The agricultural development projects of the Department of Agriculture and Forestry of Savannakhet Province were appropriated with 4.65% and 3.20% of the 1992 and 1991 development budget allocated from agricultural tax revenues.

The felling activities resulting from the plan to construct a dam upstream of H. Bak are expected to bring in at least 190 million kips, which can be used to specially cover the expenses required for office repair, the preliminary works, and the implementation of the relocation program.

3) Water Users' Association

The construction of canals after the tertiary level shall be the responsibility of the Government. Through the responsibilities and guidance of the construction office, it is only practical that farmers who shall use the canals help in their construction. The maintenance (repair, etc.) of these facilities and water management will be carried out with the guidance and supervision of the maintenance and management office, and farmers are expected to participate.

Accordingly, a water use association composed of farmers who will make use of the water for irrigation will be organized for every tertiary canal, and it will be supervised by the Operation and Maintenance Office.

The water users' association will deliberate on what water use plan and rotation plan will be suitable to the adopted cropping pattern and crop variety. It will also discuss the share of the benefitting farmers in the expenses for the renovation of the division gate, maintenance and repair of facilities, etc., and establish the beneficiary farmers' expenses-share system.

3.2.3 Relations with Similar Projects and Grant Projects of Assisting Foreign Countries

Savannakhet Province is a leading rice producing region in the country, but water resources and irrigation development measures are significantly lagging behind in this province. Further paddy irrigation ratio is only about 1.6% of rainy season paddy acreage.

Since the implementation of the 2nd Five-year plan, the

Department of Agriculture and Forestry of Savannakhet Province has worked hard to promote irrigation development.
Unfortunately, not even 10% of the objectives have been attained.

Under these conditions, the Department of Agriculture and Forestry of Savannakhet Province gained technological assistance from Japan and formulated the Master Plan for the Savannakhet Integrated Agricultural Development Project.

Also, the support of the Mekong Committee and foreign agencies made the formulation of every imaginable kind of development study and project.

Materials necessary for the construction of the facilities were procured with the support of the Japanese Government, small irrigation facilities were constructed independently by the villagers with funding from the local department of agriculture and forestry, and pump irrigation facilities were constructed with the materials received from the Mekong Committee. Nevertheless, the area added to the irrigation area is quite small in ratio to the entire Savannakhet paddy area.

However, through the promotion of KR2, an increase in the supply of fertilizer and agricultural chemicals, including those to the subject area, is predicted.

The subject area could also indirectly benefit from any assistance the Tasano Seed Production Farm might possibly receive from various countries and international agencies. However, other than the assistance from Japan, development projects of similar nature have never been implemented in the subject area or in areas adjacent to it.

3.2.4 Components of the Plan

This plan is the integrated agricultural development plan intended for the upstream area of H. Bak and Namphou at the upstream of H. Xay. It aims to improve the infrastructures for agricultural production to stabilize and increase agricultural production, improve farmers' incomes, and to foster farmers' and villagers' economic activities. In accordance with these aims, the plan is mainly composed of the three factors detailed below:

1) Irrigation Development

This plan will be carried out in the upstream area of H. Bak and Namphou, the upstream area of H. Xay.

a). Irrigation development plan for the upstream area of H. Bak
b). Irrigation development plan for the Namphou area

2) Improvement of rural infrastructures

a). Construction and improvement of rural roads
b). Rural water supply facilities plan

3) Agricultural Supporting Center Construction Plan

The construction of the tertiary canals, will be undertaken by the Government. But that plan should be formulated with integrated study.

3.2.5 Details of Requested Facilities and Materials

(1) Requested facilities

The main requested facilities are as indicated below.

1) Irrigation facilities

a). H. Bak upstream irrigation facilities

<1> Facilities for water resource development

- dam and reservoir (1) (dam, spillway)

<2> Water intake facilities

- intake facility (1), (intake tower, water conveyance pipe conduit, regulating gate)

<3> Irrigation system facilities

- main, secondary canals, division works for each canal

<4> Drainage system facilities

- secondary, waste way

b). Namphou irrigation facilities

<1> Water intake facilities

- diversion weir (1) (concrete fixed weir, sand sluice way, intake facility, regulating gate)

<2> Irrigation system facilities

- main, canals and division work for each canal

2) Facilities for the improvement of agricultural infrastructure

a) Rural roads:

Road construction and rehabilitation (3 routes): approximately 29.6 km in total bridge construction and rehabilitation: 9 bridges

b) Rural water supply facilities:

Install 10 dug wells with hand pump

3) Agricultural Supporting Center

- Building Construction:

Office, multipurpose building, granary, garage

- Installations:

Lighting, water supply and drainage, electric supply, generator, fuel tank, concrete yard for drying grain

- Fry Breeding Facilities:

  Incubator, breeding tank and pond

(2) Requested materials

1) Machinery for the management of dams and irrigation water:

   Hydrologic, meteorologic observation equipment (recording water level gauge, rain and wind velocity gauge; hygrometer, evaporimeter, thermometer, solar radiation meter)

2) Rural water supply machineries:

   Hand pumps

3) Accessories for the Agricultural Supporting Center:

a) Machineries for training and demonstration activities
   hand tractor, manual thresher, winnowing machine, cultivator, portable pumps, motor, chemical sprayer, photocopy machine, audio visual equipment, personal computer with printer

b) Machinery for granary
   weighing scale, moisture content device

c) Fry production machinery
   small refrigerator, compressor, handy water quality checker

d) Machinery for extension of agricultural techniques
   4WD pick-up, motorcycle

e) Water supply and drainage machineries
   electric motor, pump

f) Generator
   diesel engine generator (including spare)

4) O/M machinery

   loading equipment (0.4 m^3), excavators (0.3 m^3), super small excavators, vibrating rollers, bulldozers (3 tons), motor

graders (2.2 m blade), dump trucks (4 tons), pick-ups, motorcycles(75 cc), workshop car

5) Spare parts

spare parts for each kind of machinery provided

(3) The followings were requested by the Government, but as a result of discussion between the Government and the Study Team, they were excluded from the Japan's grant aid program.

1) Irrigation facilities

a) H. Bak upstream irrigation facilities
tertiary canals, tertiary drainage canals, from land consolidation, and demonstration farm

b) Namphou irrigation facilities
3 dams and 2 diversion weirs with accessorial facilities, tertiary canals, drainage facilities, and farm land consolidation

2) Agricultural Supporting Center
rice mill into necessary facilities

3.2.6 Necessity of Technical Assistance

1) Technical assistance concerning the management of irrigation facilities

The management of irrigation facilities is largely classified into operation and maintenance of facilities and water management. Regulations will be set for the maintenance of facilities.

- Dams and reservoir management will be carried out by management rules and regulations formulated prior to the completion of the construction work, the planned personnel will be subject to the rules and to undergoing technical training for proper management, due to the limited number of experienced people involved.

The management of the dam is highly technical and inefficiency could be disastrous. Accordingly, only qualified people will be assigned to the post, and they will systematically undergo technical training which would also include the management and maintenance of water intake and reservoir. On-the-job training will be conducted in every construction phase and the dispatch of some of the assigned staff and experts to Japan to undergo technical training under JICA after the completion of the facility construction works is very much desired.

- Canals are simple in structure and form and will not require any particular maintenance, operation and management technique.

- Although the management of the diversion weir shall require rules, experts from MAF or the Department of Agriculture and Forestry of Savannakhet Province will be assigned to manage these facilities, and particular training on and transmission of techniques are deemed necessary for emergency operations in times of heavy rain and flood.

  Regular dredging of sand, which accumulates upstream, emergent and highly advanced techniques such as the prevention of sand accumulation at the end of the flood season, management and operation of a sand sluiceway to maintain water intake efficiency as well as regulation of water intake activities, gate operation to balance water level against the amount of rainfall, are also needed. Middle-level engineers will be assigned to these works and will undergo training under their senior counterparts, and consequently, fully acquire the managerial and operational skills required.

- The water management will require full consideration of the water distribution plan, the planned cropping pattern, variety of crops to be introduced, usual cropping patterns, cropping rotation plan, fish breeding plan, etc., and highly integrated management based on rainfall intensity, rainfall distribution by area, and rainfall amount. Therefore, senior engineers should be assigned, and the selected personnel should be informed of the area's soil characteristics, meteorological conditions and water requirement of introduced crops, and trained in areas where projects of similar nature have been implemented.

  There are group training and individual training programs in JICA.

2) Technical assistance in the operation and management of the Agricultural Supporting Center

The Agricultural Supporting Center will be constructed to provide and accomplish various services to help the agricultural sector and the farmers.

The criteria for choosing a head of the center will be based on general management ability, advanced knowledge and experience, qualities that are deemed necessary in view of experience in market-economy principles.

Privatized government farms and enterprises, based in NEM, are observed to be undergoing economic depression mainly due to shortage in capable personnel well informed and experienced in the functions of a market economy.

Further, the operation of some facilities constructed through the support of assisting agencies or foreign countries was stopped or some facilities have deteriorated due to the over-estimation of the Lao management system. Both the assisting and recipient countries review the factors that caused the said failures.

Given these conditions, the Government of the Lao P.D.R. has decided to formulate various policies upon the implementation of the 3rd Five-year plan, conduct technological training again to improve the skills and know-how of the personnel, and re-investigate the expenses required in the operation and maintenance activities.

A study was made on the necessity of technological assistance regarding the above services of the Agricultural Supporting Center, and is shown below.

<1> Extension and improvement of agricultural production techniques

There are presently 123 engineers promoting agricultural techniques in every village in Savannakhet. The majority of these engineers, however, are below the mediocre level, and it is desired for them to undergo further training to be able to effectively extend techniques, which is one of the objectives of the agricultural center.

The ratio of the number of engineers in the Southeast Asian

countries propagating agricultural techniques to the number of farmers is 1/500 - 1/800. Since the number of farmers in this Project Area totals 1,098, 730 from H. Bak and 368 from Namphou (H. Xay upstream area), one engineer should be assigned in each zone using this ratio as base. However, to promote the importance and effectivity of modern farming techniques, an agricultural experts and his assistant will be needed at each area to help in the development activities.

If it is hard to recruit engineers of such qualifications, the assigned engineers should be trained; it is desirable that they be sent either to Japan to undergo group training or individual training of JICA, or to developed areas of neighboring countries to undergo actual training.

<2> Training and demonstration in agricultural techniques

These activities shall be carried out as a part of the extension program. Further, to cope with the farmers' desire to learn these new techniques independently, group training and the transfer of information and techniques on farming, cultivation, water management, conversion of cropping system and crops resulting from the introduction of irrigation should be carried out, including seminars and demonstrations explaining the present conditions of agriculturally advanced areas, modern cultivation, manuring and harvesting machinery. These activities should be conducted by the engineers of the Center, the Operation Committee or the Department of Agriculture and Forestry of Savannakhet Province, the MAF, and engineers of advanced areas. Accordingly, personnel with planning and executive abilities should be employed.

<3> Storage and sales of surplus rice

Surplus rice sales immediately after the harvest season will devaluate market prices, because the simultaneous sales of all produce will result in excessive market supply, which in turn will devaluate local prices set by brokers, situations extremely disadvantageous to farmers.

To be able to sell the surplus agricultural produce at a higher price, it is advisable to wait till the amount of supply has relatively decreased. This would, however, require proper storage and management of surplus rice.

The center shall be constructed to offer consignment storage of

surplus rice and to guide the farmers in coping with a market economy.

The rainy season paddy harvest term, which usually takes place at the end of the rainy season, is usually hit by heavy rains. Therefore, a drying yard for unhulled rice should be built in juxtaposition with the granary. Storage services for surplus rice also include guidance in the drying of unhulled rice.

To accomplish these, it is necessary to impart sufficient knowledge on techniques required for the drying and storage of unhulled rice, and to train the farmers how to analyze the information on fluctuating market prices and how to cope with it.

<4> Guidance in fry production and sales, and fish breeding

Breeding ponds constructed for fish culture which formerly covers 5% of the total annual fish catch, is being intensely developed.

Fish culture is the Laotians' favorite source of protein and the small scale farmers' important source of income.

The government-owned Pakubo farm in Savannakhet breeds and sells fry, and manages pisciculture operations in numerous small breeding ponds and paddy fields.

The depth of water in the irrigated paddy fields will be maintained during the rainy season to promote fish breeding in these fields as well as in the reservoir as farmers' secondary source of income.

Fresh water fish culture is carried out in the government-owned Tagon farm which was constructed in 1983 with the assistance of the Government of Holland. Many experienced engineers from the farm are dispersed in the locality to promote fry breeding.

JICA has dispatched the Japan Overseas Cooperation Volunteers group (specializing in fresh water fish breeding), and they are presently assisting the local staff in breeding fry and adult fish.

Through the support of the dispatched volunteer group assisting in Pakubo farm, the demands can be satisfied, hence technical assistance will be unnecessary.

<5> Improvement of production and training of women

Educational training of people assigned to work on promoting improved living conditions has been carried out by the Japanese Volunteer Center, NGO's base of cooperation, in cooperation with the Women's League of Laos since 1989.

The trainees are women and training lasts for 4 months. This program is carried out twice a year and mainly involves group learning and observation concerning mother-and-child health and multiple agricultural techniques. The number of trainees who have completed their term already exceeds 100, and training is also progressing in Bolikhamsay, Khammouane, Vientiane Province and Vientiane City.

Pisciculture, hog raising, and vegetable growing are popular particularly in Bolikhamsay.

The presence of the 2 women (a midwife and a specialist of soil fertilization) in the group of volunteers dispatched by JICA to Savannakhet has encouraged the Laotian Women's League to participate in activities for the improvement of living conditions.

These activities are expected to further intensify in the province, and with the demands of some village women, a women's training program will be included in the Agricultural Supporting Center's services.

The promotion of this activity is considered possible due to the cooperation of Lao's Women's League, the Japanese Volunteer Center, and also the Japan Overseas Cooperation Volunteers group.

<6> Loan and credit for the purchase of agricultural input and materials

Irrigated agriculture is expected to increase farmers' incomes and the expenses for fertilizers, agricultural chemicals, seeds and machinery, through improvements in rice production, steady increase in yield, and crop diversification.

Since small-scale farmers are poor, they will not be able to cope with the sudden increase in farm capital and will not fully benefit from the effects of irrigation.

To cope with this, the Agricultural Supporting Center will offer

farm loans, required machinery for low prices, or joint purchase as one of its important services for the farmers.

Aid and loans for farming funds have been granted by the government, foreign countries, private banking organs or fertilizer dealers and rice-sales brokers, according to their terms.

In the 3rd Five-year plan, the Government has liberalized interest rates without questioning financial sources, and formulated policies that can cope with increase in demand for funds brought about by the expanded loaning system of private bank organs for farming capital. Further, IFAD and UNDP has decided on various financing plans and terms to help farmers acquire loans for their investments.

It is, therefore, important to implement a lending system with low interest rates and long term repayment conditions and in accordance with the farmers' operation plan.

Since the Agricultural Supporting Center does not plan to provide farmers with financial support, financial support to farmers by the Government and foreign countries will be necessary, and will be made upon settlement of the policy, measures, methods of the assistance.

Accordingly the assistance offered in this phase is as follows:

- Expedite introduction of Government Loans
- Expedite introduction of foreign loans
- Introduce private bank loans and low-interest loans
- Allow use of consignment storage of rice as farmer's security in purchasing materials, and act as a guarantor between the farmers and private businessmen.
- Improve the terms for obtaining fertilizer and agricultural chemicals (stabilize low prices by expediting free import and improve low interest credit and sales terms)

To fully carry out these services, the personnel required will be recruited from privatized government firms and from among the senior employees of the Vientiane Plane Agricultural Services Corporation, one of the few successful firms in the area. Since

these people are experts in their fields, special technical cooperation and assistance are not required, but training on the improvement policies specified by the NEM and the 3rd Five-year plan will be required. Further, the loaning of low interest farming capital, including funds for the operation of the agricultural supporting center that will initiate investments for the procurement of agricultural materials for crop production is also necessary.

<7> Market Information Services for Distribution of Agricultural Produce

The Agricultural Supporting Center aims to expedite the government's plan to reconstruct and develop agriculture and the rural community, and to further ensure its offer of assistance, it will always collect and analyze new technical services, fluctuating agricultural prices, and diverse market information, and disseminate these data to the farmers. Further, one of the Center's most important roles is to guide the farmers in making decisions concerning agricultural production and purchasing and sales activities.

One or two central and local government employees with experience in similar projects are suggested to be chosen and dispatched to undergo further training and development under JICA and UNDP.

It is also considered very effective to solicit the cooperation of the members of the Japan Overseas Cooperation Volunteers posted in the Department of Agriculture and Forestry of Savannakhet Province (those who are experts in agricultural statistics and analysis) who can assist the medium engineers or experts and upgrade their skills in statistical analysis.

<8> Consignment storage and distribution services for fertilizers, agricultural chemicals, and other materials provided by grant for food production

Foreign assistance, headed by Japan, to help stimulate food production is estimated to increase annually. The granting and distribution of goods to specified areas are liable to be extended nationwide.

The distribution of these goods in Savannakhet Province is expected to increase.

However, aside from shortages in installations for the proper

storage and acceptance of these materials, transport conditions are bad and local transportation arrangements are underdeveloped. This is why priority on the granting of grants and assistance is usually given to localities with good road conditions. Therefore, improvements should be obtained.

With due consideration to this, the Agricultural Supporting Center not only conducts consignment storage of grant agricultural materials of the farmers in the subject area, but those of surrounding areas also, and at the same time, requests for more assistance from government-related organs and from foreign countries, beginning with Japan.

The personnel for the implementation of these services will be taken from related agencies, starting off with the Department of Agriculture and Forestry of Savannakhet Province, to eliminate the need for special training and to effectively carry out the services.

3.2.7 Basic Policy for Assistance Implementation

According to the results of the studies mentioned above, the implementation of the project is forecast to have an extremely large effect, and the proposed scope and scale of the Project is considered to be practical and feasible. Further, the executing agencies of the Government, namely the Agriculture and Forestry Planning and Management Bureau and the Department of Agriculture and Forestry of Savannakhet Province, are confirmed to be capable of handling the implementation, operation and maintenance aspects.

The Project is further forecast not only to stabilize farmers' and areal residents' procurement and self-sufficiency in food due to a stable increase and expansion in food production, and guarantee the welfare of the community, but will also expedite the shift to market economy, activate economy and develop socioeconomic conditions through the introduction and extension of new agricultural techniques and crop diversification.

In addition, the installation and improvement of rural socio-infrastructures will improve the standard of living of the farmers in the subject area, enliven the rural community, and activate economic activities, etc., and is expected to greatly contribute to the improvement of the living conditions of small

scale farmers. Because these effects coincide with the requirements of the Japan Grant Aid program, the implementation of this system is judged to be extremely appropriate. With the implementation of the Japanese Grant Aid program, the outline of the Project shall be studied and a basic design study will be made.

3.3 Project Description

3.3.1 Executing Agency and the Operational Structure

The executing agency and the operational structure of the Project will be changed upon completion of the Project. The agency concerned will be re-organized both by the Ministry of Agriculture and Forestry and by Savannakhet Province.

Besides the Agricultural Supporting Center, the operation maintenance office of Savannakhet Province for the Integrated Agricultural Rural Development Project that will be re-organized from the construction office of Savannakhet Province for the Integrated Agricultural Rural development Project, is responsible for operation and maintenance.

Administration of the Agricultural Supporting Center will be led by a director of the Center who will be appointed by both the Minister of Agriculture and Forestry and the Governor of Savannakhet Province.

The operation systems for each phase are shown in Figs. 3-2 and 3-3.

To cope with inquiries by the person in charge of the operation and maintenance of the Agricultural Supporting Center, the Minister of MAF and the Governor of Savannakhet Province will organize an Agricultural Supporting Center operation committee. The committee will assist the head of the Center in effectively extending their services to the farmers involved.

To effectively and smoothly carry out their responsibilities, each office will conduct regular meetings with the concerned authorities of the Department of Agriculture and Forestry of Savannakhet Province, and when the need arises, request close cooperation.

Meanwhile, the maintenance and management of terminal irrigation facilities and terminal water management will be carried out by the water users' association unit. The construction office will extend technical guidance and training in the operation and management of the facilities.

The O/M office, on the other hand, will regularly train the water

users' association on the techniques for water and facilities management.

The terminal canals will be the water users' association unit, and this association shall be organized as every canal system's or area unit's upper association. The association will deliberate on water use (the irrigation plan for rotation planting) and the maintenance and management and renewal expenses of the facilities. Under the guidance of the O/M office, the association shall endeavor to implement the effective use of the facilities and water.

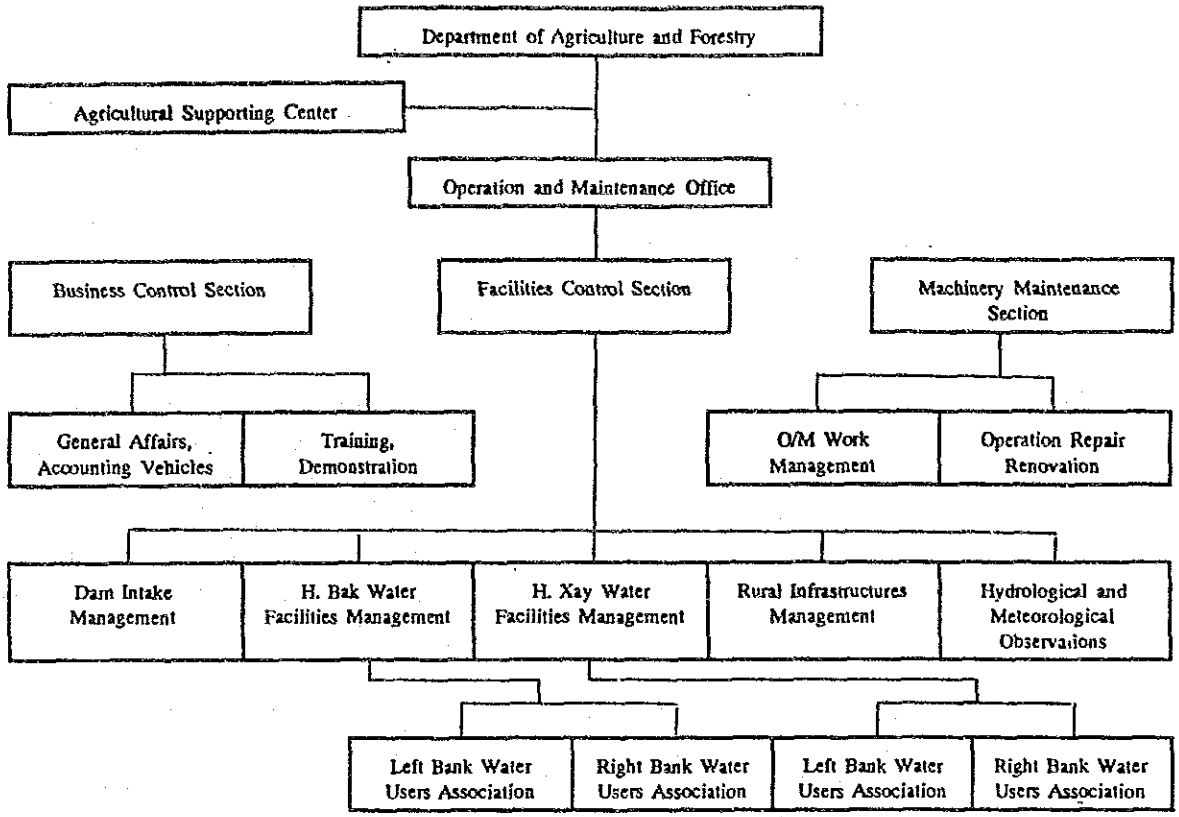


Figure 3-2 Organization Chart of the Operation and Maintenance Office

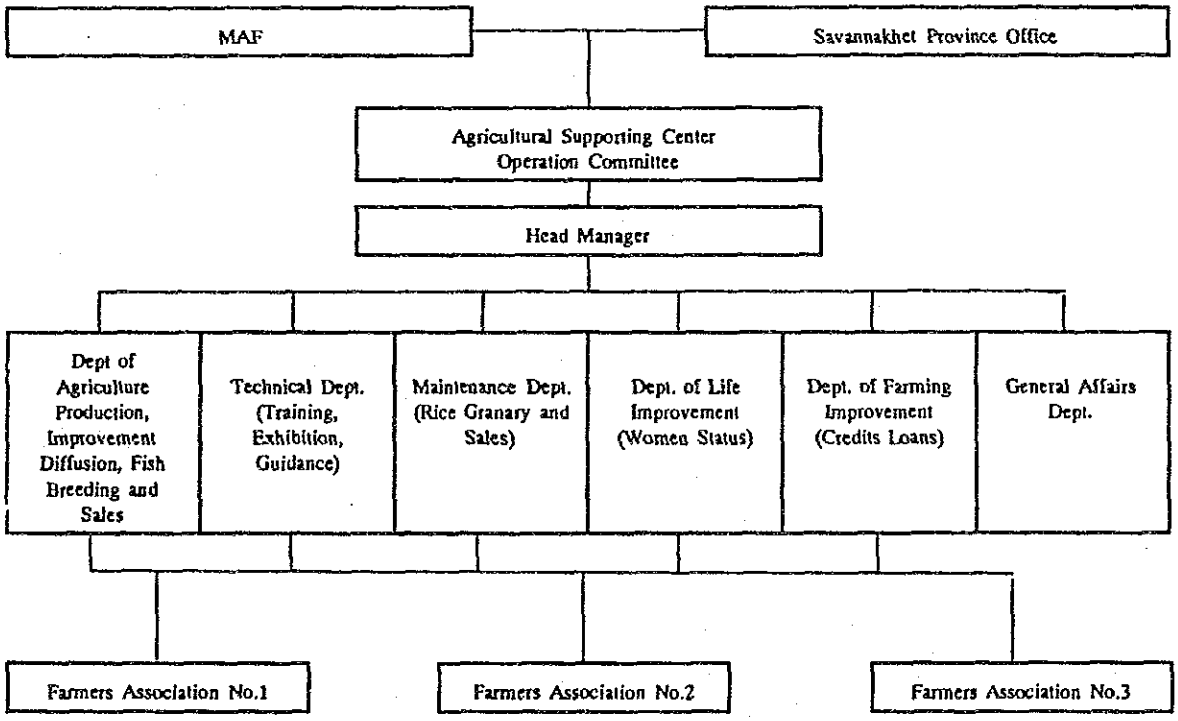


Figure 3-3 Organization Chart of the B. Lak Agricultural Center

3.3.2 Plan of Project

The design standard and the plan for the scale of the facilities are as shown hereafter.

(1) H. Bak Upstream Irrigation Development Plan

1) Water resource development plan

This plan entails the blocking and impounding of surface water with a dam which will be constructed at the village of Nonnadi, upstream of H. Bak. The surface water will be impounded and used to irrigate the 950 ha of rainy season paddy field at the basin downstream from the dam. Using the supply of water to irrigate as much area planted with dry season paddy and peanuts, etc., as possible will be studied also.

a. The development potential of H. Bak surface water, and its evaluation

With a catchment area (dam site) of 31,000,000 m^2, a mean annual rainfall of 1,713 mm in Xeno for the last 26 years, and a discharge ratio of 35%, the estimated annual discharge is calculated as:

catchment area (m^2) x annual total rainfall amount x discharge ratio

= 31,000,000 x 1,713 x 0.35 = 18,586,050 m^3

Given this, the required amount of water in the rainy season which is 4,161,000 m^3 < estimated annual discharge of 18,586,050 m^3.

Accordingly, the remaining discharge, which will be calculated as 18,586,050 - 4,161,000 = 14,425,050 m^3, will enable irrigation in the dry season in spite of loss in the reservoir. Conclusively, the use of the surface water through the construction of the dam is indeed assessed to be very possible.

b. Dam site, dam type and full water level

<1> Dam site

The dam site is chosen based on the required reservoir capacity, attainable water level, stability and economic conditions, in addition to topography, soil studies, dam type and construction method.

The site proposed in the F/S is 150 m directly upstream from the confluence of H. Bak and H. Tat rivers. This is comparatively considered favorable than the confluence point of both rivers or the site directly downstream on account of the narrowness of the river which could shorten the dam length, lessen the volume of the dam body and reduce the scale of the dam. This site will also be favorable for connecting the dam body with a comparatively gentle abutment, and the banks of both rivers can be utilized for diversion channel; these will effect stability, workability and cost-effectiveness and it can shorten the construction term.

Accordingly, the dam site which was proposed in F/S is adopted.

The proposed site is decided upon after it was confirmed that Lao counterpart's problems on the relocation of the residents in villages to be submerged has been resolved.

<2> Dam type

The dam type is decided giving full consideration to topography, geological features, hydrology and to the easy or difficult procurement of weir construction materials.

Accordingly, the following decisive factors were examined.

- The foundation ground of the dam is composed of sandy loam mixed with gravel (see Annexed Documents);

- Topography of the dam site: dam height is 24 m, and dam length is comparatively long, about 900 m. Besides, this dam is comparatively low, since the percentage of the dam length under 15 m in height represents 70% of the whole dam length.

- The dam construction material will be laterite, as it is available in great quantity. The core material, clay, is not available in large quantities.

Accordingly, the construction of an homogeneous earth dam is considered appropriate, which has a little stress action on the dam foundation and are therefore much adaptable to any foundation.

<3> Design full water level

Based on the dam site, a H-V curve (Fig. 3-4) is drawn and the design full water level is decided at EL 167.00 m.

Further, the crest elevation is settled at 170.0 m, which is 3 m higher than the design full water level. This was determined by studying the depth of overflow at the spillway and the freeboard.

The H-V curve is drawn based on the topographic map that was drawn by the former Soviet Union.

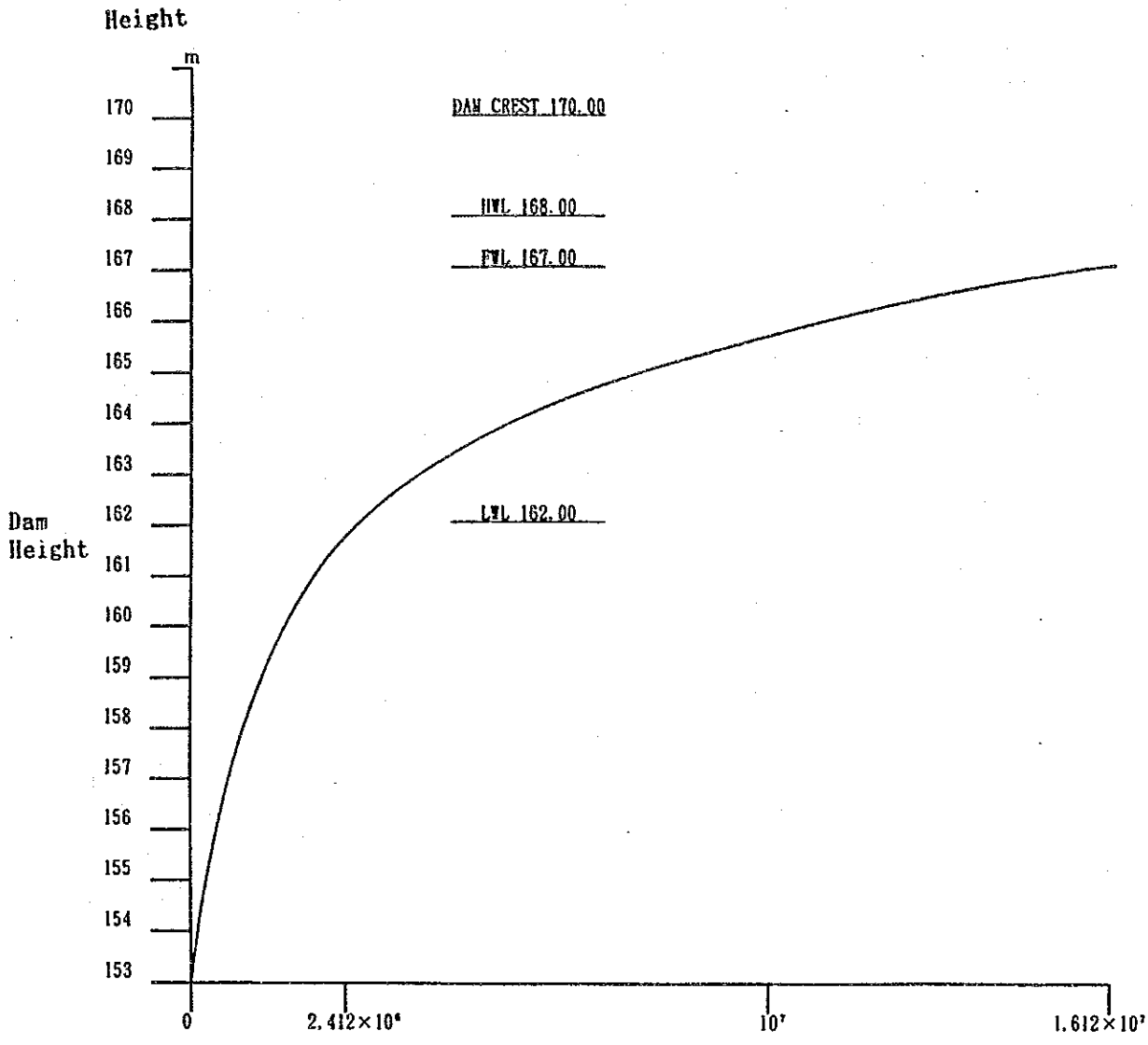


Fig. 3-4 H. Bak Water Storage Curve

2) Agricultural Production Plan

A stable supply of the required amount of water and the introduction of modern irrigation techniques will double production in rainy season paddy yield to 4 t/ha and will enable 4.5 t/ha of paddy yield and the introduction of cash crop production, e.g. peanuts in dry season, and bring about production stability.

The proposed cropping pattern is as shown in Fig. 3-5.

The cropping pattern for rainy season paddy is the same one practiced now, and its growth period (photosensitive varieties) is 145 days. The dry season paddy is transplanted in January when the temperature rises, and its growth period is 125 days. The growth period of field crops is 2 - 3 months starting from mid or late December.

The proposed cropping pattern is made so as to avoid harvest in the rainy season. A short rest will be allowed 1 or 2 months after the rainy season paddy harvest, and dry season paddy harvest will be completed 2 months prior to the onset of rainy season paddy cropping.

Dry season field crops are sown in January and harvested in May.

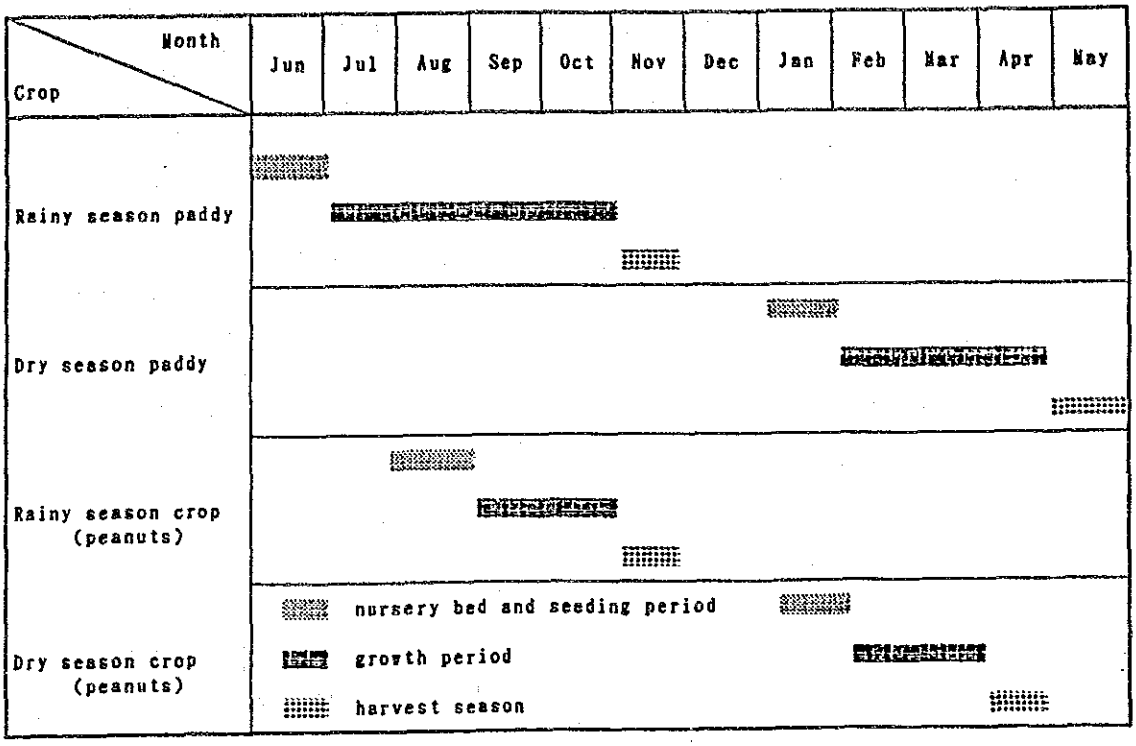


Fig. 3 - 5 Planned Cropping System

3) Irrigation Plan

The irrigation plan is in accordance with the proposed cropping pattern. It will serve as the supplementary water supply plan for rainy season paddy cultivation and the stable supply plan of the water required for dry season paddy and field cultivation. Peanuts is chosen for the formulation of the irrigation plan.

Further, based on the tertiary canal's block, whole area will be divided into 30 rotation blocks, and principally, 30 ha - 40 ha (1 block) will be planted per day.

Irrigation Period:

Rainy Season

Paddy Production (cropping period: 145 days)
Nursery bed period : June 1 to June 25 (25 days)
Puddling : June 21 to June 25 (5 days)
Paddy Field : transferred from June 26 and stays until October 23 (120 days approximately)
(Pounded water is drained from October 9)

Dry Season

Paddy Production (cropping period: 125 days)
Nursery bed period : December 16 to January 9 (25 days)
Puddling : January 5 to January 9 (5 days)
Paddy Field : transferred from January 10 and stays until April 19 (approximately 100 days)
(Pounded water is drained from April 5)

Upland crop cultivation in paddy fields

Planting (January 11 - April 10)

<1> Irrigation Method

Paddy fields will be supplied water for 24 hours a day, while furrow and intermittent irrigation will be applied to fields crops.

<2> Water requirement for crops

The water requirement for crops is calculated using the following equation.

$$ET\ crop = Kc \times ET_o$$

where,

ETcrop : Crop water requirement mm/day
Kc : Crop coefficient
ET_o : Potential Evapotranspiration mm/day

The calculation of the potential evapotranspiration (ET_o) was based on the modified Penman Method recommended by FAO.

The amount measured in the pan and other meteorological data were used as bases for the calculation of ETcrop. These data were derived from the monthly mean value taken for 22 years, from 1967 to 1989, by the meteorological observation station of Savannakhet Province. (refer to 2.2.2).

The crop coefficient of the growth phases of each crop was determined based on the FAO value published in 1974.

The monthly water requirement of every seasonal crop, as shown in the annex, indicates a maximum amount of 160 mm in October for rainy season paddy, 236 mm in March for dry season paddy, and 150 mm in February for dry season field crops.

Potential Evapotranspiration Unit: mm/day

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
4.7	5.1	6.1	6.4	5.5	4.6	4.6	4.2	4.5	4.9	4.9	4.5

(FAO)

Crop Coefficient
Paddy Rice

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1.1	1.1	1.25	1.0	0	1.1	1.1	1.05	1.05	0	0	0

(FAO)

Peanuts

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1.0	1.05	0.6	0.6	0.6	0	0	0	0	0	0	0

(FAO)

<3> Unit water requirement (Planned water requirement)

The unit water requirement was calculated as shown below:

Water requirement for paddy

IWD = (Cu + PL + NW + PW - ER) /Ei

Water requirement for field crops

IWS = (Cu - ER) /Ei

where,

IWD, IWS	: unit water requirement	mm/month
Cu	: crop water consumption	mm/month
PL	: Permeation level	mm/month
NW	: nursery bed water volume	mm/month
PW	: water volume for puddling and leveling	mm/month
ER	: effective rainfall	mm/month
Ei	: Irrigation efficiency	
	= water application efficiency	
	x water management efficiency	
	x water conveyance effectively	

a) Permeation level (PL)

The value actually measured in the F/S will be adopted.

dry season	1.5 mm / day
rainy season	3.0 mm / day

b) Nursery bed water (NW)

Nursery bed area	:	1/20 of the field area
Nursery bed period	:	25 days
Water volume required:		420 mm

(water for nursery bed development + permeation level + evaporation)

c) Effective Rainfall (ER)

The rainfall adopted was the mean rainfall recorded by the Xeno observation station for the past 30 years, from 1961 to 1990.

Effective rainfall was calculated based on the monthly effective rainfall curve line drawn by the Mekong Committee and the rainfall above mentioned (refer to Fig 3-6).

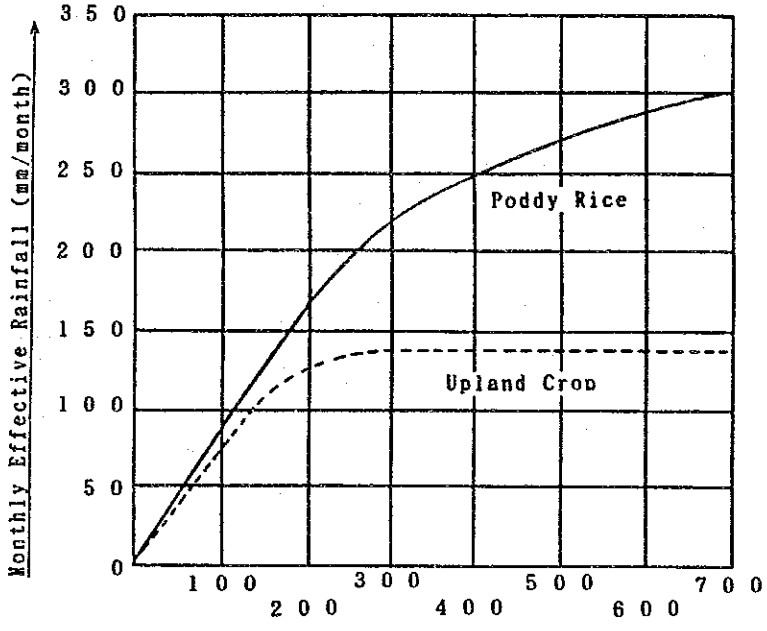


Fig. 3-6 Effective Rainfall Curve Line

d) Irrigation Efficiency (Ei)

Irrigation Efficiency is determined by efficiency in water application management and conveyance. The water application efficiency is determined taking into account soil conditions, topography and meteorology, and an 85% and 65% efficiency was observed on paddy and field crops respectively.

Efficiency in water management was rated from 50 - 100% in Southeast Asian countries, however, through effective water management it will be raised to 80%. The efficiency of water conveyance will depend on permeation and evaporation. The actual results obtained from the F/S showed a ratio of 0.11% for canals measuring 1000 m in length. Consequently, a ratio of 90% will be given for water conveyance efficiency. The

overall irrigation efficiency is summarized as 61% for rice paddies and 47% for field crops.

e) Planned water requirement

In accordance with the above items, the calculated results are as shown in the annex. The water requirement for rainy season paddy cultivation is at its largest at 10.1 mm/day, 1.17 liters/sec/ha in June; for dry season paddy cultivation, the largest volume is required in March at 15.6 mm/day, 1.81 liters/sec/ha; for dry season field crop cultivation, the largest is required in February at 10.4 mm/day, 1.20 liters/sec/ha.

<4> Irrigation interval for field crop cultivation

a. Total of readily available moisture (TRAM)

The water volume to be supplied initially is determined according to the following process, based on the water retentively of the soil and the depth of the effective root zone.

- d : depth of the effective root zone

- Cp : crop moisture absorbency figure

- AM : available moisture per layer

$$AM : \frac{1}{100} (F24 - M1)\ Sa \times d\ (mm)$$

where,

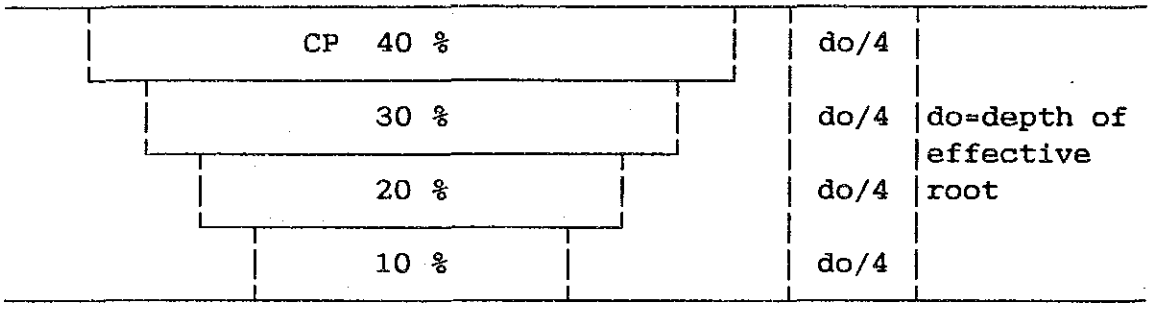
AM : available moisture content
F24 : 24 hours water capacity per layer (weight in %)
M1 : moisture content at the depletion of moisture content for optimum growth per layer
Sa : specific gravity per layer
d : depth per layer (mm)

- TRAM : total of readily available moisture

$$TRAM = \left\langle \frac{AM}{CP} \right\rangle 100$$

Cp : the moisture absorbency figure of crops is as shown below:

CP. 40% do/4
30% do/4
20% do/4 do = depth of effective root zone
10% do/4



Crop water absorption graphic
(USA, Sprinkler Irrigation.1953)

Assuming the depth of effective soil as 40cm,
AM=130mm and TRAM=39mm

b. Irrigation Interval

The irrigation interval is examined by the following equation:

$$\text{Irrigation interval} = \frac{\text{TRAM}}{\text{Peak consumption rate}}$$

Peak consumption rate is at its maximum at 5.5mm/day in February.

Assuming that the maximum TRAM = 39.0mm,

$$\text{Irrigation interval} = \frac{39.0}{5.5} = 7.1$$

From the above, the irrigation interval is 7 days.

4) Irrigation water intake, conveyance, and distribution systems

Irrigation water intake, conveyance and distribution systems shall satisfy the following requirements to fully and efficiently use the developed water resources.

a) Water intake system

- Water intake system comprises an intake section, a conveyance section, and regulation section. The structure of each section shall be simple and highly rigid and of an excellent hydraulic structure.

- Structure and function of each section shall be safely and securely responsive to fluctuations of the storage water level.

- Losses due to fluctuations in the intake level and intake amount shall be small.

- No effect shall be found on safety of dam or permeated leakage water.

- The regulating gates shall be simple and easy to operate manually.

- The discharge section shall allow safe and secure dissipation and shall have a structure that causes no effect on the downstream structures.

b) Water conveyance and distribution system

- Water conveyance and distribution system comprises division works, regulators, left and right bank main canals, secondary canals, tertiary canals, division works for each canal and water level regulators.

- The division works for the left and right main canals shall be constant-head and constant-rate. At each intake a regulating gate shall be equipped to regulate intake water amount in accordance with fluctuations in the required amount of water.

- The main canal conveys and distributes the water from division boxes to each irrigation development area by the shortest route and most economically. The main canal comprises left and right bank main canals. The main canal shall be a trapezoidal earth canal.

- Secondary canals shall be so arranged that the widest acreage can be dominated taking into consideration the topography of the irrigation area and distribution of paddy fields in the target area, and to efficiently distribute water from the main canal.

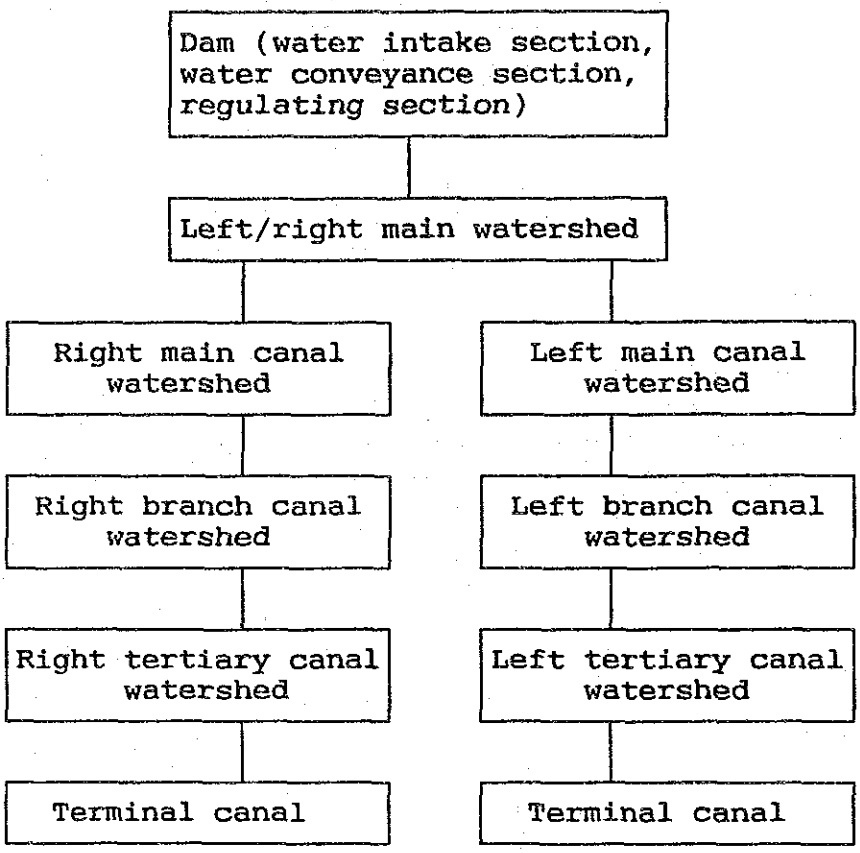
- Division from each upper canal to lower canals shall be based on constant head. Main and Secondary canals shall be equipped with check gates to regulate and maintain the water level.

  The regulating gate shall be constructed at a division box in order to regulate water flow.

- The route of each grade canal shall be located taking into consideration the following points:

  -- Minimization of canal embankments
  -- Minimization of construction cost
  -- Maintaining target water-level
  -- Facilitating maintenance for farmers

- The planned canal system is shown below.



c) Drainage canal

Trapezoidal earth canal
Catchment area : 413 ha
Planned drainage canal : 3.147 m^3/s

5) Facility plan

a) The facilities planned for the implementation of H. Bak upstream area irrigation plan are as follows:

<1> Water resources development scheme facilities : Dam, reservoir

<2> Irrigation water intake, conveyance, and distribution facilities : Intake works, division boxes, water conveyance and distribution system

<3> Drainage canal : Drainage canals

<4> Facilities needed for maintenance : Drainage canals for maintenance, hydro-meteorologic facilities

b) Therefore, the facilities should be planned taking into full consideration the purpose of their construction. The facilities should have structures and functions that would efficiently and securely attain the aim of the plan. Their construction, operation and maintenance should also be made easy and economical in comparison with those of existing projects of similar nature.

c) Dam plan

A dam is constructed to intercept the flow of H. Bak and H. Tat, store most of the total annual discharge, and supplement the additional amount of water needed for the rainy season cultivation of about 950 ha of paddy fields downstream. Moreover, the surplus water stored can irrigate the paddies in the same field in the dry season and also the newly introduced field crops.

<1> Potential water resource: Q_o

$$Q_o = (C_r A_1 R + 0.9 A_2 R) - C_e E A_2 E - P$$

where,

- Q_o : Total discharge (Potential water resource) m^3
- A_1 : Acreage of catchment(excluding average reservoir area)
  31-2.7=28.3 km^2
- C_r : Coefficient of discharge 0.35
- R : Annual precipitation 1,713 mm
- A_2 : Average reservoir area EL166 m 2.7 km^2
- C_e : Evaporation factor of reservoir area 0.75
- E : Evaporation
- ET : Annual evaporation 2,932,000 m^3
- P : Permeation loss 10% of the total reservoir capacity (16,286,000 m^3)

Q_o = 16,967,000 + 4,625,000 - 2,932,000 - 1,628,000
= 17,032,000 m^3

<2> Potential storage (effective storage capacity): Q_E

Dam crest height	EL 170.00 m
Planned full water level	WL 167.00 m
Total storage capacity	16,286,000 m^3
Effective storage capacity	WL 167-162 m
	Q_E = 14,541,000 m^3

<3> Total water requirement: Q_P

Rainy season paddy	950 ha	4,161,000m^3
Dry season paddy	550 ha	7,986,000m^3
Dry season crops in paddy field	400 ha	2,704,000m^3
	Total	14,851,000m^3

$Q_o > Q_E = Q_P$

As examined above, the effective storage capacity is nearly equal to the total planned water volume. The storage water, if efficiently taken in and conveyed and distributed to the planned irrigation area paddy fields, can steadily provide the amount of water required.

Accordingly, when planning the construction of the dam, the form and structure should be primarily determined according to the adopted preliminary design; next the base soil, topography, current use of land, usable amount of banking materials and their terms of extraction, necessary natural conditions, social conditions, terms and method of execution should be studied; and finally, an overall evaluation should be made on structural stability, hydro-geologic safety, effects on surrounding area, construction period, and economic feasibility to form the required facility plan.

<4> Planned specifications

As stated earlier, the basic specifications of the dam plan are given below. The facility plan is to be executed based on these specifications.

Location	Village of Nonnadi, Headstream of H. Bak
Type	Homogeneous earth dam
Crest height	EL 170.0 m
Planned full water level	WL 167.0 m
Effective storage capacity	14,541,000 m^3

<5> Effective intake level

Effective intake level shall be from the planned full water level to the lowest intake level. The lowest planned intake level was set at WL 162.00 m by settling the planned water level in division boxes at the head of left/right head races at WL 161.05

m, by adding various water head losses from the intake gate to the division boxes to cope with the fluctuating storage water level, and by considering hydraulic conditions at the intake gate.

<6> Banking material

A homogeneous earth dam is to be constructed. Banking material will be collected from the surrounding reservoir area. In collecting banking material, excavation depth and location should be carefully examined so as not to damage the impermeable layer.

As a rule, the soil excavated for the construction of the spillway, drainage canal and bottom conduits will not be used.

Riprap work material for revetment of upstream slopes can be collected within the project area, at a distance of 3 kilometers from the dam site.

<7> Spillway

A spillway will be constructed by excavating the left bank of the dam. The construction will be carried out taking into consideration the effects on the dam body, geological and topographical conditions (the location of discharge canals, dissipator and outlet canals), workability, and cost.

A side-ditch spillway will be constructed with hydraulic and economic considerations. The crest height will be similar to the planned full water level at EL 167.00 m. The structure will allow an increasing overflowing condition, as water level increases by increased inflow.

The following is a model examination on conditions brought about by an increase in reservoir water level:

Rainfall intensity 1/200 probability γ: 88 mm/hr
Flood spell 1.42 hr
Filled reservoir area A_2 4.70 km^2
Water intake area A_1 26.3 km^2
Discharge (inflow ratio) f reservoir 100%
f intake area 35%
Overflow amount of spillway 0

$\Delta H = f \cdot \gamma \cdot A_1/A_2 + \gamma$
$= 0.35 \times 88 \times 26.3/4.7 + 88$
$= 172.3 + 88 = 260$ mm/hr

However, if a 120 m spillway length, a 2 m/s approach velocity, and a perfect overflow are assumed, the overflow amount would be:

$$Q = CLH^{3/2}$$

where,

C = Coefficient of flow 2.1
L = Length of spillway 120 m

$$H = 0.50 + \frac{V^2}{2g} = 0.70 \text{ m}$$

$Q = 147 \text{ m}^3/\text{s}$

Therefore, the rise in water level at a flood peak time can be estimated at less than 30 cm, thus the

Planned discharge amount (Q) will be
$Q = 150 \text{ m}^3/\text{s}$

The canal for discharge shall be an open canal while dissipator works will be used for flat type discharged water shall be conveyed to H. Bak, downstream of the dam.

<8> Water intake facility

The water intake facility comprises water intake section, water conveyance section and water regulating section. Location of the water intake facility shall be at the No. 1+50.0 m measurement point close to the right bank of the dam based on studies on topography of the upstream/downstream areas of the dam, geology of the buried section of the bottom conduit, and access conditions carried out in due consideration of its convenience as a division for the left/right main canals and usefulness as a discharge canal during the construction work.

The type of water intake facility to be used shall be one that will allow safe intake of the planned intake amount, to cope with fluctuating storage water level and to provide easy regulation, maintenance and control of the intake amount. Accordingly, structural characteristics, cost effectiveness, intake amount and terms of execution must be examined.

The planned intake amount shall be a maximum of 1.26 m^3/s and a minimum of 0 m^3/s. The planned intake level shall be a maximum of 167.00 m and a minimum of 162.00 m.

Form and structure of each part of the intake facility shall satisfy hydraulic properties in order to minimize losses and prevent water leakage and permeation.

Discharge into an energy dissipator shall be made underwater to safely dissipate intake water energy.

d) Left and right main division works

After decreasing the flow energy from the dam and rectifying the flow in the division box, the planned amount of water is regulated to flow into the left and right main canals. Division will maintain the constant water level (WL 161.0 m) and regulate it by using a gate to cope with fluctuations in the required amount of water.

The inflow cross section will be planned using the maximum water amount in an ordinary year.

The regulation of the amount of divided water will be carried out through a manually operated gate. The division works will comprise the open-transition and closed conduit parts of the entrance and gateway.

The structure and form of each part should be decided to minimize water head loss after examining hydraulic conditions.

A spillway will be constructed at the division box to prevent surplus flow into the main canal.

e) Main canal

The main canal shall hold a cross section and gradient to safely and effectively convey water divided at the division works to the downstream watershed. The cross section shall be economical and passable to safely convey the maximum planned amount of water with only a little loss.

As previously mentioned, an earthen canal with trapezoidal section shall be used. The side slope gradient of the canal shall be economical, producing little friction loss and in accordance with the soil and the structure of the canal (cutting/banking).

The canal design is based on the following points:

<1> Ensure water conveyance and distribution functions

<2> Ensure safety from destruction

<3> Protection from sediment and rankness brought about by water weeds

<4> Protection from erosion caused by rapid flow

<5> Easy maintenance and control

<6> Suitability to topographical features and soil conditions

The selection of the main canal site shall be determined taking into account the following points based on topographic and geologic conditions:

<1> The water source and the target area (dividing point) is to be connected straight. The length of the canal should be minimized.

<2> The height should keep the water head.

<3> The canal should run along a contour line.

<4> The main canal should cross rivers and roads at right angles wherever possible.

<5> The bottom of the canal should be on the cutting face.

<6> Favorable and secure foundations should be chosen.

The division works and facilities for water level regulation will be of concrete.

A road for maintenance and control will be constructed on both sides of the main canal. The width of the road will be similar to that of a typical road in the target area. Bridges will be built, if necessary, and the roads will be constructed on the left or right bank of the main canal to facilitate access to paddy fields and villages.

f) Secondary canal

The secondary canal conveys water divided from the main canal

into the tertiary canal of each division works. The secondary canal will enable the maximum planned water amount to maintain the water head required; this canal shall have an economically passable cross section.

The structure of secondary canals and auxiliary facilities shall conform to the structure of the main canals. Further, like the main canals, roads for maintenance and control will also be constructed on both sides of the secondary canals.

Although the site of secondary canals is selected based on factors similar to the main canals, the following are also taken into account:

<1> Based on topographic and field features, the secondary canal site must connect the tertiary and main canal and facilitate division from the main canal.

<2> The site must be convenient for water management in the target area.

g) Secondary drainage canal

The secondary drainage canal will be designed with minimal dimensions so as not to impede crop growth. The location of the route is decided in consideration of the topographical features and intake system, and to minimize the distance to the discharge point. Accordingly, the following were decided upon:

<1> The lowest part in the target area is selected.

<2> The secondary drainage canal shall function to carry off surplus water in addition to serving normally as a surface water drainage canal. This canal shall be an earthen canal with trapezoidal cross-sections. Slope gradients shall be safe in accordance with soil characteristics.

6) Operation and Maintenance Plan

The maintenance of the dam, main and secondary canals shall be carried out by a supervisor directly under the control of the O/M Office.

a) Dam maintenance involves management of facilities and water.

Water use management entails control of storage water levels, water intake, and water distribution the different canals. A supervisor will be permanently stationed at the dam site.

The supervising staff shall inspect and record the conditions of facilities and irrigation water management, storage water levels, and water volume required for intake. Additionally, the staff shall maintain the hydrological and meteorological station facilities, records of the observation results, and archive the documents.

b) Division works of right and left main canals

The division works for the right and left main canals will be managed by the supervisor as a part of dam management.

The main and branch irrigation canals will be controlled and facilities and water will be managed directly.

(2) Namphou Irrigation Facilities located upstream of H. Xay

1) Water Resource Development Plan

The H. Xay river flows will be utilized to irrigate 410 ha of paddy field. A weir will be built at the village of B. Donghouakham in order to develop the water resources required for irrigation.

There are no reliable data on the discharge flow of H. Xay and by using the discharge estimated conditions adopted in the Feasibility Study (1991) carried out by JICA, the monthly river discharge calculation is as shown below.

The possibility of collecting the water volume required for rainy season paddy irrigation was analyzed utilizing the estimated discharge.

Terms of Calculation:

Rainfall Depth	R	:	Mean monthly rainfall (mm) observed within 2 years at the Savannakhet Station
Discharge Rate	f	:	0.35
Catchment Area	A	:	51.4 km²
Base-flow Discharge	QB	:	90 lit/s (92 lit ≒ 90 lit) 7776 m³/day x 30 m³/month
Run-off	Q	=	f . R . A x 1000 + QB

Month	Q		Water Required for Rainy Season Paddy m³/month (410 ha)	Dry Season Paddy m³/month (100 ha)	Dry Season Field Crop m³/month (100 ha)
	m³/month	m³/s			
Jan	277,036	(0.103)	-	421,000 (0.157)	209,000 (0.078)
Feb	386,834	(0.160)	-	389,000 (0.161)	311,000 (0,129)
Mar	841,921	(0.314)	-	498,000 (0.186)	199,000 (0.074)
Apr	1,715,656	(0.662)	-	92,000 (0.036)	38,000 (0.015)
May	2,903,576	(1.084)	-	-	-
Jun	5,018,620	(1.936)	1,353,000 (0.522)	-	-
Jul	4,069,328	(1.519)	176,300 (0.066)	-	-
Aug	5,810,760	(2.169)	-	-	-
Sep	4,343,995	(1.676)	28,700 (0.011)	-	-
Oct	1,822,377	(0.680)	442,800 (0.165)	-	-
Nov	299,843	(0.116)	-	-	-
Dec	251,850	(0.094)	-	176,000	-

<1> According to the estimated river discharge, the water requirement for the rainy season paddy is approximately 27% in June, 4.3% in July, and 24.3% in October. It is feasible to intake the required volume of water.

<2> The ratio of river discharge in the dry season to the irrigation water requirement is as follows:

	100 ha Paddy (%)	50 ha Paddy (%)	100 ha Field Drop (%)	50 ha Field Crop (%)
December	0.7	0.35	-	-
January	152.0	26.0	75.4	37.7
February	101.0	50.5	80.4	40.2
March	59.2	29.6	23.6	11.8
April	5.4	2.7	2.2	1.1

An intake of 100% of river discharge is theoretically possible. However, for stable intake and supply of irrigation water, 30% of the river discharge will be assumed as the limit for safe intake, it will be possible to irrigate 20 ha of paddy field or 50 ha of field crops in a normal year.

2) Agricultural Production Plan

The flow of H. Xay will be developed to irrigate the 410 ha of paddy field located on both banks downstream from the proposed weir for the stabilization of rainy season paddy production as well as increase in productivity. The designed cropping pattern conforms to one in H. Bak downstream area.

According to the proposed plan, the present rainy season paddy production of 820 tons will double (1,640 tons), and 120 tons of dry season peanuts will be produced.

3) Irrigation Plan

The supplementary irrigation plan for a stable rainy season paddy production and the irrigation plan for dry season crop conversion cultivation are as stated.

- Irrigation area should be where irrigation water can be supplied by gravity flow. Taking water resources, land

configuration and soil into consideration, the irrigation area will measure 410 ha.

- Rotation will be carried out in every tertiary canal irrigating, in principle, an average of 40 ha/day.

- Evaportranspiration of crop is calculated by the modified Penman Method. Effective rainfall is estimated by the effective rainfall curve developed by the Mekong Committee. The seasonal, maximum and designed amount of water required to irrigate the crop area are estimated by the effective rainfall.

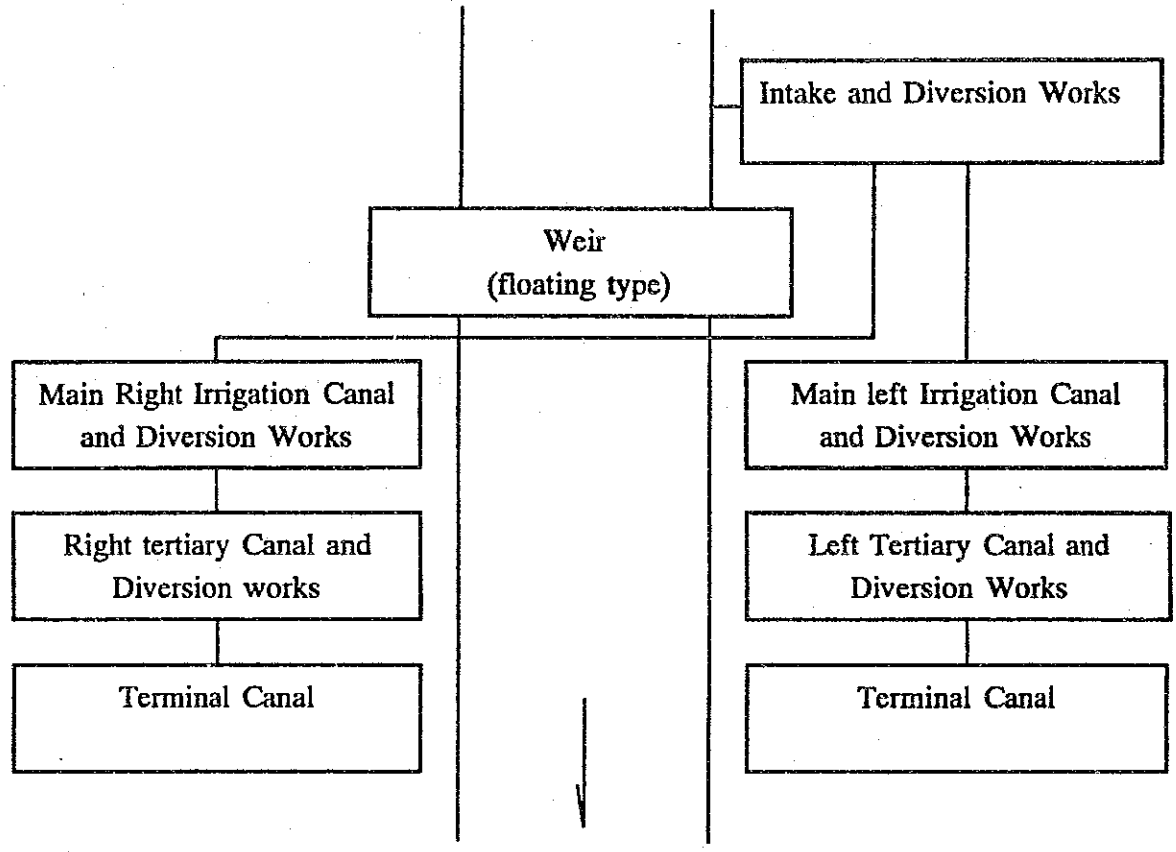
4) Irrigation Water Diversion and Conveyance Systems

- The diversion system consists of a weir and intake. The H. Xay weir will enable the river water to reach the design intake water level. The required amount of water is diverted from the intake built upstream of the weir, and conveyed to the irrigable area.

- A check gate will be built at the intake to regulate and control the required amount of water for intake.

- The conveyance system is as stated. A secondary canal is excluded from the plan because it is generally smaller in scale.

The outline of the conveyance system is shown below.



5) Plan of the Facilities

The facilities will be functional, safe and durable, in conformity with present area conditions.

a. Location

The site of the intake weir will be determined after comparative investigations and shall meet the following conditions:

- Easy attainment of the water level required for the conveyance of water up to the irrigated area; the weir will be located near the area to be irrigated; the distance to the irrigated area will be short, construction cost will be cheap, and operation and maintenance will be easy.

- Stable river bed and river bank.

- Absence of curves upstream and downstream near the weir, and of river works that might impede river flow.

- For structural stability, the construction must be easy, and the construction costs must be economical.

- Minimum negative effect of water level either upstream or downstream.

b. Form

- A floating type weir will be selected, considering the river bed foundation depth.

- The weir will be at right angle and closed in all sections toward the river channel.

- The weir will be installed with a sand sluiceway (gate).

c. Design flood discharge

- 200-year flood probability = 135m^3/s

d. Design headwater level

- Considering water head loss through the conveyance system and the ponding depth in the paddy field (100mm during the irrigation period), the design headwater level will be EL. 153.24 m.

- Height of the weir is designed so that a certain amount of water can be diverted in years of drought.

- The height and width of the gates will be determined to effectively function as a sand sluiceway. In case of flood, the gate will be opened to enable the evacuation of flood water.

- The base elevation of the sand sluiceway will be equal to one of other parts.

e. Intake

- To prevent sediments at the upstream of the weir from flowing into the intake, intake will be at least 3 to 5 m upstream from the pier of the sand sluiceway.

- Control and regulation of intake discharge will be made by manual gate operation.

The design of the main canal and division works will conform to the H. Bak upstream irrigation plan.

6) Operation and Maintenance Plan (H. Xay)

The weir and main canals will be directly controlled by the O/M Office.

a) Intake Weir Management

Intake weir management will mainly involve facility and water management.

(3) Rural Infrastructures

1) Rural Road Improvement Plan

The rural roads will be rehabilitated in order to improve the marketing of agricultural produce, transportation of input materials and the farmers' living conditions. For the design of roads, Laos's standards will be applied.

The design standards are listed below.

Objective	:	Improvement of existing roads (improvement of embankments and bridges)
Road surface width	:	4.00 - 6.00m (partially 4.00m)
Road surface	:	Laterite pavement
Route slope gradient	:	Within 10%, as a rule
Bridge	:	Effective width 3.50m; Load T-14

2) Rural Water Supply

The beneficiary villages of the Project Area are located more than 500 m from the existing wells. The design water supply is 50 liters/person/day.

Wells similar to the existing wells will be dug and equipped with manual pumps. Drain ditches and washing places will be provided, giving full consideration to the preservation of water quality and environment around the wells as well as the health and sanitary conditions of the residents.

(4) Agricultural Supporting Center

1) Objectives and activities

The Agricultural Supporting Center is designed to amplify the benefits derived from execution of the Project. In addition, the Center shall strive to support agricultural development in the area through the implementation of the Project. As a result, increase in agricultural production, economic activities and the development of living conditions in the rural area can be expected. The main services of the Center will be the following:

- Improvement, guidance and extension of agricultural production techniques
- Training and demonstration of agricultural techniques
- Storage and sales management of surplus paddy
- Guidance for fry production and fish farming
- Guidance and training for women and improvement of living conditions
- Offer sales of materials for agricultural production, credit loans and farming loans
- Safekeeping and distribution of agricultural chemicals and fertilizer received from foreign assistance
- Marketing of agricultural produce and the collection and diffusion of market information

The Agricultural Supporting Center will effectively implement the above listed activities through the facilities and equipment stated hereafter.

2) Required facility plan

Items for Construction

Operation and Maintenance Office
Multipurpose Building
Granary
Garage

Attendant Facilities and Equipment

Fry pond
Fish breeding pond
Water supply facilities
Generator and Power Supply facilities

a) Office

The design of the Center will be determined, taking climate, lifestyle, local customs and similar facilities into account (head manager room, training room, hall, lavatories, storage).

b) Demonstration hall

The following farm machinery will be exhibited to extend modern farming techniques to the farmers of the area.

Hand tractor
Manpower thresher
Winnower
Portable Pump
Motor
Chemical Sprayer

c) Granary

Paddy rice productivity through irrigation is expected to increase from the present production of 1.5 - 2 t/ha to 4.5 t/ha. Therefore farmers require the installation of a granary for the storage of surplus paddy. However, beneficiary farmers are financially poor and will not be able to afford the construction of the storage, and

the scale of the area is too limited for the construction of private granaries for each farm household.

Subsistence agriculture is still continually practiced by farmers who are also not economically well off. They are also still involved in rainfed paddy cultivation and are not well informed of the free market economy system.

Given these conditions, the granary plan will comprise guidance on storage and marketing.

The paddy rice granary shall have enough capacity to store surplus paddy produce grown with the irrigation method. Its structure shall preserve the rice quality required to compete in a free market.

The granary will be constructed in the agricultural supporting center or in each irrigated area to facilitate transportation. The location will be decided upon taking various consideration relevant aspects.

As a general rule, the stored paddy rice will be returned in accordance with the commission farmers' demand and the farmers will be responsible for their sales in the market. However, the supporting center itself will be in charge of sales consignment and shall correctly evaluate the rice market value and endeavor to preserve farmers' profit.

Storage of surplus paddy will be consigned to the Center as a guarantee for farming loans.

The granary will also be used to generally store the materials and machinery required to increase agricultural production, which are provided by foreign assistance agencies. Accordingly, one of the center's services also entail negotiations with foreign assistance agencies and distribution of the materials granted to farmers.

d) Multipurpose Facilities and their O/M

Multipurpose facilities will be built in the Agricultural Supporting Center. These facilities will be facility A - roofed and can be used under all weather conditions and B - without a roof, for the following activities : drying un-hulled rainy season rice, marketing agriculture produce, holding recreational activities for local residents, assemblies, practical training, or temporary storage of farming products and machinery.

The main objectives of the facilities (improvement of agricultural quality, betterment of production techniques, technical training, etc.) will be achieved by using the facilities for each of the above a mentioned purposes. Along with the main objectives, relationships between the residents will be bettered. Further, improvement of rural life and stimulation of socioeconomic activities will be gained.

e) Guidance and Extension in Fry Breeding and Fish Farming

As referred in Chapter 2.2, fish farming has become popular nationwide as a supplementary source of protein and compensation for the decline of natural fish resources.

According to the third Five-year plan, the Government of the Lao P.D.R. aims at increasing fish consumption from 9 to 11 kg per capita a year by fish farming.

At present, fish farming is carried out in paddy fields or small-scale reservoirs in Savannakhet Province. The implementation of the Project will enable fish farming not only in the vicinity of the reservoirs but also in the paddy fields, owing to a stable supply of irrigation water.

Fish farming in paddy fields will provide protein to the farmers and immediate cash income to the small scale farmers often in want. Besides, fish farming is expected to grow among the rural population.

The stable supply of fry and the training in and extension of appropriate techniques of fish farming in paddy fields are important issues of agricultural support.

Consequently, breeding and distribution of fry shall be one of the main activities of the Agricultural Supporting Center which will provide a stable supply of selected fish species as well as guidance on fish farming.

The selected species are Tilapia, Chinese Carp, and Indian Carp which are very popular in the region.

As regards the scale of the facilities and the production plan, the paddy fields in the irrigated area will be divided and the number of fish that can be bred evaluated. As the annual demand is estimated to be 2 million fish, fish will be produced three times a year.

The fry shall be purchased for breeding.

f) Garage

The garage will be annexed to the Agricultural Supporting Center and will house the following vehicles to be provided for the center and machines and vehicles for facility operation and maintenance services.

- Wheel loader shovel (0.4 m^3)	1	unit
- Back hoe (0.30 m^3)	1	
- Mini back hoe (0.03 m^3)	1	
- Bulldozer (3.0 t)	1	
- Vibrating roller (0.5 t)	1	
- Motor grader (2.2 m wide blade)	1	
- Dump truck (4 t)	1	
- Workshop car (4 t)	1	
- Pick-up (4WD, 2,000cc)	2	(1)
- Motorcycle (75cc)	4	(2)

( ) indicates the number of vehicles at the Agricultural Supporting Center.

g) Other Facilities

- Generator power supply facilities

There is no commercial electric power available in the Project Area. An independent power supply shall be installed in the Agricultural Supporting Center, therefore, for the supply of electricity, domestic water, and pumping water to the tanks for fry breeding.

- Water Supply Facilities

The following facilities are designed to guarantee a stable supply of water for the fry and fish, the Center's domestic water, and other purposes.

. Water resource	: deep well
. Water production	: motorized pump, etc.
. pumping water storage	: water tank
. Water conveyance	: pipeline

- Staff Lodging House

Lodging facilities will be planned especially for the security guards of the Agricultural Supporting Center.

(5) Improvement of living conditions and Women's Status

Women will be trained at the Agricultural Supporting Center in activities for improving living conditions. At the Center, seminars and lectures will be given on such topics as agricultural production, farming techniques (especially vegetable cultivation), cropping diversification, sales of agricultural produce, fry production in paddies, the sale of these products, methods for the improvement of nutrition, mother-and-child health and sanitation, etc.

3.3.3 Location and Condition of Project Site

The Project Area covers some parts of both the Champhone and Khanthabouly Districts of Savannakhet Province. The areas intended for irrigation development are the H. Bak upstream area and the Namphou area, upstream of H. Xay, located respectively in Champhone and Khanthabouly.

The 3 designated rural routes are routes A, B and C. Route A passes through the H. Bak irrigation development area, Routes B and C serve the western, southern, and northern limits of the H. Xay area. The first area is crossed by National Route No. 11 and the second by Route No. 13.

The project area for the construction of rural water supply facilities are 9 villages in the Champhone District and 1 in Khanthabouly.

The Agriculture Supporting Center will be built 700 m east of B. Lak 35, the intersection of Route No. 13 and Route No. 11.
The location, elevation, configuration, and conditions of the surroundings and of infrastructures for the project areas are described in the following tables.

Table 3.3 Location and Conditions of the Project Area

Proposed Facilities	Location	Elevation	Surroundings and Infrastructures
1. H. Bak Area	45 km East of Savannakhet City (on Route No. 11); 8 to 11 km Northeast of B. Lak 35; Upstream of H. Bak River.	140 to 165 m	The project area is distributed on both sides of H. Bak River that flows in the center of the Project Area. Villages of both areas are located every 2 or 3 km along the roads. Electricity and water supply are underdeveloped.
(Dam, Reservoir)	Headwaters of the H. Bak River, about 8 km from B. Lak 35 in the direction of Xeno. The dam site is located 5 km East of a village road that crosses Route No.13, and the reservoir area extends 2 to 5 km from the dam site.	160 to 180 m	The proposed reservoir area is covered with natural forest and sparse forest changed into paddy fields on low lands. Some roads have been built in the project area for log transport, however, they now lie in ruins and are impassable. Erosion of H. Bak River banks progresses. River crossing is impossible. The villages are made up of 35 households and 39 families, and can be reached by large vehicles from Route No. 13. To reach the dam site from the villages, about 500m of paddy fields must be forded. Electricity and water supply facilities are not developed in this area.

Proposed Facilities	Location	Elevation	Surroundings and Infrastructures
(Main Canals)	The water diversion tank is located downstream of the dam. Main canals of the left and right flow down bank along with border of the project area.	160 to 140 m	Access to the left and right bank and upstream area is possible only on foot. Total distance of the rural route is 10 km, however, car access is possible for 6 km of the lower part. Villages of the upstream area are distant from each other. Supply of drinking water and purchase of goods such as tobacco are not possible.
2. Namphou, H. Xay Area	14 to 20 km South-West from B. Lak 35; the paddy field area on both banks of H. Xay extends 5 km from the proposed intake weir, at the B. Donghaukhou.	140 to 150 m	The area is crossed by H. Xay River. Roads will be constructed on both sides of the area; Road B to the west and C to the south. Only a part of the village is electrified, and there are no water supply facilities.
(Diversion Weir)	Located at H. Xay River, upstream of the paddy fields at B. Donghauakan.	150 m	Paddy fields are located between the roads and H. Xay river bank; There are only a few roads, but the area is inaccessible by vehicles. There are no facilities that would enable crossing the left and right bank fields.

Proposed Facilities	Location	Elevation	Surroundings and Infrastructures
(Main Canals)	The main canals branch off from the intake weir and go south. Each canal length is 4 km.		Paddy field ridges are the only means of access to the main irrigation canals.
II. Rural Infrastructure Improvement Plan			
(1) Rural Roads Route A	From B. Lak 35, Route No.11 reaches B. Mai located 5 km away. From there, Route A goes North, crosses H. Bak River 9 km away and reaches B. Kolong. Length of Route A is 10 km.	140 to 150 m	There are 12 beneficiary villages located in the irrigation project area on both sides of the river. B. Donghankhou is situated 7 km away from the head of the road. The paddy field area is 1 km further and the sole access is the ridges between the fields. To reach H. Bak from the existing road, a 700 to 800 m wide paddy field area shall be crossed. Both banks of the river are deeply eroded. The main villages are equipped with common wells, however, there are no facilities enabling the supply of pure water and electricity.

Proposed Facilities	Location	Elevation	Surroundings and Infrastructures
Route B	This branches from Route No. 13 at 2 km from B. Lak 35. And goes South-West, then crosses the H. Xay River, goes down to the South and reaches the western border of the paddy field area. Route B is 14 km long.	180 to 150 m	8 beneficiary villages. 6 - 7km from Route No.13, the road O/M is comparatively good. There are 3 one-lane bridges on route B that are deteriorating, and one has a limited load of 8 tons.

Proposed Facilities	Location	Elevation	Surroundings and Infrastructures
Route C	Route C is the continuing road of route B and runs East to the South border of the irrigation area. Route C is 5 km long.	145 to 160 m	9 beneficiary villages. Elevation decreases as the road runs to the South and drainage conditions worsen, seriously damaging the road surface. Large vehicles can hardly make their way during the rainy season. Route C bridges are in worse conditions than Route B; one of these has a limited load of 3 tons. The surrounding social infrastructures of both routes B and C which are located on the same road is entirely alike. However, road conditions are worsening and maintenance works increase Southward. Each village is supplied by a public well, but there are no electricity or telephone and only 1 or 2 villages has a general store.
(2) Rural Water Supply Facilities	Implementation in 10 villages scattered on the border of Irrigation Area: 9 in H. Bak Area, and 1 in Namphou Area		The main villages have a public well and use ground water as the domestic water source, however, there are many underdeveloped villages because they are small, very scattered, or difficult to reach. Their present water resources are rivers and swamps.

Proposed Facilities	Location	Elevation	Surroundings and Infrastructures
III Agricultural Supporting Center	The center will be constructed on the left side of Route No. 13, 700 m South-East from B. Lak 35, the intersection of National Routes No. 13 and No. 11	190 m	Route No. 13 and Route No. 11 are both two-lane laterite-paved roads, with good O/M conditions and freely passable even in the rainy season. From the Center, it is 36 km to Savannakhet City and 20 km to Kenghok, which is between 40 to 50 minutes by car. H. Bak dam is about 10 km from the Center, 20 km from the central paddy field area and 15 km from Namphou Area. There are several restaurants and stores at B. Lak 35 which is a transfer station with regular bus services for Savannakhet, Kengkok and Xeno. Domestic electricity is scheduled to be completed in 1994 in the surrounding area. Public wells are the only water supply facilities.

3.3.4 Outline of Facilities and Equipment

(1) Irrigation Facilities

1) H. Bak upstream Area

a) Irrigation Area	950 ha in the rainy season 950 ha in the dry season

b) Water Resources

The H. Bak River and H. Tat River flows drop very low during the dry season, and is sometimes completely dried up. More than 80% of the annual rainfall falls for 6 months in the rainy season. The mean rainfall for the past 26 years is more than 1,700 mm. Accordingly, surface run-off will be intercepted with a dam, impounded, and developed for irrigation.

c) Water Resource Facilities - (1)

<1> Dam

Catchment Area	31.00 km^2
Type of Dam	Homogenous Earth Type
Dam Crest Elevation	EL 170.00 m
Normal Full Water Level	WL 167.00 m
Lowest Water Level	WL 162.00 m
Height of Dam	24.00 m

<2> Spillway

Type of spillway	Side-channel spillway type,
Structure	Reinforced Concrete

d) Intake Facilities

Intake Type	Inclining intake
Structure	Reinforced concrete
Maximum Intake Capacity	1.26 m^3/s

e) Irrigation System:

<1> Division works

Structure	Reinforced concrete
Division method	constant head, constant volume division

<2> Main canal

Structure	Trapezoidal section earth canal
Left main canal	length 5,705.0 m
Right main canal	length 4,981.0 m
Division Works	Structure: reinforced concrete, with a check gate Division Method: Constant level diversion

<3> Secondary canal

Structure	Trapezoidal section earth canal
Left Secondary canal	Length 4,126.00 m
Right Secondary canal	Length 13,841.00 m
Division Works	Reinforced concrete, equipped with a check gate
Division method	Constant level division
Auxiliary roads	width 4.50 m Length 28,653 m

f) Drainage Canals

Structure	Trapezoid section earth canal
	Length 2,100.00 m

2) Namphou Zone, H. Xay Upstream Area

a) Irrigation Area	Rainy season: 410 ha Dry season: 50 ha
b) Water Resources	H. Xay River

c) Water Resource and Intake Facilities

Catchment Area	51.4 km^2

Design Flood Discharge	135.0 m^3/s

<1> Intake Weir

Type of Weir	Floating type Movable weir
Structure	Reinforced concrete
Backwater Level	1.80 m

<2> Intake

Intake Method	Intake on both banks
Type	manual gate
Structure	Reinforced concrete
Max. Intake Volume	0.52 m^3/S Left bank: 0.31 m^3/s Right bank: 0.21 m^3/s
Headwater Level	WL 153.24 m

d) Canal Facilities

Canal Structure	Trapezoidal earth canal
left main canal	Length 4,344 m
right main canal	Length 3,855 m
Division Work Structure	Reinforced concrete installed with a check gate
Dividing method	Constant water head
Regulating method	gate, manual operation
Auxiliary Roads (for O/M)	Width 4.5 m Length 8,199 m

(2) Rural Infrastructures

a) Rural Roads

Structure	Laterite pavement
Width	6m, partly 4 m
Length	29.6 km

b) Rural Water Supply Facilities: 10 wells

(3) Agricultural Supporting Center

a) Location: B. Lak 35

b) Site Area: 22,500 m^2

Design Buildings

Office
Number: 1
Structure: Reinforced concrete frame, tiled-roofed, one-story house

Exhibition Facilities
Number: 1
Structure: Simple frame, slate tiling roof, One-story house, concrete floor

Multipurpose Building A
Number: 1
Structure: Simple frame, slate roof, concrete floor

Multipurpose Building B
Number: 1
Structure: Concrete floor

Granary
Number: 1
Structure: Wooden house, slate tiling roof, Concrete floor

Garage
Number: 1
Structure: Simple frame, slate roof

Janitor House
Number: 1
Structure: Wooden building, slate roof, concrete floor

Generator House
Structure: Concrete block, slate roof, concrete floor

b) Fry Breeding Facilities

Fry breeding tank
Structure: Reinforced concrete water tank

Fish breeding pond (for parent fish)
Structure: excavated pond

Fry Breeding Pond with Roof
Number: 1
Structure: Wooden building, slate roof

c) Water Supply Facilities

Structure:	Tube well equipped with an electric motor submersible pump
Scale:	Total pump head: 40 m; Pumping capacity: 30 lit/minute

(4) Machinery to be supplied

1) Machinery for Exhibition of Cultivation Techniques and Training Activities

Exhibition:	Hand tractor 8 Hp-3 Nos; Thresher
Training:	Audio-visual education materials: Television, video, video camera, photocopy machine, other (1 set)

2) Generators

Two (2) generators 25 KVA, for electric power supply of lighting, groundwater pump

3) Vehicles

One pick-up for extension and guidance, 2000 cc, 4WD
Two motorcycle (75 cc)

4) O/M Machinery (for operation and repair of irrigation facilities)

- 1 wheel loader shovel 0.4 m^3
- 1 back hoe 0.3 m^3
- 1 mini-back hoe 0.03 m^3
- 1 bulldozer 3 t
- 1 vibrating roller 0.5 t
- 1 motor grader 2.2 wide brade
- 2 dump trucks 4 tons

- 1 pick-up	2000 cc, 4WD
- 3 motorcycles	75 cc
- 1 workshop car	4 tons
- Loaded implements:	Generator,welder, compressor, oil jack, tools for heavy machinery, tools for general use, other.

3.3.5 Operation and Maintenance Plan

Execution of the Project involves the construction of irrigation facilities, rural infrastructures and Agricultural Supporting Center. The office of the Agricultural Supporting Center will be the operation and maintenance office for the procured and constructed facilities and machinery.

The O/M system of the Supporting Center and of each facility is shown on Figures 3-2 and 3-3.

The O/M Plan of each facility is as follows:

(1) Irrigation Facilities

The irrigation facilities will be maintained using manuals that will be written in every Project Area. The manuals will specify the following:

<1> Maintenance Standards
<2> Maintenance Points
<3> Methods of Reporting and Recording
<4> Measures for unusual situations

A water use plan by season will be formulated based on weather data, effective capacity of the dam, and cropping plan. Strict maintenance will be conducted to devise effective use of irrigation water.

1) H. Bak Dam

A dam maintenance room will be built and a qualified supervisor will be stationed to carry out appropriate maintenance.

The main O/M services described hereafter will be executed to guarantee daily inspection and repair and safe maintenance.

a. Facility Maintenance

- Leakage inspection (changes in gushing volume of water and leakage and effected changes in the dam body and ground, lateral fittings of the dam body and of intake works connected to ground, spillways, measurement of the dam's direct downstream discharge and discharge to the area 500 m downstream) *

- Deformation subsidence (deformation subsidence and movement of the dam body, structures, facilities; cracks and consecutive behavior; sediment flowing from leakage; various signs of damage)

- Intake Facilities (Lubrication and inspection of the gate winch in conformity with the Manual, prevention of rust, etc.)

- Patrol (dam body, facilities, reservoir area, the area 500 m from the dam downstream area)

- Daily and routine inspection and repair (inspection and repair items are specified in the manual)

- Repair, rebuilding, renovation (working out of implementation plan with consideration of the requirements, execution period and method)

- Prevention of flood due to heavy rains and countermeasures (facility inspection before and after the flood, contact with the emergency system, disposition of personnel)

* In case the ground surface subsides or caves in due to standing water and rainfall, the area should be immediately restored to its original condition by applying clayey soil, due to its damaging effects to the dam. Caution should be given to abnormalities in river inner flow direction brought about by sand discharge resulting from leakage.

b. Water Management

- Intake Plan (effective maintenance based on irrigation plan by season, confirmation and report of effective capacity; adequate intake maintenance in cases of local abnormal rainfall conditions, drought or abnormal flood in the irrigation area)

- Water storage plan (high water level period: grounds for determining the dry season crop acreage)

- Operation method and procedures (suitable maintenance of the control gate operating and opening procedures in order to regulate water intake, outlet and diversion following the Manual's prescriptions; emergency stoppage of intake and conveyance of water as a measure against accidents and other emergencies and danger)

- Maintenance in times of flood resulting from heavy rain (surveillance system, measures before and after the flood)

- Hydrological and meteorological observations (classification and conservation of observations and records; exceptional observations in case of extraordinary weather forecast; information service)

c. Dam Impounding Tests

Once the dam construction is completed, the following tests will be carried out before putting the dam into use.

<1> Preliminary Work (based on the framing of the general inspection plan for the gate operation and the completed facilities in case of flood)

<2> Impounding (increase in water level will be less than 50 cm a day; flooding will be progressively increased after changes due to water pressure are observed and safety is confirmed. Changes in the effects of the water level will be observed by decreasing the water level, making use of the decreasing capacity of the water level (1.26 m^3) after maintaining the flooding depth for 30 days).

<3> Discharging (Tests of water flowing into intake parts, conveyance parts, control parts, diversion work parts and main canals; inspection of the conditions of lateral roads connecting the irrigation facilities such as gates and spillways)

2) H. Xay Weir

Maintenance of Facilities

- Understanding of the river conditions (up, and downstream erosion, sediment and scour of the river bed, evaluation of the quantity of driftwood carried along by the rivers and countermeasures)

- Inspection of the bank protection conditions and counter measures

- Understanding of the sedimentation at the upstream of intake weir and maintenance by tractive force (sand discharge from sand sluice ways)

- Checking of the intake weir body, the rear and fore-aprons, and the prevention measures

Water Management

- Irrigation water use plan and intake plan (period of intake, seasonal maximum volume of intake, settlement of intake volume)

- Adequate control of intake gate and intake volume according to the estimates on river flow conditions and water level fluctuation; sand flash action and procedures consecutive to opening and closure of the sand sluiceway gates

- Flood maintenance (writing a manual that explains the closing over of the intake gates, full-face opening of the sand sluiceway and operation of each gate)

3) Main and Secondary Canals

Irrigation and secondary drainage canals are originally directly managed. However, the immersed area of the facilities requires the cooperation of the beneficiary population for the canal O/M and intake regulation of the division works of lower canals.

Maintenance of Facilities

- Inspection, repair, surveillance (daily and routine inspection, daily and routine repair of the gates; weeding of floating plants, surveillance of cattle so as not to damage

the canals; thorough planning of maintenance points)

- Maintenance in times of flood and unusual events (an emergency system shall be set up to contact and provide the required personnel and equipment in case of unusual events in the downstream basin, inundation or destruction of canals in times of flood.)

Water Management

- Regulation and maintenance of intake (manipulation of check gates and diversion gates)

- Control, stoppage of water conveyance; discharge of polluted water)

(2) Rural Infrastructure Maintenance

Maintenance and operation of completed facilities will be carried out by the O/M office.

O/M Office will be responsible for the management of the new facilities to be built under the present Project, except for the Agricultural Supporting Center.

1) Maintenance of Rural Roads

Development of access into the different irrigation project zones is very important, especially for transportation and delivery of the products. Consequently, the O/M Office will conduct systematic daily inspections, maintenance, and repair in order to preserve the condition of the roads all year round.

The O/M and repair of the roads will be performed effectively using the O/M equipment provided by this Project.

2) Water Supply Facilities

After completing the construction of the water supply facilities, daily maintenance will be performed by beneficiary residents under the guidance of the O/M Office. The O/M office will organize groups of beneficiary farmers for each facility and will entrust the groups with the maintenance inclusive of the renewal costs.

Moreover, the O/M office will periodically survey the fluctuations in ground water level, water quality, check the drainage conditions in the surroundings of the facilities and environmental hygiene, and devise the proper measures to be taken. Through the O/M office, regular repairs will be made.

3) O/M of the Agricultural Supporting Center

The head of the Supporting Center will supervise the Center, which will carry out its own operation and maintenance. He will also be partly responsible for the O/M of all facilities in close collaboration with the O/M office. Annual O/M plan, vehicles and machinery utilization plan will be devised to perform effective O/M services.

4) Management and O/M Costs

The O/M system and method of the designed facilities will be as shown below. This system will be implemented and the personnel secured. The expenses required for an effective management are as calculated below.

1) O/M Office

- Office Expenditure

			(Kips)
Personnel	Employees	(9)	1,832,913
	Assistant Employees	(2)	691,200
	Drivers	(5)	1,082,640
Sub-Total			3,606,753
Office Expenses	Cost of Meteorological Observations and Recording		74,482
	General Expenses		259,200
Sub-Total			333,682
TOTAL			3,940,435

- Machine Expenses

Fuel Expenses	Wheel loader shovel	(1)	100,000
	Back hoe	(1)	462,401
	mini back hoe	(1)	163,943
	Vibrating Roller	(1)	32,394
	Dump Truck 4t	(2)	925,188

	Pick up truck	(1)	714,724
	Motorcycle	(2)	86,897
	Mobile Workshop	(1)	214,417
	Motor Grader	(1)	164,339
Sub-Total			2,864,303
- Machine Repair Cost			5,630,896
Sub-Total			5,630,896
TOTAL			8,495,199
SUM-TOTAL			12,435,634

The estimated annual management cost of the O/M Office is 12,435,634 kips.

As a principle, the rural population that directly benefits from the project will cover these O/M expenses. The possibility to charge the O/M cost per ha to the beneficiaries is as studied below.

The O/M cost of water resource facilities is inferred to vary largely in the H. Bak Area and in the H. Xay Area. However, the same cost has been adopted in the following estimation. The irrigable areas are as follows:

Design Areas	H. Bak Area (ha)	H. Xay Area (ha)
Rainy season paddy	950	410
Dry season paddy	550	-
Dry season crops	400	50
Sub-Total	1,900	460

Taking the increase in production expected to result from the implementation into account, an estimated amount of 12,140,000 kips can be obtained if 3.0% of the rainy season crop and 3.5% of the dry season crop are collected as water-use charges. The O/M Office expenses of 12,436,000 kips would be thus suitably covered.

	H. Bak Area	H. Xay Area
Increase in Rainy paddy Production	950ha x (4-2 t/ha) = 1900 tons	410 x (4-2 t/ha) = 820 tons
60 kips/kg	114,000,000 kips	49,200,000 kips
Water Use Charge 3.0%	3,420,000 (3,600 kips/ha)	1,476,000 (3,600 kips/ha)
Dry season paddy	550x4.5 t/ha=2,475 tons	
	148,500,000	-
3.5%	5,197,500 (9,450 kips/ha)	
Dry season field crop	400x2.5=1,000x2of=125tons	
	52,000,000	6,500,000
3.5%	1,820,000 (4,550 kips/ha)	227,500 (4,550 kips/ha)
SUM TOTAL	12,140,000 = 12,435,634	

According to the Feasibility Study, the collection of 8% (63.6US$=45,792 kips, 30,528kips/ha) of the income of a 1.5 ha operating farm as water use charge is estimated to cover the O/M costs. Accordingly, a suitable collection ratio for water charge shall be fixed and collected from the beneficiary population.

2) Agricultural Supporting Center

Office Expenditure

	(Kips)
- Steering Committee	744,827
- Personnel Expenses	
Employees	1,944,000
Assistant Employees	864,000
Technicians (Extension)	518,400
Drivers	172,800
Janitors	172,800
Security Guards	345,600
Sub-Total	4,017,600

- Office Expenses

General Expenses	109,112
Facility Maintenance	181,853
Sub-Total	290,965

- Business Expenses

Collection and Storage of surplus paddy	120,000
Fry breeding	203,116
Training	1,728,000
Collection of market information	1,296,000
Sub-Total	3,347,116

- Machinery Expenses

Fuel Expenses

Pick-up	714,724
Motorbikes	86,897
Generators	3,484,552
Sub-Total	4,286,173

Cost of repair

Vehicles	1,608,827
Generator	1,748,979
Well pump	36,062
Facility repair	372,414
Sub-Total	3,766,282
SUM TOTAL	16,452,963

The income of the Agricultural Supporting Center is expected to be as follows:

<1> Fry Breeding Sales

1st Year	126,676	fries x 15 kips/fry	=1,900,140
2nd Year	196,494		2,947,410
3rd Year	380,028		5,700,420
4th Year	563,562		8,453,430
5th Year	760,056		11,400,840
6th Year	1,101,204		16,518,060

<2> Paddy Consignment Storage

Assuming that the charge for 100 kg of Paddy is 20 kips, and that 1,447 tons of paddy will be stored:

$$1,447,000 \times \frac{20}{100} = 289,400 \text{ kips}$$

<3> Utilization Costs of the Multipurpose Building

Area: 1,080 m^2

Utilization Cost: 50 kips/10 m^2

3 times/year $1,080 \times 3 \times \frac{50}{10} = 16,200$ kips

<4> Market Information Service and Other

If fry breeding succeeds, the sales of fry is expected to amount to 10,000,000 to 15,000,000 kips.

Besides, the Center's garage will be rented for the consignment storage of O/M machines and materials, and the rental fees paid by the O/M Office will be an additional source of income.

Improvement and extension of cultivation techniques, training, improvement in living conditions are the main services provided by the Center and were formally administrative services of the Government. Consequently, the salary of the employees and other expenses will be appointed to the MAF and to the Savannakhet Province through the Steering Committee and will be paid as operating costs of the MAF and Savannakhet Province.

The Agricultural Supporting Center will need financial support from the Government for its operation and maintenance for at least several years, although it won't have any budgetary problems regarding the hiring of employees.

To afford the initial O/M costs of the construction work, the sales price of the valuable trees cut for the construction of the designed dam and reservoir is proposed to be partly raised to subsidize the operation costs.

3.4 Technical Cooperation

As previously mentioned in the 2nd section of this Chapter, technical assistance is extremely important to the implementation of this project, albeit a plan on the matter has not been formulated.

Since the Lao P.D.R. is inexperienced in economic activities based on market economy principles, it needs technological assistance in the management of the Agricultural Supporting Center, farm management, and the management of the irrigation facilities constructed in this development project.

Assistance in farm management in the various aspects it covers such as crop selection, cultivation methods, the shipment and sales of agricultural produce, input and output of agricultural materials, and agricultural management, would be particularly of extreme importance to the farmers.

Technological assistance can be made possible through the acceptance of trainees, long and short term dispatchment and assignment of experts and through the participation of the JOCV group. Conclusively, any field of technological assistance would nevertheless be encouraging to the Lao government and extremely effective to this project.

CHAPTER 4

CHAPTER 4 BASIC DESIGN

4.1 Design Policy

The basic design of the Project is executed along the guidelines selected to cope with the natural and social conditions, material procurement and construction conditions, and the characteristics and site situations of the project respectively.

4.1.1 General Guidelines for Project Characteristics and Site Situations

The basic guidelines for the design are as follows:

<1> Local climate, topography, soil characteristics, customs and traditions are taken into consideration in order to make an appropriate design

<2> Construction materials are, in principle, procured locally in order to facilitate maintenance work in the future

<3> Construction structures are simple, resistant and durable and they are easy to maintain.

<4> The construction regulations and design standards of Laos are used. Japanese standards are used in particular cases where no related laws exist.

Irrigation facilities are initially intended to effect stable production of rainy season paddy, expansion of dry season cultivation area and crop diversification.

Rural roads have to be improved to allow vehicular passage during the rainy season. Routes to be constructed are along the existing routes. Bridge construction should be completed at an early stage in order to enable the transport of materials for dam construction. The structure of the bridges must be simple and, in principle, similar to that of existing bridges.

The structure of water supply wells should be such as to prevent intrusion of rain water and to maintain sanitation.

The location and structure of agricultural support centers are to be smoothly implemented.

4.1.2 Guidelines on Natural Conditions

The design of all facilities has to be made taking into consideration the natural conditions of the region, economy and safety.

Rain is mainly concentrated during the rainy season, June, July, August and September. All facilities have to be designed safely, in order to protect these facilities during these months.

Dams are built to effectively store and use rain water for irrigation during the dry season. The foundations are designed with due consideration for the bearing capacity and rain water infiltration.

(1) Irrigation Facilities

1) H. Bak Dam

The climate of Laos is divided into rainy and dry seasons, with almost no rainfall during the dry season. Therefore, the effective storage capacity of the dam is made large enough to hold the amount of water necessary for irrigation during the dry season.

The dimensions of the dam's effective storage capacity are chosen to allow the effective use of rain water collected during the rainy season and provide a stable supply of water to irrigate the entire Project Area of 950 ha.

Geologically the dam site is of alternating layers of shale and sandstone overlain by gravelly and sandy loam about 7 - 8m thick. The bottom center of the dam reaches to the basement rock layer.

There are various types of foundation treatment to control percolation applying core, sheet pile, grout, cut-off wall, banking, relief well, impermeable blanket, total pavement, etc. A replacement method with banking material soil is applied for

this dam from the viewpoints of the size of the dam, the construction method and its economy. However, curtain and rim grouting in the treatment should also be investigated. The construction of a horizontal drain should be considered in the design for safety of the dam to maintain the structure in terms of proper drainage of infiltration water.

Geographical and geological problems relative to the spillway design are as follows:

<1> Comparatively flat terrain extending up to the river side discharging flood water, the large amount of excavation will be necessary.

<2> As a gravel layer exists near the ground surface, the excavation route for the spillway will be very near the dam so as not to disturb the gravel layer.

<3> The existence of a gravel layer on the spillway route will necessitate the construction with concrete.

Therefore, the spillway will be constructed with concrete.

2) H. Xay Weir

The gravity method of collecting and distributing water will be adopted for the planned irrigation area. An intake weir is installed to elevate the water level of H. Xay.

According to the field survey results, H. Xay is a naturally constructed river having a gentle gradient. However, a residual oxbow of the old river lies near the site. In view of this, the site cannot be affirmed as most suitable for the construction of the weir.

Shifting river flow caused by drift wood gives rise to meanders and river bank erosion.

The location of the weir should be determined so as to attain the following conditions:

<1> Stable intake water level

<2> Straight river channel as much as possible

<3> Less-movement and stable thalweg

<4> Stable and little-eroded river bed and bank

<5> Little influences in upstream and downstream areas by the construction of a weir

A considerably straight and little-eroded sites are chosen for the location of the weir.

3) Irrigation and Drainage Canals

In view of rain and soil characteristics, the problems regarding the earthen water canal are as follows:

<1> Possibility of erosion of the cross section form. Further progress in erosion may destroy the canal.

<2> Possible infiltration of water in the sandy portion which can particularly deteriorate the bank.

The following principles are utilized in the basic design of the water canal, according to soil type:

<1> Over water depth of canals above 80 cm, the slope gradient is 1:1.5.

<2> Banking of the entire canal section should be avoided.

<3> Banking will be made from a mixture of sandy soil and clayey soil.

(2) Rural Infrastructure

The surfaces of existing rural roads are subject to serious erosion during the rainy season. Moreover, bridge abutments are exposed and piers collapse due to raging floods.

All the roads to be constructed within the framework of this project should be provided with street drains necessary for road maintenance. In addition, culverts should be buried under the ground and used as bridges in the paddy fields. Their front

surfaces are protected. Hardwood logs should be installed as pilings directly upstream to protect the piers from the impact of driftwood.

(3) B. Lak 35 Agricultural Supporting Center

The Center should be designed with due consideration of the regional meteorological conditions, customs and traditions.

The facilities should be designed with suitable structure and arrangement to the figure of the proposed land so as to function effectively.

- Office

The office will be well-ventilated and naturally well-lightened, taking the high temperature and humidity of the area into account to save energy costs. The building should be designed referring to similar facilities in the region so as to make pleasant and comfortable.

The size is determined to accommodate the number of staff, office facilities and visitors.

- Multipurpose building

A multipurpose square should be constructed with roof as protection from weather. This square is used as a market, an assembly hall, a drying area for unhulled rice, and for technical training.

- Granary

A granary that can withstand high temperature and humidity shall be constructed to prevent internal changes in the quality of the grain and to enable long-term storage. Measures to prevent the intrusion of rodents are also considered in its design.

- Garage

A garage will be constructed to protect the vehicles from weather.

- Generator

A generator house will be designed so as to protect it from heavy and concentrated rain, sun's rays, high temperature and humidity. The internal temperature is abnormally high from the heat emanated by the generator and the heat of the sun. To safely operate the generator during heavy rain, the following are considered. Measures are also taken to subdue noise.

<1> The elevation of the generator house should be higher than the surrounding area to prevent ground-surface water inflow.

<2> The walls are built of reinforced concrete frame blocks, and have openings on four sides for ventilation.

<3> Slate is used for roofing.

<4> The floor area should be 10 cm higher than the surrounding ground area and be made of concrete. The ground leading to the entrance slopes downwards.

- Fry Breeding Facilities

The temperature of the fry breeding pond increases during the day and does not decrease as expected at night. When the pond temperature increases, the amount of dissolved oxygen decreases, leading to death by suffocation of both adult fish and fry. The setting of an appropriate temperature for the pond water and the supply of oxygen is taken into consideration.

4.1.3 Socio-economic Guidelines

The basic design of the Project has duly to consider the customs, history, cultural traditions, religion, construction methods, and other social matters of Laotians

Materials and equipment will, in principle, be supplied locally in order to facilitate future maintenance.

(1) Irrigation Facilities

1) H. Bak Dam

The Department of Agriculture and Forestry in Savannakhet

Province has already decided on measures to relocate the inhabitants of the villages that will be flooded due to the dam's construction. Structures and auxiliary facilities of the dam are designed taking into consideration economic efficiency and existing structures, in order to be accepted by the concerned personnel. The supply conditions of materials for the dam body significantly affect the cost of constructing a fill-type dam.

The following conditions should be considered for selection of areas where banking soil for the dam are to be supplied are as follows;

<1> The areas should not prejudice third persons, and be preferentially selected within the reservoir area in order to increase its capacity.

<2> Easy and inexpensive land utilization rights.

<3> Places where dynamite can be utilized for collection of rocks.

2) Irrigation Canals

Ground facilities are liable to damages since the land is also used for free cattle grazing. Cattle, in particular, come to irrigation canals in order to drink water. And since these canals are made of earth, they can be easily destroyed. Therefore, it is necessary to build a water intake area near the village as a drinking and washing place for cattle, and to study the possibility of building a wooden fence around the canal and in front of the bridge to prevent the entrance of cattle.

Since transportation is mainly by traditional ox carts, the width of access roads, bridges, and auxiliary roads are determined after studying the turning radius of ox carts.

4.1.4 Guidelines for Construction and Procurement of Materials

Current Construction and Procurement Conditions

Local construction companies have been previously involved in similar types of work, although scale was small and technology inferior. It is, however, easy to assure an obedient and gentle labor force.

Small quantities of ordinary construction materials can be obtained easily, but there are limitations in terms of quality and selection. And delivery schedules have to be taken into consideration.

Ready-mix concrete is not available in Laos.

- Supply of Materials and Equipment

For easy maintenance in the future, materials and equipment shall, in principle, be supplied locally. However, importation is considered when specially desired by the Laotian side.

4.1.5 Orientations Concerning the Executive Organization's Capacity to Maintain and Manage the Project

The Office of Maintenance and Management for the Integrated Agricultural Rural Development Project in Savannakhet Province is responsible for the management of all facilities, except the Agricultural Support Center. Since the management and maintenance level of the executing organization is not up to par, facilities design and equipment selection must take into consideration the ease of management and maintenance. The Ministry of Agriculture and Forestry and the Department of Agriculture and Forestry of Savannakhet Province will organize an operation committee for the agricultural supporting center.

Conclusively, the operation and maintenance system for each facility is considered to be suitable.

1) Maintenance and Management of Irrigation Facilities

The personnel are acknowledged as capable of maintenance and management due to the existence of similar facilities. Their experience is shallow and limited, however, and thus require actual technical management training.

2) Maintenance and Management of Rural Infrastructure

The establishment and implementation of a maintenance and management plan will be discussed with all related agencies. Facilities that are malfunctioning or damaged found during patrol should be immediately repaired to prevent extensive damage and further, to curtail expenses.

4.1.6 Orientation of Work Implementation Schedule

The following items are taken into consideration upon establishing the implementation schedule.

<1> The wide expanse of the project area, extending 20 km north to south, in which the overall system of works (e.g.,dam, weir, canals, facilities, roads, and bridges) will be constructed, and to which the materials will be provided.

<2> The exclusively rural characteristic of the Project area which is about 50 km southeast of the provincial capital of Savannakhet.

<3> Condition of roads, transportation and communications

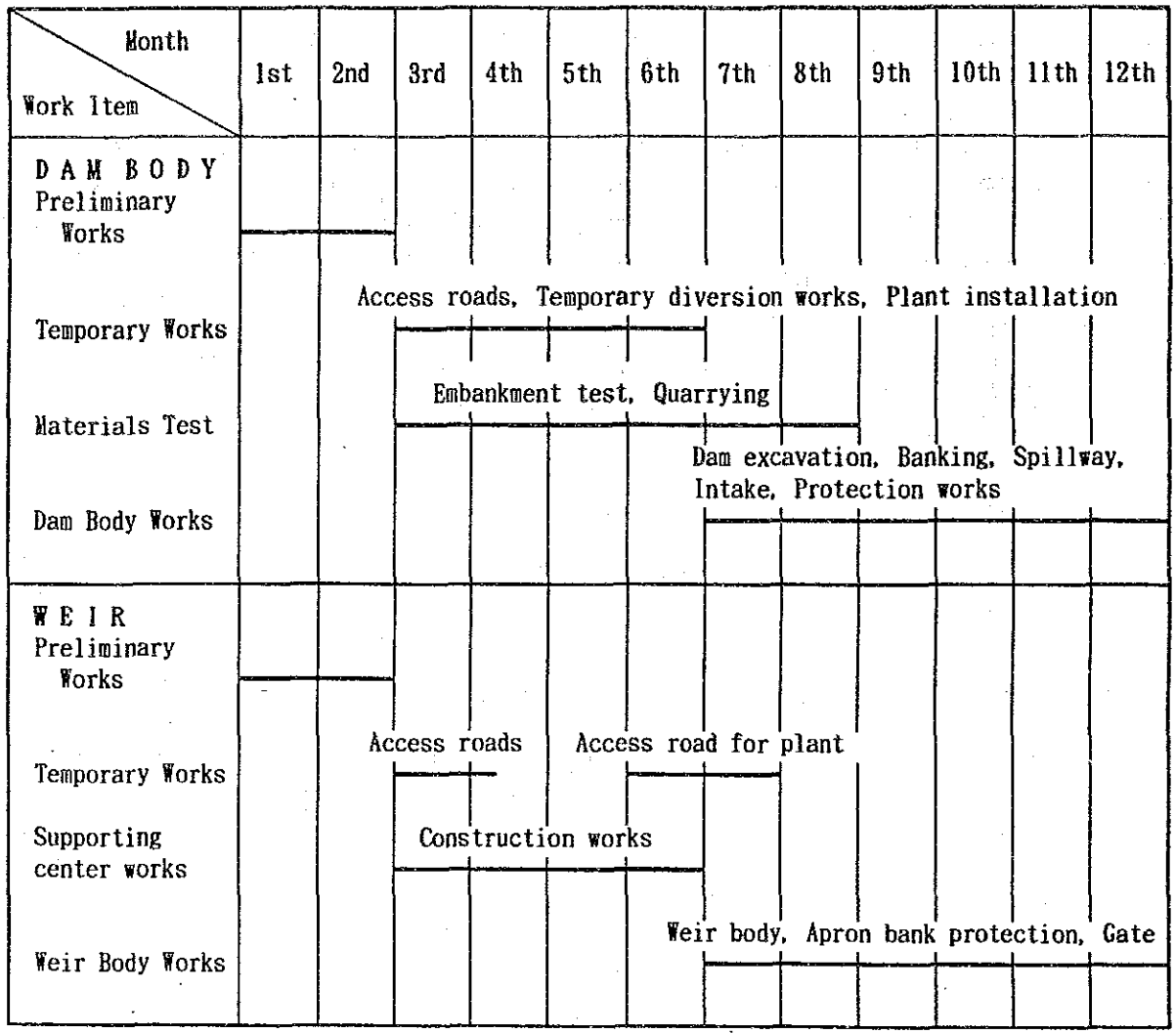
<4> Climatic conditions (rainy season dry season, torrential downpours)

<5> Construction site (mainly the river, and paddy fields)

The rainy season is during June, July, August, and September, with frequent floods in August and September. Climatic conditions significantly affect working procedures since the main construction works of this project, i.e. the dam, the weir, irrigation canals, are to be undertaken in the river and the existing paddy fields.

In consideration of previous observations, it is necessary to ascertain whether works should be completed in several stages, based on the amount of construction work economically sensible each year, including the plan for the procurement of construction material and the plan for the supervision and management of the construction work. Prior to the onset of the dam construction work, ten months will be allowed the Laotian Government to complete deforestation and felling activities, after which dam banking and weir body construction commence.

Approximate Schedule of Construction Work



4.2 Study and Examination on Design Criteria

The factors and conditions for the scale and the specifications of each facility are described below.

4.2.1 Design Criteria

(1) The construction laws and design standard in the Lao P.D.R.

(2) The criteria used in Japan are used if relevant laws and design standards do not exist in the Lao P.D.R.

4.2.2 Design Conditions

(1) Hydraulic Design Criteria

<1> The Manning formula is used in principle

<2> Roughness Coefficient of the Manning formula

Concrete lining	0.015
Steel pipe	0.013
Earth type	0.027

<3> Velocities of canal flow

Main and secondary canals -
minimum of 0.3 m/sec, maximum of 0.90 m/sec
Siphon -
minimum of 0.30 m/sec, maximum of 2.0 m/sec
Tertiary canal -
minimum of 0.50 m/sec

(2) Structural Criteria

a) Allowable stress of concrete for design structures

<1> Reinforced Concrete 210 kg/cm^2
<2> Plain concrete 180 kg/cm^2

b) Dam

<1> Dam type earth dam (homogeneous type)
<2> Slide safety factor 1.5

<3> Dam crest	6.00 m
<4> Upstream slope protection	1:3.0
<5> Downstream slope protection	1:2.5
<6> Berm	2.0 m
<7> Extrabanking	1% of dam height
<8> Upstream slope riprap	40 cm thick
<9> Design flood discharge	150 m^3/sec
<10> Maximum intake	1.26 m^3/sec
<11> Target improvement coefficient of foundation permeability	less than 1 x 0.0004 cm/sec

c) Weir

<1> Floating type	
<2> Design headwater level	153.24 m
<3> Design Flood Discharge	135.00 m^3/sec
<4> Maximum intake Discharge	0.52 m^3/sec
<5> Intake velocity	0.60 m/sec

d) Canal

<1> Earth canal	trapezoidal cross section
<2> Inside slope	1:1.0 - 1:1.5
<3> Freeboard	0.30 m for main and 0.20 m for secondary canals
<4> Division works, Drop	reinforced concret and/or brick
<5> Berm width	1.50 m (main and secondary canals, one side)
<6> Maintenance Road	4.50 m (main and secondary canals, one side)
<7> Bridge	Design Load
1.0m wide rural road	0.5 t/m^2
2.0m wide rural road	1.0 t/cm^2
3.0m wide rural road	5.0 t/cm^2

e) Secondary drainage canal

<1> Earth drain	trapezoidal earth section
<2> Inside slope	1:1.5

f) Rural roads

Road width	6.00m with ditch; partly 4.00 m;
Bridge	effective width of 3.50 m Design load of 14 tons

g) Rural wells

Type	Dug well (Hand pump)
Depth	About 10.00 - 15.00 m

h) B. Lak 35
Agricultural Supporting
Center

To bring about the most effective use of all the facilities of the agricultural supporting center, the climate, geographical conditions, customs, traditions, and construction methods shall be wholly considered in order to establish an appropriate design.

and more details of function as bellows will be disclosed in 4.3.2 Layout Plan.

Office Building, Exhibition Room, Multipurpose: A , Multipurpose: B, Garage, Granary, Generator House, Septic Tank, Janitor House, Water Supply Facilities, Fry Breeding Facilities Entrance and Flag pole.

4.3 Basic Plan

4.3.1 Site

The Project site in the upstream of H. Bak is located in Champhone district, and the other project sites in H. Xay upstream is Namphou area in khanthabouly district.

The target areas in both districts are:

- H. Bak upstream area for irrigation 950 ha
- Namphou (H. Xay upstream area) area for irrigation 410 ha

Rural Roads

Route A	B. Mai - B. Phailom (located in Nhyod H. Bak Irrigation area)
Route B	B. Phonko - National Road 13 crossing (northwest of H. Xay irrigation area)
Route C	B. Phonko - B. Nakhum (south of H. Xay irrigation area)

Rural Well Water Supply

Upstream of H. Bak
Champhone District
B. Xianban
B. Kho
B. Vatthama
B. Phonthan
B. Nongkhalong
B. Nonghong
B. Dongdokmai
B. Phailon
B. Nanokkhian

Upstream of H. Xay
Khanthabouly District
B. Dongmakfai

B. Lak 35
Agricultural
Supporting Center

Champhone and Khanthabouly Districts
Champhone District B. Lak 35

4.3.2 Layout Plan and Designs

a. Irrigation Facilities

(1) H. Bak upstream Zone

1) H. Bak Upstream Dam

Catchment area: 31.0 km^2, discharge rate: 35%, discharge rate of mean water surface area: 90%, loss in reservoir zone: evaporation loss is 75% of pan evaporation in mean water surface area, and percolation loss is 10% of total reservoir capacity.

Dam type	:	Homogeneous earth dam
Dam water loss	:	evaporation loss is 75% of pan evaporation in mean water surface area and percolation loss is 10% of the total capacity
Effective capacity of dam	:	14,541,000 m^3
Catchment area	:	31,000,000 m^2
Reservoir area	:	4,708,000 m^2
Total capacity	:	16,286,000 m^3
Dam inflow	:	Estimated by multiplying the discharge rate by rainfall: 21,593,000 m^3
Discharge rate	:	35%
Freeboard	:	3.00 m
Elevation of Dam Crest	:	EL 170.00 m
Dam Height	:	24.00 m
Crest Length	:	912.00 m
Crest width	:	6.00 m
Extra-banking	:	1% of dam height
Gradient of upstream slope	:	1:3.0
Gradient of downstream slope	:	1:2.5
Banquette	:	2.0 m

Protection works of upstream slope (Riprap)	:	Stone dimensions: 40 cm to 2.5 cm Specific gravity: more than 1/2.5
Protection works of downstream slope	:	turf
Embankment material	:	laterite
Downstream drain	:	To include a safety factor of more than 100 times of the infiltration amount from the dam and foundation
Spillway	:	Design flood amount 150 m^3/s Side ditch type Width: 120.00 m, Overflow water depth: 0.70 m Length: 620.00 m, EL 167.00 m

Water intake facilities

Water intake

Type	:	inclined gutter
Structure	:	reinforced concrete
Inflow type	:	orifice
Maximum intake amount	:	1.26 m^3/s
Entrance	:	0.80 x 0.80 m 2 holes
Screen	:	10 cm intervals
Entrance gate	:	2 gates (cast iron)
Operation room	:	16.20 m^2 (operation room, control room, rest room) 2.70 x 6.00 m

Water conveyance

Steel conduit	:	installation slope: 1:1,000
	:	Inner diameter 1.00 m Reinforced concrete lining
Joint	:	Shift type (1 place)
Cut-off wall	:	Fin height: 50 cm to 100 cm
	:	Approx. 7 to 10 times the height of fin intervals
	:	Side slope: 1:0.1 (approx.)
Substance between conduit and cut-off wall	:	mastic filler

Regulation Section

The reservoir is made in reinforced concrete.

Energy dissipating reservoir	:	Length 7.00 m x width 2.00 m x depth 5.00 m
Cut-off valve	:	High pressure sluice valve, diameter 1,000 mm, tapered on one side
Regulation valve	:	High pressure sluice valve, diameter 1,000 mm, tapered on one side
Pipe outlet	:	With hood in the upper part
Stilling facilities	:	Overflow weir height, EL 160.85 m

2) Left and right division works of main canal

The structure is made of reinforced concrete.

a) Division Box	:	5.00 m x 4.90 m x 7.00 m Spillway crest height EL = 191.10 m

Dam safety calculation

The design conditions for the dam safety calculation were as follows.

Soil coefficient	:	γd = 1.75 t/m^3 c = 3.30 t/m^2 angle ϕ = 30°
Load	:	dead weight, hydrostatic pressure, and pore pressure will be taken into consideration; seismic momentum force will not be considered.
Safety factor	:	1.5

The circular sliding surface method (soft name: slope safety calculation) will be selected for analysis and calculation carried out by personal computer.

The standard values of homogeneous earth dam were adopted for the

assumed slope gradient of the dam cross section.

$$SF = \frac{(\Sigma n - \Sigma u - \Sigma Nm)\tan\phi + C \cdot L}{\Sigma T + \Sigma Tm}$$

Where,

SF: Safety Factor

N : Normal component of force of the load that works on the slid surface of each slice (t/m)

T : Tangent component of force of the load that works on the slid surface of each slice (t/m)

u : Pore water pressure that works on the slid surface of each slice (t/m)

Nm: Normal component of force of the seismic momentum force that works on the slid surface of each slice (t/m)

Tm: Tangent component of force of the seismic momentum force that works on the slid surface of each slice (t/m)

ϕ : Internal friction angle of material of the slide surface of each slice (degree)

C : Cohesion of materials on the slide surface of each slide (t/m)

L : Length of the slide surface of each slice (m)

The slide surface of the minimum safety factor of the assumed cross section is figured below.

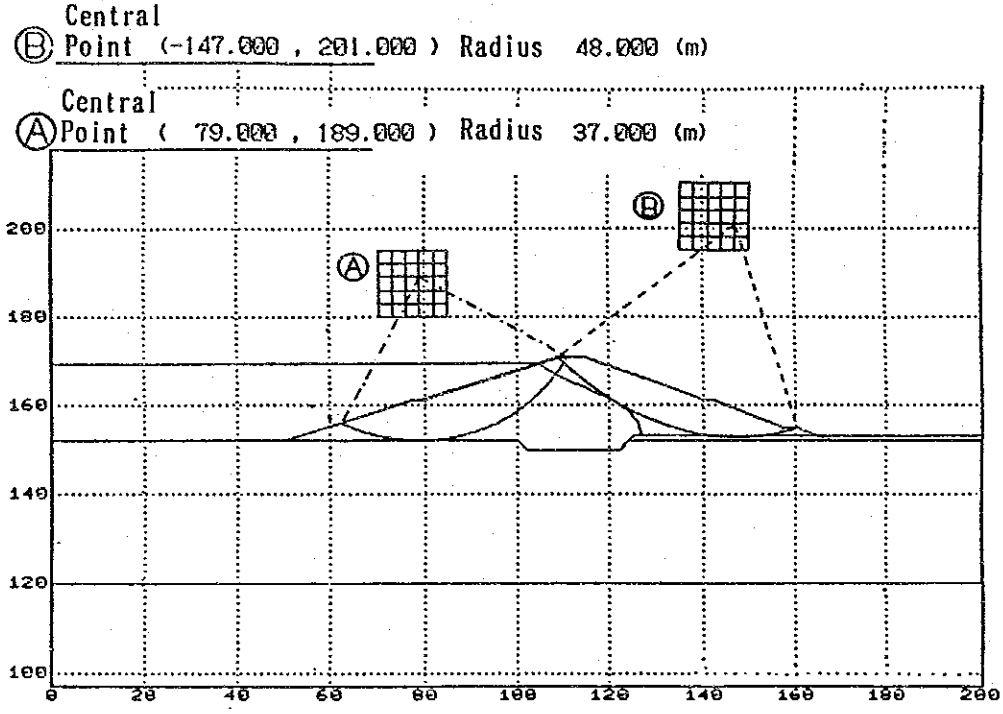


Figure 4-1 Slide Surface of Minimum Safety Factor of the Assumed Cross Section

As a result of the above analysis, the estimated safety factor of the studied section in the figure hereunder is 2.0 satisfying the design safety factor of 1.5. Since the use of the Lao workers inexperienced in similar projects is inevitable, the problems concerning the execution of the works, unpredictable social and physical influences should be taken into consideration. The cross section should be therefore as assumed as follows.

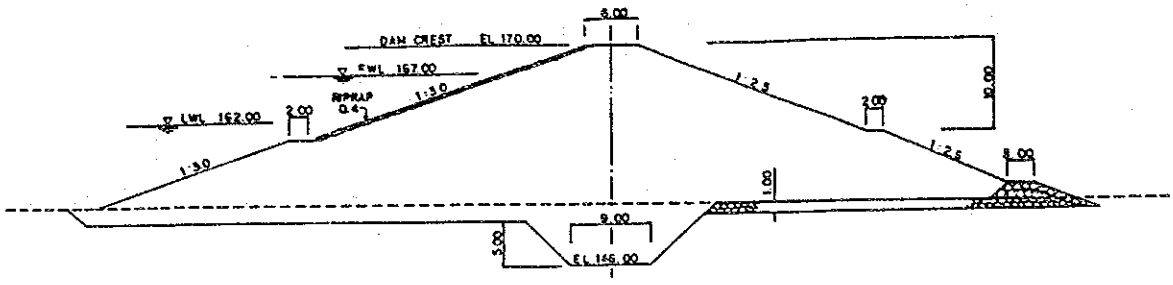


Fig. 4-2 Dam Cross Section Diagram

Spillway Works Calculation

The spillway of this project is composed of the overflow section (including the side canal) and of discharge canals.

The design conditions for the hydraulic calculation are as follows:

Design flow	:	$Q = 150\ m^3/s$
Design overflow height	:	$h = +\ 0.70\ m$
Elevation of spillway crest	:	EL 167.00 m
Water canal roughness coefficient	:	0.015 (concrete)
Calculation of overflow width	:	$B = Q/\ (CH^{3/2})$ (from the Iwasaki formula)

Q = discharge
C = Discharge coefficient

$$= 1.6 \frac{1 + 2a(H/Hd)}{1 + a(H/dH)}$$

$$a = \frac{cd - 1.6}{3.2 - cd}$$

$$cd = 2,200 - 0.0416(Hd/W)^{0.990}$$

B = Overflow width

H = Overflow water depth

in which B = 118.028 m.

Consequently, the overflow width, B = 120.00 m, has been selected.

The spillway crest type is as illustrated in the following figure.

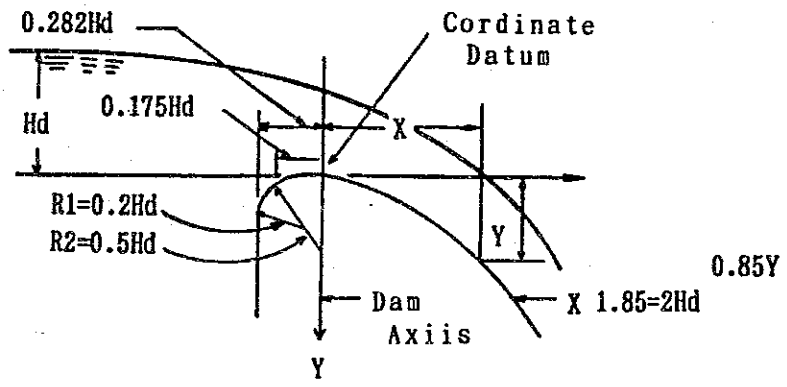


Fig. 4-3 Overflow Crest Formation

However, since an overflow width of 120.00 m is extremely large, the tailrace is examined and the selection of a side overflow was decided. The overflow depth is 0.70 m. The overflow depth and discharge curve are shown below.

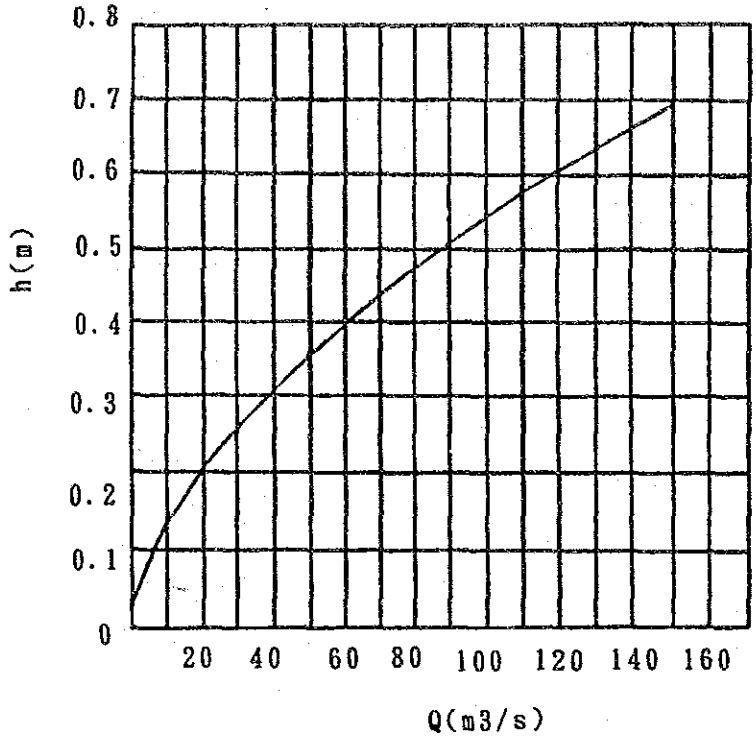


Fig. 4-4 Overflow Depth and Discharge Curve

Calculation of side canal cross-section

Based on the study of the design standards for land improvement projects of the Ministry of Agriculture, Forestry and Fisheries of Japan, the calculation of the side canal cross-section is as follows.

Base width of side canal terminal	:	10.00 m (calculated value 9.054 m)
Base width of soil flow terminal	:	5.00 m (calculated Value 4.64 m)
Slope gradient of side canal longitudinal section	:	i: 1/40
Water intake works		
Conditions	:	Froude number Fr < 0.5 Side canal width: B = 10.00 m

On the basis of the above conditions, the result of the non-uniform flow calculation is as shown below.

Slope gradient of longitudinal section: I = 1/700

- Calculation of water intake works

The water intake works include the intake section, the water conveyance section and the regulating section.

Hydraulic Calculation Design conditions

Maximum water intake = 1.26 m^3/s

Hole cross-section = 0.80 x 0.80 = 0.64 m^2

Conduit inner diameter = 1.00 m

Conduit length = 100.00 m

Water level gap = 162.00 m - 161.05 m = 0.950 m

$$0.950m \geqq fi\frac{V^2}{2g} + fge\frac{V_1^2-V_2^2}{2g} + fm\frac{\ell e}{2g}\frac{Vm^2}{Dm} + f\frac{\ell}{2g}\frac{V_2^2}{D} + fo\frac{Vo^2}{2g} + hs$$

where, $fi\frac{V^2}{2g}$: Inflow head loss m

fi : Coefficient of inflow loss = 0.50

V : Velocity after inlow = 1.969 m/s

g : Acceleration due to gravity = 9.8

$fge\frac{V_1^2 - V_2^2}{2g}$: Head loss by gradual enlargement m

fi : Coefficient of loss by gradual enlargement = 0.20

V1 : velocity before gradual enlargement = 1.969 m/s

V_2 : velocity after gradual enlargement = 1.605 m/s

$fm \frac{\ell e}{Dm} \times \frac{Vm^2}{2g}$: Head loss by friction in gradually enlarging section m

fm : Friction average coefficient in gradually enlarging section: 0.022

Vm : Average velocity in gradually enlarging section 1.787 m/s

Dm : Average inner diameter in gradually enlarging section 0.90 m

ℓe : longitudinal length of gradually enlarging section 3.05 m

$f \frac{\ell}{D} \times \frac{V_2^2}{2g}$: Head loss by friction in the conduit m

f : Friction loss coefficient = 0.02

l : Conduit length = 100.00 m

D : Conduit diameter = 1.00 m

V_2 : Flow velocity in the conduit = 1.605 m/s

$fo \frac{Vo^2}{2g}$: Outlet head loss m

fo : Outlet loss coefficient = 1.00

Vo : Outlet velocity = 0.191 m/s

hs : Head loss of screen = 0.080 m (space between bars = 0.1 m)

Total gross head loss = 0.449m

Since the water level difference between the inlet and outlet ≥ the total head loss, we realize that 0.950 m ≥ 0.449 m, thus the water intake is sufficient.

The water intake hole is selected according to the following:

Hole dimensions : 0.80 x 0.80 x 0.64 m^2

Number of holes : 2

Gate : 2 slide gates

Water conveyance section : Diameter of steel pipe = 1,000 mm

Regulating section : Water tank: Width x depth x

		length 2.00 m x 5.00 m x 7.00 m
Gate	:	2 gates, for regulation and closure, with one side tapered to more than 8 kgf/cm^2

2) Left and right division works of the main canal

The left and right division works of the main canal include a division tank and the left and right side division works. The maximum discharge at division works is 1.26 m^3/s and it is divided by means of constant head and volume. The division works should have two gates for regulation and closure. All division structures are made of reinforced concrete.

Division tank

Division works are situated both sides of the division tank and a spillway shall be provided at the end of the division tank.

The dimensions of the division tank are : width x depth x length: 5.00 m x 4.90 m x 7.00 m.

Left division works of main canal

Maximum division rate	:	Q = 0.47 m^3/s
Water intake level	:	EL 161.10 m

Entrance open transition
Conduit
Exit open transition

Right division works of main canal

Maximum division rate	:	Q = 0.79 m^3/s
Water intake level	:	EL 161.10 m

Entrance open transition
Closed conduit
Exit open transition

3) Irrigation canals and drainage canals

There are sufficient cross sectional areas and division

facilities required for the passage of design flow for irrigation canals. The division facilities are installed with manual gates with check-structure directly downstream. Sufficient cross sectional areas should be considered for the passage of design drainage flow.

Main canals

Left bank main canal

Length	:	5,705 m
Rate of water flow	:	0.47 - 0.41 m^3/s
Division works	:	4

Right bank main canal

Length	:	4,981 m
Rate of water flow	:	0.79 - 0.72 m^3/s
Division Works	:	5

Secondary irrigation canals

Left bank secondary canal

Length	:	4,126 m
Rate of water flow	:	0.29 - 0.21 m^3/s
Division works	:	8

Right bank secondary canal No.1

Length	:	2,568 m
Rate of water flow	:	0.32 - 0.21 m^3/s
Division works	:	5

Right bank secondary canal No.2

Length	:	5,705 m
Rate of water flow	:	0.40 - 0.21 m^3/s
Division works	:	4

Right bank secondary canal No.2-1

Length	:	2,568 m
Rate of water flow	:	0.23 - 0.21 m^3/s
Division works	:	4

Tertiary canal

Length	:	31,830 m

Farm ditch

Length	:	76,000 m

Secondary drainage canal

Length	:	2,110 m
Design rainfall	:	185 mm/day
Design drainage	:	6.1 lit/sec/ha

Terminal Irrigation Canal and Division Works

The capacity of cross sectional areas for flow intended for terminal irrigation canals and diversion works will depend on their rotation by 4-days intervals.

Secondary drainage canal

Design drainage capacity of the paddy fields

The design drainage capacity of the paddy fields has been set at 6.1 lit/sec./ha, as shown by the following.

$Q = q \times A$

$q = RE24 \times 10{,}000\ m2/\ (3600\ sec \times 48\ hours) = 6.1\ lit/s/ha$

Where,

$RE24 = R24 - (D1-D2) = 185 - (110 - 30) = 105\ mm$

Q	:	Design drainage capacity m^3/sec
q	:	Drainage capacity per hectare
A	:	Drainage area
R24	:	Design standard rainfall, 185 mm/day
D1	:	Effective paddy field water depth, 110 mm
D2	:	Current water depth of paddy fields, 30 mm

(2) Namphou, H. Xay upstream area, irrigation facilities

a) H. Xay Weir

The installation of the weir is intended to stabilize water intake level and assure the safe discharge of design flooding amount. As a rule, the water intake outlet is constructed near the bank where flow is stable and collectible and where river bed variations due to floods are few.

Conveyance to the opposite bank should be via a siphon which will be constructed traversal at the river. However, the small internal diameter of the siphon and the gentle gradient of the river bank at present make the construction of a sand spillway impractical. Accordingly, the following measures are considered necessary for the prevention of sand inflow and accumulation in the siphon and the removal of sand inside the pipe within the siphon:

<1> Sand accumulating at the river bed near the intake gate are discharged downstream by frequently closing and opening the sand spillway gate in an alternating manner. Also, the intake gate should be kept closed during the said operation and when intake is not carried out.

<2> A stabilization pond shall be constructed at the head of the siphon.

<3> The exit of the siphon is structured in accordance with the sand spillway.

Design conditions

Water intake level	:	153.24 m
Left main canal intake capacity	:	0.31 m^3/s
Right main canal intake capacity	:	0.21 m^3/s
Catchment area	:	51.4 km^2
Design flood	:	135 m^3/s
Weir downstream water depth	:	4.40 m
Weir Type	:	floating
Sand sluiceway	:	2 gates
Spillway	:	to be installed if necessary

Calculation of cross sectional area for weir flow

The crest elevation is 153.24 m and the weir height is 1.80 m. The section for flooding is determined by taking into consideration the flood probability rate of over 200 years and its cross sectional area.

Flow cross sectional area for 135.00 m^3/sec of floodwater volume is 43.54 m^2. Therefore, the design cross sectional area of 43.80 m^2 is enough for the passable water volume.

Calculation of downstream apron length

Conditions

L	:	Creep length (m)
H	:	Maximum difference in upstream and downstream water level (1.8 m)
C	:	Coefficient according to the type of foundation soil 12.0

Bligh Equation

$L \geq CH = 21.6$ m
L of assumed section = 22.26 m > 21.60 m

The downstream apron length is determined according to the assumed section.

Downstream riprap

Wooden mattress	:	5.00 m Frame : 2.00 m x 2.00 m x 0.50 m; immerged stone 20 kg/pc or more x more than 50%.
Upstream/Downstream Revetments	:	50.00 m

- Selection of upstream apron length

The upstream length is 5.00 m from the center of the intake.

2) Intake

Water intake conducted on one bank.

Water intake capacity (0.52 m^3/s)

left main canal maximum intake Q = 0.31 m^3/s
right main canal maximum intake Q = 0.21 m^3/s

A screen and gate are installed at each intake.

Intake gate

Open transition
Concrete pipe conduit
Left and right main canal division works
Stabilization pond and Division works
Left main canal division works
Right main canal division works

River Traversing Siphon

Steel pipe	:	400 mm in diameter
Length	:	42.50 m
Exit water tank	:	2.00 m x 2.00 m x 5.00 m
Transition	:	1.50 m long

3) Irrigation canals

Right bank main irrigation canal

Length	:	3,855 m
Discharge flow	:	0.21 m^3/s
Division works	:	9 places

Left bank main irrigation canal

Length	:	4,344 m
Discharge flow	:	0.31 - 0.21 m^3/s
Division works	:	5 places

Tertiary irrigation canal

Length	:	10,080 m

Farm ditch

Length	:	25,130 m

4) Farm ditch and division works

The capacity of the flow cross sectional area of the terminal irrigation canal and division works correspond to their rotation at 4 days intervals.

b. Improvement of Rural Infrastructure

(1) Rural roads

Road lines	:	Type similar to existing rural roads
Road width	:	6 m, some 4 m, with street drains
Banking material	:	Laterite
Bridge	:	Design load of T-14
	:	Steel girder bridge with reinforced concrete slabs Effective width - 3.50 m Handrail height - 1.00 m approx Abutment - wood piles, or reinforced concrete piles Pier - reinforced concrete piles
Conduit	:	Reinforced concrete pipe
Route	:	A,B,and C
Location	:	H. Bak and H.Xay,
Zones	:	A) from B. Mai to B. Phailom, 10,426 m B) from B. Phongkho to National Road no.13 intersection 14,164 m C) from B. Phongkho to B. Nakhum 5,018 m
Total Length	:	29,608 m
Bridge	:	4 Bridges and 1 Submarged Bridge
Conduit	:	4

(2) Rural wells

Type	:	Dug well
Depth	:	approx. 10.00 m to 15.00 m
Inner frame	:	Diameter of concrete pipe: 1,000 mm
Ground elevation	:	0.3 m, with cover
Pump	:	hand pump
Washing place	:	Reinforced concrete 1.20 x 1.20 x 0.20 m