10 day diversion water requirements for diversion dam scheme and pump scheme from 1968 to 1978 are shown in Table 2.12 and in Table 2.13.

The annual average diversion water requirements are calculated at 2,713 mm for diversion dam scheme and 2,732 mm for pump scheme.

2.5.6 Design Discharge for Major Facilities

The design discharge for the major irrigation facilities such as Intake, Main Canal, Lateral Canal and so on, is set at the second maximum value of the 10 day diversion water requirement evaluated for 11 years from 1968 to 1978.

The design discharge for each scheme for designing major irrigation facilities is shown as follows:

(Unit: ℓ/s/ha)

Scheme	Dry Season	Wet Season
Diversion Dam	2.27	1.94
Pump	2.15	1.83

2.5.7 Design Discharge for On-farm Facilities

(1) Main Farm Ditch

As discussed in Section 2.3, the rotational irrigation is applied within an irrigation block with 50 ha of area for operating irrigation facilities. Design discharge of Main Farm Ditch is determined for the most critical condition of land use with regard to water requirement during land preparation period assumed as follows:

Land Use	Water Requirement	Area (ha)
Land Preparation	165.0 mm/4 days	10
Main Field with Crop	7.0 mm/day	20
Main Field without Crop	5.8 mm/day	20

Effective rainfall is not taken into account.

Net water requirement for 50 ha is estimated at 76.0 ℓ/sec.

Irrigation efficiency is assumed as follows:

(Unit: %)

Item	Efficiency
Field Application	80
Conveyance	90
Overall	72

Accordingly, the design discharge of Main Farm Ditch is 106.3 ℓ/sec. per 50 ha or 2.13 ℓ/s/ha.

(2) Supplementary Farm Ditch

Supplementary Farm Ditch commands 10 ha of paddy field in principle. The design discharge of Supplementary Farm Ditch is determined on the condition that all 10 ha of field is at the stage of land preparation. Further, irrigation efficiency is at 80% taking only field application loss into consideration. Thus, the design discharge of Supplementary Farm Ditch is at 40.5 ℓ or 4.05 ℓ/s/ha.

2.6 Water Utilization

2.6.1 Intake Method

The possible intake method for utilizing the river discharge for the irrigation development is diversion dam or pumping station.

The irrigation service area is located between the hilly area in west and the Pampanga River in east and it has relatively slender shape with almost flat but natural slope from north to south. The intake structure will be proposed to be located at near the north end of the irrigation service area and upstream of the Arayat bridge where the Pampanga River has comparatively narrower width and stable water course regulated by Mt. Arayat and the ring levee and the Arayat bridge.

In case of diversion dam, it is necessary to elevate the river water surface by means of gate and fixed weir in order to divert and convey the irrigation water by gravity. As a result of elevating the water surface, the storage reservoir is formed at upstream of diversion dam. This reservoir volume can be utilized as a supplemental water source for irrigation in dry season. Higher water surface will create larger reservoir capacity and irrigation service area, however, raising the water surface should be limited to such elevation that will not create negative effects on the flood conveying capacity of present river system and on the land use or social conditions of inundated area by reservoir. As discussed in the Chapter 3, the maximum possible water surface elevation allowed within the above conditions is EL. 8.5 m which will enable to divert the river water for the irrigation service area below EL. 8.0 m.

In case of pumping station, the irrigation service area will be defined depending on the available river discharge. In order to irrigate the service area, maximum 11,000 ha, as discussed in Section 2.2, the required static head is about 7 m since the highest ground elevation of the area is at EL. 8.0 m and the lowest water surface elevation is at EL. 1.0 m more or less. The pump is to be the vertical mixed flow type in view of technical and economical aspects considering the required head and discharge. It is technically possible to irrigate areas being higher than EL. 8.0 m by means of other type of pumps having greater pump head in wet season. However, it is obviously less economical since such pumps will require higher initial and operation and maintenance costs despite that irrigation will be made only in wet season. It is practical to expand the irrigation area introducing other type of pumps after river discharge will be increased by return flows from the rriga-tion projects with reservoir proposed upstream in future.

2.6.2 Basic Year

The basic year for irrigation plan is determined based on the drought year in five year return period with regard to following four items:

- annual rainfall
- dry season rainfall (Nov. to May)
- annual mean river discharge
- mean river discharge in dry season (Nov. to May)

The year of 1977 is selected as a basic year for irrigation plan because the values in 1977 for the above four items are close to the values in five years return period as shown in Table 2.14.

2.6.3 Irrigation Service Area

(1) Pump Scheme

Irrigation service area of pump scheme is thoroughly depending on river discharge. Maximum possible seasonal irrigation service area without shortage, which is the minimum value of each season estimated in the method that the available discharge divided by the unit diversion requirement on 10-day basis is shown as follows:

(Unit: 10^3 ha)

	'68	'69*	'70*	'71	'72	'73*	'74*	'75	'76	'77	'78
Wet Season	11.7	10.9	11.8	>	44.4	0	7.2	>	>	22.8	>
Dry Season	11.5	5.0	3.9	13.3	15.2	0	2.2	27.1	9.4	7.3	27.0

> more than 50,000

* draught year more than 80% probability

Monthly maximum possible irrigation service area for 11 years from 1968 to 1978 is tabulated in Table 2.15. Since the basic year for planning is the year 1977 and the maximum development area is fixed at 11,000 ha, the irrigation service area of pump scheme is determined at 7,300 ha and 11,000 ha for dry and wet seasons, respectively.

(2) Diversion Dam Scheme

Irrigation service area of diversion dam scheme is also mainly depending on river discharge. Besides, the diversion dam has a storage volume of 28.5 MCM in total at water surface elevation of 8.5 m as shown in Fig. 2.5. Since 70% of maximum intake capacity is maintained at elevation 8.00 m the storage volume, 11.5 MCM, between 8.00 m and 8.50 m of water surface elevation is assumed effective for irrigation purpose. Making use of the effective storage capacity as well as the available river discharge, it is possible to irrigate 11,000 ha of paddy field both for dry and wet seasons with slight modification of cropping pattern. While, the minimum required reservoir volume to irrigate whole 11,000 ha during dry season in the basic year 1977 is 3 MCM.

Accordingly, irrigation service area of each scheme is tabulated as follows:

(Unit: ha)

Scheme	Dry Season	Wet Season
Pump	7,300	11,000
Diversion Dam	11,000	11,000

2.6.4 Deficit of Irrigation Water

The water shortages taken place in the above conditions in 11 years from 1968 to 1978 are as follows:

Item	Unit	Diversion Dam Scheme	Pump Scheme
Deficit Year	Year	4	4
Annual Max.	%	19.4	18.8
Deficit Ratio	(Year)	(1973)	(1973)
Average Annual Deficit	%	3.4	3.7

The above deficits of irrigation water are within an allowable limit for irrigation planning.

2.7 Drainage Requirement

2.7.1 General

The drainage facilities are to be provided to remove the excess water in the fields due to heavy rainfall during storm and to create adequate conditions of drawdown in a harvesting period.

As discussed in Chapter 1 there is no drainage outlet to the Pampanga River and the discharge capacity of major existing drainage courses at their most critical point is very much smaller in the development area than in the downstream area as tabulated as follows:

(Unit: m^3/sec.)

Drainage Course	Discharge Capacity	
	In Development Area	In Downstream Area
Pau River	15	50
Masalusa River	10	150

Despite that the discharge capacity in the downstream area is almost equivalent to the drainage discharge in 5 year return period, that in the development area is much smaller than the drainage discharge in 2 year return period. It is one of the major causes of the present worse drainage condition in the development area.

The probability of rainfall or flood applied to design the drainage facilities is set at one in 5 years taking the following aspects into consideration.

- In accordance with NIA criteria, the drainage requirement is estimated for the excess water in 10 year return period and it is approximately 8.6 ℓ/s/ha generally applied in the Philippines. If 10 year flood would be applied to the irrigation development area, the drainage requirement exceeds 10 ℓ/sec/ha. Besides, if 5 year flood would be applied for the irrigation development area, it is about 8.2 ℓ/sec/ha which is quite similar value to NIA criteria.

- It is surely expected that the construction of drainage facilities from on-farm level improves the drainage condition in the irrigation service area remarkably though the design discharge of drainage facilities is set for the flood in 5-year return period in lieu of 10-year return period.

- In case that the flood in 5-year return period is applied for the design discharge, the drainage plan is limited in the development area since the discharge capacity of the major drainage courses in the downstream of the development area is almost close to the flood discharge in 5-year return period.

The drainage requirement is separately estimated for the irrigation development area and the outside area in which excess water is drained into the drainage courses in the development area.

2.7.2 Drainage Discharge in Development Area

The unit drainage requirement is estimated on the basis of the rainfall with certain probability and a draining period for removing of standing water up to permissible water level.

Unit Drainage Requirement is calculated in the following formula:

$$R = \frac{I - D}{T}$$

where, R: unit drainage requirement (mm/day)
I: design rainfall (mm)
T: drainage period (day)
D: detailed depth (mm)

Design rainfall is defined as maximum three (3) days consecutive rainfall in 5-year return period. Drainage period is assumed at three days and the detained depth is considered 150 mm depending on the field condition assumed as discussed in Section 2.4.

The design rainfall of the Project is the weighted average of the probable rainfall in 5-year return period at San Fernando, Apalit and Arayat. It is estimated at 365 mm as shown in Table 2.16.

Accordingly, the unit drainage requirement in Development Area is estimated at 71.6 mm/day or 8.3 ℓ/s/ha.

2.7.3 Design Discharge from Outside of Development Area

The result of the flood analysis conducted in the second interim report is applied for determining the drainage discharge from the outside of the development area. Sub-basin No. 401 is the area in which excess water is to be drained into the drainage channel in the development area.

In accordance with the results of the flood analysis contained in Data Book, the peak discharge of the flood in 5-year return period is applied as the design discharge from the outside of the development area for the drainage plan. It is 174 m^3/sec.

2.8 Integration of Existing CIS Facilities

There are five communal irrigation systems (CIS) in the irrigation development area as mentioned in Chapter 1. In principle these irrigation systems are planned to be fully integrated into the proposed irrigation project taking into consideration the following reasons;

(i) Due to shortage of water sources in the CIS area, irrigation water is very limited during dry season. Only about 220 ha or about 20% of the CIS area is irrigated during the said period. Further unit yield of agricultural crops in the area are low. As a result economy for the farmers in the CIS area remains on the subsistence level at present. If the CIS are not integrated into the proposed irrigation project, a big difference of farm incomes of the farmers between in the CIS area and the proposed project area will occur. From the standpoint of equal distribution of farm income, integration/inclusion of the present CIS into the proposed project will be indispensable.

(ii) According to the results of the farmer's intension survey as mentioned in section 2.12 Appendix IV, over 90% of the farmers in the irrigation development area including the CIS area have a strong intention to increase rice production by acquiring perennial irrigation water throughout the year and to increase farm income. Further the survey results indicate that the farmers are ready to pay 12 cavans of paddy per year as an irrigation fee, equivalent to about 2.5 times of present irrigation fee for the National Irrigation Systems if perennial irrigation water supply is assured.

In the proposed project existing irrigation and drainage facilities for the CIS will be changed into the new proposed irrigation and drainage systems for the effective use of irrigation water. There remains the problems with respect to amortization of construction cost for the CIS. In principle the farmers in CIS area shall be released from the amortization. Institutionally the existing organization of the CIS will be affiliated into the operation and maintenance office to be established in the proposed plan for the smooth operation and maintenance of the project. As for irrigation fee, farmers in the CIS area have to pay irrigation fee of about 5 cavans of paddy per year which is required for operation and maintenance cost for the project.

However it is still afraid that integration of some CIS into the proposed irrigation project is not accepted. In this case the area of such CIS will be excluded from the proposed project. However irrigation water which the CIS aquires at present should be guaranteed by some measures. For example the water source of Inumang Baca CIS and San Isidro CIS is the Inumang Baca creek which is the proposed main drain of the project, so that reconstruction or rehabilitation of existing diversion dams are necessary for acquiring irrigation water.

It is necessary that further studies and investigation with regard to integration of the CIS into the project will be carried out in the design stage.

2.9 Operation and Maintenance Plan

The irrigation service area has slender shape from north to south of about 26 km long from Arayat to Apalit and 9 km wide from San Fernando to the Pampanga River. Irrigation facilities are provided to serve irrigation service area of 11,000 ha. The target of operation of these facilities is to attain the maximum efficiency of irrigation water to meet with the crop water requirement, in other words, to distribute irrigation water how much, when and where it is required. Operation and control of irrigation water should not be one-way control from upstream. It is therefore proposed to introduce the following control and immediate response system for the operation of facilities, in both cases of diversion dam scheme and pump scheme.

Rain-gauge and radio transmitter/receiver will be distributed for each 500 ha of command area. Water management technician and five ditchtenders will command average number of 3 head gates, 10 turnouts, 8 check gates and measurement of rainfall and discharge in the irrigation canal will be reported to the O & M head office, through radio network every day or at any time when required.

The mini-computer system in the head office will compute the diversion water requirement applying the above rainfall and discharge data and will give the optimum water distribution to each 500 ha. The computer will store all operation records and may be utilized for administrative purposes such as irrigation fee.

Drainage facilities should also be maintained to keep their normal functions at any time. During flood time, the water level or discharge in the drainage channels is reported to the O & M head office through radio network.

CHAPTER 3 PROJECT FACILITIES

3.1 General

The facilities required for the irrigation development of the project include the intake facility, diversion dam or pumping station, irrigation canals with their relevant structures, drainage canals with their relevant structures and on-farm development facilities.

The requirements of the irrigation facilities for the project will be determined in the most effective and economical manner so that each function of the facilities can be combined with the fully compatible with the proposed farming under the project. The project facilities will be prepared in accordance with the plan and preliminary design discussed in this chapter. The general features of the project facilities designed are summarized in Table 3.1 and Table 3.2.

3.2 Diversion Dam

3.2.1 Location and Dam Axis

Location of the diversion dam is selected within the reach between the confluence of the Rio Chico River and the Pampanga River at upstream and the Arayat bridge at downstream. Within this reach, the average river bed slope is about 1/3,500 and the river channel will be expected stable as the river section is fixed by the Arayat bridge construction and by the related river protection works. Low water channel of the river is meandering several times within the reach but main water course is stable whereas the left bank is protected by the ring levee and the right bank is Mt. Arayat.

The diversion dam axis was selected about 2.4 km upstream from the Arayat bridge, where the river runs along the foot hill of Mt. Arayat, the river width is smaller than the other reach and geological conditions of the dam foundation are expected advantageous. A small foot hill of Mt. Arayat is intruding to the river along the dam axis and the weathered tuff breccia has been found through the geological investigations at about the elevation of dam foundation. Other than the proposed dam axis, this tuff breccia layer will become deeper as being away from Mt. Arayat.

3.2.2 Intake Water Level

The intake water level of the diversion dam was determined at EL. 8.50 m after making the careful study discussed hereinafter.

The crest elevation of fixed weir is EL. 9.0 m at the mouth of Cabiao Candaba Floodway located at about 7 km upstream of proposed dam axis. In order to keep the flood control functions of the Floodway and ring levee at present condition, the water level to be raised by the diversion dam should not exceed crest elevation of the Floodway. Taking 0.5 m of allowance from the crest level, the maximum possible water level to be raised is EL. 8.50 m. The inundation area of San Antonio swamp with this water level, is about 2,600 ha as shown on Fig. 3.1, most of which is within the swamp grass land of no cultivation and only about 100 ha of cultivated land on the high water channel of the River are to be submerged by the reservoir to be created by the Diversion Dam. Small villages along the river course in the swamp are located at relatively upland of more the EL. 11.0 m which has sufficient clearance from the proposed reservoir water level of EL. 8.50 m.

With the water level at EL. 8.50 m, the irrigation water can be conveyed by gravity so far to the field of lower than EL. 8.0 m, and the reservoir capacity of 11.5 MCM between EL. 8.0 m and EL. 8.5 m will be utilized for the year-round irrigation among the total reservoir capacity at water level EL. 8.50 m is about 28.5 MCM as shown on Fig. 2.5.

3.2.3 Preliminary Design

(1) Design Flood Discharge

Diversion dam should be designed not to give considerable affects on the functions of existing ring levee and set-back levee, which have been constructed to meet with the flood of 20-year return period. In the design of diversion dam, the flood of 20-year return period was adopted for the analysis of proportioning of fixed weir and gated portion and for the backwater analysis. However, the flood of 100-year return period is the basic standard to be adopted for the river control planning. The safety measurements were taken for the diversion dam structure itself against the flood of 100-year return period, such as the height of pier and so on. According to the flood control analysis, the design floods at the diversion point are as follows:

20-year return period	3,100 m^3/sec
100-year return period	3,800 m^3/sec

(2) Proportioning of Gate and Fixed Weir

The proportion of low water channel and high water channel at existing river cross section is assumed as one of the guide line to the proportioning of gate and fixed weir for the diversion dam. Width of the existing low water channel of the river is about 100 - 200 m and the total river width at the proposed dam axis is about 1 km. According to the alternative study for several combinations of proportion, the following proportion was found most economical resulting the backwater effects on upstream within the allowable range.

Fixed weir portion	850 m
Gate portion	150 m

(a) Gate Portion

The gate portion is designed to be located so far to the right side of the river, since the foundation rock of weathered tuff breccia is expected at about the foundation elevation of the dam and it will become deeper at left side being away from Mt. Arayat.

The river course runs right side of the river at upstream and downstream of dam axis but it meanders to the left side at the proposed dam axis. It is necessary to construct the leading channel of about 1.3 km to connect the river course with the gate portion and to have function to keep water course at right side. Comparatively dry work condition will be obtained for the construction of gate portion without large coffering works.

Alternative study was made for the proportion of spillway gate and scouring sluice gate in terms of gate height and span.

The summary of gate portion sellected is as follows:

Length	150 m
Crest elevation of gates	EL. 8.6 m
Spillway gate	Shell type roller gate
	3 nos.
	Span 40 m
	Height 4.6 m
Scouring sluice gate	Shell type
	Double roller gate 1 no.
	Span 30 m
	Height 7.6 m

(b) Fixed Weir Portion

The ground elevation of high water channel along the dam axis is about EL. 8.0 m and the flood flow velocity for this portion is below 1.0 m/sec. The bed load material is fine sand and no gravels are expected during flood time. Considering these conditions of low dam height, low flood velocity and no gravel flow, the fixed weir is designed to be of compacted impermeable earth fill with riprap surface protection.

Length	850 m
Crest elevation	EL. 8.6 m
Weir height	0.6 m

(3) Intake Structure

Design intake discharge is given from the diversion water calculation at 25.0 m^3/sec and design intake water level is at EL. 8.50 m. Intake structure is designed to be located at right side of the river. Major dimensions are as follows:

Intake discharge	25 m^3/sec	
Intake gate	Roller gate 6 nos	
	Span	4.0 m
	Height	2.5 m
Intake sill elevation	EL. 6.65 m	

3.2.4 Backwater Analysis

Purpose of backwater calculation is to analyze the effects possibly caused by the diversion dam structure, for this, the expected river water surface during flood time is calculated with present river condition and after construction of diversion dam.

River cross section at the Arayat bridge was selected to be the start point or control point of backwater calculation as the river flow area at the Arayat bridge gives the most small value within the adjacent reach to the river and it is thought to be of bottleneck section. River cross sections surveyed for the flood control analysis were applied for the backwater calculation.

(1) Backwater Calculation for Present Condition

Backwater surface elevation for design flood discharges of 20-year return period and 100-year return period was shown in Table 3.3 for the present river condition.

(2) Backwater Calculation with Diversion Dam

The hydraulic effects of diversion dam were expressed by voltex loss and friction loss created by the diversion dam and its piers. Sedimentation effects are also included by estimating sedimentation in upstream of dam with sediment slope at 1/7,000 about half of river bed slope which is equivalent to about 1.0 MCM of sediment volume per 1 km of river length and resulted to decrease the flow area about 5% to 25%.

The results of calculation are shown in Table 3.4 and Table 3.5 for flood discharges of 20-year and 100-year return period.

The calculations without sedimentation are also shown in Table 3.6 and Table 3.7.

(3) Effects of Diversion Dam

Flood surface calculated under the dam conditions with sedimentation shows about 0.2 m rise from the water surface at present condition. (i.e., 0.24 m for flood of 20-year return period and 0.16 m for 100-year return period). Without sedimentation condition, the back-water effect is 0.13 m of rise for the flood of 20-year return period and 0.10 m for 100-year flood as shown on Fig. 3.2.

The existing levee has still the freeboard of more than 1.0 m against the rise of flood surface which satisfies the MPW's standard for freeboard. It is estimated that the rise of flood water surface will not give considerable affect on the flood control capacity of the present river system.

3.2.5 Sedimentation

(1) Present Conditions

Based on the results of sediment analysis given in the flood control study, the sediment load at Arayat is expressed by the following equations.

$$Q_B = 1.479 \times 10^{-6} \times Q^{0.990}$$

$$Q_S = 1.986 \times 10^{-6} \times Q^{1.610}$$

where, Q_B: bed load (m^3/sec)

Q_S: suspended load (m^3/sec)

Q: river discharge (m^3/sec)

Applying above equations, the sediment yield at Arayat was calculated for 10 years using daily mean discharge data (1966 - 1975) and shown in Table 3.8.

Estimating the void ratio of the sediment at 40%, the actual volume of sediment is given as follows:

$$V = (Q_B + Q_S) \times \frac{1}{1 - 0.4}$$

Average actual volume of sediment is about 1.6 MCM per year or 240 m^3/km/yr.

(2) With Diversion Dam

The purpose of diversion dam is to raise the river water level at EL. 8.5 m in order to divert and convey the irrigation water to the benefit area by gravity. As a result of dam-up the river water, a reservoir is formed having 28.5 MCM of total capacity and 11.5 MCM between EL. 8.0 m and EL. 8.5 m to be utilized as effective storage for diversion. This reservoir will have a function to intercept the sediment load flowing from the upstream.

Sediment load, however, consists mostly of suspended load, about 99% of total sediment load as shown in Table 3.8.

According to the results of sieve analysis, the mean diameter (dm) of the sediment load is 0.1 mm which is very fine silt and indicates that the sediment is mostly conveyed during the flood time in the form of suspended load.

In such flood time, the spillway and scouring sluice gates of diversion dam are all open and the flow conditions will be more or less the same as present condition. Then, suspended load and bed load conveyed by the flood as well as the previous deposits will be flushed out from the reservoir. Assuming the gate operation of the diversion dam and sediment load that the spillway gates will be opened when the river discharge exceeds the maximum capacity of scouring sluice gate at the discharge of 770 m^3/sec, the incoming sediment load of the flood will be flushed and that all the sediment load for less than the river discharge of 770 m^3/sec will be deposited, the sediment deposit balance in the reservoir is estimated on the basis of daily mean discharge as shown in Table 3.9.

About 365,000 m^3 of sediment will be deposited as annual average which will be resulted about 16.8 MCM of sedimentation for during 46 years of project life after completion of the Diversion Dam and still about 11.2 MCM of reservoir volume will remain effective.

In the actual gate operation, the spillway gates will be opened for smaller river discharge than 770 m^3/sec in order to work together with the scouring sluice gate to keep the reservoir water level at less than EL. 8.50 m during flood time. Also, the sediment load will be scoured out through the scouring sluice gate in the form of suspended load even for the ordinary gate operation other than flood time.

(3) Capacity of Leading Channel

The leading channel will be excavated to connect the gate portion of the diversion dam and the river low water channel. Sediment conveying capacity can be estimated theoretically using bed load as an indicating function.

$$\tau o = \rho \times g \times n^2 \times V^2 \times R^{-1/3}$$

$$Q_B = \frac{\psi \times (\tau o/\rho)^{3/2} \times F}{[(\sigma/\rho) - 1] \times g}$$

where, ρ: specific gravity of water 1.0 t/m^3

σ: specific gravity of sediment 2.7 t/m^3

n: Manning's roughness coefficient

R: hydraulic radius

τo: tractive force (t/m^2)

V: flow velocity (m/sec)

F, ψ: coefficient

Q_B: bed load (m^3/sec/m)

Adopting above formula, the bed load flow capacity for the leading channel is expressed by the next equation.

$$Q_B = 86.4 \times 10^6 \times 0.0374 \times \tau o^{3/2} \times F$$

Comparing the above equation and the present Q_B expressed by $Q_B = 1,479 \times 10^6 \times Q^{0.99}$, the leading channel shows greater sediment flow capacity under the reservoir storage condition for the river discharge of $Q \geq 340$ m^3/sec but smaller capacity for $Q < 340$ m^3/sec than the capacity at present condition.

Assuming that all the sediment discharge will be conveyed for the river flow discharge of $Q \geq 340$ m^3/sec and will be deposited in the reservoir for the discharge of $Q < 340$ m^3/sec, then the sediment balance will be as shown in Table 3.9. The sediment volume to be deposited will be about 143,000 m^3/per year and total sedimentation for 46 year will be about 6.6 MCM.

From these analysis, it will be concluded that the sedimentation will not limit the reservoir capacity of diversion dam within the life time under the proper gate operation.

3.2.6 Settling Basin

Generally, a settling basin is provided right after diverting irrigation water to get rid of harmful sediment load for operation and maintenance of irrigation facilities. However, since more than 90% of the river bed material at Arayat is smaller than 0.1 mm in diameter in accordance with the results of the hydrological study of the project and the velocity of the irrigation canals is not less than 0.25 m/sec, all suspended load in the irrigation water is expected to be carried down to the field taking the tractive force into consideration.

Further, the sediment discharge volume contained in the irrigation water is roughly estimated at 11,400 m^3 for the basic year of planning, 1977 on the basis of 10-day mean discharge as shown in Table 4.10 in detail. This sediment discharge will be entirely carried down to the field and spreaded over the field in the rate of 0.1 mm in depth per year which will not cause any adverse affect to the project operation.

3.3 Pumping Station

3.3.1 Location

The location of pump station was selected at right bank of the river at immediate upstream of the Arayat bridge, where the river bed and water course will be expected stable as the river section is fixed by the Arayat bridge and by its river protection works. Further upstream from the Arayat bridge, the river is meandering in almost every 2 km and it will be difficult to keep the water course constant without having large scale river training works.

The foundation of the pump station is relatively deep at the proposed location. According to the geological investigation, a firm sandy layer was found at about 29 m below the ground surface and it is estimated this layer is also same with the foundation layer for the Arayat bridge.

3.3.2 Preliminary Design

(1) Design Pump Discharge

Dry Season	15.7 m^3/sec	(2.15 l/s/ha x 7,300 ha)
Wet Season	20.1 m^3/sec	(1.83 l/s/ha x 11,000 ha)

(2) Design Intake Water Level

Diversion water requirements and the required pump head (H) from the river water level are plotted on Fig. 3.3 for 11 years (1968 - 1978) based on the results of the water balance calculation.

The required pump head on Fig. 3.3 is calculated between the river water level and the irrigation water level of EL. 8.40 m at the point of pump station. As Fig. 3.3 shows, the pump operation points are located mostly between the required pump head of 6.0 m and 7.5 m, it is desirable to design the pump to have its maximum efficiency within this range.

The maximum load for pump is given by the maximum value of H x Q that is found at 1st decade of July 1968 where the river water level at EL. 1.61 m, diversion requirement (Q) at 20.1 m^3/sec and the pump head (H) at 6.69 m.

The maximum diversion requirement is expected during wet season of late June to early July, however, the low water level in the river will occur during February and March in dry season. It will give over-estimate of pump capacity if the pump is designed based on the possible maximum water requirement combined with the lowest river water level.

The design intake water level is, therefore, set at EL. 1.61 m with which the pump performance curve will be prepared and it will be evaluated with the most critical conditions expected in dry and wet seasons.

(3) Pump Type and Pump Bore

From the required head and the capitation analysis, the vertical mixed flow type was selected suitable.

Several combinations of pump type and bore are selected from the design pump capacity and required pump head for the alternative study as follows:

Item	Alternative 1	Alternative 2	Alternative 3
1. Type of pump	- Vertical, mixed flow pump -		
2. Pump bore	ø1,350 mm	ø1,500 mm	ø1,650 mm
3. Number of pump	5 nos	4 nos	3 nos
4. Design discharge 20.1 m^3/s	242 m^3/min/no	302 m^3/min/no	402 m^3/min/no
5. Required static head Ha	7.0 m	7.0 m	7.0 m
6. Estimated head loss	0.5 m	0.5 m	0.6 m
7. Total dynamic head H	7.5 m	7.5 m	7.6 m

It was concluded from the alternative study that the combination of 4 nos of 1,500 mm pump bore be most economical combination not only for the initial cost but also for the operation and maintenance cost which is discussed in Section 3.3.3 as shown in Table 3.11.

(4) Driving Method

The electric motor drive method is applied for the pump facility taking the following aspects into consideration in comparison to the diesel engine drive method.

Item	Motor Drive	Diesel Engine Drive
1. Initial cost	Cheap	Expensive per unit output
2. Supplemental facilities	Electricity control units and power transmission line are necessary	Storage for oil and cooling water is necessary
3. Running cost	Expensive for short operation hour	Expensive for long time operation
4. Operation and control	Simple with high reliability	Rather complicated operation
5. Maintenance	Simple	Simple
6. Vibration and noise	Small	Large
7. Pump house	Small for vertical type	Requiring wide area for engine and solid foundation for its vibration
8. Others	No operation in case of power failure Diesel generator is expensive	Operation is not affected by electric power failure

(5) Discharge Control

Valve control is most commonly used for smaller range of discharge control for smaller size of pump. The pump discharge is to be regulated according to the hydraulic head loss created by the valve opening. The pump discharge may be decreased by this method into 60 - 70% of the design discharge but the motor is always at full output.

Adjustable vane pump is often applied for wide range of discharge control for large size of pump. In this method, the angle of vane is varried by oil hydraulic or mechanical unit. Control range will be usually 40 - 120% of the design discharge.

In order to cover with the wide range of required operation point as shown on Fig. 3.3 and to gain smooth linear change in pump discharge, it is necessary to introduce one to two number of adjustable vane pump. Assuming regulating range at 40 - 100% of design discharge, required number of adjustable vane pump will be two out of four number of proposed ø1,500 mm pumps.

3.3.3 Operation Cost

Operation cost of the pumps comprises the electric power charge and operation and maintenance cost.

The electric power charge is calculated in accordance with the latest electricity rate of the Pampanga Electric Cooperative II under NPC Luzon Grid as follows:

Power Charge:	0.753 ₱ per kWH
Fuel Cost Adjustment:	0.1072 ₱ per kWH

Operation cost was simulated from the diversion demand derived in accordance with the water balance calculation for 11 years (1968 - 1978) and from the river water surface elevation derived in accordance with the hydrological study shown in Appendix II.

Annual electric power consumption for 11 years for each alternative is shown in Table 3.12 and Table 3.13 shows annual electric power charge for each alternative. Further, Table 3.14 shows the operation and maintenance cost of each alternative.

3.3.4 By-Pass Culvert

During flood river water surface elevation of the outlet cistern, is sometimes higher than the designed water surface elevation, EL. 8.4 m. The by-pass culvert is provided to divert water by gravity without operating pumps when the water elevation in the inlet cistern is higher than EL. 8.4 m.

3.3.5 Settling Basin

As discussed in Section 3.2.6, the settling basin is also not necessary for the Pump Scheme.

The sediment discharge contained in the irrigation water is roughly estimated at 10,100 m^3 for the basic year of planning, 1977 as shown in Table 3.10.

3.4 Irrigation Canal and Related Structures

3.4.1 Irrigation Canal System

The irrigation canal system of the project consists of main canal, sub main canal, five secondary canals and lateral canals. Additionally there are on-farm facilities such as main farm ditch and supplementary farm ditch. Each canal is mainly distinguished in accordance with the design discharge.

Irrigation canals are aligned along the existing road and village boundary as much as possible, so that land acquisition due to construction of irrigation facilities and number of crossing structures are made small.

Since suitable earth material is available in and around the development area all irrigation canals are designed as earth canal.

The general layout of the proposed canal system is shown on Fig. 2.1.

(1) Main Canal

The design discharge of Main Canal is greater than 3.0 m^3/sec. Irrigation water is conveyed from intake of diversion dam or pump station by Main Canal to downstream. As shown on Fig. 2.1 Main Canal is to be constructed along the setback levee upto the bifurcation structure with Sub Main Canal and along the No. 10 national highway after the bifurcation.

(2) Sub Main Canal

The design discharge of Sub Main Canal is also more than 3 m^3/sec. Sub-Main Canal is to be constructed along the setback levee to deliver irrigation water to two secondary canals and lateral canals.

(3) Secondary Canals

Six secondary canals are branched off from Main and Sub Main Canals to distribute irrigation water to several lateral canals.
The design discharge is greater than 1.0 m^3/sec and less than 3.0 m^3/sec.

(4) Lateral Canals

Lateral canals are diverted from Main, Sub Main and secondary canals with approximate intervals of 1 km supplying water to several main farm ditches. About sixty lateral canals are constructed in the project area, and the commanded area of one lateral canal is from 150 ha to 200 ha on an average.

(5) Main Farm Ditches

Main farm ditch is diverted from the lateral canal with an average interval of 500 m supplying water to one rotation block as mentioned in Section 2.4. Length of one main farm ditch is 800 m on an average. The typical farm layout is shown on Fig. 3.4.

(6) Supplementary Farm Ditches

Distribution of water within the lotation block will be made by supplementary farm ditches to be branched off from the main farm ditch with an interval of 200 m. There are five supplementary farm ditches in one lotation block in principle. Length of one supplementary farm ditch is 400 m on an average.

The design discharge and the total length of each irrigation canal to be provided in the project are summarized as follows:

Canals	Design Discharge (m^3/sec)	Total Length (km)	
		Diversion Dam Scheme	Pump Scheme
1. Main Canal	$3.0 \leqq Q$	14.6	12.0
2. Sub Main Canal	$3.0 \leqq Q$	21.7	21.7
3. Secondary Canal	$1.0 \leqq Q < 3.0$	29.2	29.2
No. 1		5.7	5.7
No. 2		3.2	3.2
No. 3		6.6	6.6
No. 4		5.2	5.2
No. 5		2.6	2.6
No. 6		5.9	5.9
4. Lateral Canal	$Q < 1.0$	116.0	117.0
5. Main Farm Ditch	$Q = 0.107$	220.0	220.0
6. Supplementary Farm Ditch	$Q = 0.041$	490.0	490.0

3.4.2 Design of Irrigation Canals

All irrigation canals proposed for the project are designed as unlined canals with trapezoidal section. The design of the irrigation canals has been made based on the basic design criteria described as follows.

(1) Design Discharge

Based on the irrigation water requirement calculated in Section 2.5 and the commanding area, the design discharges for each irrigation canals are estimated. Irrigation diagram for the diversion dam scheme and for the pump scheme is shown on Fig. 3.5 and Fig. 3.6 As the commanding area of main farm ditch and supplementary farm ditch is about 50 ha and about 10 ha respectively, the design discharge for main farm ditch and supplementary farm ditch is 107 ℓ/sec and 40 ℓ/sec respectively as discussed in Section 2.5.

(2) Velocity

The maximum permissible velocity in unlined canals is determined so as not to cause scouring of canal, the minimum permissible velocity is determined so as not to induce the growth of aquatic plant and moss and not to cause the sedimentation in canal. In this project permissible velocity of each canal is determined as following table.

Canals	Maximum Velocity (m/sec)	Minimum Velocity (m/sec)
Main & Sub Main Canals	1.0	0.5
Secondary & Lateral Canals	0.8	0.3
Main Farm & Supplementary Farm Ditch	0.65	0.25

(3) Roughness Coefficient

Based on the design criteria of N.I.A, coefficient of roughness is decided as follows:

Canals	Design Discharge (m3/sec)	Coefficient of Roughness
Main Canal	$3.0 \leqq Q$	0.0225
Sub Main Canal	$3.0 \leqq Q$	0.0225
Secondary Canal	$1.0 \leqq Q < 3.0$	0.025
Lateral Canal	$Q < 1.0$	0.025
Main Farm Ditch	$Q \doteq 0.107$	0.03
Supplementary Farm Ditch	$Q = 0.040$	0.03

(4) Freeboard

The freeboard of the canals is also designed based on the design criteria of N.I.A.

- For main canal, sub main canal, secondary canal and lateral canal;

  (i) when water depth is 2.0 meters or greater;

$$Fd = 0.25d + 0.30$$

  (ii) when water depth is less than 2.0 meters;

$$Fd = 0.4d$$

- For main farm ditch and supplementary farm ditch;

$$Fd = 0.1d + 0.15$$

where, Fd: freeboard (m)
d: water depth (m)

(5) Side Slope

The side slope of 1:1.5 is adopted for the design of major canals such as main, sub main, secondary and lateral canals taking into account the results of soil mechanical study. As for minor canals such as main farm ditch and supplementary farm ditch, the side slope of 1:1 is adopted.

(6) Hydraulic Gradient

Considering the allowable water velocity and natural gradient of the ground surface, hydraulic gradient of Main and Sub Main Canals, secondary canals and lateral canals is designed to be with the range of 1/12,000 to 1/5,000, 1/10,000 to 1/5,000 and 1/6,000 to 1/600 respectively. Hydraulic gradient of main and supplementary farm ditches is within the range of 1/2,500 to 1/1,500.

(7) Canal Base Width and Water Depth

The relationship between the canal base width and maximum water depth is decided as follows:

Canal Base Width (m)	Maximum Water Depth (m)
I. Main and Sub Main Canals (n=0.0225)	
12.0	3.00
10.0	2.20
8.0	2.20
6.0	2.20
5.0	1.80
4.0	1.40
II. Secondary and Lateral Canals (n=0.025)	
3.0	1.50
2.5	1.50
2.0	1.20
1.5	1.00
1.0	0.80
0.8	0.50
0.6	0.40
III. Main and Supplementary Farm Ditch (n=0.03)	
0.5	0.45
0.4	0.30
0.3	0.30

n: Coefficient of roughness

(8) Top Berm Width

The both berm widths of major irrigation canals such as main, sub main, secondary and lateral canals are equal to the canal height (water depth plus freeboard). But in case that the farm road is constructed along the canal the top beam width is a maximum of 1.5 meters at the road side. The top both beam width of main and supplementary farm ditches are designed to be 30 centimeters.

(9) Hydraulic Formula

The hydraulic calculation in the design of canals is made by using the Manning's formula as follows:

$$Q = A \cdot V$$

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

where, Q: discharge (m^3/sec)

A: flow area (m^2)

V: velocity (m/sec)

R: hydraulic radius (m)

I: hydraulic gradient

n: coefficient of roughness

The typical cross section of each irrigation canal is shown on Fig. 3.7.

The profiles of main canal and sub main canal are shown in Appendix XI, Drawings.

3.4.3 Related Structures of Irrigation Canals

Various related structures would be provided for crossing of road and river, regulating and control of discharge, and distribution of irrigation water. The structures proposed for the irrigation canals are broadly categorized as listed below:

(1) Crossing facilities

a. Bridge
b. Culvert
c. Syphon
d. Cross drain (Drainage culvert)

(2) Regulating and control facilities

a. Check
b. Spillway
c. Bifurcation

(3) Distribution facilities

a. Head gate
b. Turnout
c. Division work

The required number of the irrigation canal related structures are summarized in Table 3.15 and the general characteristics and design criteria of those structures are mentioned hereinafter.

(1) Bridge and Culvert

Bridges or culverts are constructed where a road crosses over the canal. These bridges and culverts are strong enough for the increase of heavy traffic after the project implementation. Bridge is provided for Main, Sub Main and secondary canals and culvert is provided for lateral canals taking the construction cost and head loss into consideration.

(2) Syphon

Concrete syphon structures are contemplated to pass under the rivers and roads. Syphon consists of upstream transition, concrete barrel and downstream transition. Tow type of syphon barrel, box type and concrete pipe type, are adopted depending on the design discharge. The box barrel type is applied for the discharge more than 2.0 m^3/sec.

(3) Check Structure

In order to maintain the required water level at the site of off-taking even during periods of off-peak discharge, a check structure is provided where a number of turnouts are densely provided or where fairly large discharge is diverted. The check structure consists of upstream transition, throat section and downstream transition and is equipped with one or several rectangular slide gates and operation deck in the throat.

(4) Spillway

A spillway is constructed in the canal system for the purpose of spilling out excess flow or flushing off all the water in the canals in case of emergency and clearing and repairing canals. This structure is provided in the following sites:

(i) the upstream of syphon structure

(ii) the end of Main and secondary canals, and

(iii) the site where the canal section is reduced at the downstream of head gate and the canal section does not have a enough capacity to flow the design discharge at the upstream.

All the spillways are connected to the nearby drainage canals.

(5) Bifurcation

A bifurcation structure is constructed to bifurcate irrigation water exactly in the constant ratio to the Main Canal and Sub Main Canal by jet flow division work. The measurement of the discharge is conducted taking a jet flow depth.

(6) Head Gate and Turnout

Head gate is constructed to divert the required water from Main, Sub Main and secondary canals to lateral canal, and turnout is constructed to divert the required water from parent canal, mainly lateral canal, to main farm ditch.

The pressure flow type of both head gate and turnout is introduced for this project. Pershall flume is provided in all head gate and turnout for the purpose of measuring the discharge.

(7) Division Work

In order to divide the irrigation water from main farm ditch to supplementary farm ditch a prefabricated concrete cut-off with groove for stop log is installed on main farm ditch.

3.5 Drainage Canals and Related Structures

3.5.1 Drainage Canal System

Drainage canal system consists of main, secondary and collector drains and on-farm drains such as farm drain and drainage ditch to remove the excess water in the field, and catch drain to collect and drain the runoffs from the outside of the development area.

In the project area, there are many natural depressions, creeks and rivers. They are used for proposed drainage channel with existing condition, if the present discharge capacity of the rivers is enough to flow the design discharge, or with improvement.

(1) Main Drain

Main drains are the existing rivers in the development area. As the present discharge capacity of the rivers is only about 10 m^3/sec to 90 m^3/sec, the rivers are always flooded during heavy rain. The Pau and Matubig Rivers are improved to accommodate the drainage discharge of 234 m^3/sec at the crossing point of North Luzon Expressway. After crossing the Expressway, the main drain is divided into two routes, Tadung River and Pau River. And the two rivers are improved to accommodate the each drainage discharge, 184 m^3/sec and 50 m^3/sec respectively, up to the clossing point of McArthur Highway. After the bridges of McArthur Highway, the discharge capacity of the two rivers is equivalent to the design discharge.

(2) Secondary Drains

Two secondary drains are designed in the project area. No. 1 secondary drain is constructed in the swamp area where is located north in the irrigation service area between No. 10 National Highway and setback levee. And this secondary drain is connected into San Fernando River at the south of Santo Ana. The present discharge capacity of San Fernando River is enough to flow the design discharge in accordance with the result of field investigation.

No. 2 secondary drain starting from Santo Rosario in Municipality of San Luis, and connected into Santa Monic River at San Pablo in Municipality of San Simon. As the present discharge capacity of Santa Monic River is smaller than the design discharge, the River is improved to accommodate the design discharge from San Pablo to Lourdes in Municipality of Minalin.

(3) Collector Drains

Collector drain is defined as the drainage canal collecting excess water from farm drain and bringing the water to secondary and main drains. About 45 collector drains are constructed in the development area. Most of collector drains are excavated along lateral irrigation canals.

(4) On-farm Drains

In one lotation block of 50 ha, one farm drain and five drainage ditches are aligned as shown on Fig. 3.4. Those on-farm drains convey the excess water in the field to major drains.

(5) Catch Drains

In order to collect and drain the runoffs from the outside of the development area, catch drains are constructed along the boundary of them.

The total length of each drainage canal to be provided in the development area is tabulated as follows:

Drainage Canals	Total Length (km)	
	Diversion Dam Scheme	Pump Scheme
1. Main Drain	20.5	20.5
2. Secondary Drain	26.1	26.1
No. 1	6.5	6.5
No. 2	19.6	19.6
3. Collector Drain	57.0	57.0
4. Catch Drain	6.0	4.5
5. Farm Drain	190.0	190.0
6. Drainage Ditch	355.0	355.0

The schematic diagram of the drainage canal system of the development area is shown on Fig. 3.8.

3.5.2 Design of Drainage Canal

(1) Design Discharge

Based on the drainage water requirement calculated in Section 2.7, the design discharges for the drainage canals are obtained as shown on Fig. 3.8. The design discharge of farm drain and drainage ditch is estimated to be 415 ℓ/sec and 83 ℓ/sec respectively. As for the main drain and No. 2 secondary drain, the discharge estimated in the said Section 2.7 hereof is used for the improvement of the rivers.

(2) Canal Section

The drainage canal sections are designed for the following criteria:

		Inside	Outside
Type of canal	:	Trapezoidal earth canal	
Side slope of canal		Inside	Outside
- Main drain	:	1:3	1:1.5
- Secondary drain	:	1:2	1:1.5
- Collector and catch drain	:	1:1.5	1:1.5
- Farm drain	:	1:1.5	1:1
- Drainage ditch	:	1:1	1:1
Coefficient of roughness	:	0.03	

The hydraulic calculation in the design of canals is made by using the Manning's formula.

The typical cross section of each drainage canal is shown on Fig. 3.7.

The profile of main drain is shown on Appendix XI, Drawings.

3.5.3 Related Structures of Drainage Canals

The structures related to the drainage network are bridge, culvert and drainage outlet.

The bridge and culvert are planned and designed with the same principles as mentioned in Section 3.4.3. For bridges related in main drain, the present bridges except one bridge are used as they are. For drainage culverts, two types are provided depending on their design capacities, i.e., rectangular box barrel type and precast concrete pipe type. The former is applied for the design capacity of more than 1.0 m^3/sec.

The drainage outlet is provided at the end of secondary and collector drains, which will flow directly into the main and secondary drains, so as to prevent the canal bed erosion and retrogressive erosion in the drainage canal.

The required number of the drainage canal related structures in this project are summarized in Table 3.16.

3.6 Farm Roads

For the proper operation and maintenance of project facilities, farm road system is proposed in this project.

The proposed road system consists of main, secondary and tertiary roads. Farm roads are constructed along irrigation canals. Main farm road with 6 m in width and with gravel pavement is constructed along Main and Sub Main Canals. Secondary farm road with 6 m in width and tertiary farm road with 4 m in width are constructed along the secondary and lateral canals respectively. Typical cross section of each farm road is shown on Fig. 3.7 combining the canal section.

Road surface elevation is higher than the original ground elevation by 40 cm.

Total length of the roads is estimated as follows:

Roads	Diversion Dam Scheme (km)	Pump Scheme (km)
1. Main road	36.3	33.7
2. Secondary road	29.2	29.2
3. Tertiary road	116.0	117.0

3.7 Operation and Maintenance Facilities

In order to operate and maintain the irrigation and drainage system efficiently, operation and maintenance facilities are provided in this project. These facilities comprise the project office, living quarters and equipments for O & M.

The main office is to be established in the operation house of diversion dam or pump station after completion of construction work.

The following equipments for O & M are required for making the function of the O & M system active.

1.	Raingauge	22 nos.
2.	Radio transmitter and receiver	
	Main station	1 no.
	Handy set	22 nos.
3.	Mini-computer system	1 set
4.	Motor cycle	22 nos.
5.	Jeep with radio mounted	7 nos.
6.	Dump truck 4 ton	4 nos.
7.	Bulldozer 11 ton	2 nos.
8.	Spare parts & Equipments	1 set

CHAPTER 4 PROJECT IMPLEMENTATION PLAN

4.1 General

The implementation schedule for the irrigation development plan is prepared based on the following consideration.

(1) The project mobilization which includes financing, legalization, establishment of the project organization will be completed by the end of 1982.

(2) Annual workable days for construction equipment are estimated to be 220 days based on the rainfall records in the development area.

(3) The whole project works are broadly divided into three work divisions. The Work Division-I is the construction of the intake facility either Diversion Dam or Pumping Station. The Work Division-II comprises the construction of major irrigation and drainage facilities down to lateral canals and collector drains and the construction of the farm roads. The Work Division-III is the construction of on-farm facilities consisting of main and supplementary farm ditches and farm drain and drainage ditch.

(4) Considering the scale of works and the past experiences in the Philippines, all construction works will be conducted on contruct basis. The mechanized construction will principally be introduced in the main construction works. In order to maximize the employment opportunity in and around the development area, however, man-power construction will be adopted as much as possible. In this context, the construction works in the Work Divisions I and II will be carried out mainly by heavy construction machineries. While the construction works in the Work Division III will be carried out mainly by man power with minor construction equipments.

4.2 Implementation Schedule

The implementation schedule is shown on Fig. 4.1 and Fig. 4.2 for the Diversion Dam Scheme and the Pump Scheme respectively.

4.2.1 Preparatory Works

The preparatory works comprises the mapping, surveys and tests, detail design, tendering, land acquisition and so on.

The following mapping and survey works are essencially required before conducting detail design.

a. Map in scale of 1/5,000 and 0.5 m contour interval for the whole irrigation development area including the reservoir area of the diversion dam and Cabiao-Candaba floodway, about 500 km^2.

b. Map in scale of 1/1,000 and 0.5 m contour interval for the Diversion Dam or Pump Station about 10 km^2.

c. Longitudinal and Cross Sectional Survey on the Pampanga River from Arayat Bridge to Cabiao-Candaba floodway, about 12 km, 13 cross sections.

The detail design works will be commenced from February 1983 including the following surveys and tests.

a. Geological Survey

- Foundation of diversion dam or pump
- Foundation of major structures of irrigation and drainage facilities
- Quarry for riprap, gravel for pavement and aggregate for concrete
- Filling materials

b. Soil Mechanical Test

- Materials of foundations
- Materials for earthfilling
- Materials for riprap, gravel, pavement and concrete aggregate

c. Survey and Mapping

- Map in scale of 1/1,000 for major structure site for irrigation and drainage canal
- Longitudinal and cross sectional survey for all canals

d. Hydraulic Model Test

- Diversion dam
- Intake for pump station

The detail design with preparation of tender documents for the project facilities in the Work Division I and the major works in the Work Division II such as Main and Secondary Irrigation Canals, Main, Secondary and Catch Drains, Main Farm Road shall be completed by September 1983. Tendering and awarding follow the detail design and require three months to complete.

The detail design with preparation of tender documents for Lateral Irrigation Canal, Catch Drain and Secondary and Tertiary Farm Roads in the Work Division II shall be conducted in 1984 and 1985 for the Diversion Dam Scheme and in 1984 for the Pump Scheme.

The detail design of on-farm facilities in the Work Division III shall be carried out in parallel with organizing every farmers during the construction of major facilities.

The land acquisition for the project facilities shall be completed 6 months ahead of the construction works.

4.2.2 Work Division-I

The Work Division-I is the construction of the intake facility, Diversion Dam or Pump Station.

(1) Diversion Dam

The construction of Diversion Dam will be carried out from January 1984 to June 1987. The construction of Diversion Dam is divided into four major work items. (1) One is earthworks comprising temporary works such as access road and coffering, excavation and backfill for the structures and excavation and filling for the change of the low water channel of the River. The excavation for the structures will be carried out at the beginning of the construction works. The change of the low water channel will be conducted after construction of the structures in the low water channel before the whole works will be completed. (2) The second is the concrete works comprising piers, apron, fish ladder and retaining walls in low water channel, intake structure and so on. Piling works of sheet pile and foundation pile are included in this item. These concrete works will be continuously carried out for entire construction period. Out of these works the concrete works related to the gate installation will be completed before February 1986. (3) The third is the various protection works comprising wet masonry, concrete blocks, concrete flame with riprap, gabion and so on for both low water channel and high water channel including fixed weir. The protection works will start in the second year from the commencement, 1975 and complete 1987. (4) The fourth is the gate installation for Scouring Sluice, Spillway, Fish ladder and Intake structure. Since the gates of Scouring Sluice and Spillway are very big roller gates, it will take two year 1985 and 1987 to install gates and hoists at site. These big gates have to be ordered one year ahead of the commencement of installation for the fabrication in the factory. The gate installation for Intake structure including trash rack will be conducted in 1987.

All the construction works of Diversion Dam will be completed in 1987 and the irrigation water will be diverted from October 1987 for the dry season crop.

(2) Pumping Station

The construction of Pumping Station including installation of pump plant will be carried out from January 1984 to June 1986. The construction of Pumping Station is divided into four major items.

(1) One is earthworks comprising excavation and backfill for the structures and the excavation of Inlet Channel from the River to Pumping Station. The excavation work of the structures will be commenced at the beginning of the construction works in 1984. The excavation of Inlet Channel from the River will be carried out in 1986. (2) The second is the driving of the foundation piles on various structures. The piling works will start immediately after finishing the excavation works of the structure and complete as soon as possible in 1984. Since piling works will be conducted at the elevation of EL. - 4.6 m, about 6.0 m below the ground water table during dry season, the dewatering will be very important. (3) The third is the concrete works for the structures such as Inlet Culvert, Suction Pit, Pumping House, Outlet Cistern and so on. These concrete works including installation of crane in Pumping House will be carried out for whole construction period after the piling works. (4) The fourth is the installation of pump plants comprising pump, motor, value and other accessories including trash rack and power receiving facilities. The installation of the pump plants will be carried out 1985 and 1986. However, the pump plants will be ordered one year ahead of installation taking manufacturing time into consideration.

All the construction work of Pumping Station will be completed in June, 1986 and the irrigation water will be supplied from October 1986 for the dry season crop.

4.2.3 Work Division-II

The Work Division II is the construction of major irrigation and drainage facilities including farm roads. The construction period of the Work Division II is 4 years for the Diversion Dam Scheme and 3 years for the Pump Scheme in accordance with the construction period of the Work Division I.

(1) Irrigation Facilities

It takes 4 years and 3 years for the Diversion Dam Scheme and the Pump Scheme to complete both earthworks and structural works of Main Canal and Sub-Main Canal. The construction of Secondary Canals and Lateral Canals will be carried out from November 1984 to June 1987 for the Diversion Dam Scheme and from November 1984 to June 1986 for the Pump Scheme. In connection with the design works, some of Lateral Canals of the Diversion Dam Scheme will be constructed from November 1985 to June 1987.

(2) Drainage Facilities

The construction of Main Drain and Secondary Drains, which is mainly the improvement of the existing drainage courses will be carried out from January 1984 to June 1987 and June 1986 for the Diversion Dam Scheme and the Pump Scheme respectively. In case of the Diversion Dam Scheme, Catch Drain which is provided along Main Canal and one of Secondary Canals will be constructed in 1984 and 1985. In case of the Pump Scheme, Catch Drain will be constructed in 1985. Collector Drains, which are along Lateral Canal will be constructed in 3 years, 1985 to 1987 and 2 years, 1985 and 1986 for the Diversion Dam Scheme and the Pump Scheme respectively.

(3) Farm Road

Farm roads which are located along irrigation canals will be constructed simultaneously with the construction of irrigation canal.

4.2.4 Work Division III

The Work Division III is the construction of the on-farm facilities comprising Main and Supplementary Farm Ditches for a water distribution facility and Farm Drain and Drainage Ditch for a drainage facility.

The construction works of the Work Division III will be completed within 3 years after commencement both for the Diversion Dam Scheme and the Pump Scheme. The construction of Main Farm Ditch will be completed within two years for making maximum use of irrigation water to be supplied one year after commencement of the construction. In connection with organizing a water users' association on each Main Farm Ditch the construction of Supplementary Farm Ditch requires 3 years to complete.

Since most of excavated material of Farm Drain and Drainage Ditch will be used for the embankment of Main and Supplementary Farm Ditches, the construction of drainage facility will be carried out parallely with irrigation facilities.

4.3 Construction Materials and Equipment

4.3.1 Construction Materials

(1) Earth Material

In case of the Diversion Dam in the Work Division I, the change of low water channel is the main earthworks. Though filling of the present low water channel requires about 1 MCM of earth, the excavated materials of the new channel will be used for the filling.

In case of the Work Division II, most of the construction cost are accrued from the earthworks. Accordingly, excavated materials will be utilized for filling as much as possible within 500 m of hauling distance. The average hauling distance of the borrowed materials is assumed 1 km as borrow pits are to be available in and around the development area.

For the on-farm works of the Work Division III, filling materials shall be obtained in adjacent area in addition to excavated material.

(2) Concrete Aggregate

Fine aggregate for concrete works is to be obtained from the Pampanga River near Cabiao about 10 km away from Arayat where the Diversion Dam or Pumping Station is proposed. Coarse aggregate for concrete works is to be obtained in the Pampanga River near San Leonardo, in the Banban River near Banban and in the Porac River near Porac, all are about 25 km away from the Arayat.

(3) Others

The materials of gravel pavement for Main Farm Road shall be obtained at the same places as coarse aggregate for concrete.

Rock material used for riprap, gabion and masonry works shall be obtained from Mt. Arayat.

4.3.2 Construction Equipments

The major civil works of the project would principally be carried out by heavy construction equipment. The type and number of construction equipment to be required for the major civil works are estimated based on the work quantity, construction time schedule and the natural condition of the development area. Tables 4.1 and 4.2 shows the required type and number of major construction equipment for the Diversion Dam Scheme and the Pump Scheme respectively.

CHAPTER 5 COST ESTIMATE

5.1 General

The project cost mainly comprises construction cost, operation and maintenance cost and replacement cost. The following assumptions are made for the cost estimate of the project:

(1) The conversion rate between Peso and U.S. dollar is assumed at U.S.$1.0 = ₱7.5 = ¥225.

(2) All of the construction works would be executed by full contract basis. The machinery and equipments required for construction works would be provided by the contractors themselves. Therefore, depreciation cost of machinery and equipments would be taken into account for the cost estimate.

(3) The unit prices are divided into foreign and Peso currency components. The ratio of foreign and Peso currency components of each unit price is estimated on the basis of the following assumption referring to NIA criteria.

Item	Foreign Currency (%)	Peso Currency (%)
Cement	75	25
Steel Bars and Hardware	80	20
Fuel and Oil	50	50
Equipment Rental	75	25
Sheet Pile and Steel Pile	100	0
Labour	0	100

Manufacturing costs of gates for diversion dam and pump equipments for pump station are considered as fully foreign currency. All of the costs are estimated based on the current prices in September 1981.

(4) Physical contingency of the cost estimate is 15% of the construction cost except engineering cost, whose physical contingency is 10%, and manufacturing costs of gates for diversion dam and pump equipments for pump station, whose physical contingency is not considered.

(5) Price contingency applied in the estimate is: 6.5% per annum for the foreign currency component and 10% per annum for the Peso currency component.

(6) The associated costs to be financed by the Government, such as the costs for strengthening the extension services, improvement of the social infrastructures and so on are not included in the estimate.

5.2 Construction Cost

The construction cost comprises direct construction cost, engineering cost, compensation cost for land acquisition and cost for operation and maintenance facilities. These costs are estimated based on 1981 price level, and then price contingency is forecasted in accordance with the annual disburcement schedule.

The basic rate for cost estimated and the unit prices for major work items are as shown in Table 5.15 and Table 5.16 respectively. Each unit price comprises direct cost, 10% of overhead, 10% of profit and 3% of tax.

5.2.1 Construction Cost without Price Contingency

(1) Direct Construction Cost

The direct construction cost is estimated on the basis of quantity of the project works and the respective unit prices as follows:

(Unit: ₱10^3)

Scheme	Foreign Currency	Peso Currency	Total
Diversion Dam	146,430	160,530	306,960
Pump	96,350	110,360	206,710

The summary and the breakdown of the direct construction cost for both schemes, diversion dam and pump, are shown in Tables 5.7, 5.8 and Tables 5.9, 5.10 respectively.

(2) Cost for Operation and Maintenance Facilities

The cost for the operation and maintenance facilities comprises the construction cost of office and quarters, office equipments for O & M, vehicles, dump trucks, bulldozer and so on. The construction cost of main office is included in the construction cost of diversion dam or pump station.

This cost is estimated at ₱8.6 million for both schemes. The breakdown is shown in Table 5.11.

(3) Compensation Cost for Land Acquisition

The private land acquired for the project is to be compensated. The total compensation cost for the land acquisition is estimated at ₱33 million for diversion dam scheme and at ₱20.5 million for pump scheme. The breakdown is shown in Table 5.12.

(4) Engineering Cost

The engineering cost comprised consultant fee, administration expenses, mapping cost and so on, is estimated at ₱34.4 million for diversion dam scheme and at ₱26.6 million for pump scheme. The breakdown is shown in Table 5.13 and Table 5.14.

The construction cost excluding price contingency for diversion dam and pump schemes is estimated as follows:

(Unit: ₱10^6)

Scheme	Foreign Currency	Peso Currency	Total
Diversion Dam	191.8	240.7	432.5
Pump	132.0	165.4	297.4

The summary of construction cost of 1981 price level for the both schemes is shown in Table 5.5 and Table 5.6.

5.2.2 Construction Cost

The annual disbursement schedule is worked out based on the construction time schedule, and the total construction cost including price contingency for both schemes is estimated as follows:

(Unit: ₱10^6)

Scheme	Foreign Currency	Peso Currency	Total
Diversion Dam	256.5	371.6	628.1
Pump	169.0	242.5	411.5

The summary of financial construction cost and annual disbursement schedule for diversion dam and pump schemes are shown in Table 5.1, 5.2 and Tables 5.3, 5.4 respectively.