APPENDIX C: IRRIGATION AND DRAINAGE

THE STUDY
ON
MODEL RURAL DEVELOPMENT
IN
NAM DAN DISTRICT, NGHE AN PROVINCE

FINAL REPORT

APPENDIX-C IRRIGATION AND DRAINAGE

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C.1 INTRODUCTION

C.1.1 Objective of the Study

The main objective of the study is to clarify the present conditions of irrigation and drainage system and to suggest the optimum irrigation and drainage improvement plan in the Study Area.

In Nam Dan District, about 40 % of irrigable area is under the South Nghe An Irrigation Improvement Project which is financed by World Bank and this project area is excluded from the scope of this Master Plan Study for irrigation and drainage.

At present, irrigation facilities such as pumping and reservoir irrigation system are supplying the water for irrigable area in the Study Area, however, 48 % of irrigable area is not irrigated due to mainly deterioration of irrigation facilities and insufficient water resources.

The certain drainage system are not established in the Study Area. Especially farm land at right side of the Lam river faced to the inundation problems 2 to 3 times every year.

C.1.2 Summary of Field Work

Following data and information were collected.

- Inventory of existing irrigation scheme and their conditions
- Design command area and actual irrigated area of each facility
- Design drawings of main structure
- Present O/M system for irrigation
- Inundation damage
- Irrigation and drainage facilities design manual

Over all field survey of main irrigation schemes concerned in the Study area was carried out and physical conditions and problems were found out. Those were confirmed through the hearing investigation from farmers and irrigation officers.

C.1.3 Summary of Irrigation and Drainage Improvement Plan

Based on the results of fields survey and analysis of present conditions, several projects were proposed for irrigation and drainage improvement in the Study Area.

(1) Basic Concepts for Irrigation Improvement

There are more than 30 of pumping irrigation systems and more than 20 reservoir irrigation systems in the Study Area and present conditions of irrigation are summarized below:

System	Designed command area	Actual irrigated area
Pumping system	5,535 ha	2,575 ha
Reservoir system	1,715 ha	725 ha
Total	7,250 ha	3,300 ha

Due to deterioration of irrigation facilities and difficulties of water management, about more than 50 % of irrigable area cannot be irrigated at present. As around 2,000 mm of annual rainfall can be expected, even paddy rice can be produced without irrigation at the plain area, however, the productivity of agriculture is quite low comparing with irrigated area. As farmers in the Study Area have experience of irrigation more than 50 years, the agricultural production will be increased with improvement of irrigation facilities. Though it is necessary to improve the irrigation facilities for increasing the agricultural production, the evaluation of projects should be done with a comparison between with and without project situation considering project cost and benefit.

On the other hand, according to the results of water balance analyses for reservoir irrigation system, it is physically impossible to irrigate all the designed command area of reservoirs considering the scale of catchment area of reservoirs.

Based on the considerations above mentioned, following basic development concepts for irrigation improvement are proposed.

To increase the actual irrigated land based on the following countermeasure:
- Rehabilitation/renovation of canals for increasing the irrigation efficiency
- Construction of pumping stations for increasing of irrigation water
- Improvement of water management system for effective water use

(2) Basic Concepts for Drainage Improvement

There are two types of problem for drainage improvement in the Study Area due to topographic and soil conditions.

One is inundation problem in the rainy season at the area along the Lam river. Especially, Nam Nam area (South-western part of the Study Area), inundation coursed by back water from La river occurs mostly every year and inundation period is usually two to three weeks with 1 to 2 m of inundation depth. Agricultural production in this season is damaged and farmers life is influenced by this inundation problem at this area.

The another is poor drainage problem at North-western part of the Study Area. Agricultural production of upland crop is influenced badly in this area. Though it is necessary to improve the drainage conditions for increasing the agricultural production, the evaluation of projects should be done with a comparison between with and without project situation considering project cost and benefit.

Based on the considerations above mentioned, following basic development concepts for drainage improvement are proposed.

To mitigate inundation damage based on the following countermeasure:
- Improvement of drainage system for mitigation of inundation

- Rehabilitation/construction of structures for high river flow

To improve drainage condition at the existing poor drainage area with improvement of onfarm drainage system.

(3) Prioritization of proposed projects

The project cost (including O/M cost) and benefit of selected projects were roughly studied and prioritization was done in consideration of the following factors.

1. Urgency
2. Realization
3. Adaptability
4. Inhabitant needs
5. Sustainability
6. Impact
7. Model
8. Economy
9. Synergistic effect

The ranking for the proposed projects has been carried out based on the following criteria:

Rank	Conditions
A	Early implementation of the project is strongly recommended.
B	Early implementation of the project is recommended.
C	Implementation of the project is recommended.
D	Recommendation of the project shall be canceled.

(4) Summary of the Results of Master Plan

In irrigation and drainage sector, prioritization has been studied based on factors such as urgency, impact and economy. 16 reservoir irrigation improvement projects (13 renovation projects, 3 newly construction projects), 20 pumping irrigation projects (19 renovation projects, 1 newly installed project), 4 inundation mitigation projects and 2 drainage improvement projects are proposed for the Master Plan and the results of prioritization are summarized below:

Reservoir Irrigation Projects:

A rank	R02: Ho Thanh, R06: Trang den, R09: Cua Ong, R11: Rao Bang
B rank	R01: Vung Huyen, R04: Vuc Mau, R05: Hao Hao, R17: Khe Dinh, R19: Khe Bo
C rank	R10: Thanh Thuy, RN2: Da Han
D Rank	R07: Thung Pheo, R20: O O, RN1: Khe Dien, RN3: Ba Khe

Pumping Irrigation Projects:

A rank	P16: Nam Dong, PN1: Nam Cuong 2
B rank	P07: Nam Cuong 1, P10: Du DU, P19: Nam Tan, P20: Dai Dong 1, P23: Ru Dun, P28: Ghenh station, P31: Xuan Lam,
C rank	P09: Nam Trung, P21: Dai Dong 2, P27: Sen doi, P29: Hong Long 1, P30: Hong Long 2, P33: Ru Doi,
D Rank	P01: Duong dap, P13: Khanh Son 2, P17: Nam Loc, P22: Hong Son, P26: Nam thai,

Inundation Mitigation and Drainage Improvement Projects:

A rank	F1: Nam Nam Dike
C rank	D1: Nam Nam
D Rank	F2: North the Lam River, F3: Tan Loc Thuong, F4: Thien Nhan Mauntain, D2: Hong Long

(5) Summary of Priority Projects

1) Irrigation Improvement

From the results of alternative studies for irrigation improvement based on the present conditions, it was considered that the feasibility of realization of effective water use is the highest from the technical, economical and environmental view points using present water sources as much as possible. Basically, improvement of canal facilities including renovation of diversion works and strengthening of water management system are proposed. For the reservoir system, considering safety factor of structure, water balance with catchment area, etc., the improvement of reservoir structures such as heightening of dike, dredging of storage are not proposed except renovation of spillway. On the other hand, as there is enough capacity for present pumping facilities, it is not necessary to improve the present pumping station. The new pumping station is considered to be installed for non-irrigated area at present.

The facilities for proposed irrigation improvement plan are summarized below:

No	Name of System	Location (Commune)	Present Irrigated Area (ha)	Proposed Irrigated Area (ha)	Proposed Water Requirement (l/s)	Total Length of Main Canal (m)	Total Length of Secondary Canal (m)	No. of Diversion (unit)	No. of Other Structures (unit)
R2-1	Ho Thanh 1	Nam Kim	37	66	126	2,080	1,330	6	37
R2-2	Ho Thanh 2	Nam Kim	8	14	27	660	1,630	1	3
R6-1	Trang den 1	Nam Hung	36	80	151	1,495	790	3	11
R6-2	Trang den 2	Nam Hung	9	20	38	3,435	3,740	7	25
R9	Cua Ong	Nam Nghia	100	150	283	1,900	6,220	10	41
R11	Rao Bang	Nam Thanh	100	160	302	980	6,010	11	15
P16	Nam Dong	Khanh Son	253	800	1,530	7,492	27,650	43	41
Pn1	Nam Cuong	Nam Cuong	0	120	229	1,735	3,950	8	11
Total			543	1,410	2,685	20,677	51,320	89	184

Note Pn1: New pumping irrigation system

2) Mitigation of Inundation

Drainage System of Nam Nam Dike

The main drainage canal connected to the La river belongs to Ha Tinh Province. Therefore, it is impossible to formulate drastic mitigation plan without improvement of the drainage canal located in Ha Tinh Province. For mitigation of inundation, it is necessary to renovate/construct the following facilities from the view point of enforcement of drainage capacity and ensuring safety structure and it is expected that more or less one week of inundation period will be reduced.

Project Component	Main facilities	Main works	Purpose of facilities
Renovation of existing drainage gate	4 x 5.5 m 3 gates	Replacement of gate only	Prevention of small inundation Enforcement of drainage capacity
New construction of drainage gate	3 x 5.5 m 3 gates	New construction of gate facility	Enforcement of drainage capacity
Rehabilitation of main drainage canal	soil canal 500 m	Rehabilitation of soil canal 500 m	Enforcement of drainage capacity
Installation of new spillways (2 site)	200 m width each	Excavation and protection of dike	Ensuring safety structure
Protection of crossing point with present road	Average road width 4 m	Protection of rode and slope surface	Ensuring safety structure

3) Implementation Plan

Implementation stage of renovation/construction of irrigation and drainage facilities is divided into two stages, preparation stage (detailed design, tendering) and construction stage. Considering effective construction, it is better to set one year for preparation stage and to carry out the construction stage at dry season in next year (in this way, it is necessary to compensate for one crop season for present irrigated area and compensation cost is included in the project cost). For the implementation, basically the present implementation system can be used that is the agricultural and rural development division of the Nam Dan District will work as the executing agency under the support and inspection of agricultural and rural development department of Nghe An Province and using the local consultant and contractor in the Province. However, in case of using the international fund for finance, sometimes it is necessary to select the consultant and contractor through the international tendering. Considering the effective generation of project benefit, it is necessary to decide the implementation order for each project based on implementation schedule of relevant sectors such as rural road and rural electrification.

4) Operation and Maintenance Plan

Operation and maintenance work for irrigation system is consist of water management (decision of water distribution, irrigation water supply, watching), facility maintenance (inspection, repair) and administration (collection of water fee).

For the purpose of maintaining the drainage facility function, operation and maintenance work of drainage system is consist of inspection, routine maintenance, and periodic maintenance.

The organizations for operation and maintenance are already existed and functioned at present and it is not necessary to enforcement the present organizations

5) Project Cost and O/M Costs

The project cost and O/M cost are estimated as below:

(million VND)

Name of Project	Project Cost	Annual Average O/M Cost
1 Ho Thanh Irrigation System	7,542	44
2 Tang den Irrigation System	12,032	61
3 Cua Ong Irrigation System	10,252	63
4 Rao Bang Irrigation System	8,408	56
5 Num Dung Irrigation System	22,661	679
6 Nam Cuong Irrigation System	9,966	107
7 Nam Nam Dike	3,952	367
Total	74,813	1,477

Note: Engineering cost and physical contingency are included in the project cost. Price escalation are excluded
Replacement cost of equipment is estimated as annual average cost

C.2 PRESENT CONDITIONS OF IRRIGATION AND DRAINAGE

C.2.1 General Conditions

(1) Summary of the South Nghe An Irrigation Project

In Nam Dan District, the South Nghe An Irrigation Project is going to be implemented financed and supported by World Bank. This project covers 12/24 communes of the districts with a cultivated land of 4,130 ha as shown in Fig. C.2.1 (total area : 6,800 ha and population approximately 60,500 persons)

Nam Dan sluice which is main water source for this project was built in period 1936 - 1941, it comprises of 4 gates with 2 m width each (crest elevation is -1.30) and a shipyard of 5 m width, the mean discharge is 26.1 m^3/s (max. 33.67 m^3/s, min. 10 m^3/s) to irrigate 18,945 ha of cultivated land in the Southern part of Nghe An province.

Main objectives of this project are to supply irrigation water for totally 24,275 ha of cultivated land (5,330 ha of Nghi Loc district was added) and to supply the water for industrial and domestic uses in Cua Lo township and Vinh. The main works of this project are to renovate main canal, pumping stations, to newly install some pumping stations for 5,330 ha of additional area and to repair Nam Dan and Ben Thuy sluices (for salt water presentation and storing fresh water) with a total cost estimated of 248 billion VN dong.

(2) The Study Area

Lam river (upstream called Ca river) is one of the biggest river in the Northern Central coastal lines which originated from Lao PDR with a catchment area of 22,300 km^2 at Yen Thuong hydrological station (approximately 5 km up stream of the Study area). The base flow corresponding to river water level at Nam Dan sluice of +1.05 m a.s.l and mean discharge is estimated as 117 m^3/s with good water quality for irrigation. This river is also the main drainage of the area.

Water resources planning of Nam Dan district has been conducted many times (in French regime period, 1971 - 1975 and 1987 - 1988). So far Government and local authorities have built 85 pumping stations, more than 40 reservoirs and some drainage and flood protection structures. Total designed irrigation of head works in the district is 13,000 ha. According to the report of district development, actual irrigated area of rice in 1995 was 6,332 ha out of 6500 ha of rice growing area (or 97%) i.e. 48% of designed command area and 62% of cultivated area.

The Study area of "Model Rural Development in Nam Dan District" comprises of 12 communes and some other communes besides the South Nghe An Irrigation Project boundary with a total natural area of 22,500 ha and a population of 97,346 persons (61.6% of the total population in the district) and a cultivated land of 7,300 ha.

More than 61% of the Study area (or 14,000 ha) is mountains and plain outside the dikes. With the mean land elevation of cultivated area is from (+2.0) to (+4.0) a.s.l. all

cultivated land has to be irrigated by pumping stations and reservoirs and contrarily it can be drained by gravity.

Whole area on the left bank of the Lam river has been protected thoroughly by a dike system designed to prevent historical flood, the dike of the area on the right bank of the Lam river (comprising the area of 8 communes) was designed to prevent the flood of the Lam river up to second alarm level only, this means that when a bigger flood comes (often at the end of September or October every year) all the low lying area of the right side (including cultivated and residential land) will be inundated for 7 - 10 days.

C.2.2 Present Conditions of Irrigation System

(1) Conditions of Existing Facilities

By now 33 pumping stations have been built in the Study area with total installed capacity of 66,820 m^3/h and 31 reservoirs and ponds. The whole designed command area of these structures is about 6,000 ha, so far actual irrigated area is 3,400 ha accounting for 90 % of rice growing area or 54.6 % of cultivated land (see Tables C.2.1). Among them only one pumping station (Nam Dong) and 5 reservoirs (Ho Thanh, Trang Den, Cua Ong, Thanh Thuy and Hao Hao) are managed by South Nghe An Irrigation Enterprise. As for remaining structures are owned and managed by agricultural cooperatives. There is a big reservoir named Da Han is under construction, so far first phase of construction has been nearly completed, after completing second phase it will irrigated 220 ha of cultivated land and to be managed by the South Nghe An Irrigation enterprise.

In general, irrigation system has had great effect in agricultural production, especially rice. Along with other intensive farming measures (variety, fertilizers and plant protection) the yield of rice as well as other crops have been increased stable (see detail in agricultural section).

(2) Problems Identified

Due to the real requirements of each period the planning has not been strictly followed. Some structures, especially structures constructed and funded by cooperatives or communes were in a casual way without any permission of irrigation department or authorized body. Due to limitation of initial investment and operation and maintenance fund sources along with a long time use, most of these systems have now been seriously degraded. On the other hand, due to the changes of the cropping pattern and cropping calendar eventhough the Study area has a dense irrigation system, the water supply for agricultural production is still far below actual requirement, up to 650 ha of rice growing area has not been well irrigated, the irrigation of subsidiary crops (such as ground nut, maize, vegetables, etc.) seems not to be mentioned in the last planning. The drought in the end of winter-spring rice growing period and early stage of summer-autumn rice crop season when water level in the Lam river in the lowest period is still a normal situation in most of irrigation systems.

All reservoirs and ponds built by the years of 60s or 70s when national and local economy was still in very weak situation therefore they are very simple structures (homogenous earth dam, natural spillway, through saddle or constructed by rock masonry, outlet is operated by manual, etc.). Most of head works of these reservoirs need to be repaired (erosion and leakage of main dams, serious damages of spillways, gates and outlets broken and out of order etc.).

Head works of pumping station (excluding some of them repaired and upgraded recently such as Nam Dong, Ghenh and Nam Tan pumping stations) were all designed with simple structures (4 th grade houses) and now seriously degraded. Most of pumping stations built along the Lam river bank and in the right bank of Lam river are submerged when flood come, motors have to be lifted to a higher sites every rainy season and to install again in the dry season. The sedimentation can be seen in all suction bays of pumping stations installed along the Lam river bank, even in serious situation such as Xuan Lam pumping station. All pumping stations inside the dike in right side of the Lam river by the months of January, February, March, have not enough water source when the Lam river is in the lowest water level of the year.

Canal systems have been built but not enough for water regulation. All these systems built with simple structure (earth canals, rock masonry outlets, etc.) and to be affected by the nature and man with very little operation and maintenance cost so have been seriously degraded, especially these on the right bank of the Lam river where the area is inundated every rainy season. Most of on canal structures were damaged and out of order. Therefore although the capacity of head works is great, the tail ends of most systems, especially a bigger ones are always suffer from lacking of water (such as Nam Dong pumping system irrigates only 250 ha out of 1350 ha of its capacity, in Nam Trung pumping system it is 450 ha and 1100 ha, in Trang Den reservoir it is 45 ha and 200 ha respectively)

These above situations along with the changes of cropping pattern and cropping calendar (from main wet rice crop to early summer - autumn rice crop requires higher water requirement as hot and dry climate at early stage of early summer - autumn rice crop season and can not make full use of rain water). The shortage of electricity for agricultural production in the past (by the years of 70s and 80s, the duration of electricity supplies to agricultural production was 7 - 8 hours per day) also lead to the construction of series of pumping stations at the tail end of medium and large irrigation systems with the capacity of each pumping station is from 500 - 2000 m^3/h. The other reason of this situation is the agricultural cooperatives wanted to have their own pumping station to have a sense of initiative on water supply for agricultural production when the land has been allocated to farmers for long term use and they can freely select seeds, crop even crop calendar so that they can get the highest benefit.

Therefore the area always suffers from drought in the Study Area is up to 2,750 ha, subsidiary and other upland crops (such as ground nut, peas, soybean, maize, sweet potatoes, etc.) are all rainfed crops and or use available moisture in the soil or irrigated by handle manners.

C.2.3 Present Conditions of Drainage System

(1) Conditions of Existing Drainage

Water level of the Lam river in dry season (Winter-Spring and early stage of summer-Autumn crop seasons) is always lower field level of the project area and due to near the sea (about 40 km) the flood in the Lam river at the project area always occurs with a rather short duration (about 7 - 10 days), the Study area is therefore defined to be mainly drained by gravity through Thap canal and some sluices constructed under the dike. It is clear that in Nghe An province in general and in Nam Dan district in particular there is often no heavy rain in Winter-Spring and early stage of summer - autumn crop seasons. Rainy season starts at the end of September or early October when the rice crop has been harvested already.

Due to topographical character, the slope direction is from both sides of the Lam river to the river that easy for drainage by gravity excluding some far and low lying areas.

By above reasons the drainage system so far has not been reasonably considered. Onfarm drainage system is mainly natural streams and rivers excluding some low lying areas along Bau Non, Bau Lang and Lam Tra canals (on the left) and Thien Nhan canal (on the right to separate rain water coming from Thien Nhan mountain range out of the plain area of 5 communes) where have some artificial drainage systems.

Whole area on the left side of the Lam river is drained through Thap and Lam Tra canals and then to Ben Thuy sluice and Hung Chau pumping station (built in Hung Nguyen district to drain water when the water level in the Lam river raising up and Ben Thuy sluice has to be closed.)

Whole area on the right of Lam river (excluding area of Nam Loc, Nam Thuong and Nam Tan communes and about 100 ha of Nam Trung commune drain directly to the Lam river) drain to the La river through Ngu Hoa stream (La river is in the South of the project area). In this area there are 10 sluices under the dike in which 5 were newly built and other 5 built about 50 years ago have been seriously damaged that affect to the drainage and flood protection.

Canal and on canal structures have not been built simultaneously as irrigation system, on the other hand it did not to be repaired regularly and to be cut and stagnated by men there fore the cross sections are all not large enough to convey exceed water that damage to crop yield.

Up to now about 750 ha of rice cultivated land in the Study area always suffer from logging water (1,500 ha in the whole district) excluding vast area logged water physiologically.

Due to the changes of meteorological factors recently sometimes high water level in the Lam river and heavy rain in the project area considerably and occur earlier that damages seriously to the crops. This is a problem to be carefully studied in coming years as water distribution and regulation according to the requirement of plant growth

(including rice and subsidiary crops) is one of the important factors for increasing crop yield and crop diversification and for ensuring sustainable eco-agricultural system.

(2) Flood Prevention System:

Within Nam Dan district territory there are:

A left bank of the Lam river with 12 km long built along time ago to protect 78,000 ha of the South Nghe An province. It is designed by national criteria of historical flood (2nd grade). The crest level of the dike at Nam Dan sluice is (+10,0)

There is a beam along the dike but the cross section is small and to be eroded in many places as a limitation of fund for maintenance.

Nam Trung dike along the right bank of the Lam river with a length of 8.9 km to protect flood for 5 communes in the South of the district. It was designed with a criteria of flood protection at 2nd alarm level but it is now much higher than that (+8.0) at Khanh Son commune, (+7.0) at Nam Cuong commence. The width of the dike is around 3m and to be used as transportation road so damaged in many places. In the year when water level in the Lam river exceeds 3rd alarm level the water over flows the dike that also cause serious damages.

The dike along the South and the West (on the right bank of the Lam river) to prevent flood from the La river and rain water from Thien Nhan mountain range with a length of 11 km. The crest level of the dike is now from (+6.0)-(+6.5) with a rather small dimensions(crest width is about 2.5m and side slop: 1.50). There exists one spillway(115m long) and 4 sluices only, so when the big flood come (exceeds third alarm level), the dike has been broken many times(even in 1996).

The dike 3/2 in Khanh Son commune with a length of 1.6 km and an elevation of (+8.0) to protect 120 ha of cultivated land(130 ha totally) of the commence. The sliding is very serious in a distance of 1 km along the dike and needs to have solution for dike protection her.

In Nam Thuong commune there are two dike lines:

- The dike along right bank of the Lam river with a length of 2.5 km and a mean elevation of (+9.50) to protect 110 ha of cultivated land (150 ha totally) of the commune on the right bank of the Lam river.

- The dike along left bank of the Lam river with a length of 1.5 km to protect 50 ha of cultivated land (80 ha totally).

All this two dike lines are small and to be slided heavily.

In Nam Thai commune there are two dike line along Rao Gang river with a length of 2.3 km to protect 350 ha of Nam Thai commune, the mean elevation of the dike is about (+11.00) and in rather good condition.

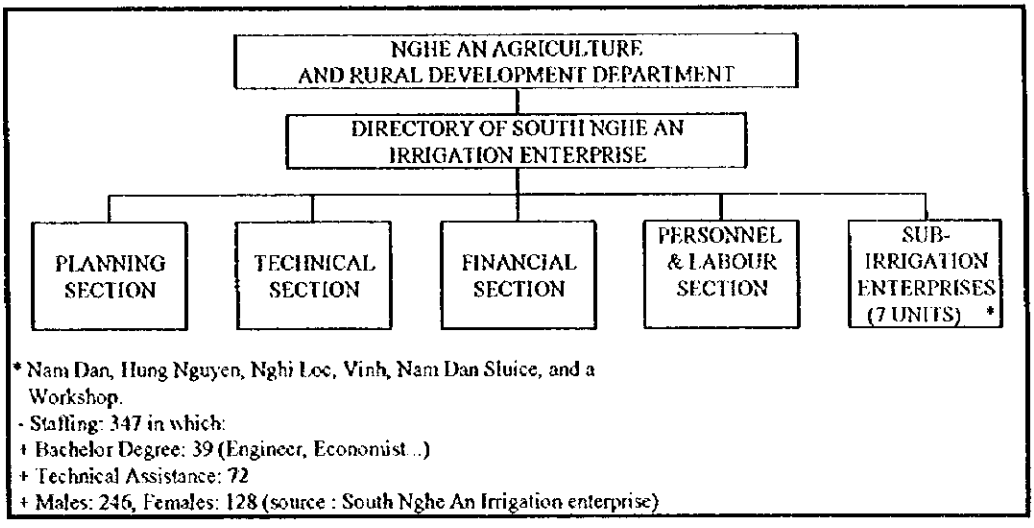
So only the dike on the left side of the Lam river managed by Central Government is designed to protect the highest historical flood, the remaining local dike systems can protect the flood or second alarm level only. All these system are small and degraded due to limitation of yearly maintenance cost.

C.2.4 Operation and Maintenance Organization.

Participating operation and maintenance of irrigation system in Nam Dan district comprises two forces (including a station in charge of Nam Dan sluice management):

(1) South Nghe An Irrigation Enterprise

Organization of the South Nghe An Irrigation Enterprise is shown below;



Nam Dan Irrigation Management enterprise in one of seven enterprises belong to South Nghe An Irrigation enterprise. It has 75 staffs in which 6 engineers and 14 technicians undertaking operation and maintenance of 9 pumping station and 5 reservoirs system in Nam Dan district, in which one pumping station and(Nam Dong) and 5 reservoirs(Cua Ong, Thanh Thuy, Trang Den, Ho Thanh and Hao Hao) are in the project area. Total fixed property value of the company(constant price in 1986) is 9.7 billion Vietnamese dong. The total designed capacity of irrigation system managed by the company is about 6,000 ha but actual irrigated area in 1995 was 2,000 ha (or 30% of designed capacity). Main reason of this situation is the degradation of the head works and on canal systems (machines and electric systems are too old, all gates of outlets and regulators are damaged etc.). On the other hand cooperative and communes have built many small pumping stations at the tail ends of these system that makes command area reduced.

- Irrigation fee is 7% of the contracted yield for winter-spring rice, 7.5% for summer-autumn rice crops, 30% of irrigation fee for rice for other cash, seedling and subsidiary crops (according to decree No 112 of the Central Government). On average, the total of irrigation fee collected within last 5 years is 900 tons of rice per year.

- The company operates independently with district authority. The contract of water use is signed directly between company and cooperatives or commune authority on the area to be irrigated and crop calendar. The company undertakes the responsibility of supplying water to the outlets of secondary canals and to be finalized for each irrigation time.

- Due to the limitation of O and M equipment and technical force the O&M of irrigation system(including irrigation drainage and flood protection system) in Nam Dan district is very simple and backward:

  + All gates, regulators and openings on the canal system are damaged or have not yet been constructed, the delivery of water from secondary canal down ward to the field is implemented by workers of commune or cooperative by manual manners(digging the canal bank) therefore it is very slow and waste water (exceeds water requirement and exhaust to the drainage canal etc.) is very serious while water never reaches to the tail ends. The irrigation efficiency is therefore very low of about 0.4 to 0.5 only. Although the irrigation calendar for each crop season is scheduled before crop season, company has to operate pump and gates of outlet in the reservoir casually when cooperative requires.

  + The service of water supply for agricultural production is a cost accounting with subsidizing for business loss. Every year, South Nghe An irrigation company has to be subsidized from 1 to 2 billion Vietnamese dong from Government for their services (excluding they do not have to pay for the consumption of fixed capital, big repairing discount, and Government also pays for drainage electricity cost and other subsidy for the year having natural calamity).

(2) Agricultural Cooperatives

Agricultural cooperatives operate and maintenance all the pumping stations and reservoirs/ponds constructed and funded by themselves.

- Each commune has a member in charge of general works of irrigation and most of cooperatives have and irrigation team (each team member in each brigade) in charge of delivering water from secondary canal to the fields (plot).

- Irrigation fee in cooperative managed system defined by each cooperative itself with the way of covering all spent costs (for electricity, repairing and salary for workers etc.) without any official regulation but always higher than that of state-run irrigation enterprise.

- In general, due to the limitation in many fields (technical level, skill and experience in operation and maintenance etc.), more over these systems are constructed with simple and temporary structures with limited fund for regular maintaining the irrigation efficiency as always very low of 30% to 40% of designed capacity only but with higher O&M cost. Therefore along with measures of upgrading bigger systems, it is necessary to study carefully to abolish some unnecessary and low efficiency pumping stations to reduce O&M cost. At the same time the applying provincial policy of allocating all irrigation systems in the district to the irrigation

management enterprise in that district as have been organized in the past (including structures constructed and funded by cooperative in the form of selling to the enterprise) should be implemented soon.

- In water and system management farmers are the direct beneficiaries but have no responsibilities. Farmers near the head works want to get more water even too much and then drain out while water rarely flow to the tail ends causing conflict among farmers, in some cases it is a serious problem. This is also the main problem in present O&M situation and necessary to have a measure to organize farmers to participate in O&M of irrigation system to serve for their production more effectively.

C.3 BASIC DEVELOPMENT CONCEPTS FOR IRRIGATION IMPROVEMENT PLAN

C.3.1 Development Potential and Constraints

(1) Irrigation System

1) Potentials:

Water source is available and in good quality from the Lam river enable the localities to develop irrigation facilities for all water users (agricultural production, fishery, domestic and industrial requirements). Especially when Ban Mai hydro-power plant built, a remarkable discharge of the Lam river will be supplemental in dry season.

Labour forces for rehabilitating and newly constructing of irrigation system are available in both quantity and quality. Local construction companies have good abilities (technical force, skilled labour and equipment, etc.) to construct all project structures in the area.

Construction materials are also available in quantity and good in quality (such as rock, sand, gravel, etc.) in the project area.

Most of existing irrigation systems are seriously degraded and need to be rehabilitated. If some project can invest a reasonable fund the efficiency of these systems will be great and all residents in that project area will be direct beneficiaries. This is also the main solution for the campaign "hunger elimination and poverty reduction" in the rural area.

Organization of operation and maintenance is very low and weak at present, the irrigation efficiency will be much improved if this field to be recognized with the participation of water users and a skilled O&M staffs.

2) Constrains:

Most of existing irrigation systems were constructed many years ago that too old and out of date and need to have a large amount of investment fund

Some dispersed and high elevation areas that difficult to supply irrigation facilities. In the future, cropping pattern should be remained as present (rainfed agriculture)

Some plain areas along and outside the river bank of the Lam river also can not to be irrigated by irrigation facilities and will rest on the nature as present.

Transportation facility is poor in the Study area that difficult to assess to the proposed project sites especially reservoirs/ponds and sites on the right side of the Lam river. The construction unit cost will be much higher than that in the plain areas.

On the right side of the Lam river, all the plain area (including residential land, cultivated land) will be flooded when water level in the Lam river exceeds 3rd alarm level that causes damages to irrigation system especially canal systems constructed by earth.

(2) Drainage System

1) Potentials:

Topographical condition in Nam Dan district is favorable for drainage: main slope direction on both sides of the Lam river is from the foot of the mountain ranges to the river. Natural streams and rivers in the study area can be used as drainage canal system.

In normal climate condition, most of cultivated land in the study area can be easily to drain by gravity through existing sluices along the Lam river bank for both winter - spring and early summer - autumn crop seasons when the water level in the Lam river is still in the lowest period.

In some low lying areas the drainage systems have been built and the main drainage system in the area has been formed. Therefore most of rice growing areas in low lying areas can grow two rice crops per year with rather stable yields when the climate is in normal conditions

2) Constrains:

Drainage system in the Study area is poor and not to be paid reasonable attention in last planning. So in cases of heavy rain or higher water level in the Lam river, a vast cropped area will be submerged for some days that damages the crops in a certain limit, especially at the end of summer - autumn crop season. Bio-water logging is a normal situation of all crops in low lying areas.

Due to limitation of investment capital, artificial measures (by electric pumping station) has not been mentioned.

Drainage problem in the Study area is affected by the drainage system of the South Nghe An region and difficult to be solved independently.

The cultivated land is mostly just near the foot of mountains that difficult to separate mountain flood out of the field.

In present economic condition the solving of drainage for main rainy season is too costly

C.3.2 Target and Strategy of Irrigation and Drainage Improvement

(1) Target Year

As year 2010 was set as the target year in the Master Plan of Socio-economic Development of Nghe An Province, the target year 2010 is also set for the Master Plan Study for Model Rural Development in Nam Dan District.

(2) Proposed Target and Strategy

1) Irrigation Improvement

As mentioned before, 54.6 % of irrigable area is not irrigated due to deterioration of irrigation facilities. Considering the time period and sustainable development, the actual irrigated area shall be increased from 3,400 ha to 5,240 ha by year 2010. Based on this consideration, irrigation facilities such as reservoirs, pumping stations, canals etc. shall be constructed as well as rehabilitated/renovated.

2) Drainage Improvement

In the South Western part of the Nam Dan District (at the right side of the Lam river, called Nam Nam region), 2 or 3 times per year of the inundation occurs coursed by flood water from the Lam river, and this make a damage to farmers living conditions as well as crops. It is considerable two alternatives such as prevention plan or mitigation plan for flood.

For the flood control, some of the prevention work should be required at the some area along the Lam river.

On the other hand, there are some of poor drainage area in the Study Area and this influenced to agricultural production. Therefore it is necessary to improve the drainage system in such area.

C.3.3 Basic Development Concepts for Irrigation and Drainage Improvement Plan

Based on the considerations above mentioned, following basic development concepts are proposed.

(1) Irrigation Improvement

To increase the actual irrigated land based on the following countermeasure:

- Rehabilitation/renovation of canals for increasing the irrigation efficiency
- Rehabilitation/renovation, heightening and new construction of reservoirs for increase of irrigation water resource
- Rehabilitation/renovation of pumping stations for increasing of irrigation capacities and for flood protection.
- Improvement of water management system for effective water use

(2) Drainage Improvement

To decrease flood damage based on the following countermeasure:
- Improvement of drainage system for mitigation of inundation
- Rehabilitation/construction of structures for high river flow

To improve drainage condition at the existing poor drainage area with improvement of onfarm drainage system.

C.4 IRRIGATION AND DRAINAGE IMPROVEMENT PLAN

C.4.1 Planning/Design Standard/Criteria Applied for Study

Following Planning/Design Standard/Criteria were applied for the Study;

- FAO Irrigation & Drainage Paper No.24 (1977)
- Viet Nam Irrigation Canal Design Standard TCVN-4118-85
- Standard on Hydraulic Computation of Spill Way QP-TL-C-8-76.
- Standard on Irrigation Structure Design QP-Tl-08-76.

C.4.2 Proposed Irrigation Projects

(1) Irrigation Water Requirements

Some information on water requirement is available in the feasibility study on the South Nghe An Irrigation Projects and the cropping conditions of cultivated land in the Study Area are almost same as that of Project Area. Therefore, for the Master Plan Study, the water requirements were estimated in the manner employed in the FAO Irrigation & Drainage Paper No.24 (1977) as described below:

1) Potential Evapotranspiration, Land Preparation Requirement, Percolation Losses and Water Layer Requirement

Based on meteorological records up to 1987, the potential evapotranspiration (ETo) for the Nam Dan District has been estimated in the South Nghe An Irrigation Project report (1994) using the Penman method. The calculation was reviewed carefully and ETo was estimated applying the same manner based on meteorological data up to 1994. The results are summarized as shown below;

Summary of Evapotranspiration

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperature (°C)	17.4	18.0	20.4	24.0	27.7	29.4	29.6	28.6	26.9	24.3	21.6	18.8
Humidity	89.2	91.1	91.2	88.7	81.2	75.6	73.9	80.1	86.2	87.2	86.6	86.7
Wind Velocity (km/d)	154.8	152.6	150.7	161.4	174.6	203.0	214.4	166.2	133.5	153.7	146.0	144.2
Sunnis (hr/d)	2.5	1.7	2.4	4.4	7.5	6.8	7.7	6.6	5.6	5.2	3.5	3.1
Solar Radiation ($MJ/m^2/d$)	12.2	15.0	17.2	20.2	22.3	21.8	21.5	20.3	17.4	15.1	12.8	11.3
Evapotranspration (ETo mm/d)	2.0	2.5	3.1	4.0	4.8	5.0	5.1	4.7	3.8	3.1	2.5	2.0

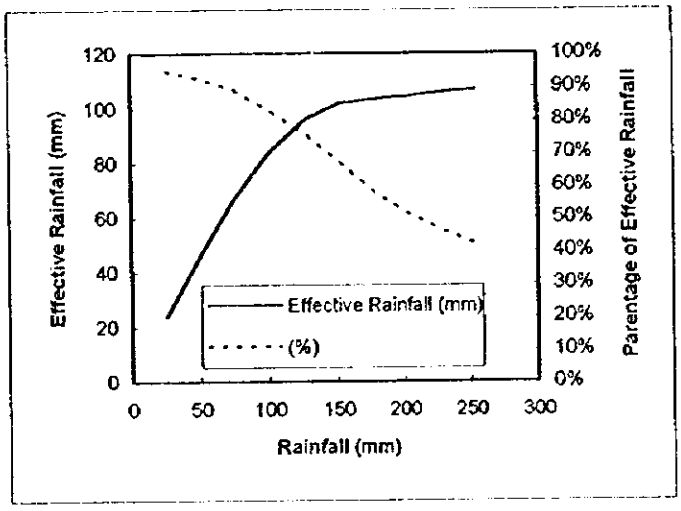
2) Crop Coefficient (kc)

Based on the results of field investigation, the crop coefficients were calculated in the manner presented in FAO Irrigation and Drainage Paper No.24 considering the data and information collected in South Nghe An Irrigation Project.

3) Rainfall and Effective Rainfall

Using the rainfall pattern in the Study Area (Nam Dan and Nam Phúc) analyzed in (Appendix-A), Effective rainfall were estimated based on the USDA criteria, as shown below, according to the FAO Irrigation and Drainage Paper No.24.

Rainfall		Effective Rainfall		
Inches	mm	inches	mm	%
1	25.4	0.95	24.13	95%
2	50.8	1.85	46.99	93%
3	76.2	2.67	67.82	89%
4	101.6	3.32	84.33	83%
5	127.0	3.79	96.27	76%
6	152.4	4.02	102.11	67%
7	177.8	4.07	103.38	58%
8	203.2	4.12	104.65	52%
9	228.6	4.17	105.92	46%
10	254.0	4.22	107.19	42%



The results are summarized as below:

Effective Rainfall

Station Nam Dan													
Return Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep.	Oct	Nov	Dec	Annual
1/ 2	24.7	26.7	33.3	59.1	98.5	101.5	95.4	106.0	116.1	115.0	97.1	42.0	185.2
1/ 4	21.2	23.0	28.8	51.6	91.8	96.6	87.1	104.4	113.0	112.1	89.3	36.2	172.5
1/ 5	20.4	22.2	27.8	49.9	89.7	94.8	85.3	104.0	112.4	111.5	87.4	34.9	169.6
1/10	18.5	20.1	25.3	45.5	84.7	89.3	79.3	103.1	110.7	109.9	81.9	31.8	162.5
1/20	17.1	18.5	23.4	42.1	79.6	85.1	74.5	102.4	109.4	108.7	77.0	29.4	157.2
Station Nam Phuc													
Return Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1/ 2	35.6	28.7	37.1	60.5	104.1	87.9	102.6	103.9	118.3	131.7	103.7	43.0	188.4
1/ 4	30.3	24.5	31.5	52.0	102.6	78.3	98.6	102.4	114.6	109.1	102.2	36.6	173.8
1/ 5	29.3	23.6	30.5	50.3	102.3	76.2	97.5	102.2	113.9	108.6	101.5	35.3	171.1
1/10	27.1	21.8	28.2	46.8	100.1	71.6	93.9	99.6	112.4	107.4	98.8	32.6	165.0
1/20	25.7	20.6	26.7	44.2	98.3	68.7	90.8	97.8	111.4	106.7	97.0	30.9	161.1

4) Irrigation Efficiency

Based on the field survey and considering the actual irrigation area, the irrigation efficiency at present condition was estimated and that of future conditions are estimated considering the rehabilitation/renovation of irrigation facilities as shown below;

	Cropping Type	Field Efficiency	Conveyance Efficiency	Total Efficiency
Present Condition	Paddy	0.95	0.45	0.43
	Upland Crop	0.63	0.45	0.28
Future Condition	Paddy	0.95	0.80	0.75
	Upland Crop	0.63	0.80	0.50

5) Unit Water Requirement and Diversion Water Requirement

Based on the above assumptions, the unit water requirement was estimated for each cropping pattern (see Appendix B). Results are shown in Table C.4.1 and maximum unit water requirements are as below;

Maximum Unit Water Requirements (l/s/ha)

Present Conditions						
Station	Station Nam Dan					
Cropping Pattern	CP1	CP2	CP3	CP4	CP5	CP6
Return Period 1/ 2	2.692	3.127	3.127	3.214	3.127	1.004
Return Period 1/ 4	2.743	3.171	3.171	3.288	3.171	1.118
Return Period 1/ 5	2.755	3.187	3.187	3.305	3.187	1.144
Return Period 1/10	2.783	3.236	3.236	3.358	3.236	1.226
Return Period 1/20	2.805	3.274	3.274	3.401	3.274	1.292
Station	Station Nam Phuc					
Cropping Pattern	CP1	CP2	CP3	CP4	CP5	CP6
Return Period 1/ 2	2.682	3.249	3.249	3.149	3.249	0.905
Return Period 1/ 4	2.740	3.335	3.335	3.185	3.335	0.975
Return Period 1/ 5	2.751	3.354	3.354	3.195	3.354	0.989
Return Period 1/10	2.776	3.395	3.395	3.227	3.395	1.025
Return Period 1/20	2.791	3.421	3.421	3.255	3.421	1.068

Note CP1 to CP6 : Cropping Pattern (see Appendix B)

Maximum Unit Water Requirements (l/s/ha)

Future Conditions						
Station	Station Nam Dan					
Cropping Pattern	CP1	CP2	CP3	CP4	CP5	CP6
Return Period 1/2	1.543	1.793	1.793	1.842	1.793	0.562
Return Period 1/4	1.573	1.818	1.818	1.885	1.818	0.626
Return Period 1/5	1.579	1.827	1.827	1.895	1.827	0.641
Return Period 1/10	1.596	1.856	1.856	1.925	1.856	0.687
Return Period 1/20	1.608	1.877	1.877	1.950	1.877	0.724
Station	Station Nam Phuc					
Cropping Pattern	CP1	CP2	CP3	CP4	CP5	CP6
Return Period 1/2	1.538	1.863	1.863	1.806	1.863	0.507
Return Period 1/4	1.571	1.912	1.912	1.826	1.912	0.546
Return Period 1/5	1.577	1.923	1.923	1.832	1.923	0.554
Return Period 1/10	1.591	1.946	1.946	1.850	1.946	0.574
Return Period 1/20	1.600	1.962	1.962	1.866	1.962	0.598

(3) Proposed Irrigation Improvement Project

1) Reservoir System

Based on the results of flow analysis and present conditions of each reservoir, reservoir system improvement projects are planed applying following manner:

a) Estimation of inflow discharge for reservoir

Based on the catchment area of each reservoir, mean runoff discharge was estimated applying following equations:

$$\text{Runoff (mm/year)} = 10773 * [\text{Catchment Area (km}^2)]^{-0.285}$$

Applying this runoff and annual runoff pattern at the Yen Thuong station, inflow discharge for each reservoir was estimated using following formula

$$Qin = Rf \times A$$

where Qin : Inflow discharge (m^3/month)
Rf : Runoff (mm/month)
A : Catchment area (km^2)

b) Water balance

Water balance for each reservoir was calculated monthly using following formula

$$V_I = V_{I-1} + Qin - Wr$$
When $V_I > V_{max}$ then $V_I = V_{max}$
When $V_I < V_{max}$ then $Qs = V_I, V_I = 0$

$$Inf = Qs/Wr$$

where V_t : Water volume of reservoir (m^3)
Wr : Water requirement (m^3/month)
V_{max}: Maximum effective storage of reservoir (m^3)
Qs : Insufficiency of water (m^3/month)
Inf : Insufficiency of water (%)

The water balance calculation was done for each reservoir and 2, 4, 5, 10 and 20 year return periods. The sample calculation is shown in Table C.4.2. Based on this insufficiency of water, irrigated area of command area for each reservoir was estimated. The results are shown in Table C.4.3 and summarized below;

Command Area (ha)				Portion of Irrigated Area (ha)		
Design Irrigated	Actual Irrigated	Simulated Irrigated at Present	Simulated After Renovation	Actual Conditions	Simulated After Renovation	Increasing Portion
1,836	711	722	1,134	51.58%	77.14%	25.56%

c) Proposed Projects

Considering the scale of command area, efficiency, urgency etc., 16 reservoir projects (13 renovation projects, 3 newly construction projects) are proposed as shown in Table C.4.4.

2) Pumping System

Based on the results of water requirement analysis and present conditions of each pumping station, pumping system improvement projects are planed applying following manner:

a) Estimation of water insufficiency of pumping system

Based on present water requirement and actual irrigated area, water insufficiency of each pumping system was estimated as shown in Table C.4.5 and the results are summarized as below;

Total Water Insufficiency of 34 Pumping Systems

Total Designed Capacity (l/s)	Total Command Area (ha)	Total Actual Irrigated Area (ha)	Total Present Water Requirement (l/s)	Estimated Water Insufficiency (%)
17,400	5,535	2,895	25,335	36%

b) Proposed countermeasure for improvement

Considering replacing the pump and renovation of canals and structures for each pumping system, required capacity of the pump was recalculated to irrigate the all command area as shown in Table C.4.6 and results are summarized as below;

Total Required Capacity of Pumping System

Total Command Area (ha)	Required Total Capacity (l/s)	Estimated Improvement of Water Sufficiency (%)
5,535	15,092	36%

c) Proposed Projects

Considering the scale of command area, efficiency, urgency etc., 20 pumping improvement projects (19 renovation projects, 1 newly installed projects) are proposed as shown in Table C.4.7.

C.4.3 Proposed Drainage Projects

(1) Inundation Mitigation Plan

At present the area of left bank of the Lam river has been protected by a dike system designed with the standard of historical flood. As for the right bank of the Lam river and a part of lower area of Nam Thai and Nam Thuong (Northern part) were designed to protect the water level of the Lam river at second alarm level only.

Based on the daily water level recorded at Nam Dan hydrological station, conditions of inundation in this regions was estimated as shown in Table C.4.8 and are summarized below;

Estimated Inundation Fluency at Nam Nam Region

Year	Number of Inundation (times/year)	Continuos days (day/time)
1962 - 1994	1.96	8.43

For reduction of this inundation damage, following two alternatives were proposal:

- Renovation of dike with drainage facilities for mitigation of flood damage.
- Heightening of existing dike for presentation of historical flood.

These alternatives are proposed for 4 sub regions:

1) Nam Nam region.
2) North part of the Lam river (Nam Thai and Nam Thuong communes).
3) Tan Loc Thuong region.
4) Thien Nhan Maintain

As for prevention of Nam Nam region from rain water coming from Thien Nhan mountain range two above alternatives has also been mentioned as shown in Table C.4.9 and summarized below;

Summary of Proposed Projects for Flood Prevention

No.	Region	Befitted Area (ha)		Dike Length (km)	Alternative 1 : Inundation Mitigation Plan	Alternative 2 : Flood Control Plan
		Total	Cultivated Land			
F1	Nam Nam Dike	1,920	1,200	8.6	Without heightening of dike	With heightening of dike
F2	North the Lam River	2,570	1,750	0.4		
F3	Tan Loc Thuong	2,665	808	14.0		
F4	Thien Nhan Maintain	4,500	750	2.7		

Alternative study was done based on the cost and benefit roughly estimated and alternative 1 should be applied considering the B/C ratio as shown below:

Summary of Alternative Study for Inundation Mitigation

No.	Project Area	Benefited area (ha)	Alternative 1			Alternative 2		
			Net Benefit (mill. VND, for 30 years)	Cost (mill. VND, including O/M)	B/C Ratio	Net Benefit (mill. VND, for 30 years)	Cost (mill. VND, including O/M)	B/C Ratio
F1	Nam Nam Dike	1,200	8,580	4,433	1.935	10,296	13,023	0.791
F2	North the Lam River	1,390	1,810	4,459	0.406	2,172	7,029	0.309
F3	Tan Loc Thuong	808	1,670	68,263	0.024	2,004	105,753	0.019
F4	Thien Nhan Maunta	750	780	3,380	0.231	936	5,780	0.162

(2) Drainage Improvement Plan

As mentioned in "present conditions of irrigation and drainage", the study for irrigation has been paid much attention and to be rather good as compares with other district in Nghe An province. As for drainage, due to real topographical condition and limitation of investment funds, it has not been reasonably mentioned. To develop agricultural production in the study area, the drainage should be invested to increase crop yields, crop diversification and to enrich and protect land fertility sustainably.

Results of computation in previous projects in Nghe An province conducted by local irrigation experts the unit designed discharge of drainage is 4.5 - 5.0 l/s ha for plain crop area and 8 - 10 l/s ha for mountainous and residential land.

In this study we mention to surface drainage only to lowering water level in the drainage canal below the root zone. This is also the general requirement at present in Viet Nam.

Due to topographical conditions, the North part of the study area is mountainous and hilly areas that easy for drainage and not to be solved independently but for all the South Nghe An Irrigation Project area as well as whole south Nghe An region. Therefore it is not to be considered in this study.

There are two poor drainage areas (Nam Nam region and Hong Long region) in the study area and drainage improvement plan was proposed as shown in Table C.4.9 and summarized below;

Summary of Drainage Improvement Plan

No.	Region	Befitted Area (ha)	
		Total	Cultivated Land
D1	Nam Nam Drainage improvement	1,650	1,400
D2	Hong Long Drainage Improvement	1,699	950

C.4.5 Implementation Plan of Master Plan

(1) Criteria of Prioritization

The proposed projects have been prioritized based on the comparison of degree of the following factors. In the comparison of the projects in a sector, the factors which are judged to produce the same effect on the objective projects are excluded from the comparison factors. Furthermore, the synergistic effect was studied in the prioritization for entire Master Plan.

Factor	Basic consideration on prioritization
1. Urgency	Projects which are used as countermeasures to solve present urgent problems in Nam Dan District
2. Realization	Projects implemented by a proposed executing agency or organization and which are envisaged to be implemented without any difficulty
3. Adaptability	Projects which are not in any kind of contradiction from higher-level plans such as the National Development Plan for other sectors' projects
4. Inhabitant needs	Projects which meet the most urgent needs of the Study Area inhabitants
5. Sustainability	Projects with sustainable development potential and which will not have a huge negative environmental impact
6. Impact	Projects which are expected to have a high socio-economical impact
7. Model	Projects expected to be used as model projects for other areas
8. Economy	Projects expected to provide with high profits to the farmers
9. Synergistic effect	Projects expected to have a high synergistic effect through the combination of those projects with others of the same or different sector

The ranking for the proposed projects of each sector has been carried out based on the following criteria.

Rank	Conditions
A	Early implementation of the project is strongly recommended.
B	Early implementation of the project is recommended.
C	Implementation of the project is recommended.
D	Recommendation of the project shall be canceled.

For the irrigation and drainage improvement, prioritization has been studied based on factors such as urgency, impact and economy.

Urgency : Present facilities which have serious problems are considered as a rank and others are considered as b rank.

Impact : Based on the net benefit for 30 years, ranking is considered as follows:
more than 5 billion VND : a rank
1 to 5 billion VND : b rank
less than 1 billion VND : c rank

Economy : Based on the benefit cost ratio (B/C), ranking is considered as follows:

more than 1.5	:	a rank
1.0 to 1.5	:	b rank
0.5 to 1.0	:	c rank
less than 0.5	:	d rank

Comprehensive Assessment:

If ranking of urgency is A, the project rank should be A.
If ranking of economy is D, the project rank should be D.
For other cases, considering economic ranking as the main factor, the comprehensive assessment is made based on the impact factor.

(2) Result of Prioritization

The results of prioritization are summarized below:

Prioritization of Reservoir Irrigation Projects

No.	Project Name	Irrigation area (ha)	Net Benefit (mill. VND, for 30 years)	Cost (mill. VND, including O/M)	B/C Ratio	Urgency	Impact	Economy	Comprehensive Assessment
R01	Vung Huyen	20	2,120	890	2.38	b	b	a	B
R02	Ho Thanh	100	10,990	6,970	1.58	b	a	a	A
R04	Vuc Mau	50	4,780	1,190	4.02	b	b	a	B
R05	Hao Hao	20	1,630	830	1.96	b	b	a	B
R06	Trang den	100	16,990	11,030	1.54	b	a	a	A
R07	Thung Pheo	15	990	3,050	0.32	b	c	d	D
R09	Cua Ong	150	14,750	9,300	1.59	b	a	a	A
R10	Thanh Thuy	100	5,010	5,220	0.96	b	a	c	C
R11	Rao Bang	160	14,780	7,640	1.93	b	a	a	A
R17	Khe Dinh	60	4,750	1,700	2.79	b	b	a	B
R19	Khe Bo	35	3,290	1,980	1.66	b	b	a	B
R20	O O	15	650	1,240	0.52	b	c	c	D
RN1	Khe Dien	30	3,510	6,210	0.57	b	b	c	D
RN2	Da Han	250	22,530	32,180	0.70	b	a	c	C
RN3	Ba Khe	150	20,170	40,350	0.50	b	a	d	D

Note : Renovation cost of irrigation canal is included in project cost

Prioritization of Pumping Irrigation Projects

No.	Project Name	Irrigation area (ha)	Net Benefit (mill. VND, for 30 years)	Cost (mill. VND, including O/M)	B/C Ratio	Urgency	Impact	Economy	Comprehensive Assessment
P01	Duong dap	100	4,590	4,750	0.97	b	b	c	D
P07	Nam Cuong 1	140	8,580	6,230	1.38	b	a	b	B
P09	Nam Trung	500	21,900	22,640	0.97	b	a	c	C
P10	Du DU	80	5,970	4,110	1.45	b	a	b	B

No.	Project Name	Irrigation area (ha)	Net Benefit (mill. VND, for 30 years)	Cost (mill. VND, including O/M)	B/C Ratio	Urgency	Impact	Economy	Comprehensive Assessment
P13	Khanh Son 2	70	3,430	3,910	0.88	b	b	c	D
P16	Nam Dong	800	70,290	36,660	1.92	b	a	a	A
P17	Nam Loc	100	3,870	5,700	0.68	b	b	c	D
P19	Nam Tan	200	14,210	10,400	1.37	b	a	b	B
P20	Dai Dong 1	90	5,640	4,010	1.41	b	a	b	B
P21	Dai Dong 2	60	4,870	3,230	1.51	b	b	a	C
P22	Hong Son	80	3,590	3,620	0.99	b	b	c	D
P23	Ru Dun	200	12,490	9,980	1.25	b	a	b	B
P26	Nam thai	100	3,880	5,690	0.68	b	b	c	D
P27	Sen doi	80	4,900	3,570	1.37	b	b	b	C
P28	Ghenh station	320	20,500	13,840	1.48	b	a	b	B
P29	Hong Long 1	135	6,710	6,840	0.98	b	a	c	C
P30	Hong Long 2	200	9,040	9,800	0.92	b	a	c	C
P31	Xuan Lam	330	17,630	14,760	1.19	b	a	b	B
P33	Ru Doi	50	3,260	2,710	1.20	b	b	b	C
PN1	Nam Cuong 2	120	16,880	11,080	1.52	b	a	a	A

Note : Renovation cost of irrigation canal is included in project cost

Prioritization of Inundation Mitigation Projects

No.	Project Area	Benefited area (ha)	Net Benefit (mill. VND, for 30 years)	Cost (mill. VND, including O/M)	B/C Ratio	Urgency	Impact	Economy	Comprehensive Assessment
F1	Nam Nam Dike	1,920	21,450	14,134	1.52	b	a	a	A
F2	North the Lam River	1,750	4,530	8,575	0.53	b	b	c	D
F3	Tan Loc Thuong	808	4,180	131,275	0.03	b	b	d	D
F4	Thien Nhan Mauntain	750	1,950	6,500	0.30	b	b	d	D

Prioritization of Drainage Improvement Projects

No.	Project Area	Benefited area (ha)	Net Benefit (mill. VND, for 30 years)	Cost (mill. VND, including O/M)	B/C Ratio	Urgency	Impact	Economy	Comprehensive Assessment
D1	Nam Nam	1,400	14,780	15,840	0.93	b	a	c	C
D2	Hong Long	950	4,880	7,408	0.66	b	b	c	D

C.4.5 Proposed Implementation Schedule of Master Plan

For implementation of each project, it is necessary to consider the preparation period such as detailed design and tendering procedure for one year before construction.

Considering the work volume of each project, with in one year of construction period for one project is expected respectively except new construction of reservoir irrigation systems.

Based on the results of prioritization, implementation schedule was proposed as shown below.

Summary of Proposed Implementation Schdule

	Period		
Projekt Rank	1998 - 2002	2003 - 2006	2007 - 2010
A Projects			
B Projects			
C Projects			

Note : Preparation Construction

C.4.6 O/M Plan of Master Plan

In the project area, farmers have experience of the operation and maintenance the facilities more than 30 years and O/M system at present is available for these project. Therefor, it is not necessary to enforcement of O/M organization. For the irrigation system, the water right will be changed based on the new water requirement and present water use associations (Cooperatives) have enough capacity for coordination.

C.4.7 Project Cost of Master Plan

Project cost and O/M cost for the Master Plan are estimated as shown below:

(mill. VND)

	A Rank		B Rank		C Rank	
	Project Cost	Annual O/M Cost	Project Cost	Annual O/M Cost	Project Cost	Annual O/M Cost
Reservoir Irrigation System	30,557	786	27,869	892	27,869	892
Pump Irrigation System	30,557	786	35,199	1,183	27,869	892
Mitigation Inundation	3,124	367				
Drainage Improvement					9,108	288
Total	64,239	1,939	63,069	2,075	64,847	2,072

C.5 PRIORITY PROJECTS

C.5.1 Irrigation Improvement

(1) Outline of Irrigation System Improvement Plan

Inventory of structures at proposed irrigation systems are summarized below:

Summary of Structures for Irrigation System

No	Name of System	Location (Commune)	Present Irrigated Area (ha)	Proposed Irrigated Area (ha)	Proposed Water Requirement (l/s)	Total Length of Main Canal (m)	Total Length of Secondary Canal (m)	No. of Diversion (unit)	No. of Other Structures (unit)
R2-1	Ho Thanh 1	Nam Kim	37	66	126	2,080	1,330	6	37
R2-2	Ho Thanh 2	Nam Kim	8	14	27	660	1,630	1	3
R6-1	Trang den 1	Nam Hung	36	80	151	1,495	790	3	11
R6-2	Trang den 2	Nam Hung	9	20	38	3,435	3,740	7	25
R9	Cua Ong	Nam Nghia	100	150	283	1,900	6,220	10	41
R11	Rao Bang	Nam Thanh	100	160	302	980	6,010	11	15
P16	Nam Dong	Khanh Son	253	800	1,530	7,492	27,650	43	41
Pn1	Nam Cuong	Nam Cuong	0	120	229	1,735	3,950	8	11

Note Pn1: New pumping irrigation system

Ho Thanh Reservoir System (R2)

Ho Thanh reservoir was constructed in 1972 and since then water leakage from the side of spillway has been continued. The discharge amount of leakage are influenced by water level of the reservoir. In spite of the leakage, the structure of dike has been stable in these 25 years according to the information obtained in the survey. On the other hand, the intake flume was damaged approximately 10 yeas ago and the farmers can not control the intake water since that time. This is the one of reasons why actual irrigated area is limited to only 45 ha at present.

This reservoir has 240 ha of command area and an alternative studies were made including reconstructing of the dike. However, considering cost and benefit, the dike reconstruction for only 240 ha was not feasible. In the Master Plan, heightening of dike was considered but the heightening will only increase the amount of leakage water. The rehabilitation of intake works will also make the same result.

The results of another alternative study conducted for this proposed system shows that the water loss will be saved with renovation of canal system and it is expected that irrigated area will be increased from present 45 ha to 80 ha. Therefore, renovation of canal system including related structures and improvement of operation and maintenance scheme are proposed.

Trang Den Reservoir System (R6)

Trang Den reservoir was constructed in 1975 and there are two canal schemes irrigating 45 ha in total at present. One of the serious problems observed in Trang Den reservoir is the damaged spillway and it is necessary to be repaired immediately. The gate structure at intake works of two irrigation schemes are timeworn and these structures should be renovated.

The canal systems including related structures are also timeworn and it is expected that the irrigated area will be increased from present 45 ha to 100 ha with the renovation of these canal systems.

Cua Ong Reservoir System (R9)

Cua Ong reservoir was constructed in 1967 and 100 ha of paddy field are irrigated at present. Small water leakage is observed and the amount of leakage water become quite high when water level is close to the top of the dike (deference of level between top of dike and water surface is less than 1 m). Therefore, it is necessary to enlarge the capacity of existing two spillways for keeping safe water level in rainy season. The gate facilities of intake works is timeworn and this is also necessary to be renovated.

The canal system including related structures is also timeworn and it is expected that the irrigated area will be increased from present 100 ha to 150 ha with the renovation of canal system.

Rao Bang Reservoir System (R11)

Rao Bang reservoir was constructed in 1966 and 100 ha of paddy filed is irrigated using the water from this reservoir at present. The present condition of existing spillway is quite poor and it is necessary to be renovated. The gate facilities is timeworn and this will be also necessary to be renovated.

The canal system including related structures is also timeworn and it is expected that the irrigated area will be increased from present 100 ha to 160 ha with the renovation of canal system.

Nam Dong Pumping System (P16)

Nam Dong pumping station was constructed in 1963 and this station has been renovated several times during the last 30 years. The total capacity of present pumps is more than 1.6 m^3/s and it is sufficient to irrigate 800 ha. However, the flowing capacity at main canal is not enough and only 253 ha of paddy field is irrigated at present. Therefore, it is necessary to enlarge flowing capacity and to save water loss with the renovation of canal system including related structures in order to irrigate 800 ha.

Nam Cuong Pumping System (PN1)

Nam Cuong pumping system has been planned since 1995 and basic survey was carried out by Nam Dan District. It is expected to irrigate 120 ha of farm land which is not irrigated at present. Therefore, it is necessary to install the new pumping station and to construct the new canal system.

(2) Preliminary Design

Based on the topographic condition including longitudinal and cross section, necessary structures to be renovated were roughly designed. Following Planning/Design Standard/Criteria are applied in the Study;

- FAO Irrigation & Drainage Paper No.24 (1977)
- Viet Nam Irrigation Canal Design Standard TCVN-4118-85
- Standard on Hydraulic Computation of Spill Way QP-TL-C-8-76.
- Standard on Irrigation Structure Design QP-Tl-08-76.

The design conditions are summarized below:

- Unit water requirement : Nam Nam area 1.912 l/s/ha
  North area 1.885 l/s/ha
  (4 year return period)
- Flow velocity (m/s)

Canal Type	Minimum	Average	Maximum	Roughness Coefficient
Masonry Canal	0.3	0.6	1.5	0.025
Masonry Lining Canal	0.3	0.6	1.5	0.030
Earth Canal	0.3	0.4	0.6	0.040

- Free board : Q> 1.0 m^3/s 30 cm
  Q< 1.0 m^3/s 20 cm
  Spillway of Dike 50 - 70 cm

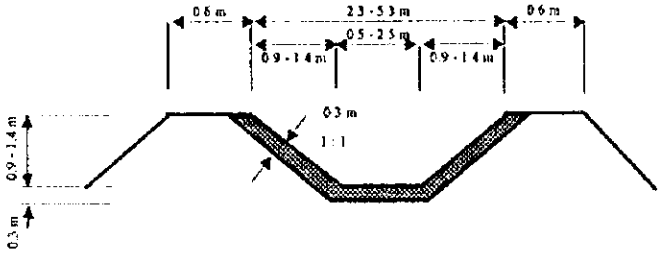
- Flood discharge at dike (50 year return period)

Peak Runoff Discharge from Rainfall

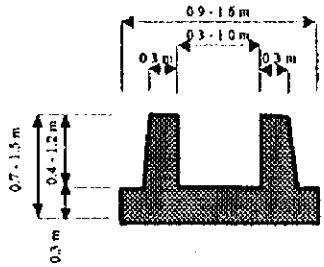
Return Period 1 / 50	Max. 24 hr Rainfall (mm) 406.67						
Reservoir	Catchment Area (km^2)	Duration Time (hr)	Rainfall Intensity	Value of f	Value of C	Peak Runoff (m^3/s)	Specific Q ($m^3/s/km^2$)
Trang Den (R6)	8.00	1.88	60.56	0.8	300	107.67	13.459
Cua ong (R9)	4.00	1.56	66.43	0.8	300	59.05	14.762
Rao bang (R11)	7.00	1.81	61.65	0.8	300	95.90	13.700
Return Period 1 / 50	Max. 24 hr Rainfall (mm) 494.52						
Reservoir	Catchment Area (km^2)	Duration Time (hr)	Rainfall Intensity	Value of f	Value of C	Peak Runoff (m^3/s)	Specific Q ($m^3/s/km^2$)
Ho thanh (R2)	2.70	1.29	88.73	0.8	300	53.24	19.718

Based on the these design conditions and topographic data, canal profile, cross section, spillway, new pumping station and other related structures were designed.

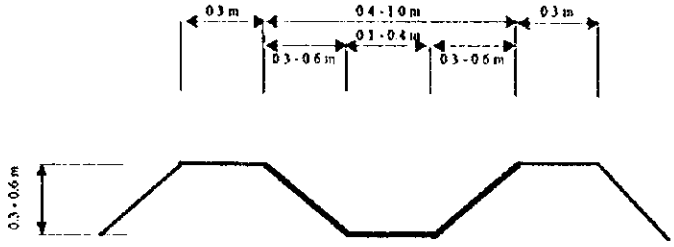
Considering effective use of irrigation water, following two types of canal are applied for main irrigation canal and earth lining canal is applied for secondary canal.



Typical Section of Stone Masonry Lining Canal

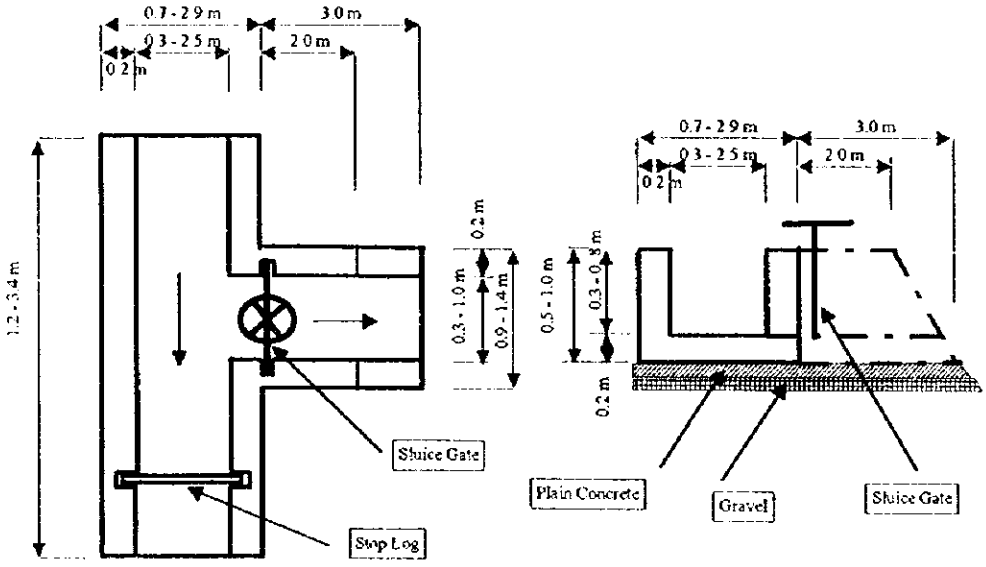


Typical Section of Stone Masonry Canal



Typical Section of Earth Lining Canal

For the improvement of water management, diversion works of concrete structure is applied.



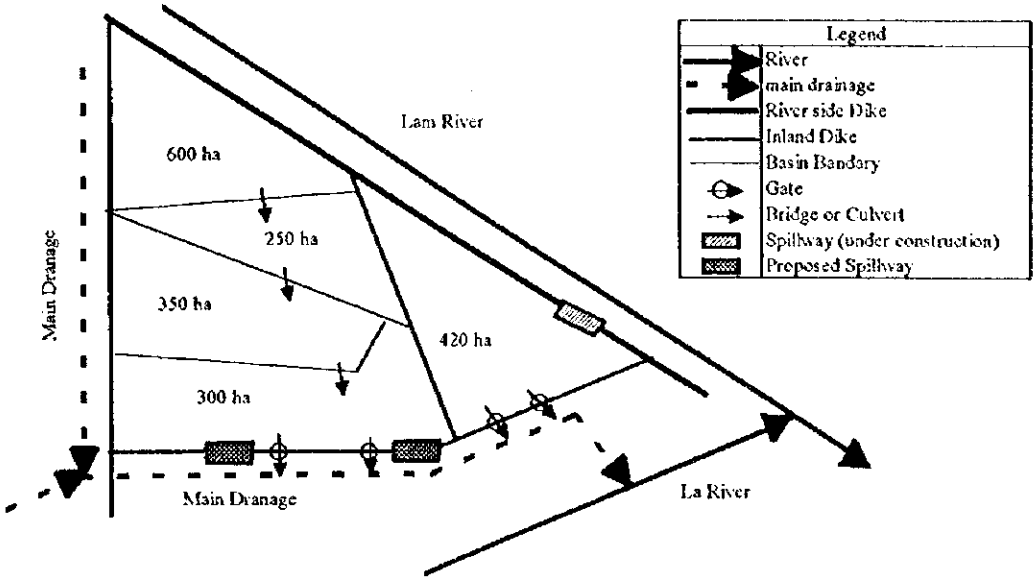
Typical Structure of Diversion Works

Based on the schematic chart of each irrigation system as shown in Fig. C.5.1, the design discharge of canal is decided. Based on the topographic condition and design discharge, the longitudinal slope and canal section are designed as shown Fig. C.5.2.

C.5.2 Mitigation of Inundation

(1) Drainage System of Nam Nam Dike

Drainage system of Nam Nam Dike can be illustrated as shown below:



Inundation caused by back water from the La river occurs mostly every year and inundation period is usually two to three weeks. Even upper part of the inside of dike is influenced by the back water and inundation depth is 1 to 2 m. The height of the dike along the Lam river is 6.8 m to 7.8 m and the elevation of the inland dike is 6.2 m a.s.l. For draining the inside of dike, it is necessary to wait the water level of La river to come down lower than that of the inside. Usually, it takes around two weeks for inundation to drain.

There are 4 gates and 3 culverts for drainage at present but one of the gates are not functioned. 3 gates was constructed between 1993 and 1996. One spillway of the dike structure for protection is under construction at the side dike in the lower part of Lam river.

(2) Outline of Inundation Mitigation Plan

The main drainage canal connected to the La river belongs to Ha Tinh Province. Therefore, it is impossible to formulate drastic mitigation plan without improvement of the drainage canal located in Ha Tinh Province. However, after starting of drainage from inside the dike, it will be possible to shorten the inundation period by enlarging capacity of drainage gate. Furthermore, it is necessary to construct spillways for protection of the dike structures.

(3) Preliminary Design

Based on the design conditions of the existing gate, an additional gate was preliminarily designed. And strengthening of existing drainage capacity by improving

the drainage canal located inside the dike was considered. Two spillways are proposed to protect the dike structure and are roughly designed based on the design conditions of spillway under construction. Consequently, renovation/construction of the following facilities are proposed from the view point of enforcement of drainage capacity and ensuring safety structure and it is expected that more or less one week of inundation period will be reduced.

	Main facilities	Main works	Purpose of facilities
Renovation of existing drainage gate	4 x 5.5 m 3 gates	Replacement of gate only	Prevention of small inundation Enforcement of drainage capacity
New construction of drainage gate	3 x 5.5 m 3 gates	New construction of gate facility	Enforcement of drainage capacity
Rehabilitation of main drainage canal	soil canal 500 m	Rehabilitation of soil canal 500 m	Enforcement of drainage capacity
Installation of new spillways (2 site)	200 m width each	Excavation and protection of dike	Ensuring safety structure
Protection of crossing point with present road	Average road width 4 m	Protection of rode and slope surface	Ensuring safety structure

C.5.3 Implementation Plan

Implementation stage of renovation/construction of irrigation and drainage facilities is divided into two stages, preparation stage (detailed design, tendering) and construction stage. Considering effective construction, it is better to set one year for preparation stage and to carry out the construction stage at dry season in next year (in this way, it is necessary to compensate for one crop season for present irrigated area and compensation cost is included in the project cost). For the implementation, basically the present implementation system can be used that is the agricultural and rural development division of the Nam Dan District will work as the executing agency under the support and inspection of agricultural and rural development department of Nghe An Province and using the local consultant and contractor in the Province. However, in case of using the international fund for finance, sometimes it is necessary to select the consultant and contractor through the international tendering. Considering the effective generation of project benefit, it is necessary to decide the implementation order for each project based on implementation schedule of relevant sectors such as rural road and rural electrification.

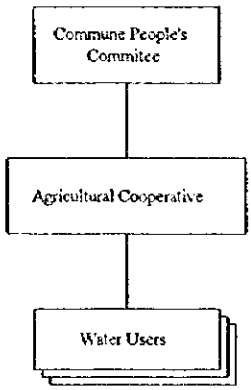
C.5.4 Operation and Maintenance Plan

Operation and maintenance work for irrigation system is consist of water management (decision of water distribution, irrigation water supply, watching), facility maintenance (inspection, repair) and administration (collection of water fee) as shown below:

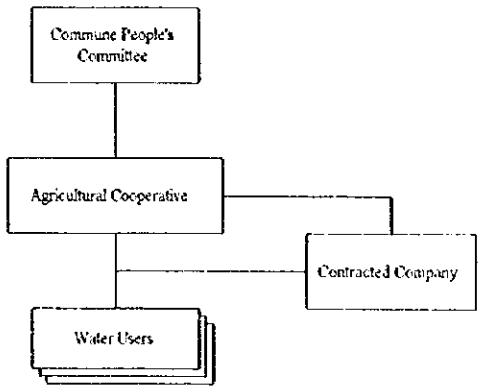
Operation & maintenance work	Contents	Proposed work interval
Water management Decision of water distribution	To collect the information of water requirement from farmers and to decide the distribution plan and water supply plan after adjustment of water amount and period.	Every crop season
Irrigation water supply	To operate the irrigation facilities based on the water supply plan	Every day in the irrigation period

Operation & maintenance work	Contents	Proposed work interval
Watching	To observe the water use condition with a periodical patrol	- ditto -
Facility maintenance Inspection	To inspect function, water leakage, facility injury, etc. and to make a repair plan of facilities	One time each before and after irrigation period and every time for watching
Repair	To repair the facilities based on the repair plan	Proper times based on the necessity (basically one time after irrigation period in the dry season)
Administration Collection of water fee	To decide the water fee with a consideration of required fund for O/M cost and farmers' payment capacity and to collect the water fee	Every crop season

Agricultural cooperatives, which are management agencies, manage the irrigation systems under the supervision of commune peoples' committee. Some pert of water management work (irrigation water supply, watching) and facility maintenance are carried out by private company with contract base.



1. O/M Organization for Reservoir System

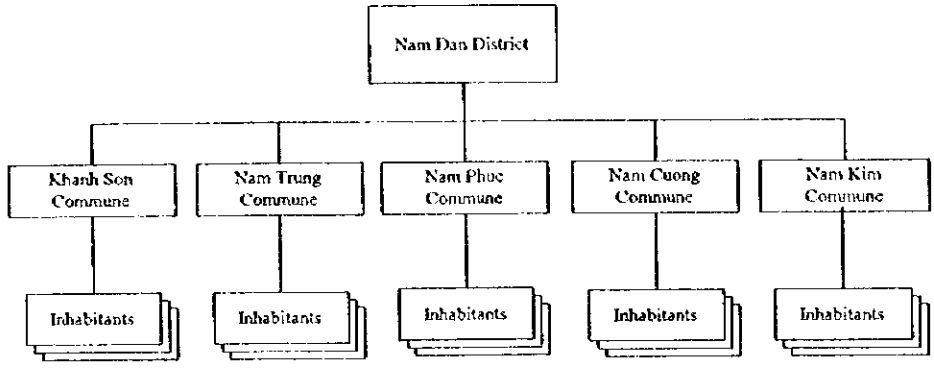


2. O/M Organization for Pumping System

For purpose of maintaining the drainage facility function, operation and maintenance work of drainage system is consist of inspection, routine maintenance, and periodic maintenance as shown below.

O/M works	Contents	Proposed interval
Inspection	To inspect with periodic patrol for checking the site and scale to be repaired and to make a periodic maintenance plan	Dry season: one time / month Rainy season: one time / month
Routine maintenance	To Rehabilitate protection work and to replace gate for maintaining facility function	Rehabilitation work: approx. one time for 5years Gate replacement: approx. one time for 20 years
Periodic maintenance	To renovate facilities based on the periodic maintenance plan	Proper period based on scale of damage

Peoples' committee of 5 communes which are management agencies carry out the O/M works under the supervision on the District peoples' committee and small scale maintenance will be carried out based on the inhabitant participation.



3. O/M Organization of Dike System

These organizations are already existed and functioned at present and it is not necessary to enforcement the present organizations (beneficiaries for new pumping station have a experience of irrigation works)

C.5.5 Project Cost and O/M Cost

The project cost are estimated as below:

Name of Project	Project Cost		
	L/C (mill.VND)	F/C (mill.VND)	Total (mill.VND)
1 Ho Thanh Irrigation System	6,558	984	7,542
2 Tang den Irrigation System	10,548	1,484	12,032
3 Cua Ong Irrigation System	9,089	1,164	10,252
4 Rao Bang Irrigation System	7,567	841	8,408
5 Num Dung Irrigation System	19,213	3,448	22,661
6 Nam Cuong Irrigation System	8,779	1,187	9,966
7 Nam Nam Dike	3,503	449	3,952
Total	65,256	9,557	74,813

Note: Engineering cost and physical contingency are included in the project cost. Price escalation are excluded

O/M cost for one year is estimated as below:

Annual O/M Cost for Irrigation System

(million VND)

Name of Project	Command Area (ha)	Canal O/M Cost	Facility Repair	Electricity Fee	Annual Average of Replacement	Annual Average O/M Cost
Ho Thanh Irrigation System	80	44				44
Tang den Irrigation System	100	61				61
Cua Ong Irrigation System	150	63				63
Rao Bang Irrigation System	160	56				56
Num Dung Irrigation System	800	39	480	40	20	679
Nam Cuong Irrigation System	120	21	72	6	8	107
Total	1,410					1,010

Note: Replacement cost of equipment is estimated as annual average cost

Annual O/M Cost for Drainage System

(million VND)

Name of project	Benefited Crop Area (ha)	Routine Maintenance	Annual Average of Replacement	Annual Average O/M Cost
Nam Nam Dike	1,200	359	8	367

Note: Replacement cost of equipment is estimated as annual average cost

C.6 RECOMMENDATION

The improvement of water use is one of major objectives in the proposed irrigation improvement plan and the facilities were designed with due consideration of realization for effective water management with simple operation. However, as it is necessary to observe the water management rules strictly for keeping the effective function of facilities, it is recommended that guidance and education on this point will be done sufficiently for beneficiaries.

APPENDIX C: TABLES

Table C.2.1 List of Irrigation Schemes in the Study Area (1/2)

(1) Existing pumping stations

Code No.	Name of stations	Location (commune)	Dimensions					Main canal		Command Area (ha)		Problems
			Year of construction	Machine number	Machine stvie Q of machine (m^3 /h)	Total Capacity (m^3 /h)	Style of Pump house	Length (km)	Dimension (b,h,m)	Designed	Actual	
P1	Duong dap	Nam kim	1985	1	1000	1000	Class IV	1.5	0.8x1x1.5	100	90	Water source is insufficient, Canals are much damaged
P2	Mu ba	Nam kim	1985	1	540	540	Class IV	2	0.6x0.8x1.5	40	40	Water source is insufficient, Canals are much damaged
P3	Geeh	Nam kim	1985	1	540	540	Class IV	2	0.6x0.8x1.5	40	29	Water source is insufficient, Canals are much damaged
P4	Vac	Nam kim	1985	1	800	800	Class IV	2.5	0.7x0.8x1.5	70	55	Water source is insufficient, Canals are much damaged
P5	Nam kim 2	Nam kim	1985	2	1000	2000	Class IV	6	0.8x1x1	140	100	Old pump set, insufficient water source , bad canal
P6	Nam kim 3	Nam kim	1990	1	1000	1000	Class IV	4	o.6x1x1.5	80	50	Insufficient water source , badly damaged canal
P7	Nam cuong	Nam cuong	1982	2	1000	2000	Class IV	2.7	1x1.2x1	140	96	Deposited canal, Insufficient water source
P8	Nam phuc	Nam phuc	1986	1	1000	1000	Class IV	1.5	0.7x0.9x1.5	70	43	Broken pump house, Old pumping machine, Badly damaged canal
P9	Nam trung	Nam trung	1961-1982	6	1000	6000	Class IV	5	1x1.2x1.5	1350	450	Sucking basin of old station is deposited, New station is flooded
P10	Du DU	Khanh son	1989	2	1000	2000	Class IV	2.5	1x1.2x1	60	40	Insufficient water source
P11	Station 1 : Khanh son1	Khanh son	1984	1	1000	1000	Class IV	1	0.8x1x1	25	20	Insufficient water source
P12	Station 3: Khanh son 1	Khanh son	1994	1	540	540	Class IV	1	0.6x0.8x1	20	14	Low power line is far (2200m)
P13	Station1 : Khanh son 2	Khanh son	1983	2	1000	2000	Class IV	2.5	0.8x1x1	70	60	Station house is flooded
P14	Station 2 : Khanh son 2	Khanh son	1985	1	1000	1000	Class IV	3	0.6x0.8x1	25	20	Insufficient water source
P15	Station 3: Khanh son 2	Khanh son	1987	1	1000	1000	Class IV	0.7	0.6x0.8x1	20	15	Badly damaged canal system
P16	Nam dong	Khanh son	1963	8	1000	8000	2 floor	8	1.2x1.5x1	1200	253	Badly damaged canal system
P17	Station 1 : Nam loc	Nam loc	1984	3	1000	3000	Class IV	1	1x1.2x1.5	130	100	Reversed canal slope, Insufficient water source , New canal is needed
P18	Station 2: Nam loc	Nam loc	1985	1	1000	1000	2 floor	0.6	0.8x1x1.5	60	30	Insufficient water source
P19	Station1 : Nam tan	Nam tan	1970	4	1000	4000	2 floor	4	0.8x1x1.5	150	120	New reconstruction , new machine , the 1st canal needs upgrading
P20	Station 1 : Dai dong	Nam thuong	1985	2	820	820	Flat roof	2	0.8x1x1.5	100	60	Old machine
P21	Station 2: Dai dong	Nam thuong	1986	1	960	960	Flat roof	0.5	0.6x0.8x1	50	20	Insufficient water source
P22	Hong son station	Nam thuong	1986	1	480	480	Flat roof	1.2	0.6x0.8x1	50	30	Small scale , canal is incompleted
P23	Ru dun station	Van dien	1987	2	800	1600	Flat roof	2.5	1x1.2x1	100	70	The head work is small
P24	Station 2: Nam thanh 1	Nam thanh	1986	1	540	540	Class IV	2.5	0.6x0.8x1	100	90	Deposited canal , insufficient water source , new machine is needed water source
P25	Station 2 : nam thanh 2	Nam thanh	1990	1	1000	1000	Class IV	1	0.6x0.8x1	60	40	Insufficient water source
P26	Nam thai	Nam thai	1983	2	1000	2000	Class IV	2	0.8x1x1.5	140	80	Insufficient water source
P27	Sen doi	Nam xuan	1991	1	1000	1000	Class IV	1.2	0.6x0.8x1.5	50	30	Temporary pump house, canal is not in good condition
P28	Ghenh station	Hung tu	1996	4	1000	4000	2 floor	3	1x1.2x1.5	320		Newly reconstructed, canal is incompleted
P29	Hong long 1	Hong long	1984	2	800	1600	Class IV	2.5	0.8x1.0x1.5	110	80	Pump house is flooded , canal is badly damaged
P30	Hong long 2	Hong long	1988	3	800	2400	Class IV	8.5	1x1.2x1.5	180	150	Pump house is flooded , canal is badly damaged
P31	Xuan lam	Xuan lam	1984	4	1000	4000	Class IV	5	1x1.2x1	235	200	Pump house is flooded , Sucking basin is deposited
P32	Bau non	Nam anh	1982	2	1000	2000	Class IV	2	0.8x1x1.5	200	80	Canal is badly damaged
P33	Doi	Nam giang	1983	1	1000	1000	Class IV	1	0.6x0.8x1	50	20	Temporary house and canal are badly damaged
	Total			67		61820		86.4		5535	2575	

Table C.2.1 List of Irrigation Schemes in the Study Area (2/2)

(2) Existing Resiorviors

No	Name of works	Location (commune)	Year of construction	Catchment Area (km^2)	Storage Capacity		Dimensions		Main Canal		Command Area (ha)		Problems and reasons
					Total (10^6 m^3)	Effective (10^6 m^3)	main dam (b, h , l,)	Outlet (b ,h ,d)	Length (km)	Dimension (b, h, m)	Designed Area	Actual Irrigated Area	
1	2	3	4	5	6	7	8	9	10	11	12	13	14
R1	Vung huyen	Nam kim	1965	2.20	0.20	0.16	3x4x300	0.4	0.8	0.6x0.8x1	20	10	Licked outlet, small dams, need enlarging and Heightening
R2	Ho thanh	Nam kim	1972	2.70	1.00	0.90	3x10x160	0.8	2	0.8x1x1	120	45	Broken outlet need restructing , Broken canals
R3	Kim Khanh	Khanh son	1962	2.60	0.15	0.12	3x4x150	0.4	0.3	0.6x0.8x1	30	15	Small lakes are in good condition , unnable to enlarge
R4	Vuc mau	Khanh son	1972	2.70	0.25	0.21	5x10x80	0.6	1.2	0.8x1x1	50	20	Licked dams and broken outlet need improving
R5	Hao Hao	Khanh son	1957	6.00	0.70	0.50	3x16x200	0.8	2	1.5x1.5x1	200	15	Broken canals, a lot of deposit on lake -bed
R6	Trang Den	Nam hung	1975	8.00	2.70	2.20	3x10x300	0.8	3.7	0.8x1x1	200	45	Low and broken subdam , bad canal and bridges
R7	Thung Pheo	Nam hung	1968	2.00	0.15	0.12	3x4x50	0.4	2	0.6x0.8x1	30	10	Low dams , bad canals
R8	10 small lakes	Nam hung		5.00				0	0			56	All in damaged conditions
R9	Cua ong	Nam nghia	1967	4.00	1.35	1.20	3x10x760	0.8	2.5	0.8x1x1.5	180	100	Bad canals and slidede/eroded dams
R10	Thanh thuy	Van dien	1936	1.83	1.24		3x8x500	0.6	2	0.8x1x1	280	70	A lot of deposit on lake -bed , steep slope on both dam sides, bad canal
R11	Rao bang	Nam thanh	1966	7.00	2.40	2.00	3x5x500	0.6	3.5	0.8x1x1	120	100	Main dam and spill way are in bad condition , licked outlet
R12	Hung coc	Nam thanh	1974	1.40	0.69	0.60	3x7x200	0.6	1	0.6x0.8x1	180	60	Licked outlet
R13	Thung vuon	Nam anh	1980	0.60			2.5x4x100	0.4	0.3	0.4x0.5x1	5	5	Small lakes with low effect
R14	Khe dau	Nam anh	1972	0.80			2.5x6x100	0.4	0.5	0.4x0.5x1	10	10	Small lakes with low effect
R15	Khe be	Nam xuan	1970	0.70	0.15		3x6x150	0.6	0.4	0.6x0.8x1.5	50	20	Normal works
R16	Khe cav	Nam xuan	1982	0.50	0.10		3x6x150	0.6	0.5	0.5x0x1.5	20	10	Normal works
R17	Khe dinh	Nam xuan	1970	1.20	0.74		4x7x300	0.6	1	0.6x0.8x1.5	100	40	Absorbent and bad dams need heightening
R18	Khe che	Nam xuan	1982	0.65	0.10		3x6x100	0.6	0.8	0.5x0x1.5	20	15	Settling works
R19	Khe bo	Nam linh	1976	1.80	0.12	0.10	3x6x500	0.6	2	0.6x0.8x1	31	15	Low and bad dams, Absorbent drain , bad canal
R20	O O	Nam linh	1976	1.00	0.10	0.08	3x5x200	0.6	2	0.6x0.8x1	20	15	Low dam, bad canal
R21	Ru doi	Nam giang	1962	1.10	0.18	0.15	3x4x800	0.8	1.5	0.6x0.5x1	50	35	A lot of deposit on lake -bed , licked drain , bad canal
	Total			58.78							1716	724	

Table C.2.2 List of Flood Prevention Structures in the Study Area (1/2)

(1) Drain works (Canal , Drainage Sluices and Sluices under the Dike)

No	Name of works	Location (Commune)	Year of construction	Dimensions (m) (b , h, l)	Crest Level (m, a.s..)	Darin Area (ha)	Problems
PF1	Thien nhan canal	Nam Nam	1987	5 x 2.5 x9,700m	(+3) to (0.0)	2400	Canal is insufficient to supply water
PF2	Bau lang canal	Nam tan	1956	2 x 2.5 x 2000	+ 1.0	25	Canal is deposited
PF3	Bau non canal	Nam anh	1977	5 x 3 x 1,500	- 0.5	690	
PF4	Drainage Sluices : 3 gates	Nam kim	1989	2 x 4.5 x10	+ 1.5	→ 1735	Reconstructed recently
PF5	Drainage Sluices : 4 gates	Nam kim	1992	2 x 4.5 x10	+ 1.5		Reconstructed recently
PF6	Drainage Sluices : 2 gates	Nam cuong	1992	2 x 4.5 x10	+ 1.0		Reconstructed recently
PF7	Drainage Sluices : 4 gates	Nam cuong	1993	2 x 4.5 x10	+ 1.0		Reconstructed recently
PF8	Sluices under the Dike	Nam trung	1995	1.2 x 1.2 x2.0	+ 1.0	65	Reconstructed recently
PF9	Drainage Canal	Nam trung	1975	2 x 2 x 3,600	+ 1.0	65	Reconstructed recently
PF10	Hongson drain (2 gates)	Nam thuong	1947	1.3 x 2 x 8	+ 5.5	50	Badly damaged , untight gates
PF11	Hongson -Cavda Drainage Sluice	Nam thuong	1947	1.3 x 1.5 x 8	+ 5.5	50	Badly damaged , untight gates
PF12	Drainage Canal	Nam loc	1976	6 x 4 x 5,000	+ 1.0	170	Deposited canal caused difficult draining
PF13	Daidong -Trodanh Drainage Sluice	Nam thuong	1947	2 x 1.5 x 8	+ 2.5	50	Badly damaged
PF14	Baudai Drainage Sluice	Nam thuong	1947	1.5 x 1.5 x 8	+ 2.5	10	Badly damaged
PF15	Duongcho Drainage Sluice	Nam thuong	1947	1.5 x 1.0 x8	+ 2.5	15	Badly damaged

Table C.2.2 List of Flood Prevention Structures in the Study Area (2/2)

(2) Existing Dikes

No	Name of dike	Location	Dike class	Dimensions (m) (b. h. l)	Protected area (her)	Problems
1	Dike 42	Left of Lam river	2	10.050 m	78000	Rather good quality but still need strengthening every year
2	Van dien dike	Van dien	2	2000m	78000	Rather good quality but still need strengthening every year
3	Nam trung dike	Right of Lam river	4	3 x 2.2 x 8,860	3900	Cross section is small , dike body is incomplete
4	Dike 5 - nam	Right of Lam river	4	3 x 2.5 x 11,000	1800	Low dike so its quality is not good
5	Quai rac dike	Khanh son	4	3 x 1.7 x963	640	Small cross section
6	Dike 3/2	Khanh son	4	3 x 4 x 1,600	120	Low dike that is affected by slided river bank
7	Hung son dike	Nam thuong	4	2.5 x 2 x 1,500	50	Small dike
8	Dai dong dike	Nam thuong	4	2 x 2.5 x 2,500	110	Low dike that is much damaged
9	Nam thai dike	Nam thai	4	3 x 3 x 2,050	350	Small dike
10	Phuong hoang dike	Nam thai	4	3 x 3 x 270	350	Small dike

Table C.4.1 Unit Water Requirement (1/4)

(1) Unit Water Requirement (Present Conditions)

Station Nam Dan												
CP1 Net Water Requirement (l/s/ha)												
Return Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1/ 2	1.142	1.263	1.385	1.138								2.692
1/ 4	1.173	1.296	1.425	1.206								2.743
1/ 5	1.180	1.304	1.434	1.221								2.755
1/10	1.198	1.322	1.457	1.260								2.783
1/20	1.211	1.337	1.474	1.291								2.805
CP2 Net Water Requirement (l/s/ha)												
Return Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1/ 2	1.142	1.263	1.385	1.138		3.127	1.370	0.868				2.692
1/ 4	1.173	1.296	1.425	1.206		3.171	1.444	0.883				2.743
1/ 5	1.180	1.304	1.434	1.221		3.187	1.461	0.886				2.755
1/10	1.198	1.322	1.457	1.260		3.236	1.514	0.894				2.783
1/20	1.211	1.337	1.474	1.291		3.274	1.557	0.900				2.805
CP3 Net Water Requirement (l/s/ha)												
Return Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1/ 2	0.239		3.125	1.389	0.957	3.127	1.370	0.868		0.193		0.331
1/ 4	0.286		3.165	1.457	1.018	3.171	1.444	0.883		0.219		0.410
1/ 5	0.297		3.174	1.473	1.036	3.187	1.461	0.886		0.225		0.428
1/10	0.324		3.197	1.511	1.081	3.236	1.514	0.894		0.239		0.472
1/20	0.344		3.214	1.543	1.127	3.274	1.557	0.900		0.250		0.505
CP4 Net Water Requirement (l/s/ha)												
Return Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1/ 2	0.342	0.769	0.182				3.214	1.164	0.823	0.652	0.475	
1/ 4	0.390	0.819	0.244				3.288	1.178	0.850	0.678	0.544	
1/ 5	0.400	0.831	0.258				3.305	1.181	0.856	0.684	0.562	
1/10	0.427	0.860	0.292				3.358	1.189	0.871	0.698	0.611	0.017
1/20	0.447	0.881	0.319				3.401	1.196	0.883	0.709	0.655	0.050
CP5 Net Water Requirement (l/s/ha)												
Return Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1/ 2		0.201	0.598	1.004		3.127	1.370	0.868	0.277	0.443		0.000
1/ 4		0.251	0.660	1.108		3.171	1.444	0.883	0.305	0.469		0.079
1/ 5		0.263	0.674	1.132		3.187	1.461	0.886	0.311	0.475		0.097
1/10		0.291	0.709	1.191		3.236	1.514	0.894	0.326	0.489	0.008	0.141
1/20		0.313	0.735	1.239		3.274	1.557	0.900	0.337	0.500	0.076	0.174
CP6 Net Water Requirement (l/s/ha)												
Return Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1/ 2	0.115	0.485	0.95	0.012		0.307	1.004					5E-04
1/ 4	0.162	0.535	1.013	0.116		0.374	1.118					0.079
1/ 5	0.173	0.547	1.027	0.140		0.399	1.144					0.097
1/10	0.200	0.576	1.061	0.199		0.475	1.226				0.008	0.141
1/20	0.220	0.597	1.087	0.247		0.532	1.292				0.076	0.174

Table C.4.1 Unit Water Requirement (2/4)

(1) Unit Water Requirement (Present Conditions)

Station Nam Phuc												
CP1 Net Water Requirement (l/s/ha)												
Return Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1/ 2	1.044	1.245	1.351	1.126								2.682
1/ 4	1.092	1.283	1.401	1.203								2.740
1/ 5	1.101	1.291	1.410	1.217								2.751
1/10	1.121	1.308	1.431	1.249								2.776
1/20	1.133	1.318	1.444	1.272								2.791
CP2 Net Water Requirement (l/s/ha)												
Return Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1/ 2	1.044	1.245	1.351	1.126		3.249	1.305	0.887				2.682
1/ 4	1.092	1.283	1.401	1.203		3.335	1.341	0.900				2.740
1/ 5	1.101	1.291	1.410	1.217		3.354	1.351	0.903				2.751
1/10	1.121	1.308	1.431	1.249		3.395	1.383	0.926				2.776
1/20	1.133	1.318	1.444	1.272		3.421	1.412	0.942				2.791
CP3 Net Water Requirement (l/s/ha)												
Return Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1/ 2	0.088		3.091	1.377	0.908	3.249	1.305	0.887		0.222		0.316
1/ 4	0.161		3.141	1.454	0.921	3.335	1.341	0.900		0.246		0.406
1/ 5	0.175		3.150	1.468	0.923	3.354	1.351	0.903		0.251		0.422
1/10	0.205		3.171	1.501	0.943	3.395	1.383	0.926		0.261		0.460
1/20	0.225		3.184	1.523	0.959	3.421	1.412	0.942		0.267		0.483
CP4 Net Water Requirement (l/s/ha)												
Return Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1/ 2	0.191	0.741	0.130				3.149	1.183	0.803	0.681	0.416	
1/ 4	0.264	0.800	0.206				3.185	1.196	0.836	0.705	0.428	
1/ 5	0.278	0.811	0.221				3.195	1.198	0.842	0.710	0.435	
1/10	0.309	0.837	0.252				3.227	1.221	0.856	0.720	0.460	0.005
1/20	0.328	0.853	0.273				3.255	1.237	0.865	0.726	0.475	0.029
CP5 Net Water Requirement (l/s/ha)												
Return Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1/ 2		0.173	0.546	0.985		3.249	1.305	0.887	0.258	0.472		
1/ 4		0.231	0.622	1.103		3.335	1.341	0.900	0.291	0.496		0.075
1/ 5		0.243	0.637	1.125		3.354	1.351	0.903	0.297	0.501		0.092
1/10		0.269	0.669	1.174		3.395	1.383	0.926	0.311	0.511		0.129
1/20		0.285	0.689	1.209		3.421	1.412	0.942	0.320	0.517		0.153
CP6 Net Water Requirement (l/s/ha)												
Return Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1/ 2		0.457	0.898			0.494	0.905					
1/ 4	0.037	0.515	0.975	0.111		0.626	0.960					0.075
1/ 5	0.051	0.527	0.989	0.133		0.655	0.975					0.092
1/10	0.081	0.553	1.021	0.182		0.718	1.025					0.129
1/20	0.101	0.569	1.042	0.217		0.759	1.068					0.153

Table C.4.1 Unit Water Requirment (3/4)

Unit Water Requirement (Future Conditions)

Station Nam Dan												
CP1 Net Water Requirement (l/s/ha)												
Return Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1/ 2	0.655	0.724	0.794	0.653								1.543
1/ 4	0.673	0.743	0.817	0.692								1.573
1/ 5	0.677	0.747	0.822	0.700								1.579
1/10	0.687	0.758	0.835	0.723								1.596
1/20	0.694	0.766	0.845	0.740								1.608
CP2 Net Water Requirement (l/s/ha)												
Return Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1/ 2	0.655	0.724	0.794	0.653		1.793	0.785	0.498				1.543
1/ 4	0.673	0.743	0.817	0.692		1.818	0.828	0.506				1.573
1/ 5	0.677	0.747	0.822	0.700		1.827	0.838	0.508				1.579
1/10	0.687	0.758	0.835	0.723		1.856	0.868	0.513				1.596
1/20	0.694	0.766	0.845	0.740		1.877	0.893	0.516				1.608
CP3 Net Water Requirement (l/s/ha)												
Return Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1/ 2	0.134		1.792	0.797	0.549	1.793	0.785	0.498		0.111		0.185
1/ 4	0.160		1.815	0.836	0.584	1.818	0.828	0.506		0.125		0.230
1/ 5	0.166		1.820	0.844	0.594	1.827	0.838	0.508		0.129		0.240
1/10	0.181		1.833	0.867	0.620	1.856	0.868	0.513		0.137		0.264
1/20	0.192		1.843	0.884	0.646	1.877	0.893	0.516		0.143		0.283
CP4 Net Water Requirement (l/s/ha)												
Return Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1/ 2	0.192	0.431	0.102				1.842	0.667	0.472	0.374	0.272	
1/ 4	0.218	0.459	0.136				1.885	0.675	0.487	0.389	0.312	
1/ 5	0.224	0.465	0.144				1.895	0.677	0.491	0.392	0.322	
1/10	0.239	0.481	0.164				1.925	0.682	0.500	0.400	0.350	0.009
1/20	0.250	0.494	0.178				1.950	0.685	0.506	0.406	0.376	0.028
CP5 Net Water Requirement (l/s/ha)												
Return Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1/ 2		0.112	0.335	0.562		1.793	0.785	0.498	0.159	0.254		0.000
1/ 4		0.140	0.370	0.621		1.818	0.828	0.506	0.175	0.269		0.044
1/ 5		0.147	0.378	0.634		1.827	0.838	0.508	0.178	0.272		0.054
1/10		0.163	0.397	0.667		1.856	0.868	0.513	0.187	0.281	0.004	0.079
1/20		0.175	0.412	0.694		1.877	0.893	0.516	0.193	0.287	0.043	0.097
CP6 Net Water Requirement (l/s/ha)												
Return Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1/ 2	0.064	0.272	0.532	0.007		0.172	0.562					3E-04
1/ 4	0.091	0.300	0.567	0.065		0.209	0.626					0.044
1/ 5	0.097	0.306	0.575	0.078		0.224	0.641					0.054
1/10	0.112	0.322	0.594	0.112		0.266	0.687				0.004	0.079
1/20	0.123	0.334	0.609	0.138		0.298	0.724				0.043	0.097

Table C.4.1 Unit Water Requirment (4/4)

Unit Water Requirement (Future Conditions)

Station Nam Phuc

CP1 Net Water Requirement (l/s/ha)

Return Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1/ 2	0.599	0.714	0.774	0.646								1.538
1/ 4	0.626	0.736	0.803	0.690								1.571
1/ 5	0.631	0.740	0.808	0.698								1.577
1/10	0.643	0.750	0.820	0.716								1.591
1/20	0.650	0.756	0.828	0.729								1.600

CP2 Net Water Requirement (l/s/ha)

Return Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1/ 2	0.599	0.714	0.774	0.646		1.863	0.748	0.509				1.538
1/ 4	0.626	0.736	0.803	0.690		1.912	0.769	0.516				1.571
1/ 5	0.631	0.740	0.808	0.698		1.923	0.775	0.518				1.577
1/10	0.643	0.750	0.820	0.716		1.946	0.793	0.531				1.591
1/20	0.650	0.756	0.828	0.729		1.962	0.809	0.540				1.600

CP3 Net Water Requirement (l/s/ha)

Return Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1/ 2	0.049		1.772	0.790	0.520	1.863	0.748	0.509		0.127		0.177
1/ 4	0.090		1.801	0.834	0.528	1.912	0.769	0.516		0.141		0.227
1/ 5	0.098		1.806	0.842	0.529	1.923	0.775	0.518		0.144		0.237
1/10	0.115		1.818	0.860	0.541	1.946	0.793	0.531		0.149		0.257
1/20	0.126		1.826	0.873	0.550	1.962	0.809	0.540		0.153		0.271

CP4 Net Water Requirement (l/s/ha)

Return Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1/ 2	0.107	0.415	0.073				1.806	0.678	0.460	0.390	0.238	
1/ 4	0.148	0.448	0.115				1.826	0.685	0.479	0.404	0.246	
1/ 5	0.156	0.454	0.124				1.832	0.687	0.483	0.407	0.250	
1/10	0.173	0.469	0.141				1.850	0.700	0.491	0.413	0.264	0.003
1/20	0.184	0.478	0.153				1.866	0.709	0.496	0.416	0.273	0.016

CP5 Net Water Requirement (l/s/ha)

Return Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1/ 2		0.097	0.306	0.552		1.863	0.748	0.509	0.148	0.271		
1/ 4		0.130	0.349	0.618		1.912	0.769	0.516	0.167	0.285		0.042
1/ 5		0.136	0.357	0.630		1.923	0.775	0.518	0.170	0.287		0.051
1/10		0.150	0.375	0.658		1.946	0.793	0.531	0.178	0.293		0.072
1/20		0.160	0.386	0.677		1.962	0.809	0.540	0.183	0.297		0.086

CP6 Net Water Requirement (l/s/ha)

Return Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1/ 2		0.256	0.503			0.277	0.507					
1/ 4	0.021	0.289	0.546	0.062		0.351	0.538					0.042
1/ 5	0.028	0.295	0.554	0.075		0.367	0.546					0.051
1/10	0.046	0.310	0.572	0.102		0.402	0.574					0.072
1/20	0.057	0.319	0.583	0.122		0.425	0.598					0.086

Table C.4.2 Water Balance Culculation (1/2)

Code R21 Reservoir Ru doi

Present Condition

Return Period	Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1/ 2	Inflow (l/s)	49.29	35.91	32.52	29.45	36.15	49.30	55.41	73.21	157.65	187.54	139.45	71.43
	Water Requirwmwnt (l/s	114.24	126.34	138.46	113.82		156.36	68.49	43.42				269.20
	Strage Volume (m3)	0	0	0	0	5000000	0	0	5000000	5000000	5000000	5000000	0
	Insufficiency (l/s)	-64.95	-77.06	-89.18	-64.53		-105.14	-19.20					-217.98
	Over flow (l/s)					47.36			3.94	49.29	49.29	49.29	
1/ 4	Inflow (l/s)	39.86	29.04	26.30	23.82	29.23	39.87	44.81	59.20	127.49	151.66	112.77	57.76
	Water Requirwmwnt (l/s	117.33	129.60	142.51	120.61		158.53	72.20	44.15				274.34
	Strage Volume (m3)	0	0	0	0	5000000	0	0	0	5000000	5000000	5000000	0
	Insufficiency (l/s)	-77.47	-89.75	-102.65	-80.75		-116.74	-32.35	-4.29				-232.55
	Over flow (l/s)					37.93				37.93	39.86	39.86	
1/ 5	Inflow (l/s)	37.83	27.56	24.97	22.61	27.75	37.84	42.53	56.20	121.01	143.96	107.04	54.83
	Water Requirwmwnt (l/s	118.03	130.37	143.42	122.14		159.36	73.04	44.31				275.49
	Strage Volume (m3)	0	0	0	0	5000000	0	0	0	5000000	5000000	5000000	0
	Insufficiency (l/s)	-80.20	-92.53	-105.59	-84.31		-119.60	-35.21	-6.48				-235.73
	Over flow (l/s)					35.91				35.91	37.83	37.83	
1/10	Inflow (l/s)	33.02	24.06	21.79	19.73	24.22	33.03	37.12	49.05	105.62	125.65	93.43	47.86
	Water Requirwmwnt (l/s	119.76	132.24	145.66	126.02		161.82	75.72	44.71				278.34
	Strage Volume (m3)	0	0	0	0	5000000	0	0	0	5000000	5000000	5000000	0
	Insufficiency (l/s)	-86.74	-99.22	-112.64	-93.00		-126.87	-42.70	-11.69				-243.39
	Over flow (l/s)					31.09				31.09	33.02	33.02	
1/20	Inflow (l/s)	29.56	21.53	19.50	17.66	21.68	29.56	33.23	43.90	94.54	112.46	83.62	42.83
	Water Requirwmwnt (l/s	121.07	133.66	147.39	129.14		163.68	77.87	45.02				280.49
	Strage Volume (m3)	0	0	0	0	5000000	0	0	0	5000000	5000000	5000000	0
	Insufficiency (l/s)	-91.51	-104.10	-117.83	-99.58		-132.19	-48.31	-15.46				-249.00
	Over flow (l/s)					27.63				27.63	29.56	29.56	

Table C.4.2 Water Balance Culculation (2/2)

Code R21 Reservoir Ru doi

After Canal Improvement													
Return Period	Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1/ 2	Inflow (l/s)	49.29	35.91	32.52	29.45	36.15	49.30	55.41	73.21	157.65	187.54	139.45	71.43
	Water Requirwmwnt (l/s	65.50	72.44	79.39	65.26		89.64	39.27	24.89				154.34
	Strage Volume (m3)	0	0	0	0	10000000	0	0	10000000	10000000	10000000	10000000	0
	Insufficiency (l/s)	-29.59	-36.53	-43.48	-29.35		-49.88	-3.36					-114.57
	Over flow (l/s)					32.05			7.16	35.91	35.91	35.91	
1/ 4	Inflow (l/s)	39.86	29.04	26.30	23.82	29.23	39.87	44.81	59.20	127.49	151.66	112.77	57.76
	Water Requirwmwnt (l/s	67.27	74.31	81.71	69.15		90.89	41.40	25.31				157.29
	Strage Volume (m3)	0	0	0	0	10000000	0	0	9659680	10000000	10000000	10000000	0
	Insufficiency (l/s)	-38.23	-45.27	-52.67	-40.11		-57.99	-12.36					-124.39
	Over flow (l/s)					25.18				28.91	29.04	29.04	
1/ 5	Inflow (l/s)	37.83	27.56	24.97	22.61	27.75	37.84	42.53	56.20	121.01	143.96	107.04	54.83
	Water Requirwmwnt (l/s	67.67	74.74	82.23	70.03		91.37	41.88	25.40				157.95
	Strage Volume (m3)	0	0	0	0	10000000	0	0	5594908	10000000	10000000	10000000	0
	Insufficiency (l/s)	-40.11	-47.18	-54.67	-42.46		-59.95	-14.31					-126.53
	Over flow (l/s)					23.71				25.86	27.56	27.56	
1/10	Inflow (l/s)	33.02	24.06	21.79	19.73	24.22	33.03	37.12	49.05	105.62	125.65	93.43	47.86
	Water Requirwmwnt (l/s	68.66	75.82	83.51	72.25		92.78	43.42	25.64				159.58
	Strage Volume (m3)	0	0	0	0	10000000	0	0	0	10000000	10000000	10000000	0
	Insufficiency (l/s)	-44.61	-51.76	-59.46	-48.19		-64.86	-19.36	-1.58				-131.66
	Over flow (l/s)					20.20				20.20	24.06	24.06	
1/20	Inflow (l/s)	29.56	21.53	19.50	17.66	21.68	29.56	33.23	43.90	94.54	112.46	83.62	42.83
	Water Requirwmwnt (l/s	69.41	76.63	84.50	74.04		93.84	44.65	25.81				160.81
	Strage Volume (m3)	0	0	0	0	10000000	0	0	0	10000000	10000000	10000000	0
	Insufficiency (l/s)	-47.88	-55.10	-62.97	-52.51		-68.45	-23.11	-4.28				-135.42
	Over flow (l/s)					17.67				17.67	21.53	21.53	

Table C.4.3 Estimation of Irrigated Area under Reservoirs

Code No.	Name of Reservoir	Catchment Area (km2)	Effective Storage (mill. m3)	Length of Main Canal (km)	Command Area (ha)				Portion of Irrigated Area (ha)		
					Design Irrigated	Actual Irrigated	Simulated Irrigated at Present	Simulated After Renovation	Actual Conditions	Simulated After Renovation	Increasing Portion
R1	Vung huyen	2.20	0.16	0.80	20	10	10	16	50.00%	80.85%	30.85%
R2	Ho thanh	2.70	0.90	2.00	120	45	49	81	37.50%	67.09%	29.59%
R3	Kim Khanh	2.60	0.12	0.30	30	15	15	25	50.00%	83.00%	33.00%
R4	Vuc mau	2.70	0.21	1.20	50	20	19	32	40.00%	64.30%	24.30%
R5	Hao Hao	6.00	0.50	2.00	200	15	13	21	7.50%	10.64%	3.14%
R6	Trang Den	8.00	2.20	3.70	200	45	50	82	22.50%	41.13%	18.63%
R7	Thung Pheo	2.00	0.12	2.00	30	10	11	18	33.33%	60.65%	27.31%
R8	10 small lakes	5.00	0.12		120	56	56	93	46.67%	77.69%	31.02%
R9	Cua ong	4.00	1.20	2.50	180	100	102	169	55.56%	94.03%	38.47%
R10	Thanh thuy	1.83	1.12	2.00	280	70	75	125	25.00%	44.47%	19.47%
R11	Rao bang	7.00	2.00	3.50	120	100	98	120	83.33%	100.00%	16.67%
R12	Hung coc	1.40	0.60	1.00	180	60	60	99	33.33%	55.19%	21.86%
R13	Thung vuon	0.60	0.27	0.30	5	5	5	5	100.00%	100.00%	0.00%
R14	Khe dau	0.80	0.27	0.50	10	10	10	10	100.00%	100.00%	0.00%
R15	Khe be	0.70	0.14	0.40	50	20	20	33	40.00%	65.40%	25.40%
R16	Khe cay	0.50	0.09	0.50	20	10	10	16	50.00%	81.02%	31.02%
R17	Khe dinh	1.20	0.67	1.00	100	40	38	63	40.00%	63.23%	23.23%
R18	Khe che	0.65	0.09	0.80	20	15	15	25	75.00%	125.21%	50.21%
R19	Khe bo	1.80	0.10	2.00	31	15	15	25	48.39%	80.57%	32.18%
R20	O O	1.00	0.08	2.00	20	15	15	25	75.00%	125.48%	50.48%
R21	Ru doi	1.10	0.15	1.50	50	35	35	50	70.00%	100.00%	30.00%
Total					1836	711	722	1134	51.58%	77.14%	25.56%

Table C.4.4 Proposed Projects for Reservoir Irrigation System

No	Name of Reservoir	Location (Commune)	Actual Irrigated Area (ha)		Main work quantities (m^3)			Activities
			Presently	Proposed	Earth Exv. & Filling	Rock masonry	Concrete	
R1	Vung Huyen	Nam Kim	10	20	1,500	850	3	Repairing main outlet, raising main dam and spillway (0.5 m). Upgrading 0.8 km of main canal by rock masonry and 2 outlets
R2	Ho Thanh	Nam Kim	45	80	5,000	2,000	30	Reconstructing outlet under the main dam, main canal (by rock masonry 1.5km) and one elevated flume and 5 outlets.
R4	Vuc Mau	Thanh Son	20	50	1,000	850	3	Raising main dam & spillway (1m) Upg. main canal (1 km) and 2 outlets.
R5	Hao Hao	Khanh Son	15	20	1,000	850	5	Repairing spillway, Upg. 1 km of main canal by rock masonry 2 outlets
R6	Trang den	Nam Hung	45	100	4,500	3,300	15	Upgrading Sub-dam (300m); Repairing spillway; Upgrading 3 km main canal by rock masonry, constructing 3 elevated flumes & 5 outlets
R7	Thung Pheo	Nam Hung	10	15	12,000	1,800	30	Building a new pond upstream, Upgr. main canal by rock mas (2 km) and 2 outlets
R9	Cua Ong	Nam Nghia	100	150	9,000	3,200	10	Raising & enlarging main dam, building filter layer down stream foot, Upgrading 2 km main canal and 10 outlets
R10	Thanh Thuy	Van Dien	70	100	12,000	3,000	100	Repairing outlet, digging pond bed, Upg. main canal 2 km & outlets. (6 units)
R11	Rao Bang	Nam Thanh	100	160	7,000	1,800	5	Raising spillway & dam (50cm), Upg. main canal (1 km) and 10 outlets.
R17	Khe Dinh	Nam Xuan	40	60	3,500	900	-	Raising and enlarging main dam 0.5 and 1 m respectively, repairing spillway and energy dissipater, Upg. 1 km main canal and s outlets (20 units).
R19	Khe Bo	Nam Linh	15	35	4,000	1,700	20	Raising main dam (50cm), Repairing main outlet, Upg. main canal (2km) by rock masonry and 3 outlets.
R20	O O	Nam Linh	15	15	4,000	900	5	Raising main dam (50cm), repairing spillway, Upg. main canal (1 km) and outlets of 2nd canals (2 units).
RN1	Khe Dien	Nam Hung	0	30	30,000	2,100	45	Newly built of head work, main canal 2 km and 3 outlets of 2 nd canals
RN2	Da Han	Nam Thanh	95	220	170,000	5,700	1,000	Completing 2nd phase of main dam from +29.4 to +33.4, main spillway, main canal system (1 km).
RN3	Ba Khe	Nam Loc	0	150	220,000	7,000	270	Newly built of head works and 2km main canal, outlets of 2nd canals (8 units).
	TOTAL:		**580**	**1205**	**484,500**	**35,950**	**1541**	

Note RN : New Construction

Table C.4.5 Water Insufficiency of Pumping System

Code No.	Name of Station	Designed Capacity (l/s)	Command Area (ha)	Actual Irrigated Area (ha)	Present Water Requirement (l/s)	Estimated Water Insufficiency (%)
P1	Duong dap	278	100	90	469	41%
P2	Mu ba	150	40	40	188	20%
P3	Geeh	150	40	29	188	28%
P4	Vac	222	70	55	328	32%
P5	Nam kim 2	556	140	100	657	29%
P6	Nam kim 3	278	80	50	375	38%
P7	Nam cuong	556	140	96	657	31%
P8	Nam phuc	278	70	43	328	39%
P9	Nam trung	1,667	1350	450	6,332	74%
P10	Du DU	556	60	40	281	33%
P11	Station 1 : Khanh son1	278	25	20	117	20%
P12	Station 3: Khanh son 1	150	20	14	94	30%
P13	Station1 : Khanh son 2	556	70	60	328	14%
P14	Station 2 : Khanh son 2	278	25	20	117	20%
P15	Station 3: Khanh son 2	278	20	15	94	25%
P16	Nam dong	2,222	1200	253	5,629	79%
P17	Station 1 : Nam loc	833	130	100	610	23%
P18	Station 2: Nam loc	278	60	30	281	50%
P19	Station1 : Nam tan	1,111	150	120	704	20%
P20	Station 1 : Dai dong	456	100	60	469	40%
P21	Station 2: Dai dong	267	50	20	235	60%
P22	Hong son station	133	50	30	235	43%
P23	Ru dun station	444	100	70	469	30%
P24	Station 2: Nam thanh 1	150	100	90	469	68%
P25	Station 2 : nam thanh 2	278	60	40	281	33%
P26	Nam thai	556	140	80	657	43%
P27	Sen doi	278	50	30	235	40%
P28	Ghenh station	1,111	320	320	873	0%
P29	Hong long 1	444	110	80	516	27%
P30	Hong long 2	667	180	150	844	21%
P31	Xuan lam	1,111	235	200	1,102	15%
P32	Bau non	556	200	80	938	60%
P33	Ru Doi	278	50	20	235	60%
Total		17,400	5,535	2,895	25,335	36%

Table C.4.6 Required Capacity of Pumping System

Code No.	Name of Station	Command Area (ha)	Required Total Capacity (l/s)	Estimated Improvement of Water Sufficiency (%)
P1	Duong dap	100	273	41%
P2	Mu ba	40	109	20%
P3	Gech	40	109	28%
P4	Vac	70	191	32%
P5	Nam kim 2	140	382	29%
P6	Nam kim 3	80	218	38%
P7	Nam cuong	140	382	31%
P8	Nam phuc	70	191	39%
P9	Nam trung	1,350	3,681	74%
P10	Du DU	60	164	33%
P11	Station 1 : Khanh son1	25	68	20%
P12	Station 3: Khanh son 1	20	55	30%
P13	Station1 : Khanh son 2	70	191	14%
P14	Station 2 : Khanh son 2	25	68	20%
P15	Station 3: Khanh son 2	20	55	25%
P16	Nam dong	1,200	3,272	79%
P17	Station 1 : Nam loc	130	354	23%
P18	Station 2: Nam loc	60	164	50%
P19	Station1 : Nam tan	150	409	20%
P20	Station 1 : Dai dong	100	273	40%
P21	Station 2: Dai dong	50	136	60%
P22	Hong son station	50	136	43%
P23	Ru dun station	100	273	30%
P24	Station 2: Nam thanh 1	100	273	68%
P25	Station 2 : nam thanh 2	60	164	33%
P26	Nam thai	140	382	43%
P27	Sen doi	50	136	40%
P28	Ghenh station	320	873	0%
P29	Hong long 1	110	300	27%
P30	Hong long 2	180	491	21%
P31	Xuan lam	235	641	15%
P32	Bau non	200	545	60%
P33	Ru Doi	50	136	60%
Total		5,535	15,092	36%

Table C.4.7 Proposed Pumping System Improvement Projects

Code No.	Name of Pumping Station	Location (Commune)	Required Total Capacity (m^3/h)	Dimensions		Command Area		Main work quantities			Activities
				Presently	Proposed	Presently (ha)	Proposed (ha)	Earth excavation & filling	Rock masonry	Concrete	
P1	Duong dap	Nam Kim	968	1x1,000	2x1,000	90	100	500	1,500	10	Upg. pump house, 1 km of main canal & 6 outlets of 2 nd canal.
P7	Nam Cuong 1	Nam Cuong	1,355	2x1,000	2x1,000	96	140	1,100	1,600	20	Upg. pump house, 1 km main canal and 8 outlets of secondary canals.
P9	Nam Trung	Nam Trung	4,841	6x1,000	5x1,000	450	500	3,500	9,000	95	Newly building pump house for flood protection, Upg. main canal (3 km) and 10 outlets of 2nd canal.
P10	Du DU	Khanh son	775	2x1,000	2x1,000	40	80	1,000	1,500	5	Upg. 1 km of main canal, 5 outlets of 2 nd canal
P13	Khanh Son 2	Khanh Son	678	2x1,000	2x1,000	60	70	1,500	1,100	40	Newly building pump house for flood protection and repairing canal system (0.5 km) by rock masonry, 3 outlets of 2 nd canal.
P16	Nam Dong	Nam Dong	7,745	9x1,000	9x1,000	253	800	11,000	22,500	120	Upg. 8km main canal by rock masonry, 20 outlets of 2nd canals, 3 elevated flumes and tertiary outlets (100 units).
P17	Nam Loc	Nam Loc	968	3x1,000	2x1,000	100	100	2,000	2,800	65	Replacing pump sets, newly building pump house for flood protection, Upg. 1 km main canal by rock masonry & 6 outlets.
P19	Nam Tan	Nam Tan	1,936	4x1,000	4x1,000	110	200	3,000	5,000	15	Upg. 2.5 km main canal, 2nd outlets (10 units) and 6 bridges across main canal
P20	Dai Dong 1	Nam Thuong	871	2x420	2x540	60	90	1,100	1,200	10	Exchanging pump type, Upg. 1 km of main canal & 7 outlets.
P21	Dai Dong 2	Nam Thuong	581	1x1,000	1x1,000	20	60	2,000	1,000	45	Newly building pump house, Upg. 500 m of main canal & 5 outlets.
P22	Hong Son	Nam Thuong	775	1x480	2x480	50	80	1,000	1,200	10	Upgrading 1 km main canal, 6 outlets of 2nd canals, adding one more pump set.
P23	Ru Dun	Van Dien	1,936	2x540 m^3/h	4x540 m^3/h	70	200	3,500	4,400	95	Newly building pump house, upgrading 3km main canal, 10 outlets (enlarged command area) of 2nd canal and 2 elevated flume.
P26	Nam thai	Nam Thai	968	2x1,000	2x1,000	80	100	1,500	2,500	90	Newly building pump house for flood protection, Upg. 1.5km of main canal and 8 outlets of 2nd canals.
P27	Sen doi	Nam xuan	775	1x1,000	1x1,000	30	80	800	1,200	3	Upg. 1 km of main canal, 4 outlets of 2 nd canal
P28	Ghenh station	Hung tu	3,098	4x1,000	4x1,000	102	320	1,500	4,000	15	Upg. 2 km of main canal, 2 outlets & 4 bridges of 2 nd canal
P29	Hong Long 1	Hong Long	1,307	2x1,000	2x1,000	80	135	1,500	2,500	90	Newly building pump house for flood protection, Upg. 1.5km of main canal and 9 outlets of 2nd canals.
P30	Hong Long 2	Hong Long	1,936	3x1,000	3x1,000	150	200	2,000	3,500	90	Newly building pump house for flood protection, Upg. 1.5km of main canal and 10 outlets of 2nd canals.
P31	Xuan Lam	Xuan Lam	3,195	3x1,000	4x1,000	200	330	2,500	4,000	95	Newly built at other site, Upg. canal system (2 km) and 15 outlets.
P33	Ru Doi	Nam giang	484	1x1,000	1x1,000	20	50	1,500	1,200	10	Newly building pump house, 1km of main canal, 3 outlet of 2 nd canal
PN1	Nam Cuong 2	Nam Cuong	1,162	-	2x1,000	-	120	2,000	3,200	90	Newly built at Lam river bank, 2 km of main canal and 8 outlets of 2 nd canal.
	TOTAL:					2,061	3,755	44,500	74,900	1,013	

Note PN : New Construction

Table C.4.8 Estimated Inundation Frequency at Nam Nam Region

Year	Number of Inundation	Maximum Water Level (m)	Continuos days (day)	Maximum Water Level (m)	Continuos days (day)	Maximum Water Level (m)	Continuos days (day)	Maximum Water Level (m)	Continuos days (day)
1962	1	8.18	9						
1963	4	7.72	20	7.50	7	6.69	6	7.48	8
1964	2	7.88	33	6.35	5				
1965	1	6.14	3						
1966									
1967	3	6.25	4	6.36	9	6.56	12		
1968									
1969									
1970	2	6.19	4	6.00	3				
1971	2	7.26	11	7.43	6				
1972	2	7.79	8	6.29	3				
1973	1	8.00	44						
1974	1	6.11	3						
1975	3	6.45	10	6.01	3	6.97	5		
1976	1	6.32	3						
1977									
1978	3	6.72	6	9.65	24	7.56	7		
1979	2	6.26	5	6.36	4				
1980	3	7.54	12	8.15	9	7.03	6		
1981	1	6.74	6						
1982	3	7.29	7	6.95	9	6.85	7		
1983	1	7.74	7						
1984	1	6.64	7						
1985	1	6.41	7						
1986	1	6.87	6						
1987	1	7.04	5						
1988	1	9.51	14						
1989	4	7.09	4	6.74	4	6.18	3	7.46	22
1990	4	6.24	4	6.78	5	7.69	8	6.00	4
1991	1	7.36	6						
1992									
1993									
1994	3	7.07	7	6.03	4	6.91	9		

Table C.4.9 Proposed Projects for Flood Prevention and Drainage Improvement

(1) Flood Privation Plan

No.	Region	Befitted Area (ha)		Alternative 1:Inundation Mitigation Plan				Alternative 2: Flood Control Plan		
		Total	Cultivated Land	Earth Exca. & Filling (m^3)	Rock Masonry (m^3)	Concrete (m^3)	Estimated Cost mill. VND	Earth Exca. & Filling (m^3)	Rock Masonry (m^3)	Concrete (m^3)
F1	Nam Nam Dike	**1,920**	**1,200**	**16,600**	**3,400**	**50**	**3,000**	**240,000**	**1,000**	**50**
F2	North the Lam River	**2,570**	**1,750**	**25,500**	**500**	**50**	**600**	**35,000**	**500**	**50**
	Dike	510	360	1,000	100	10	70	10,500	100	10
	Onfarm	2,060	1,390	24,500	400	40	530	24,500	400	40
F3	Tan Loc Thuong	**2,665**	**808**	**402,000**	**15,000**	**105**	**18,000**	**411,000**	**12,300**	**100**
	Dike	750	750	381,000	4,600	45	15,500	390,000	1,900	40
	Onfarm	2,665	808	16,000	400	60	500	16,000	400	60
	Embankment			5,000	10,000		2,000	5,000	10,000	
F4	Thien Nhan Mauntain	**4,500**	**750**	**20,000**	**300**	**30**	**450**	**95,000**	**1,300**	**80**
	Dike							75,000	1,000	50
	Onfarm	4,500	750	20,000	300	30	450	20,000	300	30

(2) Drainage Improvement Plan

No.	Region	Befitted Area (ha)		Proposed Plan			
		Total	Cultivated Land	Earth Exca. & Filling (m^3)	Rock Masonry (m^3)	Concrete (m^3)	Estimated Cost mill. VND
D1	Nam Nam Drainage improvement	**1,650**	**1,400**	**57,000**	**650**	**60**	**1,150**
D2	Hong Long Drainage Improvement	**1,699**	**950**	**36,000**	**450**	**50**	**750**

APPENDIX C: FIGURES

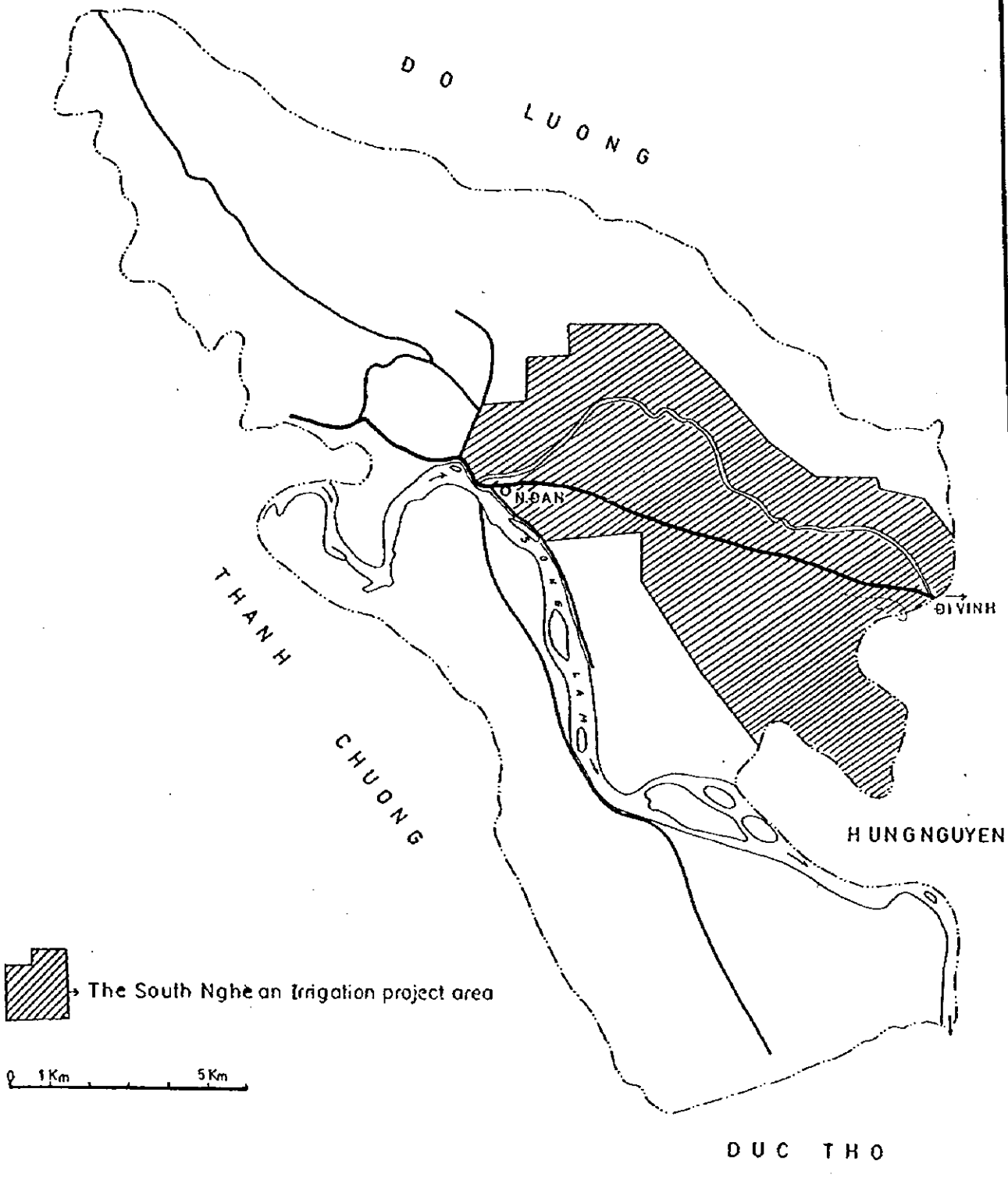


Fig. C.2.1 Location of the South Nghe An Irrigation Project

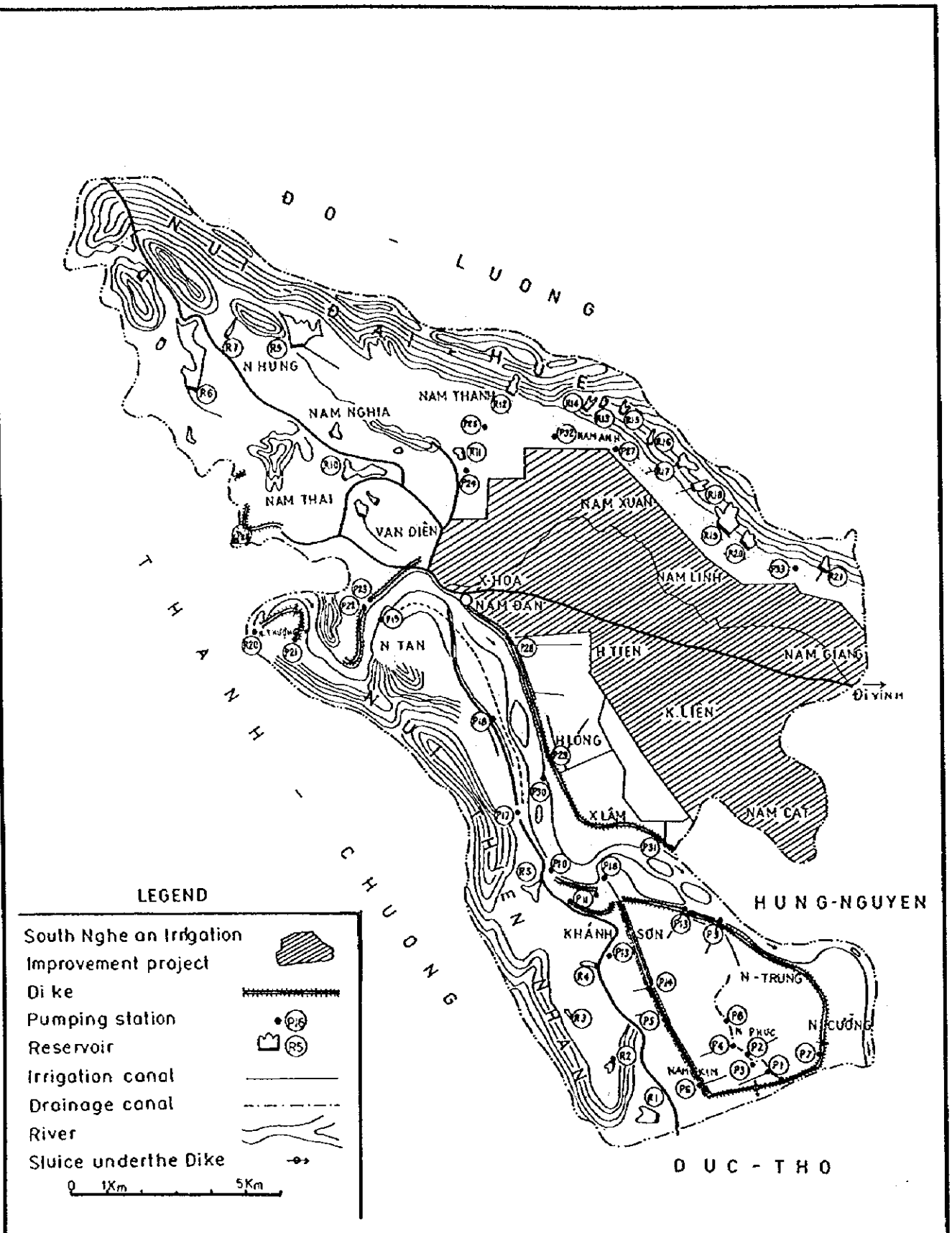


Fig. C.3.1 Existing Irrigation and Drainage System

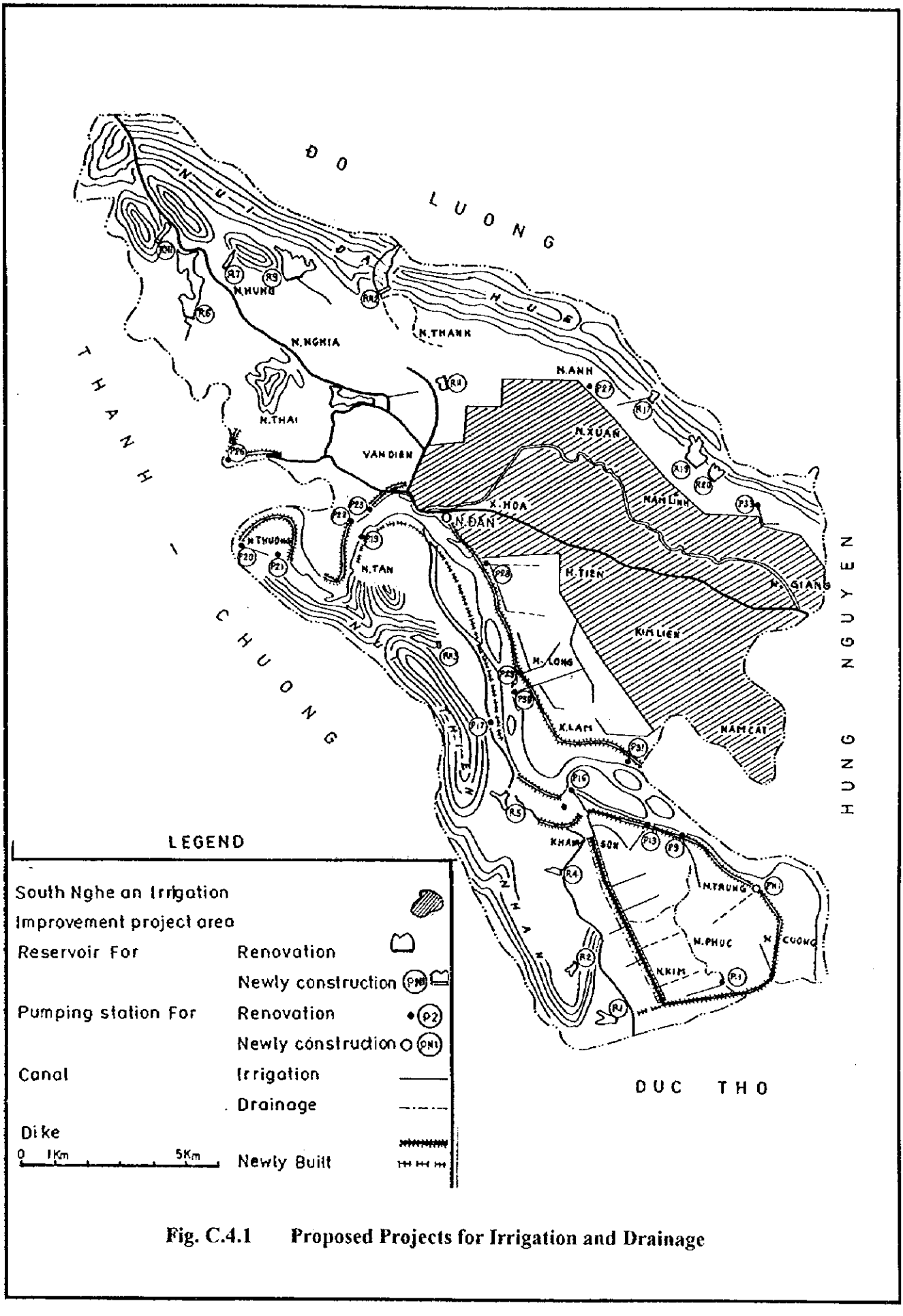


Fig. C.4.1 Proposed Projects for Irrigation and Drainage

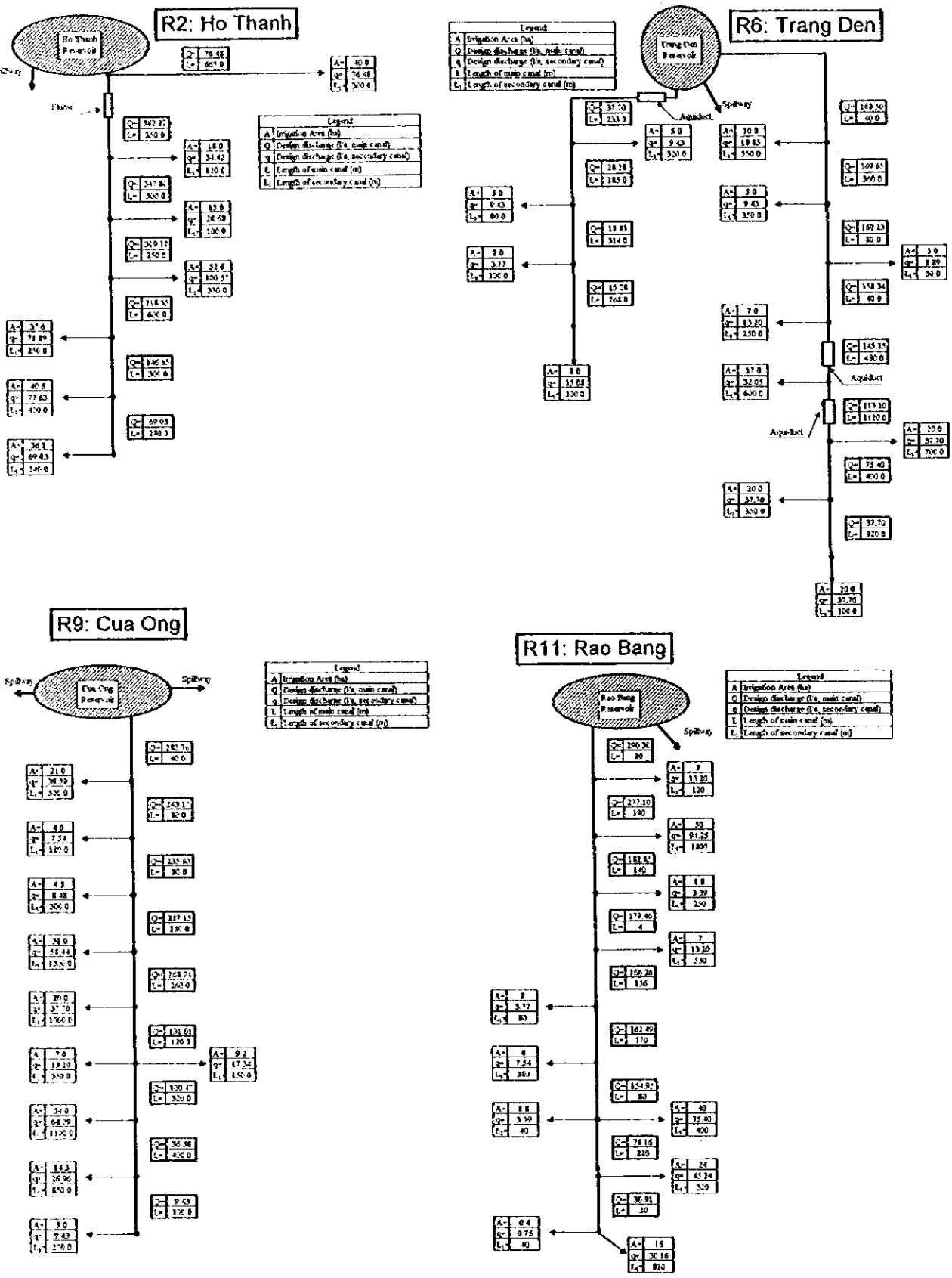


Fig. C.5.1 Schematic Chart of Irrigation System (1/2)

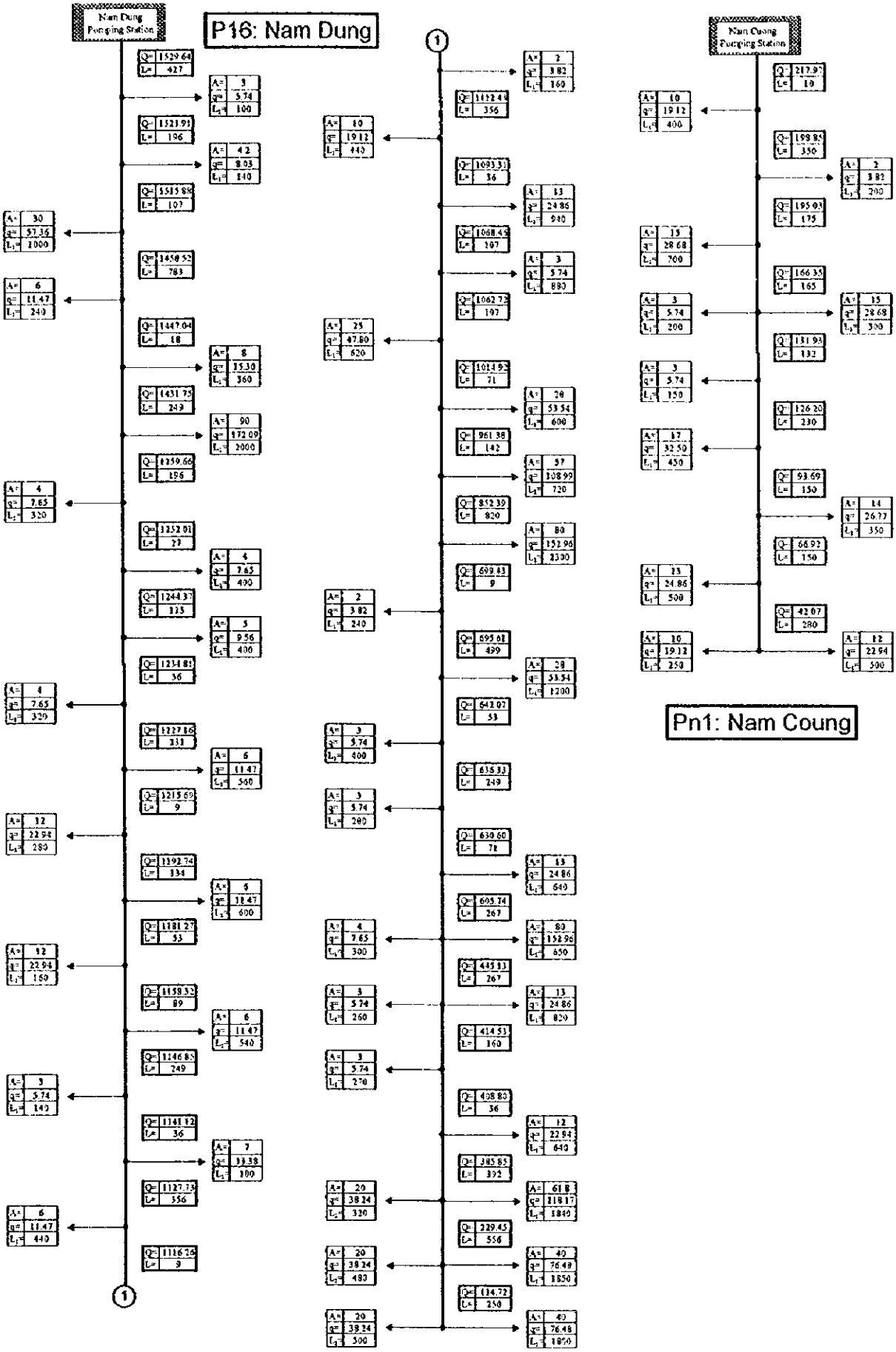


Fig. C.5.1 Schmatic Chart of Irrigation System (2/2)

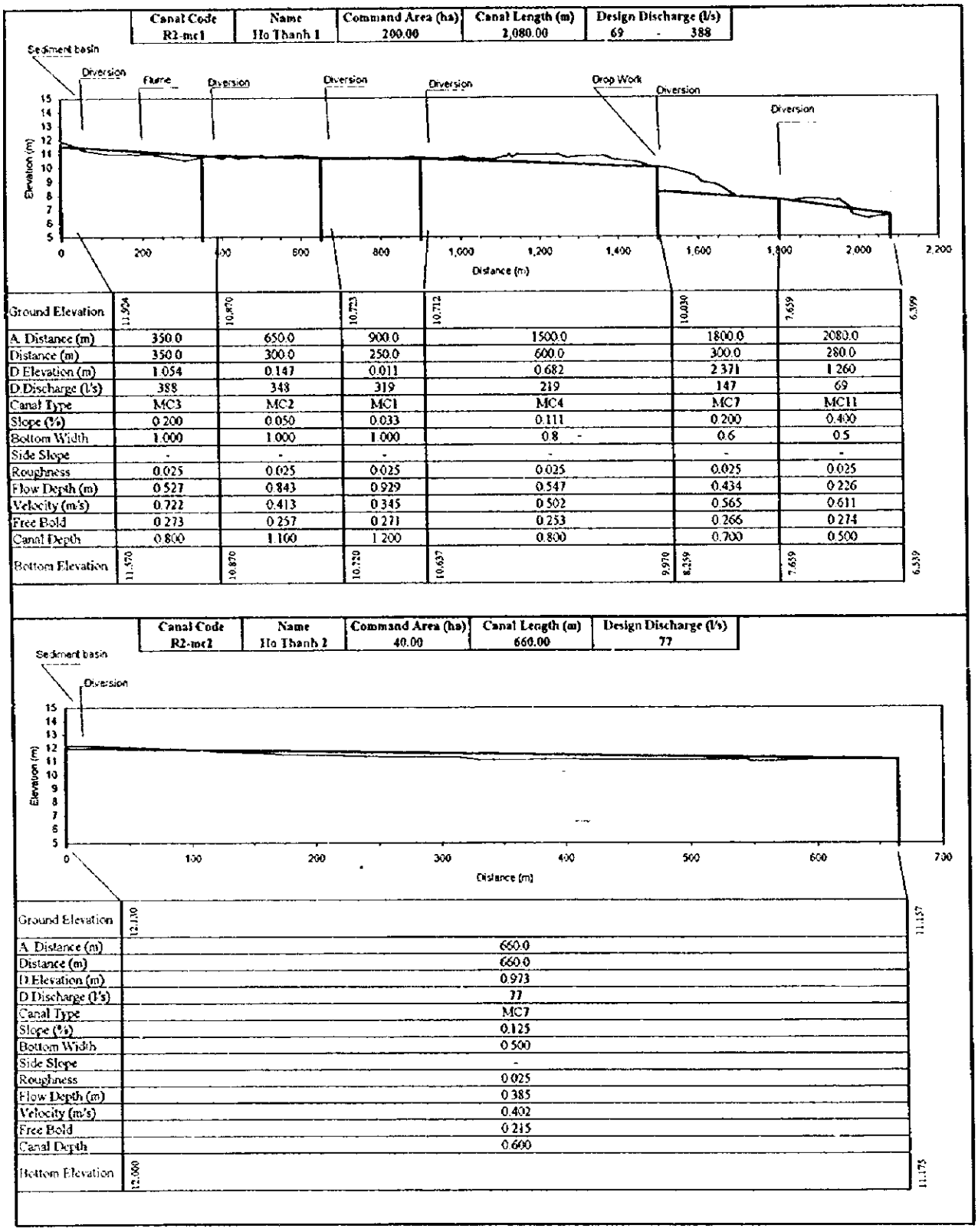


Fig. C.5.2 Profile of Irrigation Canal (1/5)

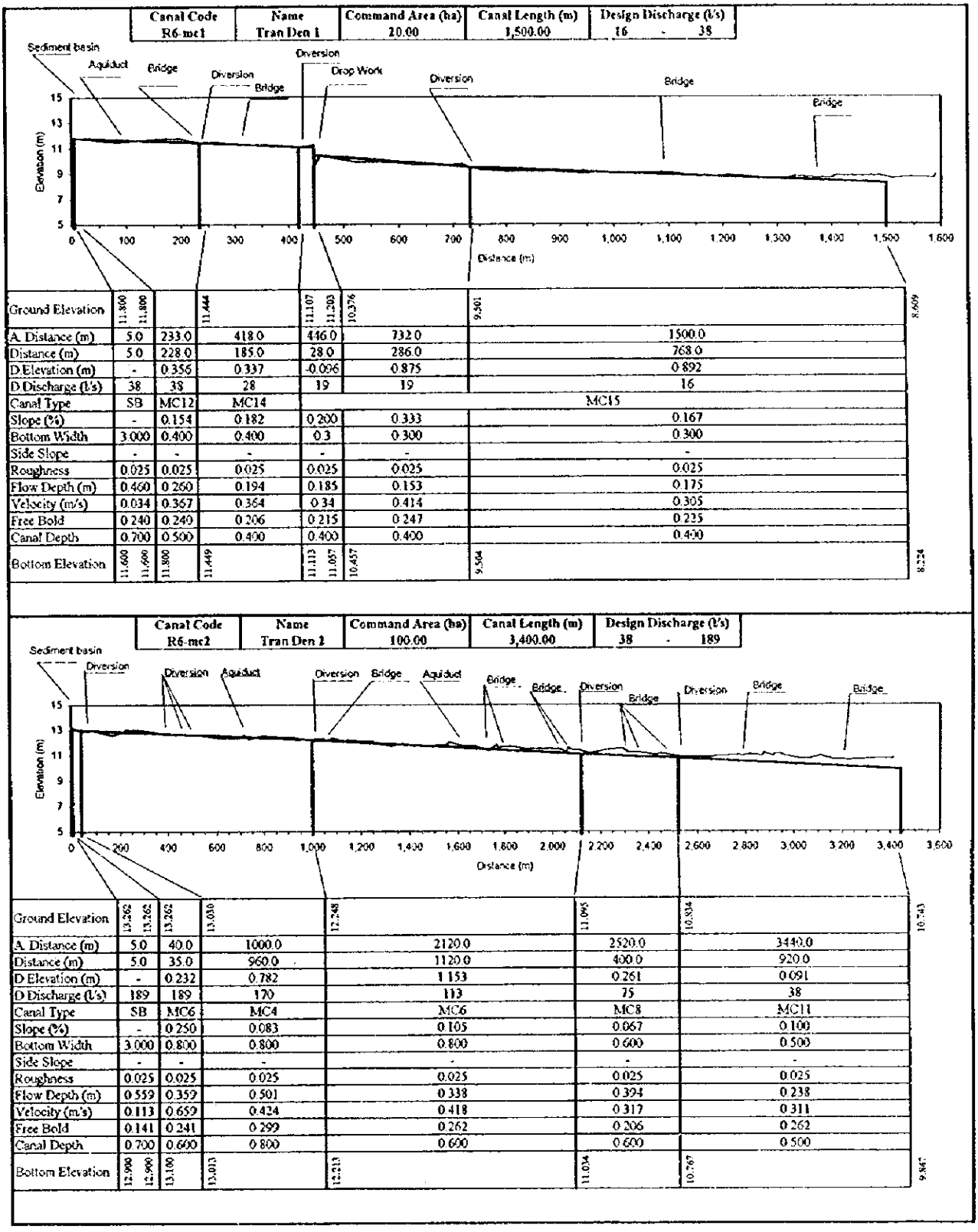
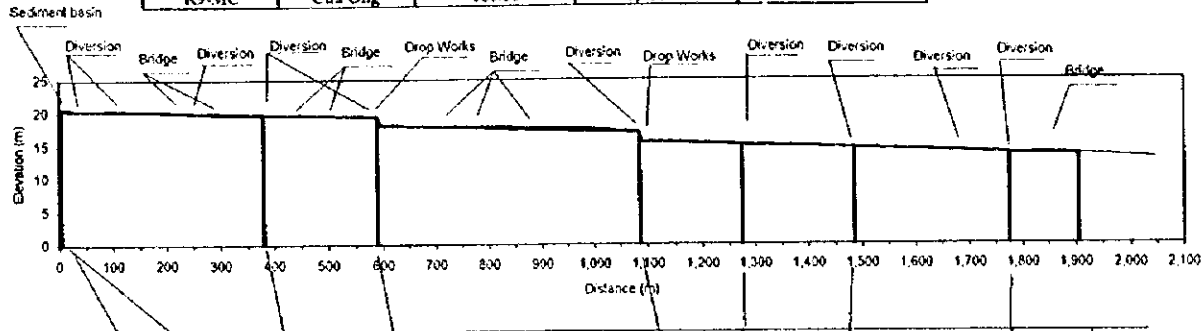


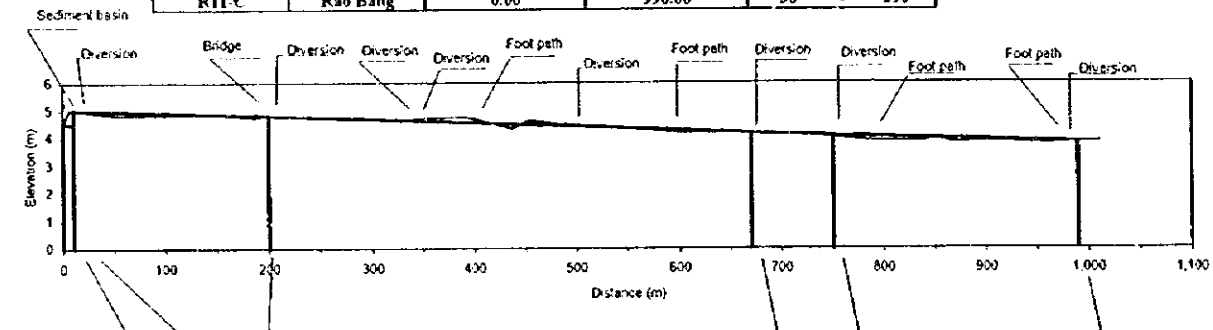
Fig. C.5.2 Profile of Irrigation Canal (2/5)

Canal Code	Name	Command Area (ha)	Canal Length (m)	Design Discharge (l/s)
R9-MC	Cua Ong	180.00	1,900.00	27 - 340



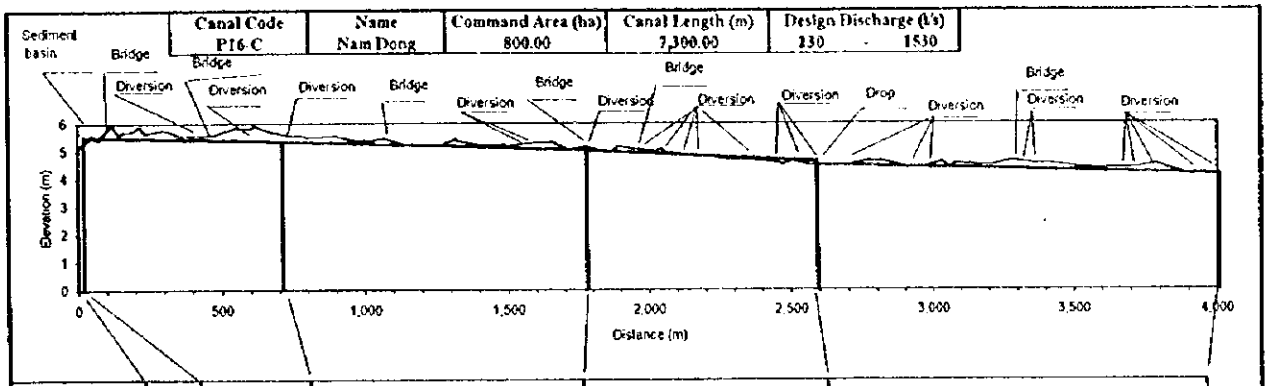
Ground Elevation	20.844	20.844	20.344	19.676	19.294	18.253	17.030	15.575	15.106	14.630	13.799	13.650
A Distance (m)	5.0		380.0	590.0		1085.0		1275.0	1485.0	1775.0	1905.0	
Distance (m)	5.0		375.0	210.0		495.0		190.0	210.0	290.0	130.0	
D Elevation (m)	-		1.165	0.382		1.221		0.469	0.476	0.831	0.149	
D Discharge (l/s)	340		340	225		188		157	93	66	27	
Canal Type	SB6		MC3	MC5		MC6		MC6	MC9	MC9	MC13	
Slope (%)	-		0.167	0.200		0.250		0.250	0.222	0.286	0.118	
Bottom Width	4.000		1.000	0.800		0.800		0.8	0.6	0.6	0.5	
Side Slope	-		-	-		-		-	-	-	-	
Roughness	0.015		0.025	0.025		0.025		0.025	0.025	0.025	0.025	
Flow Depth (m)	0.818		0.518	0.445		0.358		0.313	0.294	0.210	0.182	
Velocity (m/s)	0.104		0.656	0.633		0.659		0.627	0.529	0.531	0.306	
Free Bold	0.182		0.282	0.255		0.242		0.287	0.206	0.290	0.218	
Canal Depth	1.000		0.800	0.700		0.600		0.600	0.500	0.500	0.400	
Bottom Elevation	20.500	20.200	20.500	19.875	19.455	18.155	16.918	15.518	15.043	14.576	13.747	13.594

Canal Code	Name	Command Area (ha)	Canal Length (m)	Design Discharge (l/s)
R11-C	Rao Bang	0.00	990.00	30 - 290

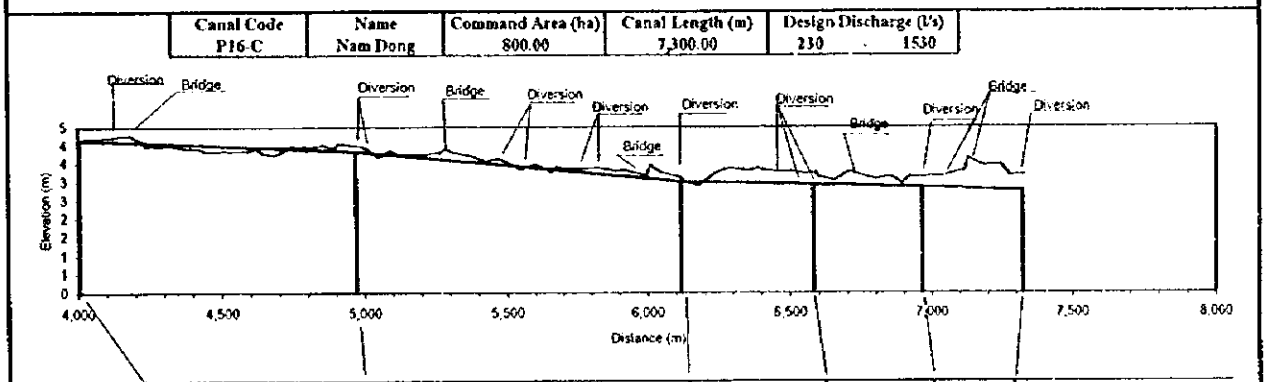


Ground Elevation	4.491	5.001	4.812	4.190	4.065	3.863	
A Distance (m)	10	200	670	750	990		
Distance (m)	10	190	470	80	240		
D Elevation (m)	-0.510	0.189	0.622	0.125	0.202		
D Discharge (l/s)	290	277	183	155	76		
Canal Type	SB3	MC3	MC5	MC6	MC8		
Slope (%)	-	0.100	0.133	0.154	0.091		
Bottom Width	4.500	1.000	0.800	0.800	0.600		
Side Slope	-	-	-	-	-		
Roughness	0.015	0.025	0.025	0.025	0.025		
Flow Depth (m)	0.378	0.540	0.444	0.371	0.353		
Velocity (m/s)	0.612	0.515	0.517	0.523	0.359		
Free Bold	0.622	0.260	0.256	0.229	0.247		
Canal Depth	1.000	0.800	0.700	0.600	0.600		
Bottom Elevation	4.500	4.500	5.001	4.811	4.184	4.061	3.963

Fig. C.5.2 Profile of Irrigation Canal (3/5)



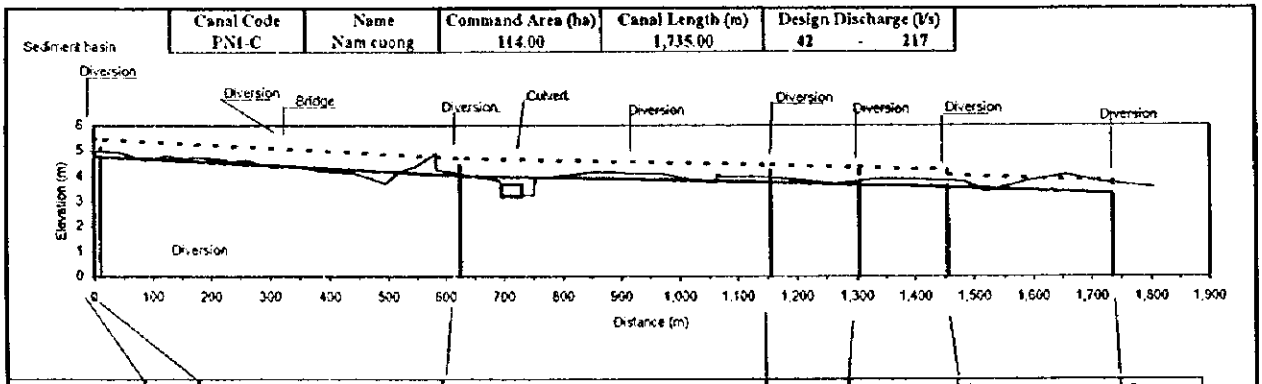
Ground Elevation	5.17	5.279	5.557	5.153	4.502	4.184
A. Distance (m)	20	730	1780	2591	4007	
Distance (m)	20	710	1050	811	1416	
D Elevation (m)	-0.11	5.279	0.404	0.651	0.318	
D Discharge (l/s)	1530	1530	1459	1260	1158	
Canal Type	SB1	MLC1	MLC2	MLC3	MLC4	
Slope (%)	-	0.02	0.03	0.05	0.03	
Bottom Width	4	2.5	2	1.5	1.5	
Side Slope	-	1 : 1	1 : 1	1 : 1	1 : 1	
Roughness	0.025	0.025	0.025	0.025	0.025	
Flow Depth (m)	1.4	1.013	0.953	0.896	1.029	
Velocity (m/s)	0.273	0.596	0.519	0.587	0.445	
Free Bold	0.3	0.387	0.347	0.404	0.371	
Canal Depth	1.7	1.4	1.3	1.3	1.4	
Bottom Elevation	5.2	5.5	5.358	5.008	4.6025	4.503	4.149



Ground Elevation	4.184	4.018	3.131	3.254	3.153	3.199
A. Distance (m)	4969	6117	6580	6965	7321	
Distance (m)	962	1148	463	385	356	
D Elevation (m)	0.166	0.887	-0.123	0.101	-0.046	
D Discharge (l/s)	961	699	445	386	230	
Canal Type	MLC5	MLC6	MLC6	MLC6	MLC7	
Slope (%)	0.03	0.07	0.02	0.02	0.03	
Bottom Width	1	1	1	1	0.5	
Side Slope	1 : 1	1 : 1	1 : 1	1 : 1	1 : 1	
Roughness	0.025	0.025	0.025	0.025	0.025	
Flow Depth (m)	1.007	0.705	0.776	0.721	0.642	
Velocity (m/s)	0.475	0.582	0.323	0.311	0.314	
Free Bold	0.293	0.295	0.224	0.279	0.258	
Canal Depth	1.3	1	1	1	0.9	
Bottom Elevation	4.149	3.828333333	3.008333333	2.919333333	2.963333333	2.740619048

Fig. C.5.2 Profile of Irrigation Canal (4/5)

Canal Code	Name	Command Area (ha)	Canal Length (m)	Design Discharge (l/s)
PN1-C	Nam cuong	114.00	1,735.00	42 - 217



Elevation	5.100	5.050	4.080	3.950	3.790	3.780	3.650
A. Distance (m)	10.0	625.0	1155.0	1305.0	1455.0	1735.0	
Distance (m)	10.0	615.0	530.0	150.0	150.0	280.0	
D.Elevation (m)	0.050	0.970	0.130	0.160	0.010	0.150	
D.Discharge (l/s)	217	198	132	94	67	42	
CanaC Type	MCN1	MCN1	MCN1	MCN2	MCN3	MCN4	
Slope (%)	0.167	0.125	0.053	0.067	0.067	0.083	
Bottom Width	0.800	0.800	0.800	0.600	0.500	0.500	
Side Slope	-	-	-	-	-	-	
Roughness	0.025	0.025	0.025	0.025	0.025	0.025	
Flow Depth (m)	0.463	0.482	0.492	0.471	0.441	0.281	
Velocity (m/s)	0.585	0.513	0.335	0.333	0.304	0.300	
Free Bold	0.237	0.218	0.208	0.229	0.259	0.219	
Canal Depth	0.700	0.700	0.700	0.700	0.700	0.500	
Bottom Elevation	4.800	4.783	4.015	3.736	3.636	3.536	3.302
Hight Elevation	5.500	5.483	4.715	4.436	4.336	4.036	3.802
					4.236		

Fig. C.5.2 Profile of Irrigation Canal (5/5)