
M-L_{14}	230	Non CIS	
M-L_{15}	199	Balacuit	46
M-L_{16}	181	Non CIS	
M-L_{17}	194	Omec	40
M-L_{18}	391	Nagbitin	167
		Ibung	153
		Banuton	61
		Pieza Ibung	75
M-L_{19}	143	Massin	95
M-L_{20}	460	Cabulaluan	166
		Pieza Nagalisan	113
M-L_{21}	155	Non CIS	
M-L_{22}	63	Non CIS	
Sub-total	2,117	Higher portcono	916
Higher-elevation Paddy	188	Nigher portcono Uddiawan	188
Total	5,625		4.'57

INTEGRATION PLAN OF EXISTING CIS

Canal Name	Irrigable Area (ha)	CIS Name	Irrigable Area (ha)	Canal Name	Irrigable Area (ha)	CIS Name	Irrigable Area (ha)
3. Lanog Main Canal				4. Sto. Domingo Main Canal			
LL-L_1	52	Non CIS		S-L_1	80	Manantam	91
LL-L_2	73	Gannib Cabari	170	S-L_2	60		
LL-L_4	145	Tan		S-L_3	139		
LL-L_3	77	Non CIS		S-L_4	60	Sto. Domingo	475
LL-L_5	161	Magnad	386	S-L_5	30		
LL-L_7	100			S-L_6	74		
LL-L_6	70	Bakir	190	S-L_7	33	Non CIS	
Direct diversion	115			S-L_8	44	Non CIS	
Sub-total	803		746	S-L_9	129	Non CIS	
LR-L_1	267	Dapat	400	S-L_{10}	170	Bayag	156
LR-L_2	397	Sto. Cruz-Careb	340	S-L_{11}	55	Nagragadian	227
LR-L_3	100			S-L_{12}	90	- do -	
LR-L_4	100			S-L_{13}	30	Non CIS	
LR-L_5	476	Non CIS		S-L_{14}	36	Ipil	40
LR-L_6	50	- do -		Total	1,090		989
LR-L_7	117	- do -		Grand Total	12,680		10,177
LR-L_8	135	- do -					
LR-L_9	100	- do -					
LR-L_{10}	167	- do -					
Direct diversion	33						
Sub-total	1,942		740				
Total	2,745		1,486				

TABLE VII-12

MAXIMUM CONTINUOUS RAINFALL

Observed

Year	1 Day	2 Days	3 Days
1956	76.2	101.6	121.4
1957	114.3	114.8	119.9
1958	80.8	129.8	132.3
1959	94.7	115.5	121.9
1960	84.3	113.0	137.9
1961	129.1	129.1	129.1
1962	78.5	157.0	208.6
1963	97.3	146.8	150.6
1964	135.9	165.6	172.0
1965	122.4	137.1	186.6
1966	63.8	96.3	133.9
1967	130.7	111.7	138.9
1968	48.3	60.6	72.7
1969	90.7	132.8	171.4
1970	113.5	170.4	224.6
1971	99.9	150.9	181.5
1972	59.5	94.4	123.0
1973	91.5	103.0	103.0
1974	43.1	80.8	80.8
1975	75.7	75.7	80.5
1976	71.1	86.3	124.7

Probable

Return Period	1 Day	2 Days	3 Days
1/5	112.7	143.1	171.4
1/10	125.5	157.2	193.6
1/30	142.2	175.5	224.7
1/50	149.0	183.0	238.2

LENGTH OF IRRIGATION CANAL

PROPOSED

Main Canal

Canal	Length (m)
M - 1	2,350
M - 2	5,650
M - 3	6,500
M - 4	7,650
M - 5	3,900
Sub total	26,050
C - 1	2,850
C - 2	5,800
C - 3	6,250
C - 4	6,200
Sub total	21,100
LL - 1	4,400
LL - 2	6,700
LR - 1	2,200
LR - 2	3,800
LR - 3	4,900
Sub total	22,000
S - 1	9,250
S - 2	8,400
S - 3	3,550
Sub total	21,200
Total	90,350

M: Mountain Side Main Canal

C: Colocol Main Canal

LL: Lanog Left Main Canal

LR: Lanog Right Main Canal

S: Sto. Domingo Main Canal

Lateral Canal

Canal	Length (m)
M - L1	850
M - L2	7,800
M - L2 - 1L	5,200
M - L3	1,700
M - L4	3,900
M - L4 - 1R	1,350
M - L5	5,700
M - L6	1,100
M - L7	1,200
M - L8	1,650
M - L8 - 1L	650
M - L9	1,650
M - L9 - 1R	1,200
M - L10	5,700
M - L10 - 1R	1,600
M - L11	2,700
M - L12	3,500
M - L13	1,850
M - L14	2,900
M - L15	2,000
M - L15 - 1R	700
M - L16	2,250
M - L17	3,100
M - L18	3,300
M - L19	2,750
M - L20	6,900
M - L20 - 1R	900
M - L21	3,000
M - L22	1,000
Sub total	78,100
C - L1	500
C - L2	3,600
C - L3	5,100
C - L3 - 1R	1,800
C - L3 - 2R	1,300
C - L4	1,500
C - L4 - 1L	900
C - L5	7,500
C - L5 - 1L	1,100
C - L5 - 2L	1,800
C - L6	2,500
C - L7	2,000
C - L7 - 1L	600
C - L8	1,500
C - L9	3,800
C - L9 - 1L	1,100
C - L9 - 1R	1,500
C - L9 - 2L	1,150
C - L10	2,900
C - L11	1,300
C - L12	1,200
C - L13	2,400
C - L13 -1R	2,450
C - L14	2,500
C - L14 - 1L	1,400
C - L14 - 1R	2,450
C - L15	4,300
C - L15 - 1R	800
C - L15 - 2R	900
Sub total	60,100
LL - L1	1,550
LL - L2	1,100
LL - L3	2,100
LL - L4	1,300
LL - L5	2,300
LL - L6	1,800
LL - L7	800
LR - L1	4,300
LR - L1 - 1L	1,600
LR - L2	5,700
LR - L3	1,200
LR - L4	700
LR - L5	5,600
LR - L5 - 1L	1,400
LR - L6	500
LR - L7	1,100
LR - L8	2,100
LR - L9	1,300
LR - L10	900
Sub total	37,350
S - L1	1,400
S - L2	950
S - L3	2,000
S - L3 - 1R	1,650
S - L4	1,600
S - L5	2,100
S - L6	900
S - L7	400
S - L8	1,000
S - L9	1,550
S - L10	2,000
S - L11	300
S - L12	500
S - L13	300
S - L14	1,200
Sub total	17,800
Total	193,400

LENGTH OF IRRIGATION CANAL

NEWLY CONSTRUCTED AND REVISED

	Main canal			Lateral canal Type A			Type B			Type C			Type D		
	Total	Newly	Rev.	Total	Newly	Rev.	Total	Newly	Rev.	Total	Newly	Rev.	Total	Newly	Rev.
M-1	2,350	2,350		7,800	3,900	3,900	5,200	1,000	4,200				850		850
M-2	5,650	5,650					3,900	2,700	1,200	8,750	6,200	2,550			
M-3	6,500	6,500					5,700	1,200	4,500	15,250	5,000	10,250	1,850		1,850
M-4	7,650	7,650					3,300		3,300	13,000	11,800	1,200	700	700	
M-5	3,900	3,900					6,900	3,500	3,400	3,000	1,200	1,800	1,900	1,000	900
	26,050	26,050		7,800	3,900	3,900	25,000	8,400	16,600	40,000	24,200	15,800	5,300	1,700	3,600
C-1	2,850		2,850	5,100		5,100				5,400	3,100	2,300	1,800	1,800	
C-2	5,800		5,800				7,500	1,100	6,400	5,300		5,300	5,100	800	4,300
C-3	6,250		6,250				3,800	2,800	1,000	5,100	3,200	1,900	8,650	700	7,950
C-4	6,200		6,200				4,300	3,300	1,000	5,750	4,450	1,300	2,300	1,800	500
	21,100		21,100	5,100		5,100	15,600	7,200	8,400	21,550	10,750	10,800	17,850	5,100	12,750
LL-1	4,400	3,500	900							1,300	1,300		4,750	4,200	550
LL-2	6,700	2,600	4,100							3,100	2,300	800	1,800	600	1,200
LR-1	2,200	2,200					5,700	5,700		5,900		5,900			
LR-2	3,800	3,800					5,600	5,600		3,300	3,300				
LR-3	4,900	3,200	1,700							5,400	5,400		500	500	
	22,000	15,300	6,700				11,300	11,300		19,000	12,300	6,700	2,050	5,300	1,750
S-1	9,250	4,650	4,600							2,000		2,000	5,600	2,450	3,150
S-2	8,400	8,400								3,550		3,550	4,400	900	3,500
S-3	3,550	3,550											2,300	1,300	1,000
	21,200	16,600	4,600							5,550		5,550	12,300	4,650	7,650
Tot.	90,350	57,950	32,400	12,900	3,900	9,000	51,900	26,900	25,000	86,100	47,250	38,850	42,500	16,750	25,750

NUMBERS OF IRRIGATION CANAL RELATED STRUCTURES

NUMBERS OF RELATED STRUCTURES

Name of Structures	Numbers Main Canal	Lateral	Total
1. Headgate and Parshall Flume	2	-	2
2. Double Orifice	76	292	368
3. Fixed Proportional Divisor	-	24	24
4. Check	78	292	370
5. Chute	67	-	67
6. Vertical Drop	-	747	747
7. Wasteway	17	-	17
8. Syphon	20	13	33
9. Drainage Culvert	12	-	12
10. Bridge	36	-	36
11. Pipe Road Crossing	17	83	100
12. Drain Inlet	69	-	69
Total			1,845

NUMBERS OF IRRIGATION CANAL RELATED STRUCTURES

NUMBERS OF MAIN CANAL STRUCTURES

Name\Type	Turnout Headgate A	B	C	Turnout Double Orifice A	B	C	D	Check A	B	C	D	E	F	Drop (Chute) A	B	C	D	E	F	Syphon B	D	E	F	Drainage Culvert A	B	D	E
M-1		1				1			2											1					1		
M-2				1	2				3											1							
M-3				1	7				8											2					4		
M-4				1	5						6						1				3					4	
M-5				1	1	1						3						7				2					1
C-1			1		1	1				3						3											
C-2				1	2	1				4						8											
C-3				1	3	2					6						10										
C-4					2		5					7						3				1					
LL-1					3	1	1					5						1				2					
LL-2					2	1	3						6						8								
LR-1				1	1						2						1									1	
LR-2				1	2		1				4																
LR-3					4	1						5						5									1
S-1					1	3						4						17				1					
S-2					2	4						6						2				5					
S-3						4							4						1				2				
Sub-total	-	1	1	8	38	20	10	-	13	7	18	30	10	-	-	11	12	35	9	4	3	11	2	-	5	5	2
Total			2				76						28						62				20				12

Name\Type	Road Crossing Bridge A	B	C	D	Road Crossing Pipe R.Cros E	F	Drain Inlet	Waste Way A	B	C	D	E	F
M-1		3					2		1				
M-2		2					6		1				
M-3		7					7		1				
M-4				7			8				1		
M-5					1		4					1	
C-1										1			
C-2			6					1					
C-3				3							1		
C-4					3							1	
LL-1				2	1		4					1	
LL-2						2	7						1
LR-1							2				1		
LR-2				4			4				1		
LR-3					2		5					1	
S-1					2		9					1	
S-2					6		8					1	
S-3				2			3						1
Sub-total	-	12	6	18	15	2	69	1	3	1	4	6	2
Total				36		17	69						17

NUMBERS OF IRRIGATION CANAL RELATED STRUCTURES

NUMBERS OF LATERAL CANAL STRUCTURES

	Turnout				Check	Drop				Syphon	Road Crossing	Divisor		
	Double Orifice					Vertical Drop					Pipe R.Cr.			
Name\Type	A	B	C	D	F	A	B	C	D	F	F	A	B	C
M-1				25	25	29	23		3	1	9	1		
M-2				17	17		18	35		1	6		1	
M-3				35	35		25	60	6	1	5		1	2
M-4				28	28		15	51	2	1	5			1
M-5				16	16		31	12	6		5			1
C-1				19	19	19		21	6	3	9		1	1
C-2				20	20		33	21	15	1	9		1	3
C-3				22	22		17	20	25	1	9			4
C-4				19	19		19	23	7	1	8		2	2
LL-1				10	10			5	14	1	1			
LL-2				11	11			12	6	1	1			
LR-1				14	14		25	23		1	5		1	
LR-2				15	15		25	13			5		1	
LR-3				13	13			21	2		3			
S-1				10	10			8	17		1			1
S-2				12	12			14	13		1			
S-3				6	6				7		1			
Sub-total	-	-	-	292	292	48	231	339	129	13	83	1	8	15
Total				292	292				747	13	83			24

EVALUATION OF PRESENT CREEK

Section	Present Capacity of Flow: Depth (m)	Flow Area (sq.km)	Hydrolic Radius (m)	n	I 1/	Capacity (cu.m/s)	Estimated Flow Discharge (cu.m/s)
1	1.8	11.4	1.0	0.03	0.005	26.64	16.05
2	1.1	6.8	0.6	0.03	0.005	10.88	17.75
3	1.7	5.5	0.6	0.03	0.005	9.19	6.62
4	0.6	6.1	0.5	0.03	0.005	8.60	2.80
5	1.6	3.8	0.5	0.03	0.005	5.93	2.78
6	1.0	4.8	0.7	0.03	0.005	8.76	1.40
7	1.7	12.6	0.9	0.03	0.005	27.57	1.76
8	1.3	7.6	0.8	0.03	0.005	15.77	11.09
9	1.5	18.5	1.1	0.03	0.005	46.52	14.48
Lanog 1	3.3	60.6	2.3	0.03	0.002	164.35	65.51
Lanog 2	2.3	51.1	1.7	0.03	0.002	110.30	95.12
Lanog 3	3.4	81.4	2.1	0.03	0.002	186.17	223.24
Lanog 4	4.0	82.0	2.4	0.03	0.002	205.85	223.24
Lanog 5	4.0	109.4	2.8	0.04	0.002	221.39	250.92

1/ ; Estimated Slope of Creek under Present Conditions

Length of Proposed Drainage Canal

1) Rivers, Creek and Main Canal (Partial Improvment)

Name of Canal	Length (m)	Remarks
N - 1	1,460	N: Nangalisan River
N - 2	4,370	
N - 3	1,440	L: Lanog River
N - 4	3,990	
Subtotal	11,260	
L - 1	6,570	2,480 mimproved
L - 2	3,280	entirely improved
L - 3	1,190	-do-
L - 4	1,900	-do-
L - 5	1,150	-do-
L - 6	1,260	
L - 7	2,290	
L - 8	1,520	
L - 9	1,930	
L - 10	1,230	
L - 11	2,100	
L - 12	1,600	
Subtotal	26,020	
W	5,120	W: Wacal Creek
RB - 1	1,040	RB: River in right side of Bintawan River
RB - 2	1,640	
RB - 3	1,600	
RB - 4	2,250	
Subtotal	6,530	
B - 1	200	B: Bintawan River
B - 2	1,710	
B - 3	2,610	
Sub total	4,520	
LB	2,410	LB: River in left side of Bintawan river
A - 1	4,220	
A - 2	2,890	A: Apad Creek
M11	2,400*	M11:Apad Floodway
Subtotal	9,510	
Total	65,370	

Total of New Canal 2,400

Total of Partial Improvement 6,500

2) Lateral Drainage Canal

Name of Canal	Length (m)	Remarks
LU1	4,100	LU: flow in Lamut River
LU2	3,600	
Sub total	7,700	
N - L1	1,600	N: Nangalisan River
N - L2	3,910	
N - L3	3,660	
N - L4 - 1	2,250	
N - L4 - 2	3,340	
N - SL1	2,560	
Sub total	17,320	
L - L1	1,280	L: Lanog River
L - L2	1,550 *	
L - L3	2,000 *	
L - L4	1,000 *	
L - L5	2,660	
L - L6	2,260	
L - L7 - 1	1,760	
L - L7 - 2	1,040	
L - L7 - 3	2,150	
L - L8	4,960	
L - L9	3,240	
L - SL1	1,730	
L - SL2	1,200	
L - SL3	1,440	
Sub total	28,270	
RB - L1	2,560	RB: River in right side of Bintawan River
RB - L2	1,840	
RB - L3	1,700	
RB - L4	1,580	
Sub total	7,680	
A - L1	3,350	A: Apad Creek
B - L1 - 1	2,330	B: Bintawan River
B - L1 - 2	4,070	
B - L2	1,950	
B - SL1	2,940	
Sub total	11,290	

*: Newly Constructed

Name of Canal	Length (m)	Remarks
M1	4,480	M: flow in Magat River
M2 - 1	1,030	
M2 - 2	1,600	
M2 - L1	1,440	
M3 - 1	1,930	
M3 - 2	300	
M3 - 3	1,040	
M3 - 4	1,730	
M3 - L1	1,880	
M3 - L2	610	
M3 - L3	890	
M4	2,010	
M5	950*	
M6 - 1	2,320*	
M6 - 2	3,830*	
M6 - L1	3,450*	
M7	2,400	
M8	1,570	
M9	3,850	
M10	1,180*	
M12 - 1	790	
M12 - 2	2,210	
M12 - L1	1,620	
M13	1,890*	
Sub total	45,000	
S1	2,120	S: flow in Magat River at Sto Domingo
S2	720	
S3	1,030	
S4	730	
S5	1,160	
S6	1,680*	
Sub total	7,440	
Floodway for Colocol Main Canal	1,500	*: Constructed Newly
Total	129,550	

Total of New Canal 19,850

Total of Partial Improvement 13,400

TABLE VII - 16

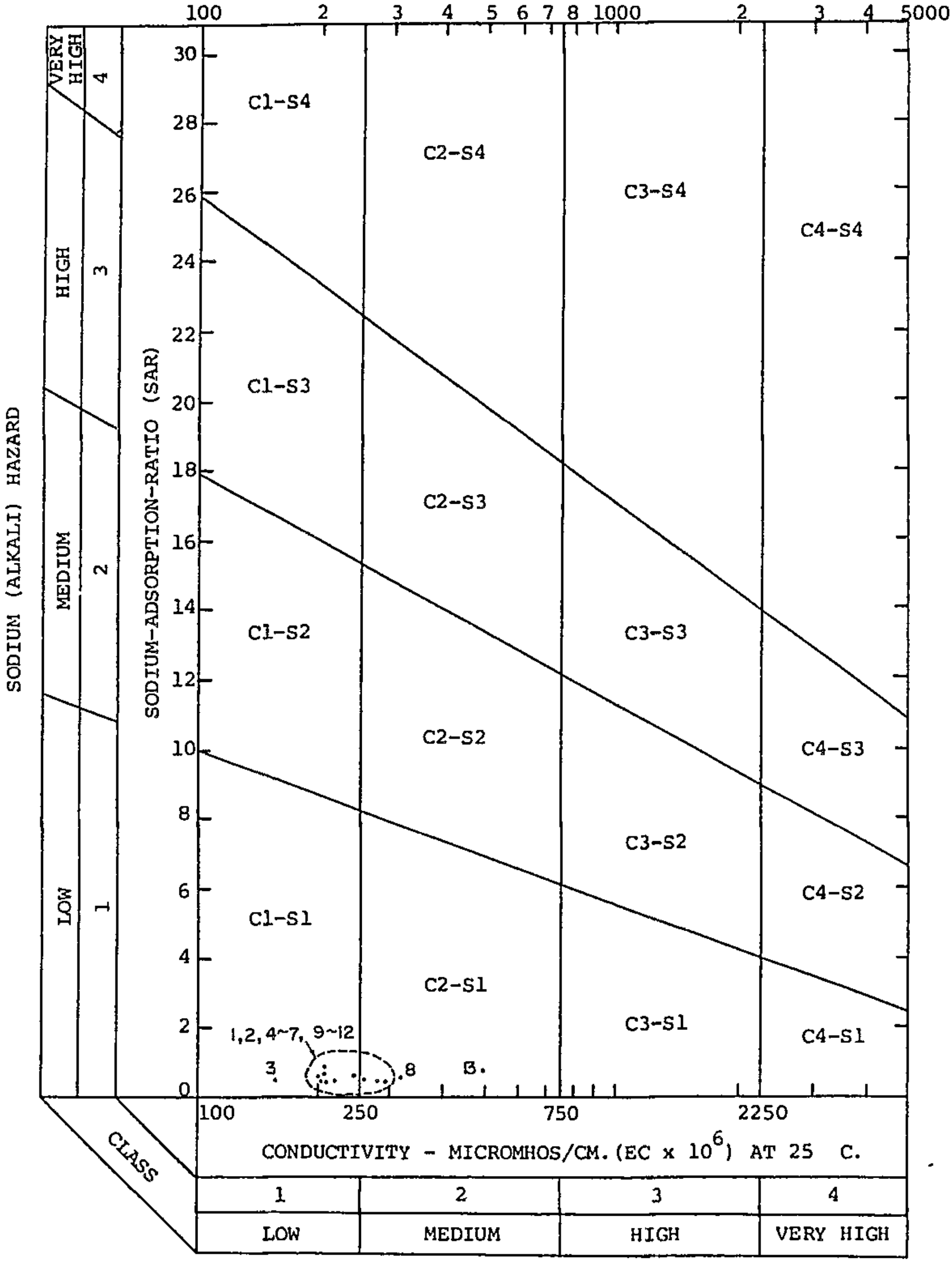
LENGTH OF PROPOSED INSPECTION ROADS

Unit: m

Road width	Mountain side Main Canal		Colocol Main Canal		Lanog Main Canal		Sto. Domingo Main Canal		Total
	Main Canal	Lateral Canal	Main Canal	Lateral Canal	Main Canal	Lateral Canal	Main Canal	Lateral Canal	
6 m	14,500	-	-	-	-	-	-	-	14,500
4 m	11,550	95,440	21,100	55,390	22,000	39,700	21,200	7,300	273,680
3 m	-	6,950	-	23,400	-	9,270	-	16,100	55,720
Total	26,050	102,390	21,100	78,790	22,000	48,970	21,200	23,400	343,900
	(128,440)		(99,890)		(70,970)		(44,600)		

FIG.VII-1

DIAGRAM FOR CLASSIFICATION OF IRRIGATION WATER



SALINITY HAZARD

IRRIGATION PLAN FOR RIGHT BANK OF MAGAT RIVER

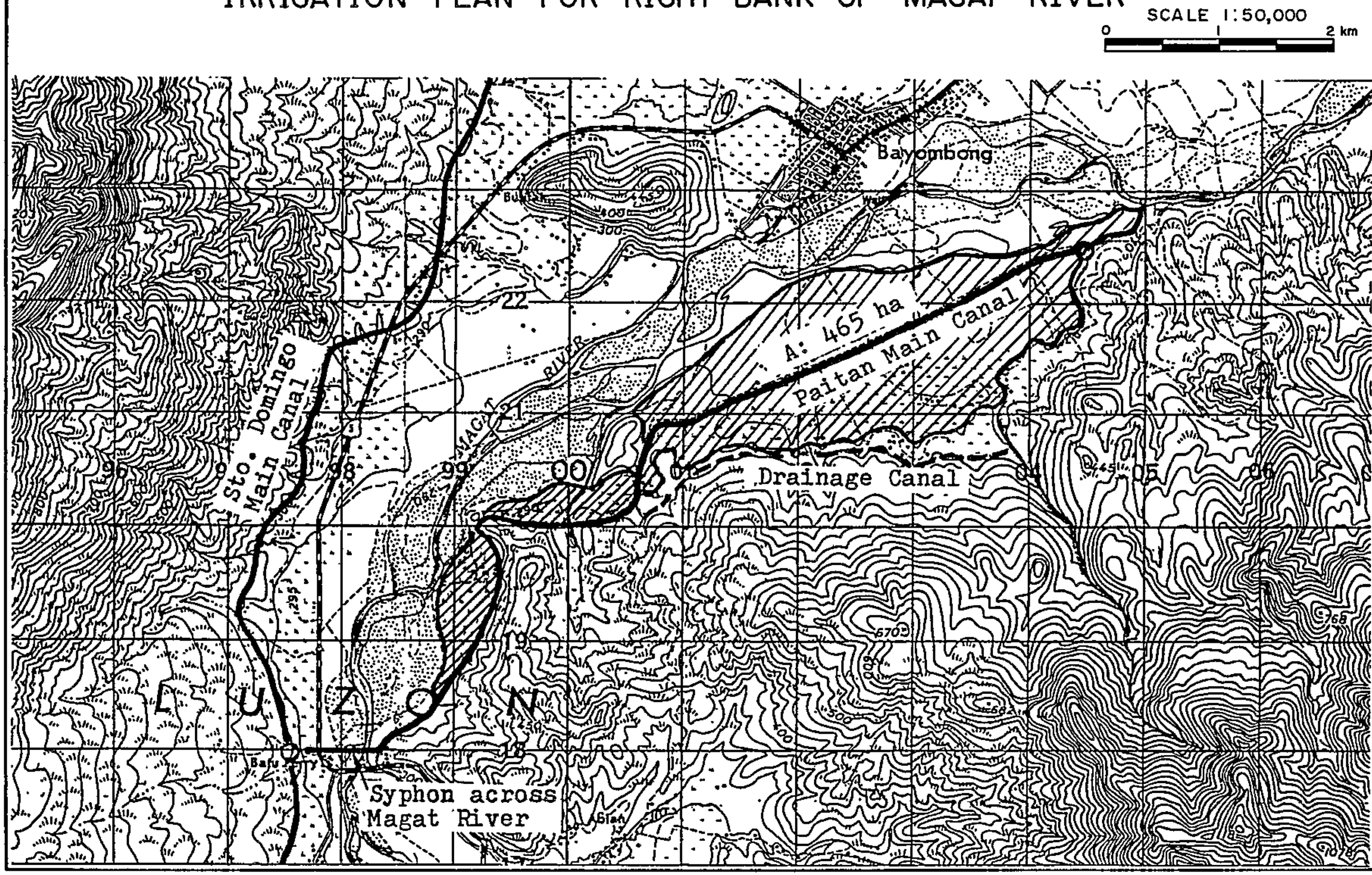
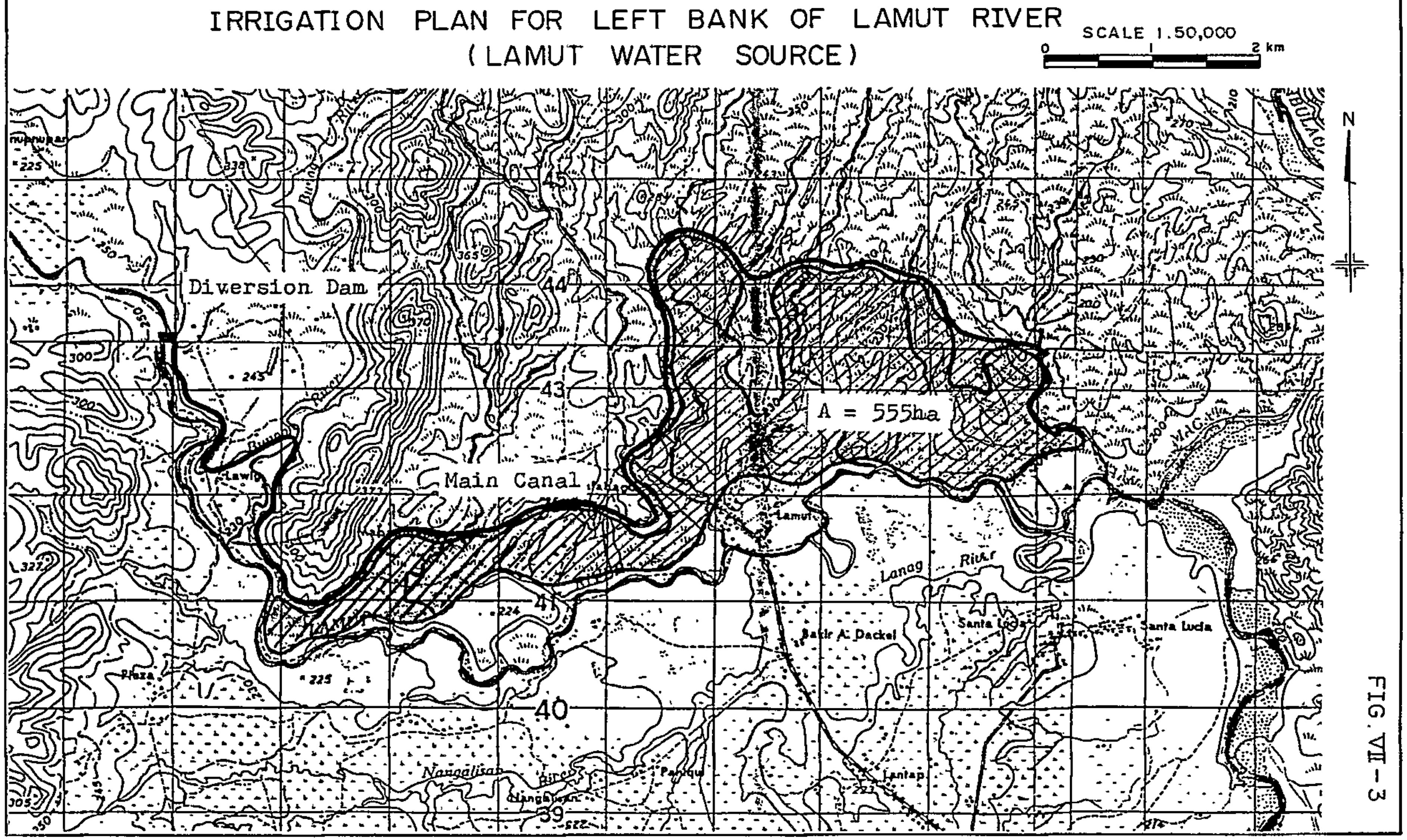


FIG. VII - 2

FIG. VII - 3

IRRIGATION PLAN FOR LEFT BANK OF LAMUT RIVER
(LAMUT WATER SOURCE)



IRRIGATION PLAN FOR LEFT BANK OF LAMUT RIVER (MAGAT WATER SOURCE)

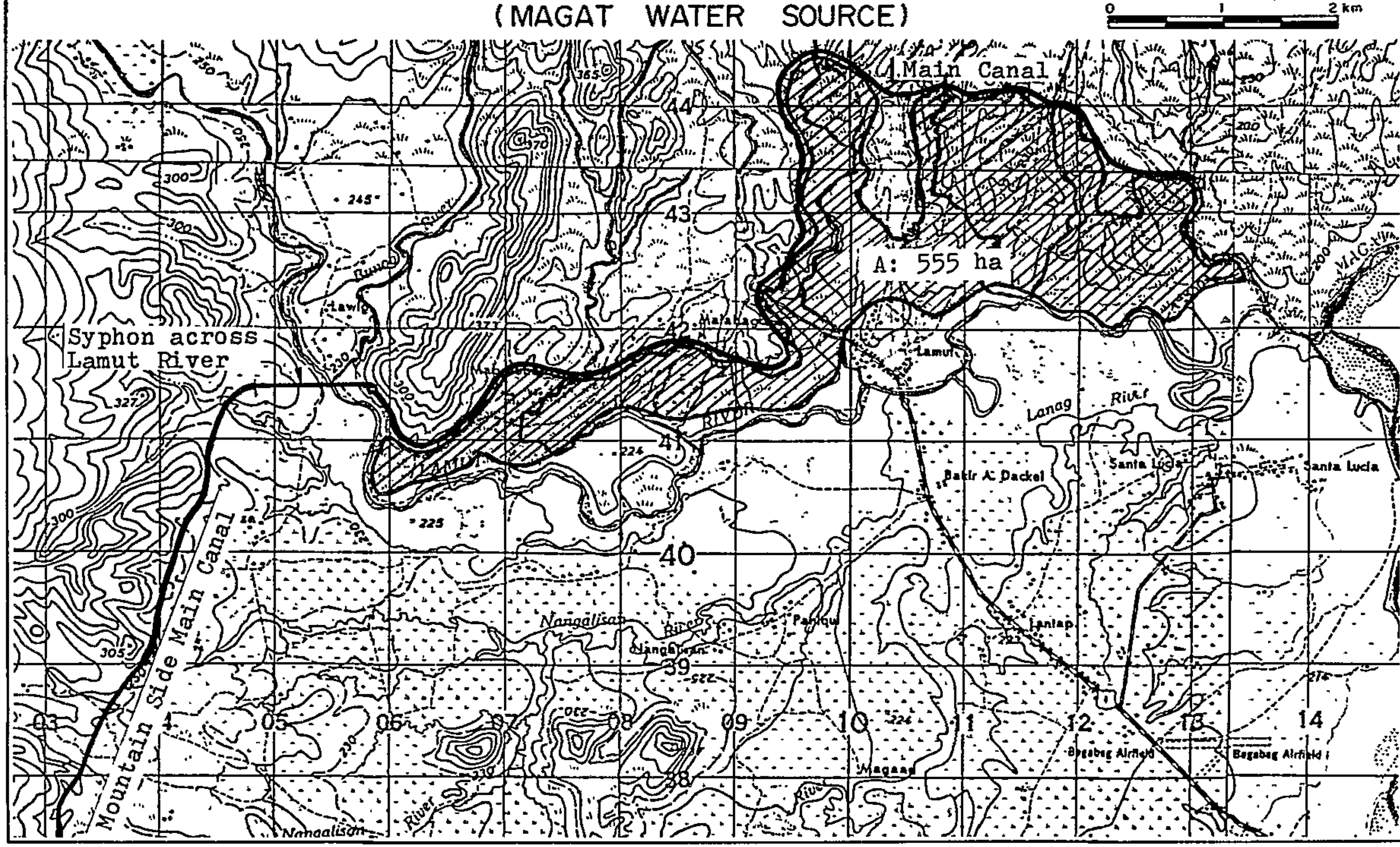
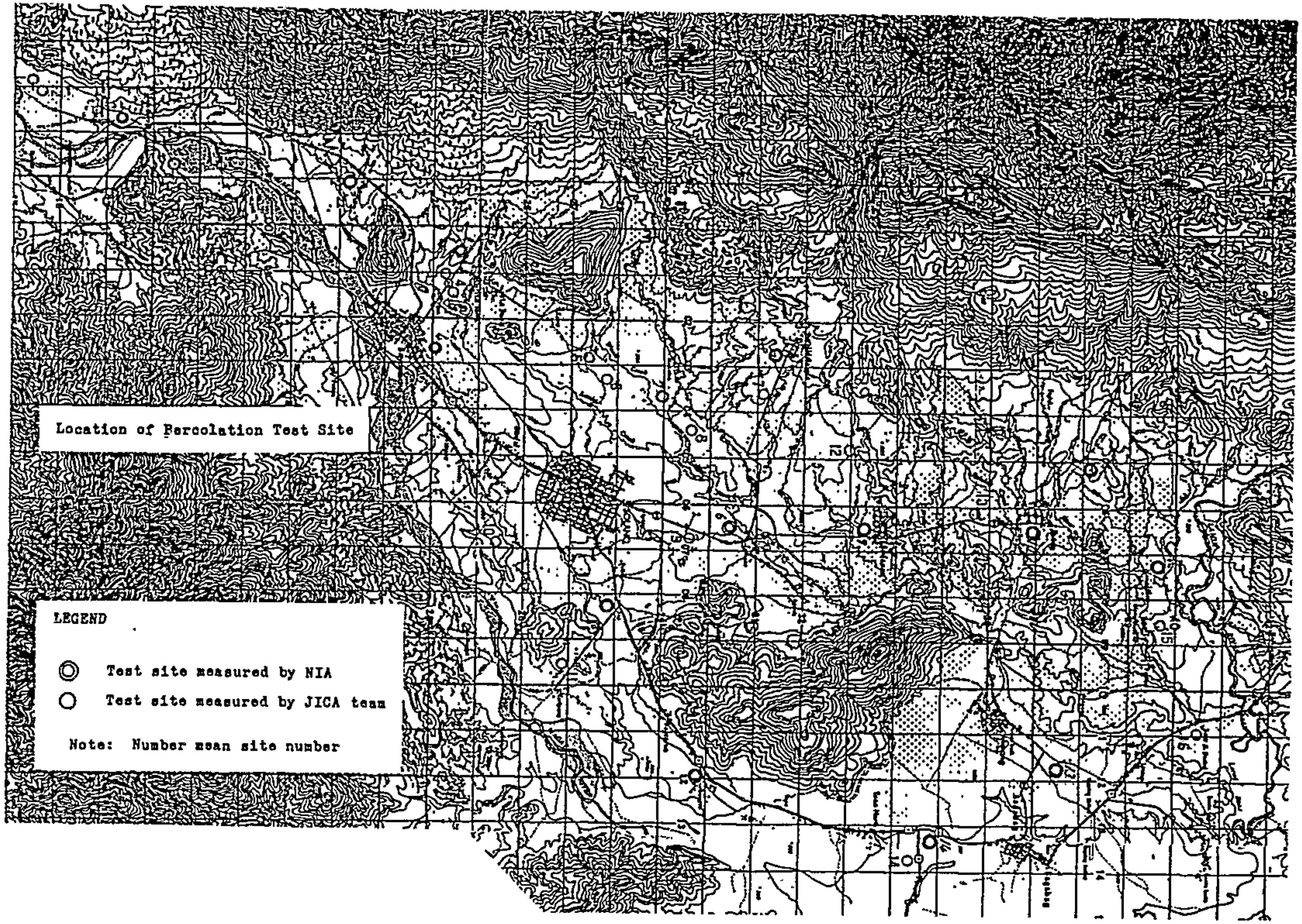


FIG. VII-4

LOCATION OF PERCOLATION TEST SITE



GENERAL PLAN OF PROPOSED IRRIGATION SYSTEM

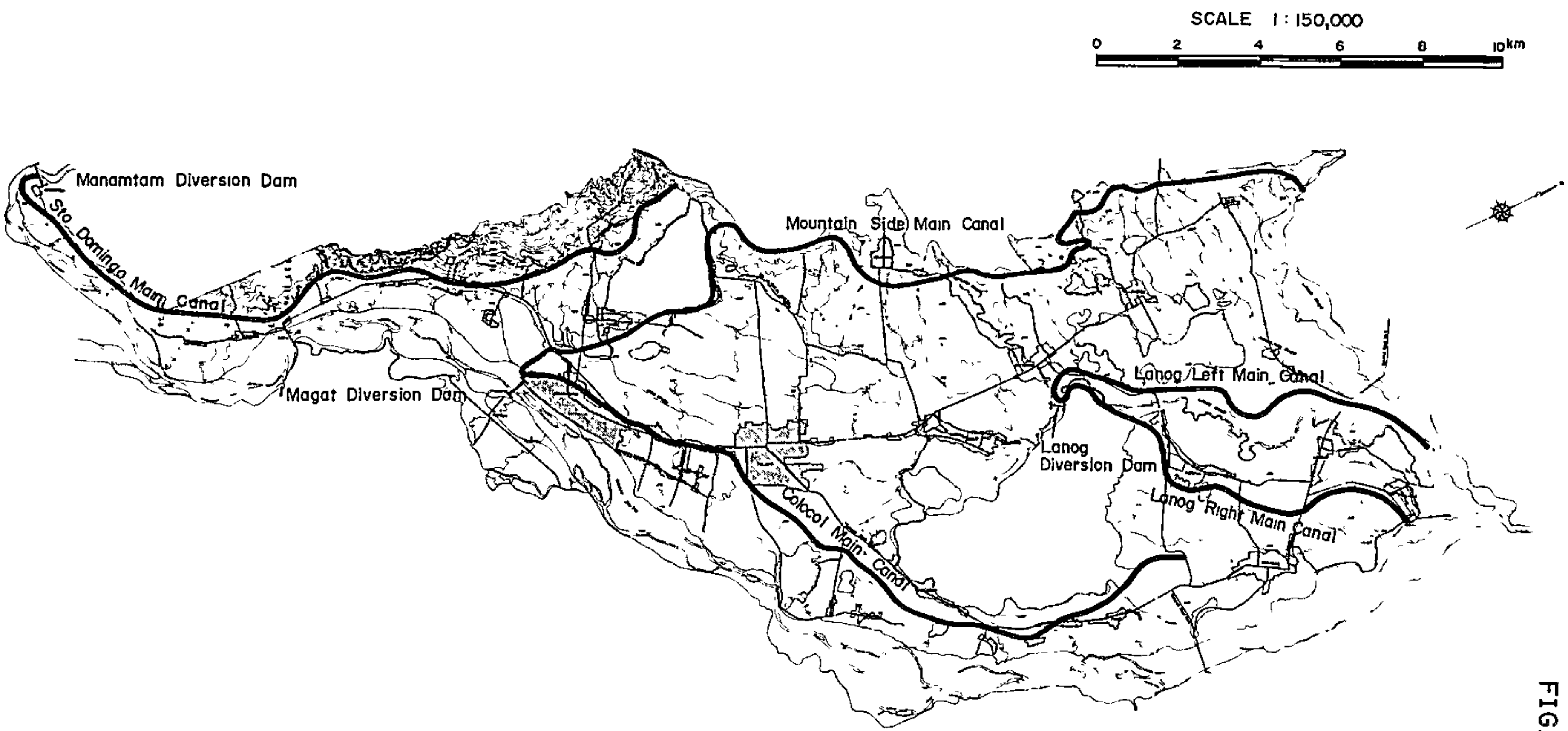


FIG. VII-6

FIG. VII-7

ALTERNATIVE PLAN OF IRRIGATION SYSTEM (MANAMTAM PLAN)

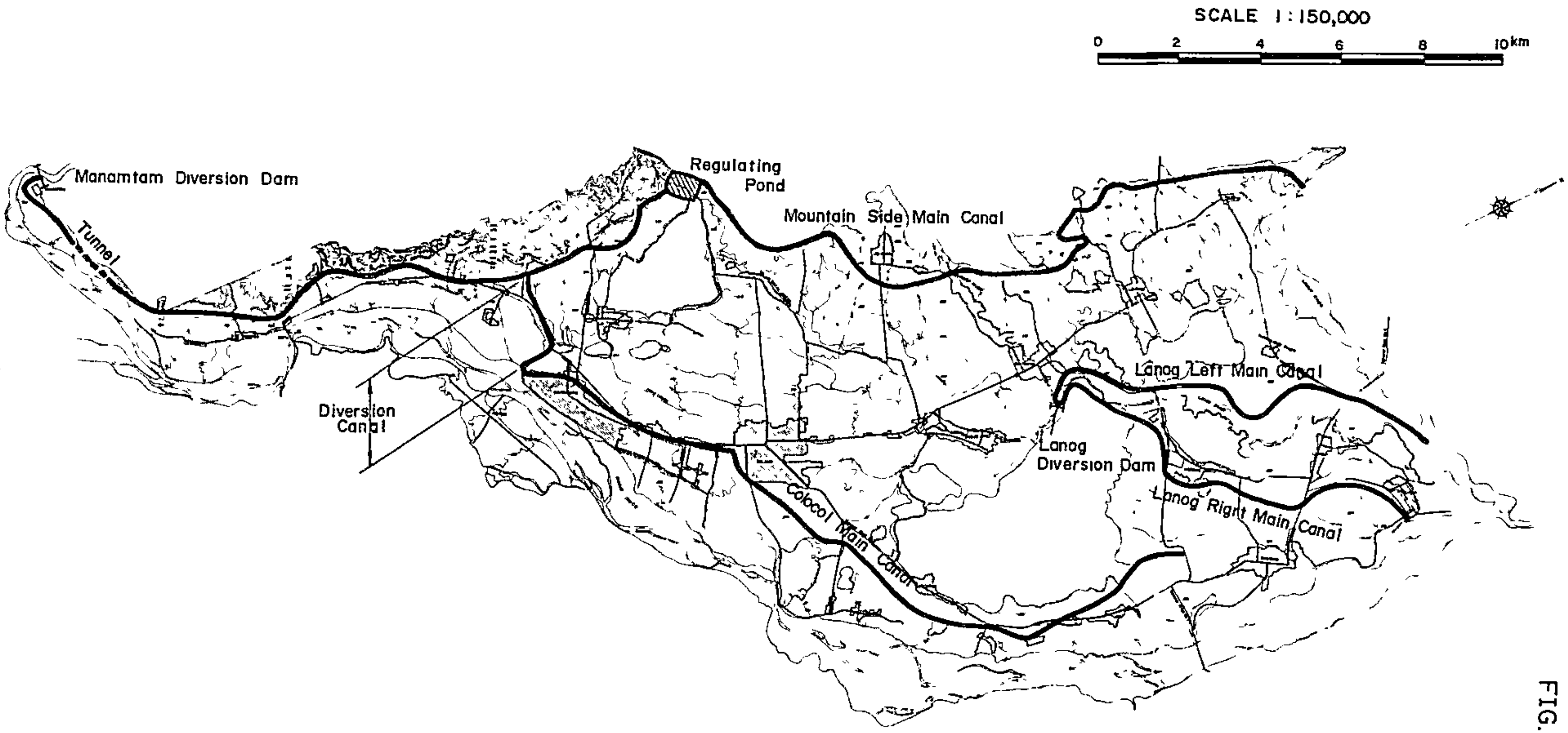
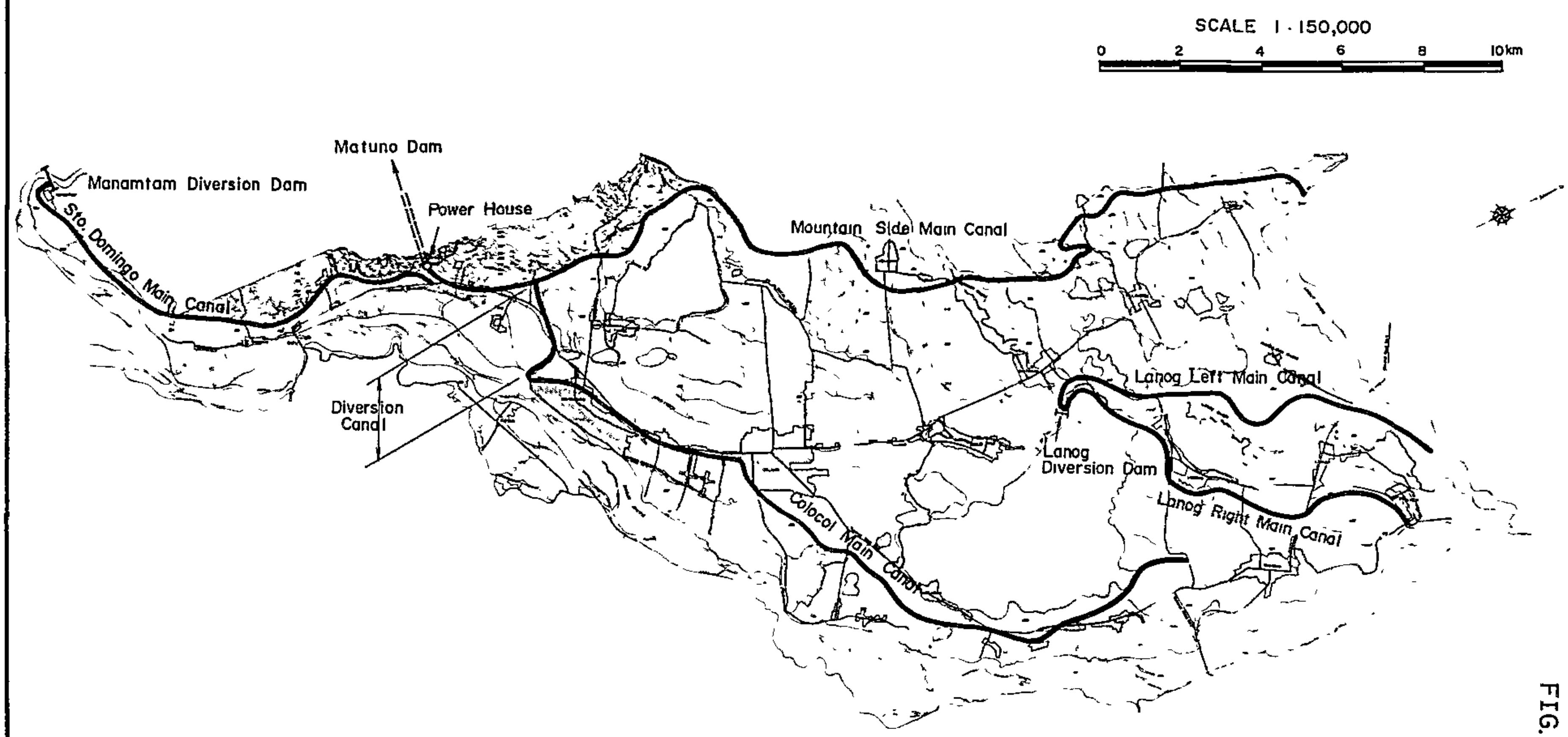
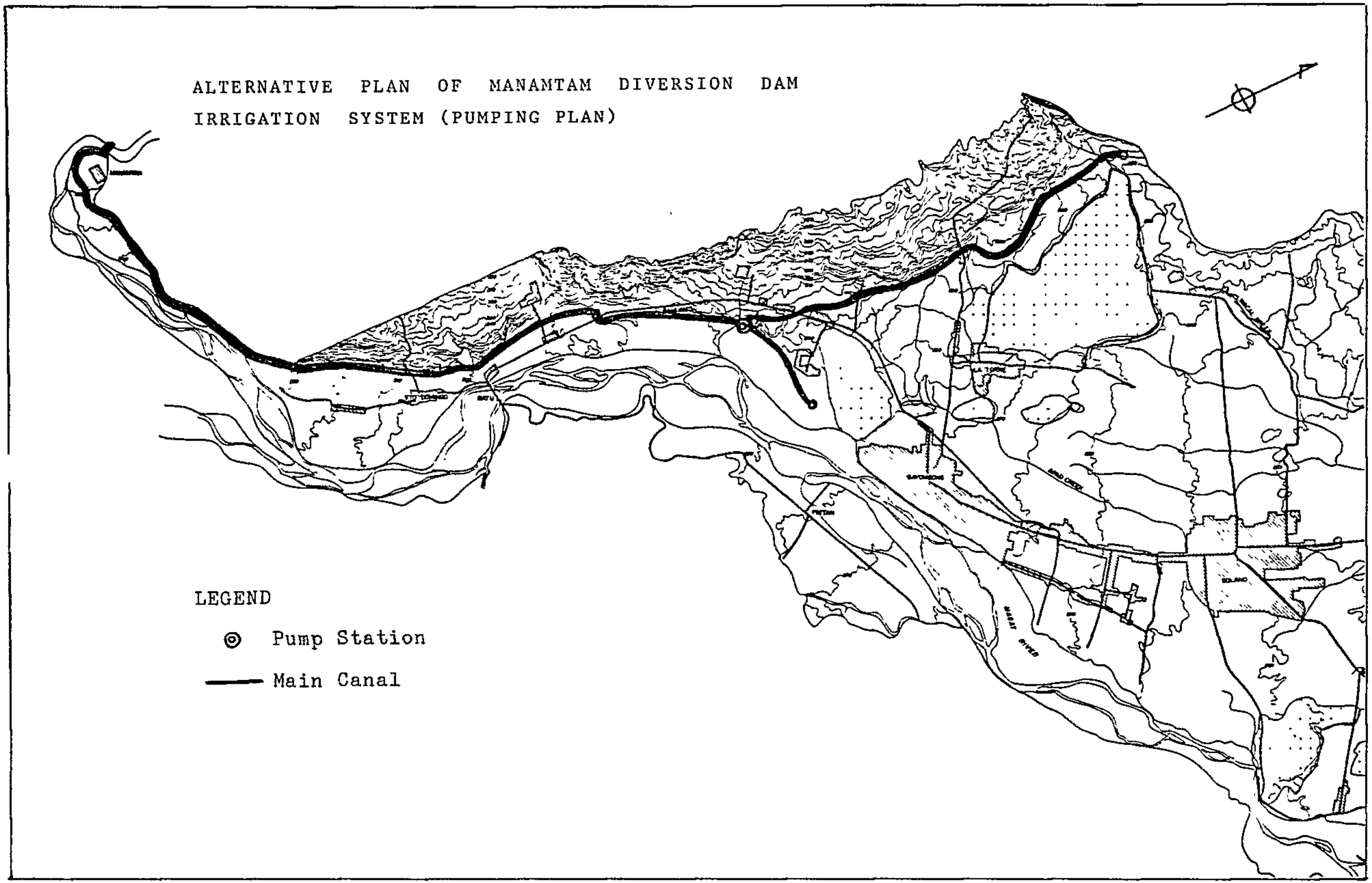


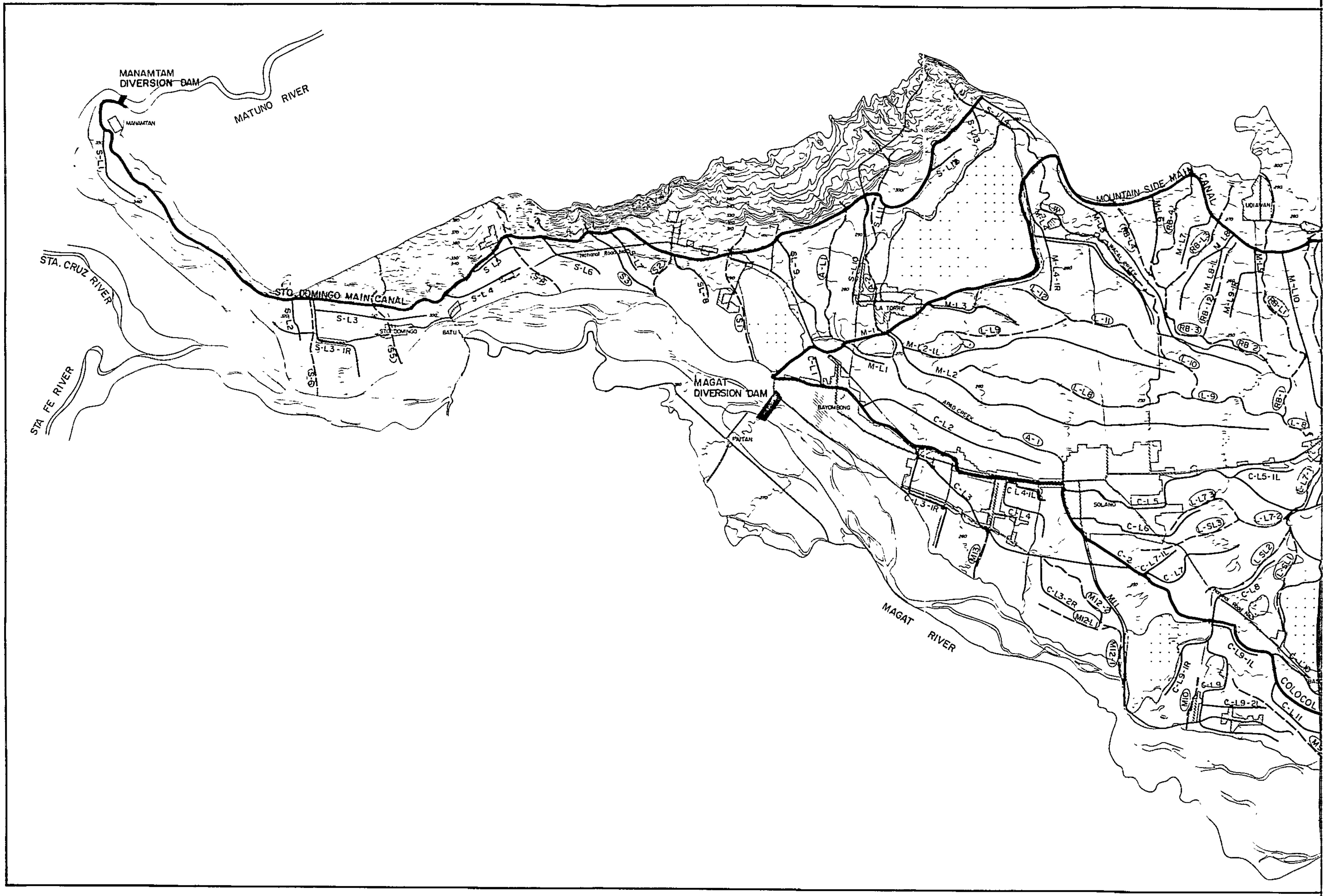
FIG. VII-8

ALTERNATIVE PLAN OF IRRIGATION SYSTEM (TAILRACE PLAN)



ALTERNATIVE PLAN OF MANAMTAM DIVERSION DAM IRRIGATION SYSTEM (PUMPING PLAN)

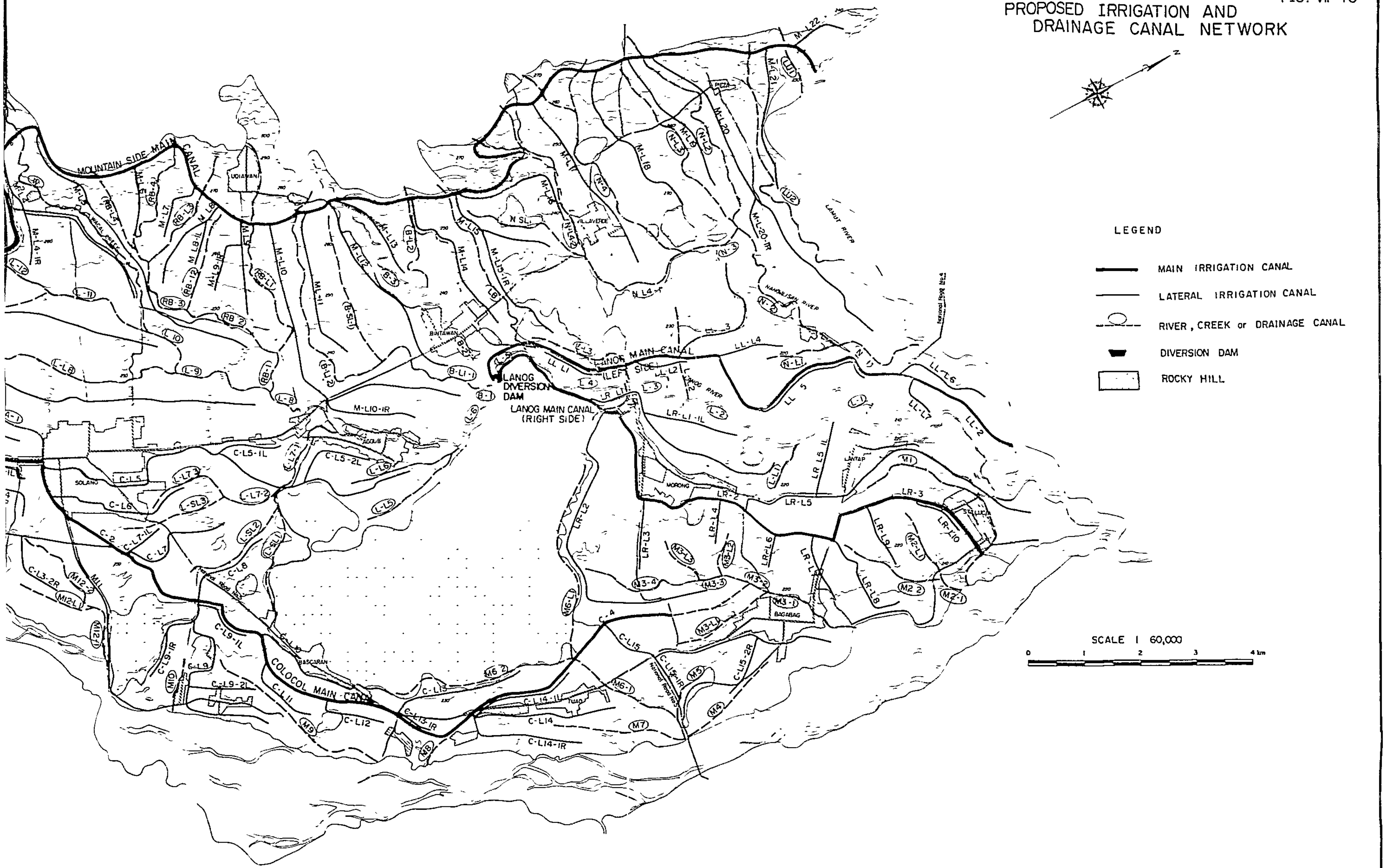


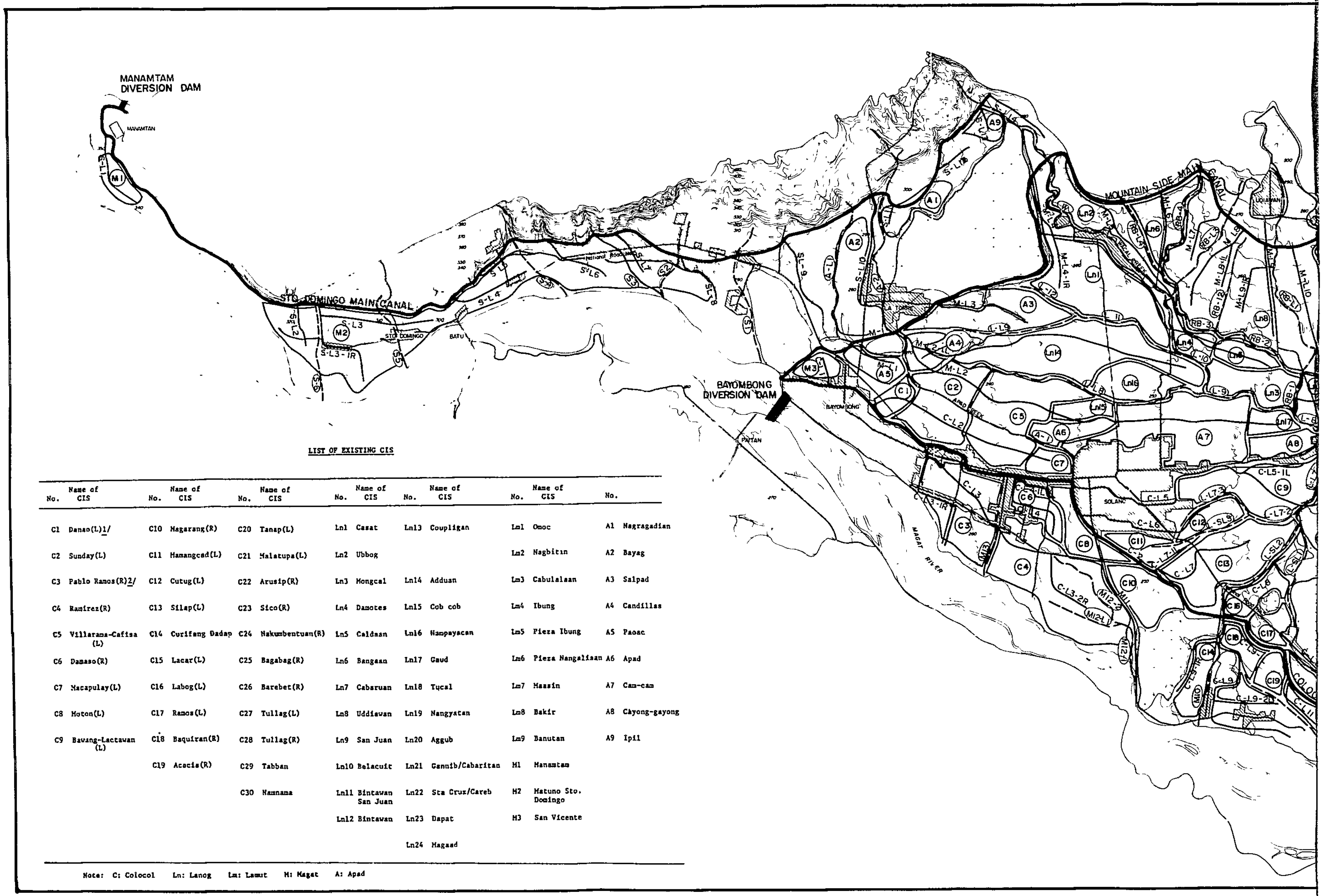


MANAMTAM
DIVERSION DAM
MATUNO RIVER
STA. CRUZ RIVER
STA FE RIVER
STO. DOMINGO MAIN CANAL
MAGAT
DIVERSION DAM
MAGAT RIVER
MOUNTAIN SIDE MAIN CANAL
BAYOMBONG
LA TORRE
SOLANO
STO DOMINGO
BATU
APAO CREEK

FIG. VII-10

PROPOSED IRRIGATION AND DRAINAGE CANAL NETWORK

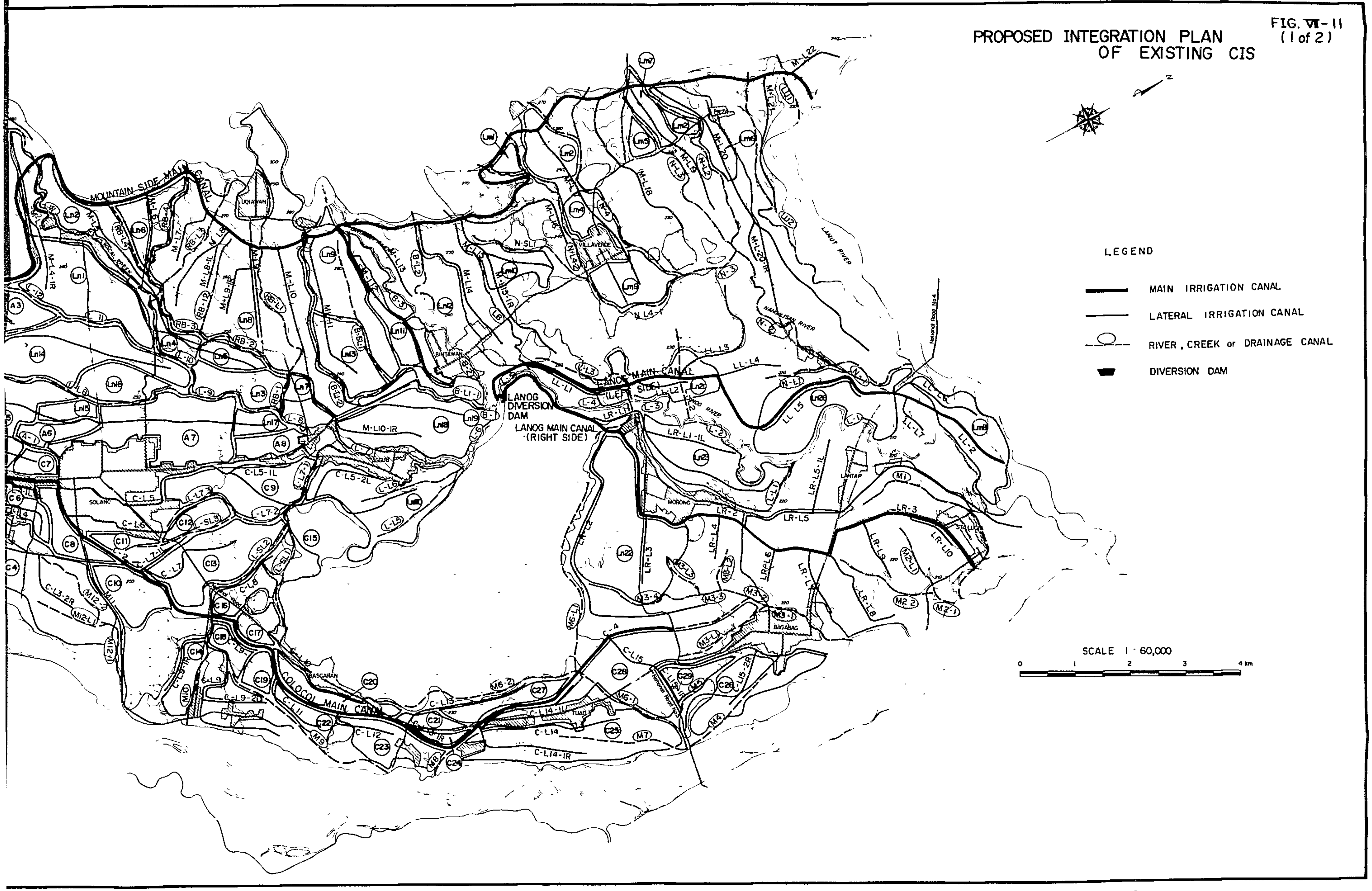




LIST OF EXISTING CIS

No.	Name of CIS	No.	Name of CIS	No.	Name of CIS	No.	Name of CIS	No.	Name of CIS	No.	Name of CIS	No.	
C1	Danao(L)1/	C10	Magarang(R)	C20	Tanap(L)	Ln1	Casat	Ln13	Coupligan	Lm1	Omoc	A1	Nagragadian
C2	Sunday(L)	C11	Hamangcad(L)	C21	Malatupa(L)	Ln2	Ubbog			Lm2	Nagbitin	A2	Bayag
C3	Pablo Ramos(R)2/	C12	Cutug(L)	C22	Arusip(R)	Ln3	Mongcal	Ln14	Adduan	Lm3	Cabulalaan	A3	Salpad
C4	Ramirez(R)	C13	Silap(L)	C23	Sico(R)	Ln4	Damotes	Ln15	Cob cob	Lm4	Ibung	A4	Candillas
C5	Villarama-Cafisa (L)	C14	Curifang Dadap	C24	Nakumbentuan(R)	Ln5	Caldaan	Ln16	Hampayacan	Lm5	Pieza Ibung	A5	Paoac
C6	Damaso(R)	C15	Lacar(L)	C25	Bagabag(R)	Ln6	Bangaan	Ln17	Gaud	Lm6	Pieza Nangalisan	A6	Apad
C7	Macapulay(L)	C16	Labog(L)	C26	Barebet(R)	Ln7	Cabaruan	Ln18	Tycal	Lm7	Maasin	A7	Cam-cam
C8	Moton(L)	C17	Ramos(L)	C27	Tullag(L)	Ln8	Uddiawan	Ln19	Nangyatan	Lm8	Bakir	A8	Cayong-gayong
C9	Bawang-Lactawan (L)	C18	Baquiran(R)	C28	Tullag(R)	Ln9	San Juan	Ln20	Aggub	Lm9	Banutan	A9	Ipil
		C19	Acacia(R)	C29	Tabban	Ln10	Belacuit	Ln21	Gannib/Cabaritan	M1	Manamtam		
				C30	Namnama	Ln11	Bintawan San Juan	Ln22	Sta Cruz/Careb	M2	Matuno Sto. Domingo		
						Ln12	Bintawan	Ln23	Dapat	M3	San Vicente		
								Ln24	Magaad				

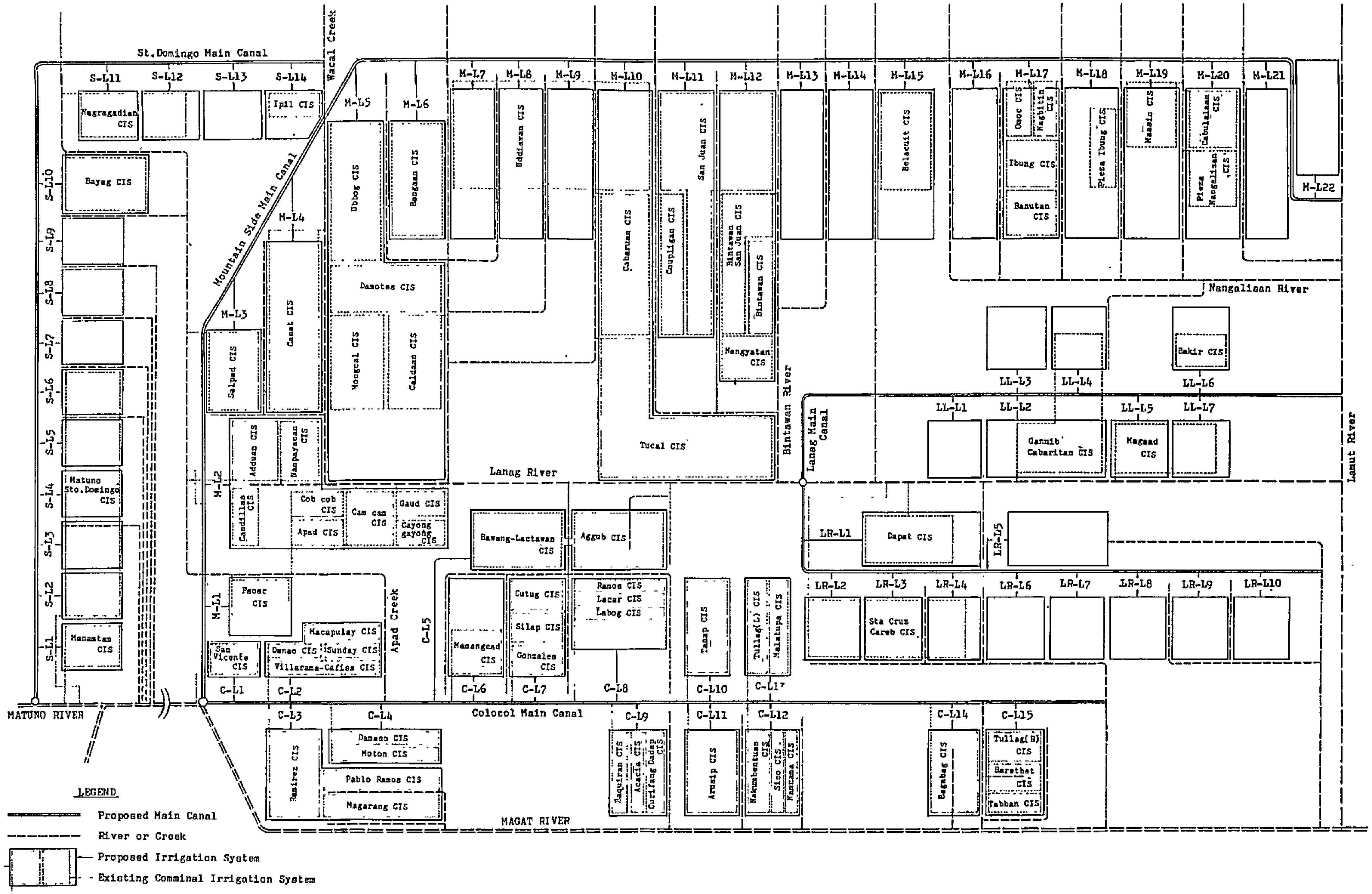
Note: C: Colocol Ln: Lanog Lm: Lamut M: Magat A: Apad



PROPOSED INTEGRATION PLAN
OF EXISTING CIS
FIG. VII-11
(1 of 2)
LEGEND
MAIN IRRIGATION CANAL
LATERAL IRRIGATION CANAL
RIVER, CREEK or DRAINAGE CANAL
DIVERSION DAM
SCALE 1 : 60,000
0 1 2 3 4 km
MOUNTAIN SIDE MAIN CANAL
LANOG MAIN CANAL (LEFT SIDE)
LANOG DIVERSION DAM
LANOG MAIN CANAL (RIGHT SIDE)
COLOCOL MAIN CANAL
LAMUT RIVER
SOLANO
BAGABAG
VILLAVERDE

FIG-VII-11
(2 of 2)

PROPOSED INTEGRATION PLAN OF EXISTING CIS



PROPOSED TYPICAL LAYOUT OF ON-FARM FACILITIES

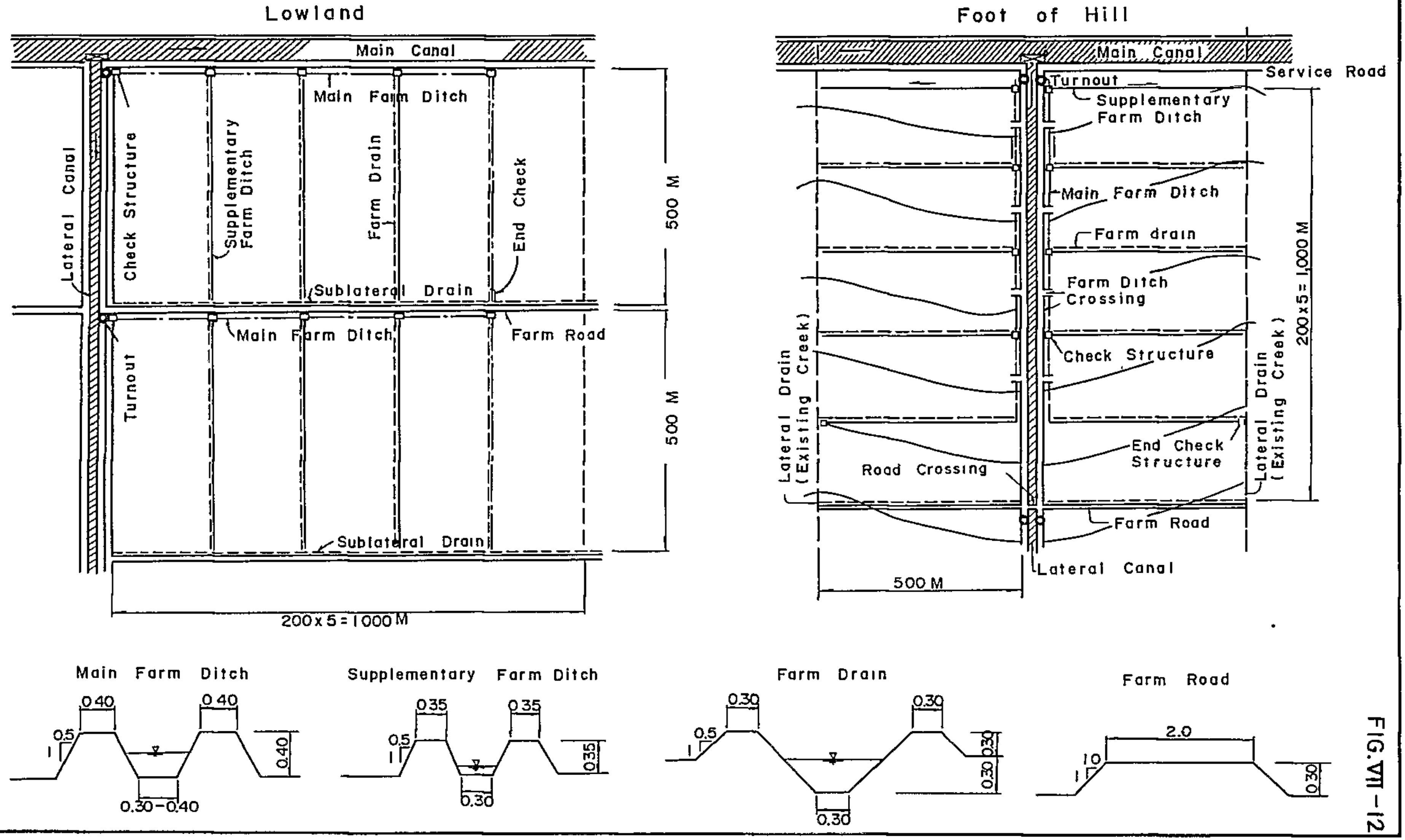
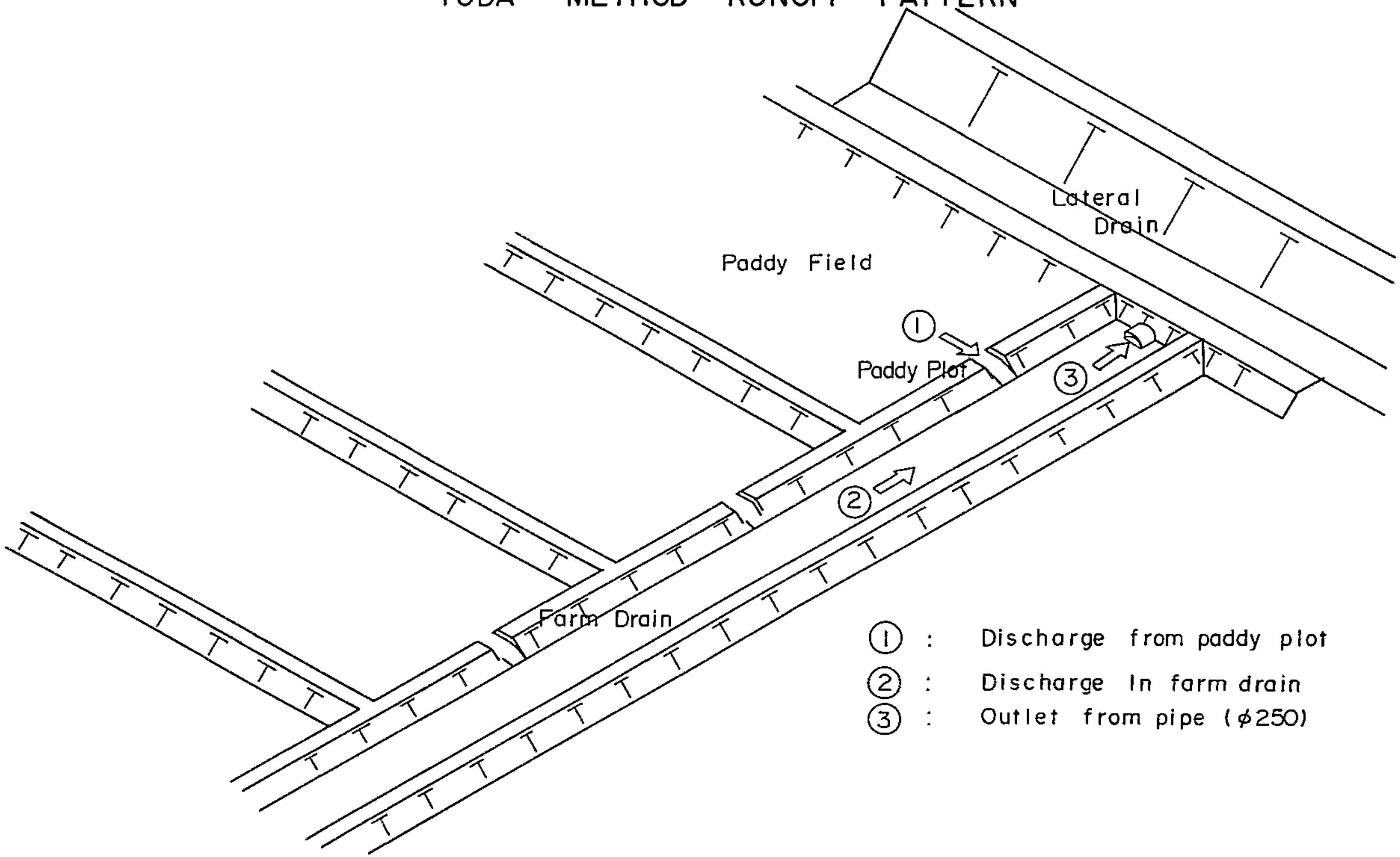


FIG.VII-12

FIG. Ⅶ - 13

TODA METHOD RUNOFF PATTERN



① : Discharge from paddy plot
② : Discharge In farm drain
③ : Outlet from pipe (ϕ250)

FLOW CAPACITY OF EACH PROCESS FOR TODA METHOD

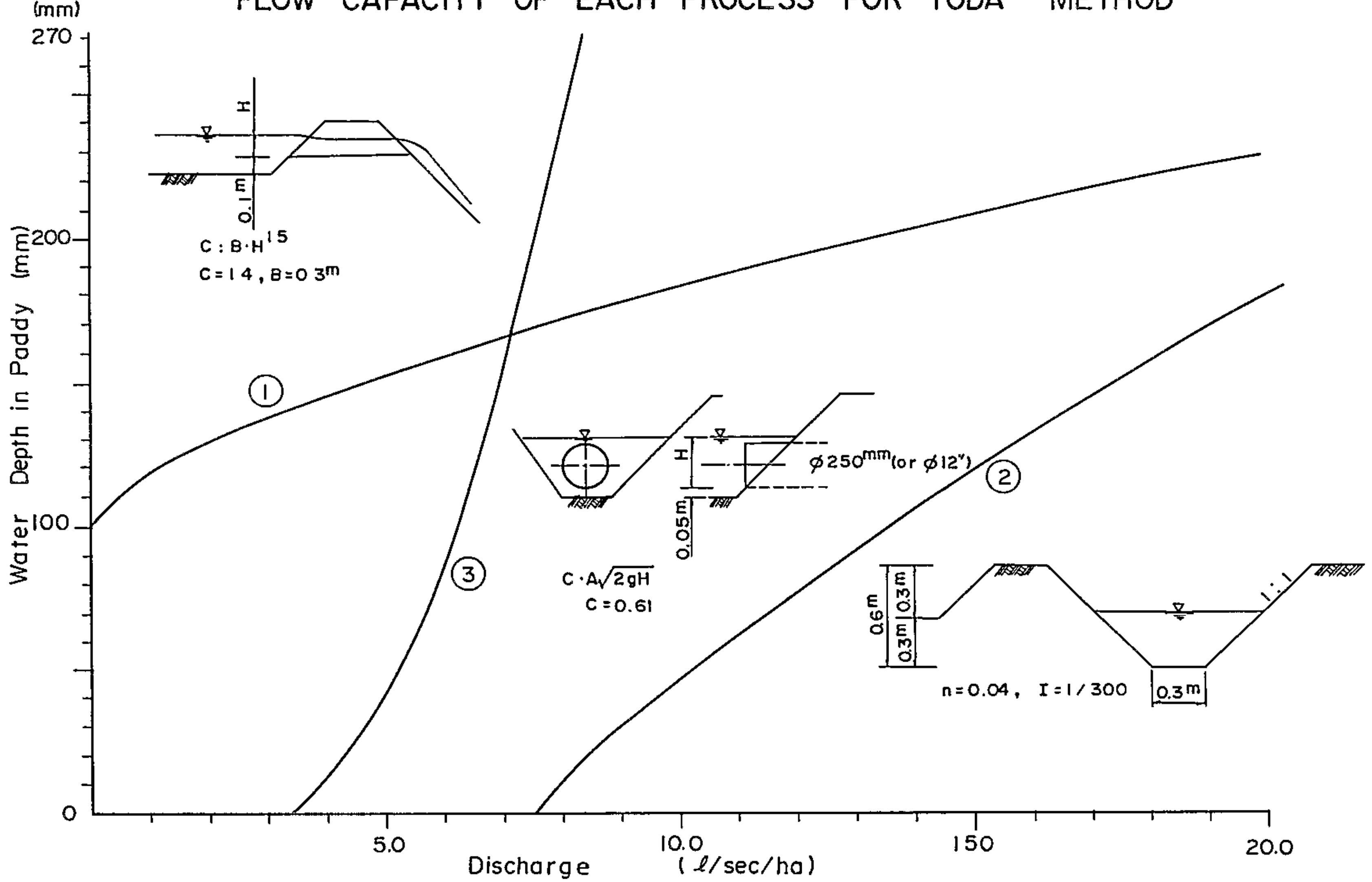


FIG. VII - 14

ESTIMATED DISCHARGE BY TODA METHOD

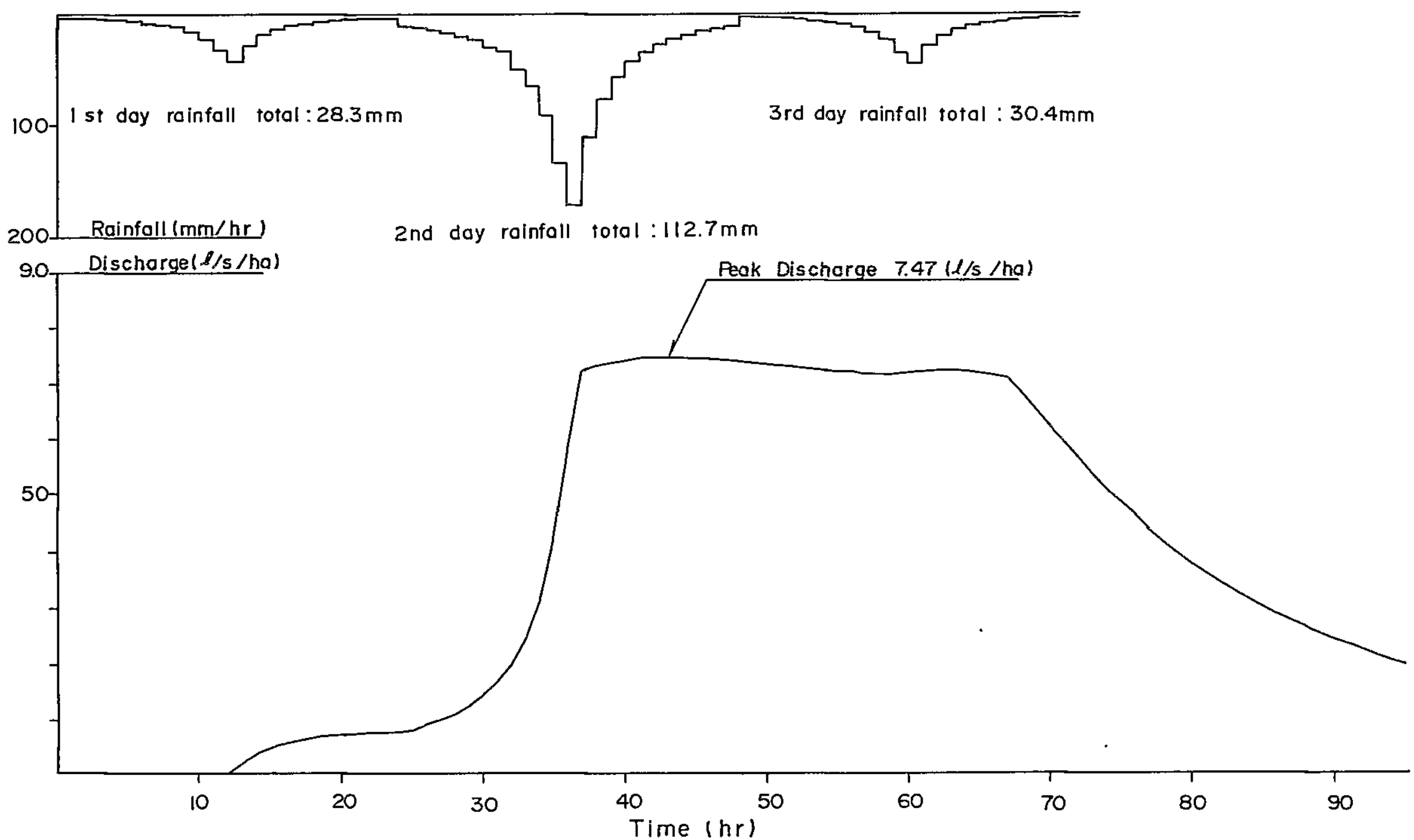


FIG. VII - 15

PLOT TO PLOT METHOD RUNOFF PATTERN

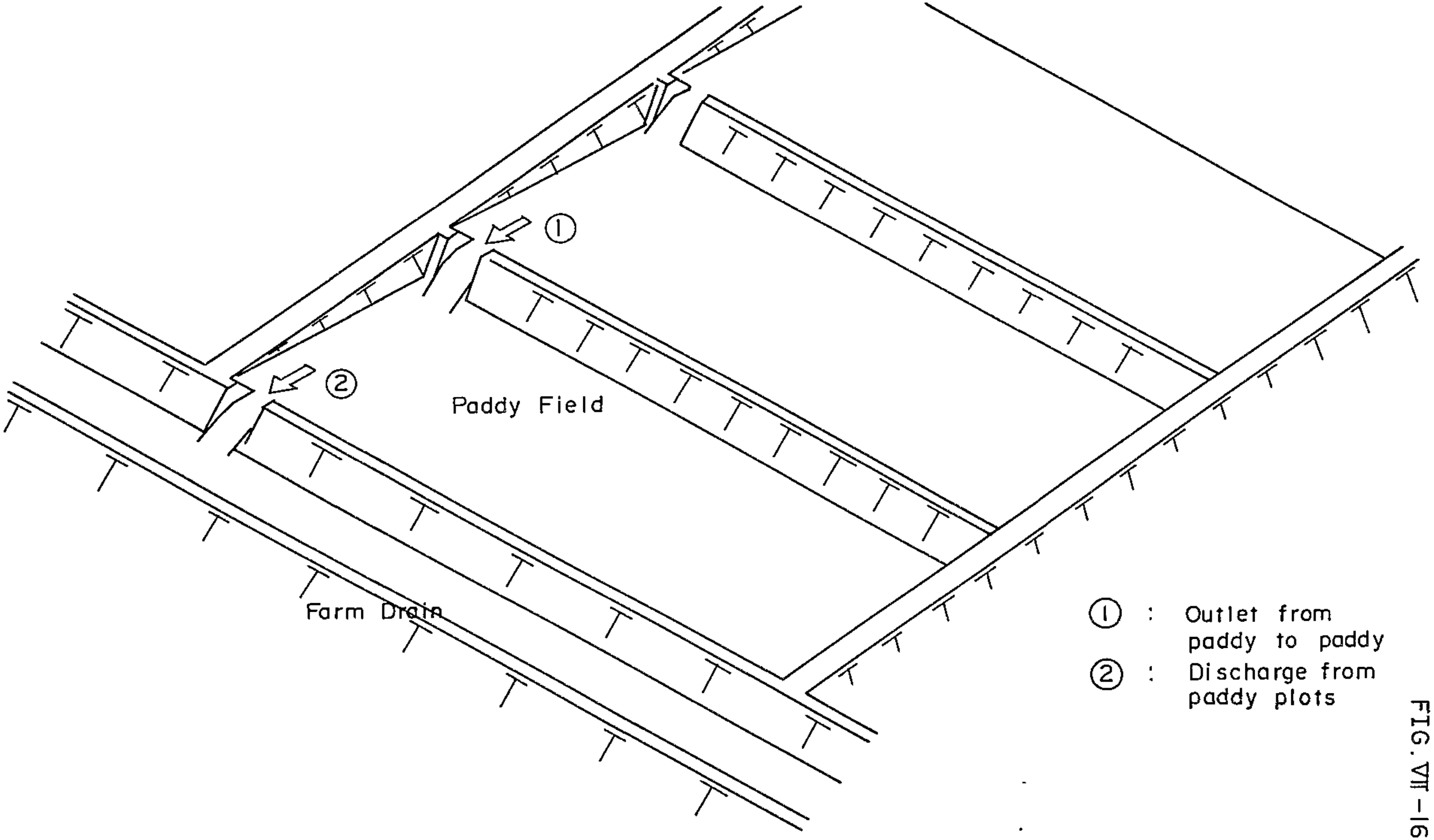


FIG. VII -16

FIG. VII - 17

ESTIMATED DISCHARGE BY PLOT TO PLOT METHOD

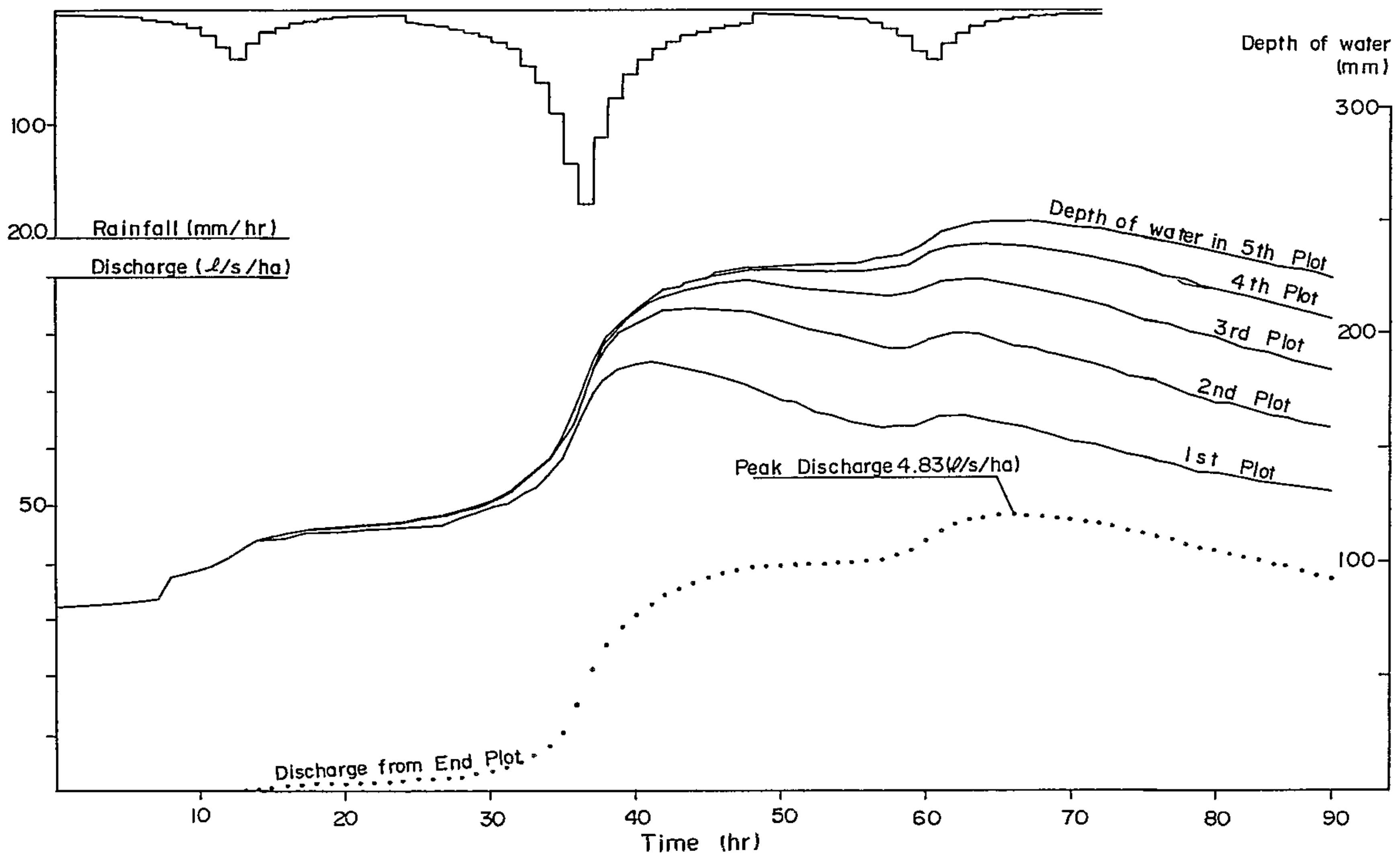


FIG. VII-18

ALTERNATIVE SITES FOR MAGAT DIVERSION DAM