The Khoua Khao storage pond

Storage volume (Compound section)	32,000 m^3
Revetment works (Concrete block)	2,500 m
Nos. of bridge	10

The lateral canal (Saya Settathirath)	3 km

6.9 Construction Plan and Cost Estimate

6.9.1 Construction work of the Hong Ke system

The civil works to be constructed under the Project are broadly divided into two categories; the drainage facilities. and the retarding basin. The drainage facilities are further divided into two categories; the main drainages canal and the lateral canals. Main works for each category are listed as follows;

(1) Main Drainage canal

- Khoua Khao Drainage canal
- Hong Thong Drainage canal
- Hong Ke Drainage canal

(2) Lateral Canal

- Canal system along Say Setthathirath road

(3) Retarding Basin

- Nong Chanh Retarding basin

6.9.2 Construction Schedule of the Hong Ke system

(1) Project schedule

The target date for completion of the Project is assumed to be the end of 36th month. Approximately, 3 years would be required for the project work from the commencement of Engineering basic design to the

completion of construction work. The necessary periods are summarized as follows;

a)	Engineering design including preparation of tender documents for construction	:	5.5 months
b)	Prequalification and Tendering	:	5.5 months
c)	Main construction works	:	24 months

Note: Civil works would constitute the critical path work of the Project; mobilization. site preparatory works and the improvement of the Hong Ke and Hong Thong. The lateral canal box culvert and the Hong Ke retarding basin are constructed in the first one (1) year and remaining construction works in the latter one (1) year.

(2) Construction work schedule

Fig 6.10 shows the construction time schedule of the Project. Major works scheduled in each year are described below.

First year

a) Award of main construction work contract
b) Construction of temporary facilities for contractor use
c) Construction of access road and haul road
d) Care of water and dewatering
e) Fascine hurdle with Sand bags (coffering)
f) Excavation, embankment and slope protection works of the Hong Ke main drainage canal
g) Excavation and concrete works of the Morning Market box culvert
h) Excavation and concrete work of lateral canal

Second Year

a) Care of water and dewatering
b) Fascine hurdle with sandbags (coffering)
c) Excavation, embankment and slope protection works of the Khoua Khao and Hong Thong main drainage canal
d) Excavation, embankment and slope protection works and related structure of the Nong Chanh retarding basin
e) Finishing works

6.9.3 Construction Method

(1) Main drainage facilities

The construction of the main drainage facilities will be mainly executed during the dry season when water level of the existing drainage canal is low. Care of water and dewatering will be carried out firstly and this will be immediately followed by a temporary fascine hurdle with sandbags (coffering) construction. Then excavation, embankment, slope trimming and slope protection works will follow thereafter.

Earth works for main drainage canals will be carried out mainly by a back hoe and bulldozers. Excavation of high water canal will be conducted by combination of swamp type bulldozers and Amphibious excavators. The trimming of canal side slopes will be made by back hoes or manual labors. The compaction for canal embankment will be carried out by vibration rollers after conditioning the fill materials to have a moisture content in the required range. The embankment materials will be obtained from suitable excavated materials in drainage canals,. and/or the extracted from borrow-pits.

Revetment and sod facing works are also carried out by manual power mainly.

Bank protection work and structures with wet masonry will be carried out using a portable type concrete mixer as the supporting equipment to the manual construction.

(2) Box Culvert

A combination works by manual power and a back hoe will be applied for this works. A portable type concrete mixer will be used for the concrete.

(3) Lateral Canal

The construction of lateral canal improvement will be carried out divided into several stages of the construction section in order to secure the drainage system during construction.

Based on the run-off discharge to the drainage canal and economical point of view, it is planned that the lateral canal improvement works should be carried out by the stepwise construction taking account of the site conditions. The works will be executed by two to three crews in a parallel way.

Excavation will be carried out by a back hoe and dump trucks for hauling works.

A portable type of concrete mixer will be provided for the small quantity of concrete of the lateral canal improvement works.

(4) Nong Chanh Retarding Basin

The retarding basin construction works will be carried out by the stepwise construction in accordance with the site condition providing the partial coffering method using fascine hurdle with sand bags. The works will be executed by two to three crew in a parallel way.

The coffering material will be shifted to the next step construction

The construction works will be concentrated to the retarding basin in the dry season.

Excavation of high water portion will be conducted by the combination of a swamp type bulldozer, an amphibious excavators and dump trucks under the dry condition to be secured by partial coffering.

Fascine hurdle with sand bags for coffering will be provided mainly by manual power.

Excavated soil will be disposed to the spoil bank by dump trucks.

The trimming of side slopes will be made by back hoe or manual labor. The compaction for embankment will be carried out by a vibration roller after conditioning the fill materials to have a moisture content in the required range. The embankment materials will be obtained from the suitable excavated materials in canals, and/or the extracted from borrow-pits.

Stone or concrete block masonry works will be conducted by manual power mainly.

Revetment and sod facing works are also carried out by manual power mainly.

(5) Metal Works

The installation of gate, screen and it's accessories will be conducted in later stage of construction works.

Installation will be conducted mainly by manual power. Truck crane will be utilized as the supporting equipment to manual work for installation of gates, screens and accessories.

(6) Crossing Facilities

There are crossing utilities in the Vientiane city Intercepter such as power lines, water supply pipes and telephone lines.

Those facilities are planned to be replaced following to drainage canal works.

Required works for renewal will be conducted by the nominated contractors of each agencies.

6.9.4 Cost Estimate

The main works of the Hong Ke system are excavation and embankment of earth, concrete block or the revetment works, concrete works for culvert and weir, sod facing for the bank protection, dry stone masonry for the bank protection, metal works for gates and the constructions of bridges. Meanwhile the main construction works for the improvement of the lateral canals are excavation of earth and concrete works. The work volumes thereof are estimated as summarized below;

(1) Main Canal and Retarding Basin

Excavation	427,700 m^3
Embankment	32,900 m^3
Concrete block	22,210 m^2
Concrete works	8,550 m^3
Metal works	82 ton
Sod facing	49,000 m^2
Stone masonry	1,700 m^2
Concrete pile	5,900 m
Reinforcement bar	541 ton
Asphalt pavement	25,950 m^2
Laterite pavement	10,100 m^2
Bridge (Concrete slab)	17 nos
Bridge (Metal girder)	4 nos

(2) Lateral Canal

Excavation	44,100 m^3
Concrete	8,200 m^3

The estimated unit prices as described in Part 1 is applied to the work volumes estimated and the direct cost is thus estimated.

In addition to this, indirect costs are estimated. Indirect costs comprise the land acquisition cost, engineering service cost and government's administration cost including the operation, maintenance and repair costs. The land acquisition cost or the compensation costs were estimated on the basis of the area for the right-of-way and the unit price of land. The engineering service cost and the government's administration cost are estimated on man-month basis to cover the costs of supervisions and management of the Project.

The financial costs thus estimated are summarized as follows;

Item	Foreign (J. Yen) (1,000)	Local (US$) (1,000)	Total (Equivalent) (US$1,000)
(1) Direct Cost			
a) Hong Thong	128,802	694	1,607
b) Khoua Khao	171,336	973	2,188
c) Hong Ke	192,140	919	2,281
d) Nong Chanh	150,736	907	1,976
e) Box culvert	61,261	405	839
(Main works sub total)	704,275	3,898	8,891
f) Lateral canal-1	77,849	436	987
g) Lateral canal-2	137,881	919	1,898
(Direct cost total)	920,005	5,253	11,778
(2) Indirect Cost			
a) Land acquisition	-	122	122
b) Government's administration	-	271	271
c) Engineering service	177,745	184	1,445
d) O&M equipment	135,241	-	959
(Indirect cost total)	312,986	577	2,797
(3) Physical contingency	92,001	525	1,178
(4) Grand total	1,324,992	6,355	15,753

(Current price as of October 1989)

6.10 Economic Evaluation

6.10.1 Conditions Adopted in the Evaluation

Several conditions are employed in this economic evaluation. The time basis for the estimations of benefit and cost are set at October 1989. The foreign exchange rates adopted are as follows;

Japanese Yen 100 = Kip 418 = US$ 0.709

In other words, US$1.0 is equivalent to Kip 590 or Yen 141.

The project life is assumed to be 50 year. The OMR cost after 2020 is assumed to be the same with that at present. The benefit after 2020 is assumed to increase in accordance with the growth of GRDP.

The improvement of the lateral and main drainage eventually entail an increase in the peak discharge to That Luang marsh with a water surface area of 1,000 ha. The increase is, however, minimized through providing the maximum storages in Nong Chanh retarding basin and the channel storages in the Hong Thong and the Khoua Khao. The flood might be further regulated by spilling out from the Hong Ke to the paddy field located along the right bank thereof. In this consequence, the adverse effect of the proposed plan to That Luang marsh is assumed to be insignificant.

6.10.2 Economic Benefit of the Drainage Improvement

The study on the inundation damage in the study area yielded the following proportions of damage in relation to the magnitudes of storms. Where the estimated damage to be incurred by 10-year storm is assumed 100;

2-year storm	21
5-year storm	86
10-year storm	106
20-year storm	114
50-year storm	133

Since the main drainage is to be improved with the design discharge by 10-year storm and lateral drainage by 2-year storm, the damage reduction thereby is not always 100%. The analysis of the field survey yielded the following rates of damage reduction;

2-year storm	100%
5-year storm	72%
10-year storm	48%
20-year storm	38%
50-year storm	25%

The figure indicates that if a 5-year storm occurs, 72% of potential damage is reduced but 28% of damage may remain.

According to the results of the damage analysis, a small storm, smaller than 2-year storm but brings about inundation damage to the area occurs 4 times a year on an average. The average damage incurred thereby is estimated to be 5% of one by 10-year storm.

The possible benefit of the drainage improvement is obtained as the expectation of the total damage reduction. the estimated average annual benefits by area and by year are presented in Table 2.14 upto the year 2040. The benefit of the Hong Ke system is obtained by the benefit of the sub areas, C, E, F, G and H.

The project is assumed to yield benefit after the completion of the main works. The damage reductions in the areas lower than El. 168.0 m should be smaller than that in the areas above El. 168.0 m. The damage reduction thereof is assumed to be 20% of that in the area above El. 168.0 m.

6.10.3 Economic Cost of Drainage Improvement

The economic cost is estimated on the basis of the estimated financial cost. The methods adopted to the conversion are described below;

(1) Foreign currency portion: The import tax of 5% is deducted.
(2) Tradable goods: A conversion factor of 0.9 is applied.

(3) Labour cost: A shadow wage rate of 0.37 and a conversion factor of 0.9 are applied.

(4) Land acquisition cost for farm land: Production foregone estimated is applied.

(5) Building: A conversion factor of 0.9 is applied.

(6) Cost for the excavation at Nong Chanh marsh: The soils are utilized to the embankment. The respective conversion factors of 50% and 70% are applied.

(7) The direct cost for the improvement of lateral canals are estimated by applying the unit cost of US$24,000/ha to the urbanized area. The indirect cost is assumed to be 30% of the obtained direct cost.

(8) The OMR cost is estimated to be 1% of the construction cost.

The cost for the main works are presented in Table 6.3. The costs for the improvement of lateral are summarized in Table 6.4.

6.10.4 Economic Internal Rate of Return (EIRR)

A cash flow for the Hong Ke system is prepared as shown in Table 6.5. The obtained EIRR is 7.3%.

CHAPTER 7. SYSTEM FOR SUB-AREA L (NAM PASAK)

7.1 Constraint

The improvement of the System for Sub-area I (Nam Pasak) comprises the channel improvement. The potential flood discharge for the 10-year storm rainfall is estimated assuming the projected land use in the year 2020. The estimated peak discharge is 23.3 m^3/s in the lowest reach at the confluence with the Hong Xeng.

According to the hearing survey to the local people, the highest water level at the Dong Deng bridge on the Upstream Nam Pasak left branch in the recent 5 years is El. 167.5 m on the basis of the hydraulic analysis. The water level at the time at the confluence with the Nam Pasak is estimated to be El. 167.2 m. The figure was confirmed referring to the water level recorded at the gate site. Consequently the design water level of the down-most reach of the Nam Pasak right branch is designated to be El. 167.2 m. The topographic survey and the damage survey carried out by the Study proved that the harmless water levels are El. 167.6 m at the confluence with the Hong Thong and El. 168.0 m at the upper-most reach of the Nam Pasak right branch. The river crosses some national highways and the main roads of the municipality. The surface elevations thereof are mostly around El. 169.0 m. The Nam Pasak should pass under these road with certain clearances. Fig. 7.1 shows the present condition of the System.

7.2 Alternative Drainage Plans

(1) Alternative cases

The Nam Pasak meanders heavily. This might have been caused by the lack of riverbed slope. The recent flow direction which is reverse of the original one made the alignment further complicated. The meandering decreases its flow capacity to some extent. In view of this, short-cut was contemplated as one of the channel improvement. The short-cut stretches were selected with river morphologic tendencies, referring to the topographic map prepared in 1954. There are some portions where

short-cuts are recommended from the river morphologic viewpoint but cannot be provided in order to avoid possible social problems. Finally, five short-cuts were envisaged through the discussion with the Government. In the light of this, 2 (two) cases were adopted for the comparative study. One is the case to improve the existing channel and the other is the case with short-cuts. The proposed locations of short-cuts are shown in Fig. 7.2. The total canal length can be shortened by 30 per cent through the provision of the shortcuts.

Comparative study was carried out in terms of the cost which consists of the construction, maintenance and land acquisition.

(2) Water level and bed elevation

In reference to the conditions mentioned above, the design flood water levels are designated. A uniform slope is contemplated for the drainage channel in view of the existing flat riverbed slope. And the elevations of channel beds at the strategic points were determined through interpolation of the existing river bed elevation of the upper-most reach and the lowest reach (Hong Xeng). Thereby a smooth profile is secured for the designed channel. The elevations determined are given as follows:

Canal/ chainage (m)	Location	Design Max. Water Level (m)	Design Bed Elevation (m)	Observed Max. Water Level (m)	Present Bed Elevation (m)
Hong Xeng					
HX/443	Sluice Gate	EL. 166.4	EL. 164.1	EL. 165.9	EL. 164.1
HX/736	Bridge of Route 13	EL. 166.7	EL. 164.2	EL. 166.0	EL. 164.7
HX/3344	Confluence with Nam Pasak	EL. 167.2	EL. 164.4	EL. 166.5	EL. 164.4
Nam Pasak					
NP/0	Confluence with Hong Xeng	EL. 167.2	EL. 164.4	EL. 166.5	EL. 164.2
NP/3200	Confluence with Hong Thong	EL. 167.6	EL. 165.4	EL. 166.9	EL. 166.5
NP/4700	Close to Mekong	EL. 168.0	EL. 165.8	EL. 166.9	EL. 165.8

7.3 Design Flood Discharge for Alternative Drainage Plans

The following table summarizes the design flood discharges of the Nam Pasak-R at different stretches:

Peak discharge for Nam Pasak-R

Case/ stretch	Catchment area (ha)	Peak discharge (m^3/s)
Original		
0 - 1800	110	18.5
1800 - 3600	60	11.4
3600 - 4750	44	4.8
Case 1		
0 - 1920	152	23.3
1920 - 3220	62	6.8
Case 2		
0 - 1920	138	23.3
1920 - 4750	82	8.9

7.4 Flood Routing

Flood routing was carried out for the Nam Pasak with the assumptions given below:

(1) Examination is carried out for the design discharge of 10-year discharge.

(2) At the confluence of the Nam Pasak and Hong Xeng, the water level of El. 167.2 m in the Hong Xeng is adopted.

(3) There are many bend portions in the river stretch of Nam Pasak. In case of the existing channel improvement, therefore, the bend loss as well as the friction loss is taken into consideration.

(4) A revetment works of concrete block is assumed in the section of short cut. The coefficient of roughness of channel is assumed to be 0.025. Meanwhile sod facing is applied to the improvement of the existing channel. The side slope of 1 to 0.6 is adopted to the concrete block revetment works and 1 to 2.5 to the sod facing.

(5) Because of the flat topography, a unique bed slope of 1 to 2,500 is assumed for the improved channel as shown in the figure.

(6) Two different discharges are applied for the upstream reach and the downstream reach respectively.

The results of the routing are presented below:

Item	Alternatives	
	Case 1 (short-cut plan)	Case 2 (existing route plan)
Design discharge (m^3/s)		
Upstream reach	6.8	8.9
Downstream reach	23.3	23.3
Water surface EL.(EL.m) at the upstream end of channel	168.0	168.0
Channel bottom width (m)		
Upstream reach	3.0	5.0
Downstream reach	7.0	8.0
River course length (m)		
Upstream reach	1,300	1,920
Downstream reach	1,920	2,830

7.5 Comparative Study

The comparative study was carried out in terms of the implementation cost for the 2 (two) alternatives for the Nam Pasak. In this cost estimation the following assumptions were employed.

(1) The cost for principal works are estimated.

(2) The excavation volume was estimated using the longitudinal profile and several cross-sections.

(3) Maintenance road is necessary. The width thereof is 4.0 m.

(4) The cost of bridge is estimated by applying a unit cost per square meter. All the existing bridges will be reconstructed. And the existing 5 (five) culverts crossing the main roads are replaced by new bridges.

(5) The compensation cost for the relocated houses was estimated by counting the number of relevant houses. The price of house was estimated to be $6,000/house. The land cost was estimated by the unit price of $2.5/m^2 for residential area and $1.0/m^2 for paddy field.

(6) Maintenance cost is small and is neglected.

The estimated costs were tabulated as follows.

Unit: US$1,000

Case	Low Channel	Cut	Maintenance Road	Bridge/ Culvert	Slope Facing	Land/House Compensation	Total
1 (Short cut)	966	409	234	919	804	226	3,558
2 (Existing)	1,425	693	387	940	162	0	3,607

As shown in the above table, the short-cut plan (Case 1) is more economical as compared with the improvement of the existing channel plan (Case 2). The cost of revetment work for the low flow channel can be reduced by the shortening the total length. Judging from the economical point of view, the short-cut plan (Case 1) may be proposed to be the selected alternative.

7.6 Selection of the Conceptual Plans

The comparative study indicated that the improvement with short cut works is advantageous in view of economics and hydraulics.

The area of the proposed system is zoned from the environmental view points. The area along the upstream reach is identified to be the zone which should be reconstructed but the green area should be conserved as much as possible. Meanwhile the downstream reach is identified to be the zone which should be reconstructed to enhance the land use therein.

The plan with shortcut works will conform to the environmental zoning mentioned above. Green areas are to be conserved in the wide crescent channels in the upstream reach area which is identified to be green zone. On the other hand, the narrow channels of shortcut in the lower reach area save the space to develop for the reconstruction in the urban reconstruction zone.

In the light of this, the conceptual plan with shortcut is selected for the drainage improvement of the Nam Pasak.

7.7 Alternative Facility Plan

7.7.1 Conceivable Alternative Structure

The proposed plans comprise the existing channel and short cut. the structures related to the canal are section, revetment works and crossing structure. The proposed conceptual plan specify the hydrologic and hydraulic figures such as the design water level and design discharge at the strategic points of the proposed drainage structures.

Several conceivable types were compared for each structure. And subsequently the most suitable ones were adopted in the plan. In this connection, several conditions of the project sites were considered and referred to as follows;

I) The topography is flat and the depth of channel is limited mostly to less than 3 meters and slope is less than 1 to some thousands.
II) Soils are mostly sandy clay and silt.
III) The Study area is located in the center of the town.
Accordingly the available land area is limited and yet the plan should produce good views.
IV) The construction methods being adopted in the prevailing construction works in and around the Study area may be suitable method and materials to the local condition.
V) The complicated operation and maintenance should be avoided.

In the light of the considerations mentioned above, the following types were adopted as the alternatives of each structure;

Channel	;	Single section and compound section.
Revetment works	;	Sod facing, concrete block (2D), concrete block (3D), concrete block 3D with finishing and Stone masonry.
Crossing structure	;	Box culvert, pipe culvert, rigid frame bridge, RC slab bridge and steel I-girder bridge.

In addition to the types given in the list, RC T-girder bridge is considered. However the girder, thereof is relatively deep and may not afford the sufficient clearance for the drainage channel. Consequently this type is discarded. A wood bridge is provided for private use if the existing one is to be demolished.

The technical features of each type are summarized as follows;

Single section :
- Construction is simple.
- Work volume is comparatively small.
- The discharge of low flow is not smooth.
- Stage wise construction is not suitable.

Compound section :
- The discharge of low flow is smooth.
- Multipurpose utilization of the high water channel is possible.
- Suitable for stage wise construction.
- Work volume is large.
- Construction is slightly complicated.

Sod facing :
- Domestic supply of material is possible.
- The coefficient of roughness is large (0.030 or more).
- A gentle slope is required (1 to 3 or more).

Concrete block(2D) :
- The stability of slope can be controlled (1 to 0.3).
- Required concrete volume is small as compared with the 3D-type.

- A wider channel is required as compared with the 3D-type.
- The coefficient of roughness is moderate (0.025).

Concrete block(3D) :
- The stability of slope can be controlled (1: 0.3).
- A width of channel can be the most narrow.
- The coefficient of roughness is small (0.020).
- Maintenance is easy.
- A considerable concrete volume is necessary.

Concrete block(3D) With finishing
: Same as the type of concrete block (3D). The coefficient of roughness is small (0.015).

Stone masonry :
- Domestic supply of material is possible.
- Manual construction is necessary.
- Required slope is moderate (1 to 2).
- The coefficient of roughness is large (0.035).

Box culvert and Rigid frame bridge
:
- Girder is not necessary
- Special foundation treatment is not necessary.
- The required concrete volume is larger as compared with a concrete slab bridge.
- The increase in the flow area is proportional to the increase in the water Level.

Pipe culvert :
- Mostly be precast concrete made. The placing of concrete at site is difficult.
- Accordingly a pipe culvert is suitable for only a small scale works.

RC Slab bridge :
- Girder is not necessary.
- Foundation works may be necessary.
- The required concrete volume is small.

- The original river section therein can be secured.
- The span length should not exceed 10 meters.

Steel I-girder bridge : -A girder with a depth of less than 500 mm is available if the span length is less than 10 meters
- Foundation works may be necessary.
- The original river section therein can be secured.
- The construction cost is high.

7.7.2 Proposed Improvement of the System

The proposed improvement of the system comprised the existing Nam Pasak channel and the short cut channel proposed at the heavily meandering stretches. The design discharges thereof varies from the upstream reach to the downstream reach. The maximum discharge of 23.3 m^3/s is for the lowest reach of the river. Meanwhile that in the upstream reach is 6.8 m^3/s. Since the meandering is heavy, the width of the existing river varies from section to section. Some section have the width of more than 30 m. A corrugate pipe with a diameter of 900 mm is provided as a road crossing.

In accordance with the future land use plan, the river stretch is divided into the following two portions;

Stretch 1 : From the origin to the crossing with Sam Sen Thai road (900 m)

Stretch 2 : From the crossing with Sam Sen Thai road to the confluence with the Hong Xeng.

Since the area of the Nam Pasak is one of the most densely populated zone, the land acquisition is difficult. However the low flow must be discharged without any stagnation. In this accord, the compound section is considered throughout the channel. And in respect of the revetment works, the following three alternatives were examined;

Stretch	Channel	Case 1	Cases 2	Case 3
Stretch 1	Existing canal			
	HW channel	CB2D	SOD	SOD
	LW channel	CB3D	CB3D	CB3D
	Short cut portion			
	HW channel	CB3D	CB3D	CB3D
	LW channel	CB2D	CB2D	CB2D
Stretch 2	Existing canal			
	HW channel	CB2D	SOD	CB2D
	LW channel	CB3D	CB3D	CB3D
	Short cut portion			
	HW channel	CB3D	CB3D	CB3D
	LW channel	CB2D	CB2D	CB2D

Where CB2D means a revetment work by concrete blocks for 2 dimensions. CB3D means a revetment work by concrete blocks for 3 dimensions. SOD means a revetment work by sod facing. The width of a shortcut portion is minimized by applying 3 dimensional revetment works in the high water channel.

All the cases are featured as follows;

Case 1 :
- The width of canal is small as compared with the alternative having sod facing portions.
- The requisite concrete volume is large.

Case 2 :
- The requisite concrete volume is small.
- The side slope is gentle and the right-of-way become large
- Amenity spaces are provided.
- The existing purification function of the river may be maintained.

Case 3 :
- The construction cost may be the medium of the case 1 and 2.

Applying the tentative unit prices, the construction costs for three cases are estimated. The results of the estimation is shown below;

Case 1	:	US $4.3 x 10^6
Case 2	:	US $3.3 x 10^6
Case 3	:	US.$4.2 x 10^6

Case 2 yielded the least cost of US $ 3.3 x.10^6

The green areas can be secured in the area along the stretch 1. However it might be difficult in the area along the stretch 2 in the shortcut portion. Sod facing is preferable to conserve a natural environment. Along this line, case 2 was adopted as the feasibility plan for the Nam Pasak.

The width of the channel is 6 to 9 meters at each crossing with road. Accordingly concrete slab bridge is proposed at all the crossings. The river crosses 7 roads in total.

The proposed cross section facility plan are illustrated in Fig. 6.7 and Fig. 6.8 together with the Hong Ke system. The proposed profile and cross sections are presented in Fig. 7.3.

7.7.3 Preliminary Features of Feasibility Plans

The comparative study for the Nam Pasak proved that the case 2 is the least costly alternative. The case improves the existing river channel with several shortcuts. In this case the high water channel of a shortcut is lined with sod facing to conserve the green area and to maintain the natural water purification function. The case is preferable from environmental point of view. The required land acquisition is mostly within the existing channel. Case 2 is the best alternative from both economical and environmental view points. Along this line, the case 2 is adopted for the feasibility plan.

The principal features of each feasibility plan are provisionally envisioned as presented below.

The Nam Pasak system

Design water level (Hong Xeng)	El. 167.2
Design discharge (max.)	23.3 m^3/s
Design discharge (min.)	6.8 m^3/s

Length of channel (compound)	3,220 m
Nos. of shortcut channel	5
Total length of shortcut channel	1,140 m
Width of shortcut (max)	10.4 m
Revetment works (concrete block)	6,440 m
Nos. of bridge	7

7.8 Construction Plan and Cost Estimate

7.8.1 Construction Schedule

The civil works to be constructed under the Project is the drainage facilities and the retarding basin. The drainage facilities are further divided into two categories; the main drainages canal and the lateral canals. Main works for each category are listed as follows;

(1)	Nam Pasak Main Drainage Canal	3,300 m
(2)	Lateral canal	1,800 m

The schedule for the works are considered as follows;

(1) Project Schedule

The target date for completion of the System for Sub-area L is assumed to be the 36th month. Approximately, 3 years would be required for the improvement of the System from the commencement of engineering design to the completion of construction work. The necessary periods are summarized as follows;

a)	Engineering design including preparation of tender documents, and prequalification	:	6 months
b)	Tendering	:	6 months
c)	Main construction works	:	24 months

(2) Construction Work Schedule

Fig. 7.4 shows the proposed construction schedule of the Nam Pasak System. Major work scheduled in each year are described below.

The First Year

a) Signing of Exchange Notes
b) Selection and contract of consultant
c) Detailed design and preparation of tender document
d) Advertising
e) Prequalification
f) Tendering and evaluation of civil works

The Second Year

a) Award of main construction work contract and mobilization
b) Construction of temporary facilities for contractor use
c) Construction of access road and haul road
d) Care of water and dewatering
e) Fascine hurdle with sand bags (coffering)
f) Excavation, embankment and slope protection work of the Nam Pasak main drainage canal
g) Excavation and concrete work of lateral canal

The Third Year

a) Care of water and dewatering
b) Fascine hurdle with sand bags (coffering)
c) Excavation, embankment and slope protection work of the Nam Pasak main drainage canal
d) Excavation and concrete work of lateral canal
e) Finishing works

7.8.2 Construction Method

(1) Main Drainage Facilities

The construction of the Nam Pasak main drainage canal will be started at after completion of access road. Excavated soil will be conveyed by dump trucks and partly by utilized for embankment. the rest of them will be deposited into the old channel (short cut portion), which has an enough capacity to receive the soil from excavation.

The construction of the main drainage facilities will be mainly executed during the dry season when water level of the existing drainage canal is low. Care of water and dewatering will be carried out firstly and this will be immediately followed by a temporary fascine hurdle with sand bags (coffering) construction, then excavation, embankment, slope trimming and slope protection works will follow thereafter.

Earth works for main drainage canals will be carried out mainly by a back hoe and bulldozers. Excavation of high water canal will be conducted by combination of swamp type bulldozers and/or Amphibious excavators. The trimming of canal side slopes will be made by back hoes or manual labors. The compaction for canal embankment will be carried out by vibration rollers after conditioning the fill materials to have a moisture content in the required range. The embankment materials will be obtained from suitable excavated materials in drainage canals, and/or the extracted from borrow-pits.

Stone or concrete block masonry works will be conducted by manual power mainly.

Revetment and sod facing works are also carried out by manual power mainly.

Bank protection work and structures with wet masonry will be carried out using a portable type concrete mixer as the supporting equipment to the manual construction.

(2) Lateral Canal

The construction of lateral canal improvement will be carried out divided into several stages of the construction section in order to secure the drainage system during construction.

Based on the run-off discharge to the drainage canal and economical point of view, it is planned that the lateral canal improvement works should be carried out by the stepwise construction taking account of the site conditions. The works will be executed by two to three crews in a parallel way.

Excavation will be carried out by a back hoe and dump trucks for hauling works.

A portable type of concrete mixer will be provided for the small quantity of concrete of the lateral canal improvement works.

(3) Crossing Facilities

There are crossing utilities in the Vientiane city Intercepter such as power lines, water supply pipes and telephone lines.

Those facilities are planned to be replaced following to drainage canal works.

Required works for renewal will be conducted by the nominated contractors of each agencies.

7.8.3 Cost Estimate

The main works of the System for Sub-area L are excavation and embankment of earth, concrete block for the revetment works, concrete works for culvert, sod facing for the bank protection and the constructions of bridges. Meanwhile the main construction works for the improvement of the lateral canals are excavation of earth and concrete works. The work volumes thereof are estimated as summarized below;

(1) Main Canal and Retarding Basin

Excavation	122,850 m^3
Embankment	10,770 m^3
Concrete block	31,300 m^2
Concrete works	3,020 m^3
Reinforcement bar	126 ton
Concrete pile	3,530 m
Sod facing	53,000 m^2
Asphalt pavement	14,900 m^2

Laterite pavement	6,500 m^2
Bridge (Concrete slab)	7 nos

(2) Lateral Canal

Excavation	14,200 m^3
Concrete	2,640 m^3

The estimated unit prices as described in Part 1 is applied to the work volume estimated and the direct cost is estimated.

In addition to this, indirect costs are estimated. Indirect costs comprise the land acquisition cost, engineering service cost and government's administration cost including the operation, maintenance and repair costs. The land acquisition cost or the compensation costs were estimated on the basis of the area for the right-of-way and the unit price of land. The engineering service cost and the government's administration cost are estimated on man-month basis to cover the costs of supervisions and management of the Project.

The financial costs thus estimated are summarized as follows;

Item	Foreign (¥1,000)	Local (US$1,000)	Total Equivalent) (US$1,000)
(1) Direct Cost			
a) Nam Pasak	313,903	2,440	4,666
(Main works sub total)	313,903	2,440	4,666
b) Lateral canal	51,183	321	684
(Direct cost total)	365,086	2,761	5,350
(2) Indirect Cost			
a) Land acquisition	-	226	226
b) Government's administration	-	124	124
c) Engineering service	69,897	96	592
d) O&M equipment	98,559	-	699
(Indirect cost total)	168,456	446	1,641
(3) Physical contingency	36,500	276	535
(4) Grand total	570,042	3,483	7,526

(Current price as of October 1989)

7.9 Economic Evaluation

7.9.1 Conditions Adopted in the Evaluation

Several conditions are employed in this economic evaluation. the time basis for the estimations of benefit and cost are set at October 1989. The foreign exchange rate adopted are as follows;

Japanese Yen 100 = Kip 418 = US$ 0.709

In other word, US$1.0 is equivalent to Kip 590 or Yen 141.

The project life is assumed to be 50 year. The OMR cost after 2020 is assumed to be the same with that at present. The benefit after 2020 is assumed to increase in accordance with the growth of GRDP. The peak discharge of the Nam Pasak increases as the consequence of the improvement. The paddy field

of 400 ha may absorb the increased inflow to the Hong Xeng. Accordingly the adverse effects of the improvement to the Hong Xeng and the Makhiao supposed to be insignificant.

7.9.2 Economic Benefit of the Drainage Improvement

The study on the inundation damage in the study area yielded the following proportions of damage by the magnitudes of storms. Where the estimated damage to be incurred by 10-year storm is assumed 100;

2-year storm	21
5-year storm	86
10-year storm	106
20-year storm	114
50-year storm	133

Since the main drainage is to be improved with the design discharge by 10-year storm and lateral drainage by 2-year storm, the damage reduction thereby is not always 100%. The analysis of the field survey yielded the following rates of damage reduction;

2-year storm	100%
5-year storm	72%
10-year storm	48%
20-year storm	38%
50-year storm	25%

The figure indicates that if a 5-year storm occurs, 72% of potential damage is reduced but 28% of damage may remain.

According to the results of the damage analysis, a small storm, smaller than 2-year storm which bring about inundation damage to the area occurs 4 times a year on an average. The average damage incurred thereby is estimated to be 5% of one by 10-year storm.

The possible benefit of the drainage improvement is obtained as the expectation of the total damage reduction. the estimated average annual

benefits by area and by year are presented in Table 2.14 upto the year 2040. The benefit of the Nam Pasak system is obtained by the benefit of the sub area L.

The project is assumed to yield benefit after the completion of the main works. The damage reductions in the areas lower than El. 168.0 m should be smaller than that in the areas above El. 168.0 m. The damage reduction thereof is assumed to be 20% of that in the area above El. 168.0 m.

7.9.3 Economic Cost of Drainage Improvement

The economic cost is estimated on the basis of the estimated financial cost. The methods adopted to the conversion are described below;

(1) Foreign currency portion: The import tax of 5% is deducted.
(2) Tradable goods: A conversion factor of 0.9 is applied.
(3) Labour cost: A shadow wage rate of 0.37 and a conversion factor of 0.9 are applied.
(4) Land acquisition cost for farm land: Production foregone is applied.
(5) Building: A conversion factor of 0.9 is applied.
(6) Cost for the excavation in the shortcut of the Nam Pasak: The soils are utilized to the embankment. The respective conversion factors of 50% and 70% are applied.
(7) The direct cost for the improvement of lateral canals are estimated by applying the unit cost of US$24,000/ha to the urbanized area. The indirect cost is assumed to be 30% of the obtained direct cost.
(8) The OMR cost is estimated to be 1% of the construction cost.

The cost for the main works are presented in Table 7.1. The costs for the improvement of lateral canals are summarized in Table 6.4.

7.9.4 Economic Internal Rate of Return (EIRR)

A cash flow for the System for Sub-area L is prepared as shown in Table 7.2. The obtained EIRR is 4.2%.

CHAPTER 8. SYSTEM FOR SUB-AREA I (HONG KAI KEO)

8.1 Conditions and Design Drainage

The Hong Kai Keo drains the subarea I. The catchment area thereof is 2.76 km^2. The length of the river channel is 1,300 m with the average widths of 6 to 9 m. The slope of the existing channel is estimated to be 1 to 900. The river emanate from a marsh area named Nong Bon. The water area of Nong Bon is about 9 ha. According to the urban plan of the municipality, an area of 4 ha thereof is to be reclaimed for residential use. The remaining 5 ha is to be conserved as water area. This conserved area is proposed to utilize for the retarding basin.

The Hong Xeng has marked the flood water level of El. 166.7 m at the bridge of the No. 13 highway. the water level of El. 166.9 m is obtained at the confluence of the Hong Xeng and the Hong Kai Keo on the basis of the water level at the bridge. The elevations of the lands located along the Hong Kai Keo are mostly El. 166.0 to El. 167.0 and presently utilized for paddy cultivation. The area is susceptible to inundation. According to the urban plan of the municipality, the area is to be urbanized by the year 2000. In this drainage plan it is assumed that the land is elevated to El. 168.0 when it is reclaimed for the urbanization like other reclaimed lands along the national highway No. 13. Accordingly it is assumed that the harmless water level of Nong Bon is El. 167.5 m with head of about 60 cm from the confluence.

Another assumption was employed with regard to the urbanization. The land reclamation provides lateral drainage canals in the area. Consequently the runoff from the area is estimated by means of the rational method.

The operational depth of 1.0 m is assumed for the proposed Nong Bon regarding basin. The effective space of the basin for the retarding in thus assumed to be 50,000 m^3.

Along this line, the design discharges were proposed for both Nong Bon retarding basin and the Hong Kai Keo. The proposed are summarized as presented below;

Design Flood Discharge of Hong Kai Keo

Canal, pond chainage	Catchment (ha)	Design discharge (m^3/s)
Nong Bon Pond		
Outlet	160.8	16.8
Hong Kai Keo		
HKK 840 - 1,340	32.8	20.2
HKK 0 - 840	31.2	23.5

8.2 Drainage System

The flood water level of Nong Bon is set at El. 167.5 m as the elevation of the circumference land is El. 168.0. The low water level of the retarding basin is designated to be El. 166.5 m so that a flood control space of 50,000 m^3 is secured. At the outlet of the retarding basin a concrete weir is provided. The weir is free over flow type with sand flush gates. The crest elevation of the weir is set at El. 167.0 m with stoplog. The sill of the stoplog is set at El. 166.5 m so that the water surface could keep the elevation of El. 166.5 m in the ordinary case. If the water level of the Hong Xeng is anticipated to rise upto more than El. 166.5 m, the stoplog is closed to prevent the intrusion of the backwater. Thereby the flood control space of 50,000 m^3 is secured. The case may occur once in a few years. The basin impounds water permanently and allows multi-purpose use to the local people.

The bed elevation of the Hong Kai Keo is El. 164.5 m at the lowest reach of the channel. The elevation coincides with the bed elevation of the Hong Xeng at the confluence. Meanwhile the channel bed slope of 1:1,300 is adopted on the basis of the existing channel profile. The bed elevation is set at El. 165.5 m at the uppermost section.

The compound section is contemplated for the Hong Kai Keo. The low flow section has the dimensions of 2 m wide and 0.5 m deep. The side slope of the low flow channel is 1 to 0.3 and a concrete block revetment works is provided. The bed width of the high water channel is 6 m. The side slope

thereof is 1 to 2.5 and is protected by sod facing. The typical section and the profile of the Hong Kai Keo is presented in Fig. 8.1.

On the left bank of the Hong Kai Keo, a maintenance road is provided. The width of the road is 5 m and is paved with asphalt. The road crosses several lateral canals. The largest on is located at about 1,000 m upstream from the confluence. A box culvert with a section of 1 m wide and 1 m deep is provided to cross he inspection road. Other lateral canals are connected to the Hong Kai Keo though concrete pipe culverts with a diameter of 600 mm embedded under the inspection road. The numbers of pipe culvert tally 10.

The Hong Kai Keo crosses Nong Soan Tho road and Phong Sa Ath road. A box culvert is provided at the former crossing and a wooden bridge is provided at the latter. Both crossing structures are to be demolished. A concrete slab bridge is to be constructed for the bridges. The width of Nong Soan Tho bridge is 4 m and designed for TL-14. The new bridge of Phong Sa Ath has the width of 2 m. The bridge is good for pedestrian and motor cycle.

8.3 The Principal Features of the System for Sub-area I

The System for Sub-area I comprises a channel improvement, a retarding basin and an inspection road. The woks incidental to the drainage improvement are two bridges and culvert to cross the inspection road. The principal features of the system are presented below;

Design water level:

The Hong Xeng	El. 166.9 m
Nong Bon retarding basin (FWL)	El. 167.5 m
Nong Bon retarding basin (LWL)	El. 166.5 m

The Hong Kai Keo canal:

Design discharge (Downstream)	20.2 m^3/s
Design discharge (Upstream)	23.5 m^3/s
Length	1,300 m
Bed slope	1 : 1,300
Width (channel bed)	6 m

Bank slope		1 : 2.5
Low flow channel (W x H m^2)		2.0 x 0.5 m^2
Nong Bon retarding basin		
Water surface area		50,000 m^2
Flood control space		50,000 m^3
Concrete weir crest el.		El. 167.0
Concrete weir length		20 m
Flush gate	Sluice	1 m x 1.5 m x 1 leaf
Stoplog width		4 m
Maintenance road		
Elevation		El. 168.0 m
Width		5 m
Pavement		Asphalt
Road crossing culvert		1 m x 1 m
Road crossing concrete pipe		Dia. 600 mm
Bridge		
Nong Soan Tha road	type	Concrete slab
	width	4 m
	load	TL-14
Phong Sa Ath road	type	Concrete slab
	width	2 m

8.4 Construction Plan and Cost Estimate for the System for Sub-area I

8.4.1 Construction Schedule

The civil works to be constructed under the Project are broadly divided into two categories; the drainage facilities and the retarding basin. The drainage facilities are further divided into two categories; the main drainages canal and the lateral canals. Main works for each category are Hong Kai Keo Main Drainage Canal of 1,270 m and Nong Bon Retarding Basin of 5 ha.

The schedule for the works are considered as follows;

(1) Project Schedule

The target data for completion of the System for Sub-area I is assumed to be the 24th month. Approximately, 2 years respectively would be required for the Hong Kai Keo system work from the commencement of Engineering detailed design to the completion of construction work. The necessary periods are summarized as follows;

a)	Engineering design including preparation of tender documents, and prequalification	:	6 months
b)	Tendering	:	6 months
c)	Main construction works	:	24 months

(2) Construction Work Schedule

Fig. 8.2 shows the proposed construction schedule of the System for Sub-area I. Major works scheduled in each year are described below.

<u>The First Year</u>

a) Signing of Exchange Notes
b) Selection and contract of consultant
c) Detailed design and preparation of tender document
d) Advertising
e) Prequalification
f) Tendering and evaluation of civil works

<u>The Second Year</u>

a) Award of main construction work contract and mobilization
b) Construction of temporary facilities for contractor use
c) Construction of access road and haul road
d) Care of water and dewatering
e) Fascine hurdle with sand bags (coffering)
f) Excavation, embankment and slope protection work of the Hong Kai Keo main drainage canal
g) Excavation and concrete work of lateral canal for area I

The Third Year

a) Care of water and dewatering
b) Fascine hurdle with sand bags (coffering)
c) Excavation and concrete work of lateral canal
d) Excavation, embankment and slope protection work of the Nong Bon retarding basin
e) Finishing works

8.4.2 Construction Method

(1) Main Drainage Facilities

The construction of the Hong Kai Keo main drainage canal will be started at after completion of access road. Excavated soil will be conveyed by dump trucks and partly by utilized for embankment. the rest of them will be deposited into the old channel (short cut portion), which has an enough capacity to receive the soil from excavation.

The construction of the main drainage facilities will be mainly executed during the dry season when water level of the existing drainage canal is low. Care of water and dewatering will be carried out firstly and this will be immediately followed by a temporary fascine hurdle with sand bags (coffering) construction, then excavation, embankment, slope trimming and slope protection works will follow thereafter.

Earth works for main drainage canals will be carried out mainly by a back hoe and bulldozers. Excavation of high water canal will be conducted by combination of swamp type bulldozers and/or Amphibious excavators. The trimming of canal side slopes will be made by back hoes or manual labors. The compaction for canal embankment will be carried out by vibration rollers after conditioning the fill materials to have a moisture content in the required range. The embankment materials will be obtained from suitable excavated materials in drainage canals, and/or the extracted from borrow-pits.

Stone or concrete block masonry works will be conducted by manual power mainly.

Revetment and sod facing works are also carried out by manual power mainly.

Bank protection work and structures with wet masonry will be carried out using a portable type concrete mixer as the supporting equipment to the manual construction.

(2) Lateral Canal

The construction of lateral canal improvement will be carried out divided into several stages of the construction section in order to secure the drainage system during construction.

Based on the run-off discharge to the drainage canal and economical point of view, it is planned that the lateral canal improvement works should be carried out by the stepwise construction taking account of the site conditions. The works will be executed by two to three crews in a parallel way.

Excavation will be carried out by a back hoe and dump trucks for hauling works.

A portable type of concrete mixer will be provided for the small quantity of concrete of the lateral canal improvement works.

(3) Nong Bon Retarding Basin

The regarding basin construction works will be carried out by the stepwise construction in accordance with the site condition providing the partial coffering method using fascine hurdle with sand bags. The works will be executed by two to three crew in a parallel way.

The coffering material will be shifted to the next step construction.

The construction woks will be concentrated to the retarding basin in the dry season.

Excavation of high water portion will be conducted by the combination of a swamp type bulldozer, an amphibious excavators and dump trucks under the dry condition to be secured by partial coffering.

Fascine hurdle with sand bags for coffering will be provided mainly by manual power.

Excavated material will be disposed to the spoil bank by dump trucks.

The trimming of side slopes will be made by back hoe or manual labor. The compaction for embankment will be carried out by a vibration roller after conditioning the fill materials to have a moisture content in the required range. The embankment materials will be obtained from the suitable excavated materials in canals, and/or the extracted from borrow-pits.

Stone or concrete block masonry works will be conducted by manual power mainly.

Revetment and sod facing works are also carried out by manual power mainly.

(4) Metal Works

The installation of gate, screen and its accessories will be conducted in later stage of civil construction works.

Installation will be conducted mainly by manual power. Truck crane will be utilized as the supporting equipment to manual work for installation of gates, screens and accessories.

(5) Crossing Facilities

There are crossing utilities in the Vientiane city Intercepter such as power lines, water supply pipes and telephone lines.

Those facilities are planned to be replaced following to drainage canal works.

Required works for renewal will be conducted by the nominated contractors of each agencies.

8.4.3 Cost Estimate

The main works of the Hong Kai Keo system are excavation and embankment of earth, concrete block for the revetment works, concrete works for culvert and weir, sod facing for the bank protection and the constructions of bridges. Meanwhile the main construction works for the improvement of the lateral canals are excavation of earth and concrete works. The work volumes thereof are estimated as summarized below;

(1) Main Canal and Retarding Basin

Excavation	101,700 m^3
Embankment	8,600 m^3
Concrete block	6,800 m^2
Concrete works	1,210 m^3
Gate	1 set
Sod facing	30,000 m^2
Stone masonry	1,220 m^3
Bridge (Concrete slab)	2 nos
Concrete Pile	570 m
Reinforcement bar	46 ton
Asphalt pavement	55,340 m^2
Laterite pavement	2,600 m^2

(2) Lateral Canal

Excavation	43,120 m^3
Concrete	8,000 m^3

The estimated unit prices as described in Part 1 is applied to the work volume estimated and the direct cost is estimated.

In addition to this, indirect costs are estimated. Indirect costs comprise the land acquisition cost, engineering service cost and government's

administration cost including the operation, maintenance and repair costs. The land acquisition cost or the compensation costs were estimated on the basis of the area for the right-of-way and the unit price of land. The engineering service cost and the government's administration cost are estimated on man-month basis to cover the costs of supervisions and management of the Project.

The financial costs thus estimated are summarized as follows;

Item	Foreign (¥1,000)	Foreign (US$1,000)	Total (Equivalent) (US$1,000)
(1) Direct Cost			
a) Hong Kai Keo canal	70,675	621	1,122
b) Nong Bon retarding basin	71,903	390	899
(Main works sub total)	142,578	1,011	2,021
b) Lateral canal	158,343	996	2,119
(Direct cost total)	300,921	2,007	4,140
(2) Indirect Cost			
a) Land acquisition	-	-	-
b) Government's administration	-	96	96
c) Engineering service	57,163	70	475
d) O&M equipment	-	334	334
(Indirect cost total)	57,163	500	905
(3) Physical contingency	30,092	200	413
(4) Grand total	388,176	2,707	5,458

(Current price as of October 1989)

8.5 Economic Evaluation

8.5.1 Conditions Adopted in the Evaluation

Several conditions are employed in this economic evaluation. the time basis for the estimations of benefit and cost are set at October 1989. The foreign exchange rate adopted are as follows;

Japanese Yen 100 = Kip 418 = US$ 0.709

In other word, US$1.0 is equivalent to Kip 590 or Yen 141.

The project life is assumed to be 50 year. The OMR cost after 2020 is assumed to be the same with that at present. The benefit after 2020 is assumed to increase in accordance with the growth of GRDP. The peak outflow from the Hong Kai Keo to the Hong Xeng may increase as a consequence of the improvement. However the increase is minimized through the provision of Nong Bon retarding basin with a regulating space of 50,000 m^3. Further the paddy fields with an area of 400 ha located along the Hong Xeng and the Hong Kai Keo have regulating functions. In this consequence, the adverse effect of the improvement to the Hong Xeng is considered to be insignificant.

8.5.2 Economic Benefit of the Drainage Improvement

The study on the inundation damage in the study area yielded the following proportions of damage by the magnitudes of storms. Where the estimated damage to be incurred by 10-year storm is assumed 100;

2-year storm	21
5-year storm	86
10-year storm	106
20-year storm	114
50-year storm	133

Since the main drainage is to be improved with the design discharge by 10-year storm and lateral drainage by 2-year storm, the damage reduction

thereby is not always 100%. The analysis of the field survey yielded the following rates of damage reduction;

2-year storm	100%
5-year storm	72%
10-year storm	48%
20-year storm	38%
50-year storm	25%

The figure indicates that if a 5-year storm occurs, 72% of potential damage is reduced but 28% of damage may remain.

According to the results of the damage analysis, a small storm, smaller than 2-year storm which bring about inundation damage to the area occurs 4 times a year on an average. The average damage incurred thereby is estimated to be 5% of one by 10-year storm.

The possible benefit of the drainage improvement is obtained as the expectation of the total damage reduction. the estimated average annual benefits by area and by year are presented in Table 2.14 up to the year 2040. The benefit of the Hong Kai Keo system is obtained by the benefit of the Sub-area I.

The project is assumed to yield benefit after the completion of the main works. The damage reductions in the areas lower than El. 168.0 m should be smaller than that in the areas above El. 168.0 m. The damage reduction thereof is assumed to be 20% of that in the area above El. 168.0 m.

8.5.3 Economic Cost of Drainage Improvement

The economic cost is estimated on the basis of the estimated financial cost. The methods adopted to the conversion are described below;

(1) Foreign currency portion: The import tax of 5% is deducted.
(2) Tradable goods: A conversion factor of 0.9 is applied.
(3) Labour cost: A shadow wage rate of 0.37 and a conversion factor of 0.9 are applied.

(4) Land acquisition cost for farm land: Production foregone is applied.

(5) Building: A conversion factor of 0.9 is applied.

(6) The direct cost for the improvement of lateral canals are estimated by applying the unit cost of US$24,000/ha to the urbanized area. The indirect cost is assumed to be 30% of the obtained direct cost.

(7) The OMR cost is estimated to be 1% of the construction cost.

The cost for the main works are presented in Table 8.1. The costs for the improvement of lateral are summarized in Table 6.4.

8.5.4 Economic Internal Rate of Return (EIRR)

A cash flow for the System for Sub-area I is prepared as shown in Table 8.2. The obtained EIRR is 3.5%.

CHAPTER 9. SYSTEM FOR SUB-AREA K

9.1 Drainage Plan

The area may be divided into three zones. The first is the hilly area located in the south of the Hong Xeng. This area is already urbanized and has rather steep slope. The storm water in the area is drained to the Hong Xeng. Since the area is fairly sloped, no water stagnates in the area and inundation has not occurred. No significant increase in the flood discharge is foreseeable because the area is already urbanized. Along this line no special drainage improvement is considered for the area.

The second is the other hilly area located in the northern part of the Sub-area. The area has a certain slope and no water stagnation occurs. The storm water in the area is drained into the irrigation drainage canal which runs through the sub-area from north-east to south-west and joins the Hong Xeng at near Phon Kheng village. The flood from the hilly area has been accommodated in the irrigation canal without causing any difficulty. Since the area is already urbanized, no significant increase in the flood discharge from the area is foreseeable. Consequently no special drainage improvement is considered for the area.

The other is the area enclosed by the Hong Xeng, the irrigation drainage canal and the national highway route No. 13. The topography of this area is low and flat. Paddy cultivation is the main land use so far. The area is susceptible to inundation. The area of 30 ha is planned to be urbanized along the national highway route No. 13 by the year 2020. The improvement of lateral canals in this 30 ha is necessary.

The southern part of 30 ha may be drained by the canal along route 13 and finally discharged to the Hong Xeng at the just upstream from the bridge on route No. 13. Meanwhile the water from the northern part of the area is conveyed to the culvert which cross the route No. 13. The culverts are connected to the canals which joint to the Houei Makhiao.

The canals and culverts to be improved are 6 and 3 respectively. The locations of canals and culverts are shown in Fig. 9.1.

9.2 The Principal Features of the System for Sub-area K

The improvements of 6 canals and 3 culverts are proposed for the drainage system in the Sub-area K. the main features are summarized as follows;

Lateral No. 1

Design discharge	0.51 m^3/s
Length	310 m
Width	0.6 m
Slope	1 to 370

Lateral No. 2

Design discharge	0.68 m^3
Length	390 m
Width	0.8 m
Slope	1 to 670

Lateral No. 3

Design discharge	1.05 m^3/s
Length	270 m
Width	1.0 m
Slope	1 to 670

Lateral No. 4

Design discharge	0.39 m^3/s
Length	230 m
Width	0.7 m
Slope	1 to 670

Lateral No. 5

Design discharge	2.26 m^3/s
Length	230 m
Width	1.3 m
Slope	1 to 670

Lateral No. 6

Design discharge	0.26 m^3/s
Length	310 m
Width	0.6 m
Slope	1 to 670

Culvert No. 1

Design discharge	1.42 m^3/s
Length	20 m
Width	1.25 m
Height	1.25 m

Culvert No. 2

Design discharge	2.26 m^3/s
Length	20 m
Width	1.5 m
Height	1.5 m

Culvert No. 3

Design discharge	0.26 m^3/s
Length	20 m
Width	1.0 m
Height	1.0 m

9.3 Construction Plan and Cost Estimate

9.3.1 Construction Schedule

Main works for the drainage improvement in the Sub-area K is the improvement of the lateral canal for 1,800 m.

The construction schedule for the Sub-area K is 24 month as described below;

(1) Project Schedule

The target date for completion of the Sub-area K is assumed to be the 24th month. Approximately, 2 years respectively would be required for the System for Sub-area K from the commencement of engineering detailed design to the completion of construction work. The necessary periods are summarized as follows;

a)	Engineering design including preparation of tender documents, and prequalification	:	6 months
b)	Tendering	:	6 months
c)	Main construction works	:	24 months

The First Year

a) Signing of Exchange Notes
b) Selection and contract of consultant
c) Detailed design and preparation of tender documents
d) Advertising
e) Prequalification
f) Tendering and evaluation of civil works

The Second Year

a) Care of water and dewatering
b) Fascine hurdle with sand bags (coffering)
c) Excavation and concrete work of lateral canal
d) Excavation and concrete work of box culvert

The Third Year

a) Care of water and dewatering
b) Fascine hurdle with sand bags (coffering)
c) Excavation and concrete work of lateral canal and street inlet structure
d) Finishing works

The construction schedule is presented in Fig. 9.2.

9.3.2 Construction Method for Lateral Canal

The construction of lateral canal improvement will be carried out divided into several stages of the construction section in order to secure the drainage system during construction.

Based on the run-off discharge to the drainage canal and economical point of view, it is planned that the lateral canal improvement works should be carried out by the stepwise construction taking account of the site conditions. The works will be executed by two to three crews in a parallel way.

Excavation will be carried out by a back hoe and dump trucks for hauling works.

A portable type of concrete mixer will be provided for the small quantity of concrete of the lateral canal improvement works.

There are crossing utilities in the Vientiane city Intercepter such as power lines, water supply pipes and telephone lines.

Those facilities are planned to be replaced following to drainage canal works.

Required works for renewal will be conducted by the nominated contractors of each agencies.

9.3.3 Cost Estimate

The main construction works for the improvement of the drainage system in the area are the improvement of the lateral canals. The works are the excavation of earth and concrete works for canal lining and culvert. The installation of the pipe culverts the other substantial works. The work volumes thereof are estimated as summarized below;

Reinforcement bar	105 ton
Manhole cover	180 nos.

The estimated unit prices as described in Part I is applied to the work volume estimated and the direct cost is estimated.

In addition to this, indirect costs are estimated. Indirect costs comprise the land acquisition cost, engineering service cost and government's administration cost including the operation, maintenance and repair costs. The land acquisition cost or the compensation costs were estimated on the basis of the area for the right-of-way and the unit price of land. The engineering service cost and the government's administration cost are estimated on man-month basis to cover the costs of supervisions and management of the Project.

The financial costs thus estimated are summarized as follows;

Item	Foreign (¥1,000)	Foreign (US$1,000)	Total (Equivalent) (US$1,000)
(1) Direct Cost			
Lateral canal-1	37,797	207	475
Lateral canal-2	184,851	1,012	2,323
(Direct cost total)	222,648	1,219	2,798
(2) Indirect Cost			
a) Land acquisition	-	-	-
b) Government's administration	-	65	65
c) Engineering service	42,624	41	343
d) O&M equipment	-	224	224
(Indirect cost total)	42,624	330	632
(3) Physical contingency	22,265	122	280
(4) Grand total	287,537	1,671	3,710

(Current price as of October 1989)

9.4 Economic Evaluation

9.4.1 Conditions Adopted in the Evaluation

Several conditions are employed in this economic evaluation. the time basis for the estimations of benefit and cost are set at October 1989. The foreign exchange rate adopted are as follows;

Japanese Yen 100 = Kip 418 = US$ 0.709

In other words, US$1.0 is equivalent to Kip 590 or Yen 141.

The project life is assumed to be 50 year. The OMR cost after 2020 is assumed to be the same with that at present. The benefit after 2020 is assumed to increase in accordance with the growth of GRDP. The improvements of the lateral canals may increase the peak outflow. However the discharge from this 30 ha is assumed to be absorbed in the surrounding paddy fields. Consequently the adverse effect due to the proposed improvement is supposed to be insignificant.

9.4.2 Economic Benefit of the Drainage Improvement

The study on the inundation damage in the study area yielded the following proportions of damage by the magnitudes of storms. Where the estimated damage to be incurred by 10-year storm is assumed 100;

2-year storm	21
5-year storm	86
10-year storm	106
20-year storm	114
50-year storm	133

Since the main drainage is to be improved with the design discharge by 10-year storm and lateral drainage by 2-year storm, the damage reduction thereby is not always 100%. The analysis of the field survey yielded the following rates of damage reduction;

2-year storm	100%
5-year storm	72%
10-year storm	48%
20-year storm	38%
50-year storm	25%

The figure indicates that if a 5-year storm occurs, 72% of potential damage is reduced but 28% of damage may remain.

According to the results of the damage analysis, a small storm, smaller than 2-year storm which bring about inundation damage to the area occurs 4 times a year on an average. The average damage incurred thereby is estimated to be 5% of one by 10-year storm.

The possible benefit of the drainage improvement is obtained as the expectation of the total damage reduction. The estimated average annual benefits by area and by year are presented in Table 9.1 up to the year 2040. The benefit of the Hong Ke system is obtained by the benefit of the Sub-area K.

The project is assumed to yield benefit after the completion of the main works. The damage reductions in the areas lower than El. 168.0 m should be smaller than that in the areas above El. 168.0 m. The damage reduction thereof is assumed to be 20% of that in the area above El. 168.0 m.

9.4.3 Economic Cost of Drainage Improvement

The economic cost is estimated on the basis of the estimated financial cost. The methods adopted to the conversion are described below;

(1) Foreign currency portion: The import tax of 5% is deducted.
(2) Tradable goods: A conversion factor of 0.9 is applied.
(3) Labour cost: A shadow wage rate of 0.37 and a conversion factor of 0.9 are applied.
(4) Land acquisition cost for farm land: Production foregone is applied.
(5) Building: A conversion factor of 0.9 is applied.

(6) The direct cost for the improvement of lateral canals are estimated by applying the unit cost of US$24,000/ha to the urbanized area. The indirect cost is assumed to be 30% of the obtained direct cost.

(7) The OMR cost is estimated to be 1% of the construction cost.

The costs for the main works are presented in Table 9.2. The costs for the improvement of lateral canal are summarized in Table 9.3.

9.4.4 Economic Internal Rate of Return (EIRR)

A cash flow for the drainage improvement in the Sub-area K system is prepared as shown in Table 9.4. The obtained EIRR is 3.5%.

PART IV.

IMPLEMENTATION PROGRAM AND RECOMMENDATIONS

PART IV. IMPLEMENTATION PROGRAM AND RECOMMENDATIONS

CHAPTER 10. IMPLEMENTATION PROGRAM

10.1 Priority of Whole Project

The economic internal rate of returns are estimated as follows;

Hong Ke system	: 7.3%
System for Sub-area L (Nam Pasak)	: 4.2%
System for Sub-area I (Hong Kai Keo)	: 3.5%
System for Sub-area K	: 3.5%

In view of other aspects such as environment, the highest priority of the Hong Ke system cannot be denied. The Nam Pasak system may follow the Hong Ke system. The economic priorities of Sub-area I and K are equivalent. The urbanization in the area along the national highway route No. 13 in the Sub-area K may precede to the urbanization of Sub-area I. In view of this, the improvement in Sub-area K is scheduled next to the System for Sub-area L. consequently the improvement of the Hong Kai Keo system come to the fourth adjacent to the improvement of Sub-area K.

As discussed in the Basic Plan in Part 2 of this report, the priority of Sub-areas J, O, M and N follow the four systems mentioned above. The improvements therein should be implemented in the fifth stage. The priority of Sub-areas A and B is the lowest. And the drainage systems therein may be improved in the last stage as sixth project.

10.2 Implementation Schedule

All the projects are assumed to be constructed under contract base. And the implementation comprises preconstruction works and construction works. Preconstruction work period comprises the engineering design of 6 months and tendering of 6 months. The actual construction is mainly carried out during the dry season. The period necessary for the construction depend on

the work volume. The constructions of the Hong Ke system, System for Sub-area L (Nam Pasak), Systems for Sub-areas J, O, M and L and Systems for Sub-areas A and B have rather large volume of earth works which are liable to be affected by rainfall and the periods for the constructions thereof are estimated to be 24 months. Meanwhile the constructions of the System for Sub-area I (Hong Kai Keo) and Sub-area K may be completed within 12 months.

The preconstruction works of the Hong Ke system may be commenced in the first year of the Master Plan period of 30 years. The actual constructions thereof are commenced in the second year and completed at the end of the third year. The detailed design for the System for Sub-area L may be carried out thereafter. The proposed implement program is scheduled as shown in Fig. 10.1. The whole project is completed by the end of 23 years.

10.3 Organization and Budgetary Allotment

The construction of the drainage system has been carried out by municipality of Vientiane. The works have been usually entrusted to a state owned construction company. However the projects might be constructed by contractor under contract base because the projects have considerable work volumes and are technically complicated. The state companies may join to the works forming joint venture with the contractors. As the implementing agency, the department should employ more staff to reinforce its administrative and technical abilities. An independent department may be established if it is necessary for the construction, operation, maintenance and repair. The required staff exclusive for construction, operation, maintenance and repair tentatively estimated as shown in Table 10.1.

The constructions of the identified six projects are allotted in 23 years as mentioned in the previous subsection. The investment thereto are disbursed in the period. In addition to the investment for the constructions of the projects, the investment is necessary for the lateral improvement in accordance with the improvement schedule. The budgetary arrangement is necessary for the OMR cost as the annual expenditure. The investment costs including O&M equipment cost except cost for O&M material, stuff and labour is estimated and summarized in Table 10.2 in line with the proposed implementation schedule. The investment costs at the time basis of October 1989 are summed up as follows;

Project implementation	US$51,964 x 10^3
Improvement of lateral	US$23,488 x 10^3
Total investment	US$75,452 x 10^3

The overall EIRR of the Basic Plan is estimated to be 6.0% as shown in Table 10.3.

CHAPTER 11. RECOMMENDATIONS

(1) The Hong Ke system attested to be economically viable and technically sound. With urbanization and intensification of the land use in the area, the inundation damage will increase remarkably. In view of this, implementation of the proposed Hong Ke system should be undertaken urgently.

(2) In order to make improvement of the main drainage system effective, the improvement of lateral canals is one of the most important works to be carried out by the Government of Lao P.D.R. The Municipality should accelerate the progress of this improvement work.

(3) Other related urban plans should be consistent with the proposed drainage improvement plans so that safety against inundation and enhancement of amenity contemplated in this Study can be secured.

(4) In order to realize the drainage master plan smoothly and effectively, the reinforcement of the executive agency and budgetary arrangement will be indispensable. The channels of communication with concerned agencies should be enhanced to achieve better coordination with other related plans.

(5) The water quality of the drainage water is poor due to the influx of domestic sewerage. The pollutant loads may increase with the growth in population and economic activities in the Study area. In order to secure the amenity for the local residents and to improve the sanitary condition, the water quality should be improved. In this connection, the introduction of sewerage systems and garbage collection and treatment system should be considered. Amongst these, garbage treatment is considered to be of the most urgent need.

(6) The continuous maintenance and cleaning of the proposed drainage canals will contribute to the improvement of the water quality. The siltings of the suspended solid should be trapped and removed periodically. The dilution of polluted water by introducing fresh water

from the Mekong and/or groundwater will be effective during the dry season. The artificial agitation of water by means of pumping will increase DO and be effective in improving water quality. These measures should be adopted as soon as convenient. In this connection the periodic monitoring of water quality is recommended, as well as the continuous data collection on storm rainfall and water levels by the instruments installed by the Study team.

(7) The drainage plan should be consistent with the development plan of the Houei Makhiao river basin, since the plan proposes the discharge of storm water to the Houei Makhiao. This river has large retarding spaces enough to accommodate the water without causing any significant adverse effect thereto. In this connection, data collection and recording should be commenced as soon as possible for hydrology, topography and socio-economy including water quality and environment.

(8) At present, the management of rivers is not integrated and no regulation have been enacted on the water right with regard to quality and quantity. The situation may cause institutional difficulty in the drainage management. It is recommended that the Government establishes an integrated institution and regulations for the improvement and OMR of drainage systems.

TABLES

Table 2.1 Net Material Product and Gross Domestic Product (In millions of kip; 1986 constant prices)

	1982	1983	1984	1985	1986	1987 /b
Agriculture and forestry	31,324	32,292	34,638	37,292	40,026	39,965
Industry	3,440	3,569	3,785	4,469	5,298	5,329
Construction	1,023	1,378	1,613	2,261	2,050	2,466
Transport and communication	575	642	687	725	741	920
Commerce	3,923	4,293	4,478	4,631	4,834	4,926
Other	344	357	378	447	530	533
Net Material Product	40,629	42,531	45,579	48,825	53,479	54,139
Depreciation	2,438	2,552	2,735	2,990	3,209	3,248
Government and other services	6,062	5,520	5,547	5,959	6,204	6,876
GDP	49,129	50,603	53,861	58,774	62,891	64,263
GDP deflator /a	20.2	35.8	48.2	71.4	100.0	103.8
GDP at current prices	9,910	18,130	25,959	41,969	62,891	66,699

/a IMF estimates.

/b Estimated on the basis of official growth rates (in 1987 prices).

Source: World Bank, 1988

Table 2.2 Gross Regional Domestic Product

Gross Regional Material Product of Government Sector

	GRMP (million kip)			Share	Growth Rate	
	1987	1988	1989	% (88)	87/88	88/89
Agriculture	13,494	17,889	19,690	83.7%	32.6%	10.1%
Industry	1,866	2,132	2,564	10.0%	14.3%	20.3%
Commerce	235	280	398	1.3%	19.1%	42.1%
Transportation & Communication	219	415	619	1.9%	89.5%	49.2%
Construction	407	440	488	2.1%	8.1%	10.9%
Others	186	213	256	1.0%	14.5%	20.2%
Total	16,407	21,369	24,015	100.0%	30.2%	12.4%

Estimated Gross Regional Domestic Product

	GRDP (million kip)			Share	Growth Rate	
	1987	1988	1989	% (88)	87/88	88/89
Agriculture	13,494	17,889	19,690	79.9%	32.6%	10.1%
Industry	2,195	2,508	3,016	11.2%	14.3%	20.3%
Commerce	783	933	1,327	4.2%	19.2%	42.2%
Transportation & Communication	219	415	619	1.9%	89.5%	49.2%
Construction	407	440	488	2.0%	8.1%	10.9%
Others	186	213	256	1.0%	14.5%	20.2%
Total	17,284	22,398	25,396	100.0%	29.6%	13.4%

* Share of private sector in whole GDP was estimated as below agriculture & industry 15%, commerce 70%, Other 0%.
** GMP of agriculture included product of private sector.
*** 1987 & 1988 actual, 1989 planned.

Source: Department Economic Planning and Finance of Vientiane Municipality

Table 2.3 GDP Projection from 1987 to 2020 (1986 Constant Price)

	1987	1990	1995	2000	2010	2020
HIGH GROWTH CASE						
GDP (Million kip)	64,263	86,400	141,299	231,207	619,049	1,657,479
GDP GROWTH RATE (%)		10.35%	10.35%	10.35%	10.35%	10.35%
POPULATION (1,000 persons)	3,757	4,093	4,722	5,448	7,251	9,650
PER CAPITA GDP (kip / person)	17,105	21,100	29,900	42,400	85,400	171,800
LOW GROWTH CASE						
GDP (Million kip)	64,263	77,300	100,500	133,900	249,400	497,000
GDP GROWTH RATE (%)		5.30%	5.40%	5.40%	6.00%	7.20%
POPULATION (1,000 persons)	3,757	4,016	4,402	4,825	5,645	6,426
PER CAPITA GDP (kip / person)	17,105	19,300	22,900	27,800	44,200	77,300

Table 2.4 Annual Maximum One-day Rainfall at Vientiane (1/2)

Year	Month	Day	[1]	[2]	[3]	[4]	Adopted one-day rainfall in mm	Remarks
1900	7	12				93	93.0	
1901	5	3				177	177.0	
1902	8	22				36	36.0	
1903	7	29				98	98.0	
1904	5	18				132	132.0	
1905	7	23				182	182.0	
1906	9	8				86	86.0	
1907	5	24				79	79.0	
1908	5	30				138	138.0	
1909	6	5				163	163.0	
1910	5	26				83	83.0	
1913	7	12				104	104.0	
1914	5	25	48.0			78	78.0	
1915	9	9				73	73.0	
1916	7	17				99	99.0	
1917	8	15				92	92.0	
1918	6	8				118	118.0	
1919	6	7				139	139.0	
1920	6	8	126.9			127	126.9	
1921	5	23				80	80.0	
1922	9	13	99.0			99	99.0	
1923	6	25		155.9		84	155.9	
1924	7	6		129.5		130	129.5	
1925	6	2		104.5		105	104.5	
1926	8	10				95	95.0	
1927	7	24		100.3		100	100.3	
1928	7	22				93	93.0	
1929	9	7				76	76.0	
1930	10	2		130.2		130	130.2	
1931	9	16	73.0			73	73.0	
1932	10	20	72.8			82	82.0	
1933	7	30	109.8	109.8		110	109.8	
1934	7	26	79.4	117.5		116	117.5	[1] lists the date as 7/28
1935	9	28	75.7			76	75.7	
1936	5	21	100.7	100.7		84	100.7	[2] lists the date as 5/29
1937	5	3	115.6	115.6		103	115.6	
1938	8	24	131.2	131.2		131	131.2	
1939	7	12	68.3			93	93.0	

Source:
[1] Nippon Koei for the United Nations, Comprehensive Project Feasibility Report on th Nam Ngun Project Part II: Lower Nam Ngun Irrigation Project, 1962
[2] Department of the Interior Bureau of Reclamation, Pa Mong Stage One Feasibility Report, 1970
[3] Mekong Committee, Lower Mekong Hydrologic Yearbook, respective volumes
[4] Department of Meteology and Hydrology, in-house data

Table 2.4 Annual Maximum One-day Rainfall at Vientiane (2/2)

Year	Month	Day	[1]	[2]	[3]	[4]	Adopted one-day rainfall in mm	Remarks
1940	8	20	87.7			88	87.7	
1941	8	11	105.5			106	105.5	
1949	7	30	81.8				81.8	
1950	8	5	80.7			81	80.7	
1951	10	23	73.2			73	73.2	
1952	9	17		130.0		130	130.0	
1953	9	6	101.4	101.4		101	101.4	
1954	8	15	106.7	106.7		107	106.7	
1955	7	30	132.9	132.9		133	132.9	
1956	8	2	101.3			101	101.3	
1957	7	5	80.5			85	80.5	
1958	6	26	92.5	138.7	92.5	93	92.5	[2] lists the date as 9/2
1959	9	2	138.7		138.7	139	138.7	(may be mistaken for 1959)
1960	9	27	109.8	109.8	109.8	110	109.8	
1961	6	3	111.7	111.7	111.7	112	111.7	[2] lists the date as 7/3
1962	5	18		100.2		100	100.2	
1963	6	3		106.6	106.6	107	106.6	
1964	9	6			91.1	91	91.1	
1965	9	13		112.0	112.0	112	112.0	
1966	8	13			110.5	111	110.5	
1967	9	20			137.3	137	137.3	
1968	7	23			93.1	93	93.1	
1969	7	11			134.8	135	134.8	
1970	8	17			116.3	116	116.3	
1971	5	5			84.7	85	84.7	
1972	4	12			75.9	76	75.9	
1973	5	28			96.2	96	96.2	
1974	4	16			133.5	134	133.5	
1975	6	19			94.0	94	94.0	
1976	8	26			224.2	224	224.2	
1977	6	20			95.4	95	95.4	
1978	9	16			82.7	83	82.7	
1979	5	24			81.2	81	81.2	
1980	7	24			86.8	87	86.8	
1981	7	20			181.0	181	181.0	
1982	8	10			133.2	133	133.2	
1983	9	10			115.0	80	115.0	
1984	8	18			73.9	74	73.9	
1985	0	12			82.2	82	82.2	
1986	9	25			119.7	120	119.7	
1987	6	1			162.0	162	162.0	

Source:
[1] Nippon Koei for the United Nations, Comprehensive Project Feasibility Report on th Nam Ngun Project Part II: Lower Nam Ngun Irrigation Project, 1962
[2] Department of the Interior Bureau of Reclamation, Pa Mong Stage One Feasibility Report, 1970
[3] Mekong Committee, Lower Mekong Hydrologic Yearbook, respective volumes
[4] Department of Meteology and Hydrology, in-house data

Table 2.5 Annual Maximum Discharges of the Mekong at Vientiane (1/2)

(Unit: cu.m/sec)

Year	Source [1]			Source [2]			Source [3]		Source [4]	Adopted
	Level	Discharge	Date	Level	Discharge	Date	Discharge	Date	Discharge	discharge
1913							17,300	8-24	17,400	17,400
1914							18,400	9-14	19,000	19,000
1915							13,900	8-23	13,900	13,900
1916							12,300	9-13	12,300	12,300
1917							19,000	8-12	20,000	20,000
1918							18,100	8-16	18,400	18,400
1919									14,200	14,200
1920							12,600	9-21	12,600	12,600
1921							16,800	10-03	16,900	16,900
1922							18,300	8-31	18,800	18,800
1923				169.98	19,300	8-22	19,300	8-22	20,600	20,600
1924				170.70	21,400	8-29	21,200	8-29	25,600	25,600
1925				167.76	13,600	8-01	14,000	8-01	14,000	14,000
1926				169.33	17,600	8-20	17,700	8-20	17,900	17,900
1927				169.26	17,400	8-02	17,500	8-02	17,700	17,700
1928				168.42	15,200	7-20	15,500	7-20	15,500	15,500
1929				170.46	20,700	8-23	20,500	8-23	23,500	23,500
1930				169.52	18,100	8-13	18,100	8-13	18,400	18,400
1931				168.56	15,600	9-19	15,800	8-19	15,800	15,800
1932				168.04	14,300	8-11	14,900	10-17	14,900	14,900
1933				168.78	16,100	8-26	16,300	8-26	16,300	16,300
1934				167.96	14,100	8-27	14,900	8-27	14,900	14,900
1935				169.30	17,500	8-16	17,600	8-16	17,800	17,800
1936				169.08	16,900	9-13	17,000	8-13	17,100	17,100
1937				169.18	17,200	9-08	17,300	9-08	17,400	17,400
1938				169.60	18,300	8-28	18,300	8-28	18,800	18,800
1939				169.90	19,100	8-22	19,100	8-22	20,200	20,200
1940							17,900	8-09	17,900	17,900
1941							19,400	8-13	20,900	20,900
1942				170.30	20,200	8-13	20,100	8-13	22,600	22,600
1943				168.53	15,500	8-26	15,800	8-26	15,800	15,800
1944				167.87	13,900	9-02	14,300	9-02	14,300	14,300
1945							20,300	8-21	23,000	23,000
1946							19,400	9-18	20,900	20,900
1947				169.52	18,100	8-13	18,100	8-14	18,400	18,400
1948				168.58	15,600	10-02	15,600	9-07	15,600	15,600
1949				168.08	14,400	10-01	14,800	10-01	14,800	14,800
1950				168.27	14,900	9-05	15,200	9-05	15,200	15,200
1951				168.78	16,100	8-25	16,300	8-25	16,300	16,300
1952				169.20	17,200	9-10	17,300	9-10	17,400	17,400
1953							14,100	8-29	14,100	14,100
1954							15,700	9-02	15,700	15,700
1955							18,000	9-05	18,300	18,300
1956							16,300	8-24	16,300	16,300
1957							11,300	10-02	11,300	11,300

Table 2.5 Annual Maximum Discharges of the Mekong at Vientiane (2/2)

(Unit: cu.m/sec)

Year	Source [1]			Source [2]			Source [3]		Source [4]	Adopted
	Level	Discharge	Date	Level	Discharge	Date	Discharge	Date	Discharge	discharge
1958							11,500	7-28	11,500	11,500
1959							17,600	8-30	18,300	18,300
1960							17,800	8-20	18,600	18,600
1961	169.21	18,300	9-10				17,900	9-10	18,800	18,800
1962	168.34	15,400	8-26				15,300	8-26	15,400	15,400
1963	168.51	15,800	8-11				15,700	8-11	15,800	15,800
1964	169.03	17,200	8-27				16,900	8-27	17,300	17,300
1965	167.18	12,800	10-31				12,800	10-31	13,000	13,000
1966	170.74	21,300	9-04				25,900	9-04	26,000	26,000
1967	167.21	12,900	8-24				12,400	8-24		12,900
1968	168.20	14,700	8-18				14,600	8-18		14,700
1969	169.92	19,100	8-20				18,800	8-21		19,100
1970	169.89	19,000	8-15							19,000
1971	170.55	22,900	8-22				23,000	8-22		23,000
1972	167.90	14,200	8-27							14,200
1973	169.72	19,700	8-29							19,700
1974	168.36	15,900	9-03							15,900
1975	168.80	16,400	9-05							16,400
1976	168.80	18,200	8-17							18,200
1977	167.94	14,400	8-02							14,400
1978	170.12	21,300	8-16							21,300
1979	168.24	15,200	9-16							15,200
1980	169.94	20,600	9-06							20,600
1981	168.76	16,600	8-08							16,600
1982	168.78	16,600	8-26							16,600
1983	168.01	14,600	8-08							14,600
1984	168.32	15,400	7-18							15,400
1985	169.54	17,100	9-02							17,100
1986	167.88	13,400	8-12							13,400

Source [1] Mekong Committee, Lower Mekong Hydrologic Yearbook.
[2] Water levels by Dept. of Meteology;
conversion to discharge by 1971 rating curve.
[3] U.S.A.I.D., Report on Vientiane Laos Flood Control Project, 1971.
[1966 and 1971 discharges are adjusted for overbank flow.]
[4] U.S.Depatment of the Interior, Bureau of Reclamation, Pa Mong
Appendix III, 1972. [All data above Gauge Height 11 m adjusted
for possible overbank flow]

Table 2.6 Results of Water Level Hearing Survey of Main Canal

Sample No.	Description of the sample	Lived here since:	Highest water level in last 5 years (El. m)
1) Khoua Khao at Gate to Mekong (Point 1)			
	(Date: 3 November, 1989)		
1	Public servant	1983	168.6
2	Farmer	1976	168.7
3	Public servant	1981	168.8
4	Public servant	1984	168.8
5	Rice cultivation	1960	168.9
Adopted HWL for Point 8			168.8
2) Hong Thong at Gas Station (Point 3)			
	(Date: 2 November, 1989)		
1	Mechanic near the river	1950	168.4
2	Officer	1954	168.3
3	Rice cultivation	1940	168.3
4	Rice cultivation	1940	168.3
5	Officer	1952	168.2
Adopted HWL for Point 8			168.5
3) Nam Pasak at Wat Khao Vieng (Point 4)			
	(Date: 2 November, 1989)		
1	Monk at Khao Vieng	1981	168.0
2	Public servant	1950	168.0
3	Monk at Khao Vieng	1985	168.1
Adopted HWL for Point 8			168.1
4) Hong Ke at Ban Fay Bridge (Point 5)			
	(Date: 2 November, 1989)		
1	Unemployed	1953	168.2
2	Rice cultivation	1945	168.2
3	Unemployed	1943	168.2
4	Public servant	1944	168.4
Adopted HWL for Point 8			168.4
6) That Luang at outlet of drainage canal (Point 11)			
	(Date: 9 June, 1989)		
1	Farmer	1979	165.2
2	Remedy physician	1976	165.2
3	Farmer	1977	165.4
4	Cigarette factory worker	1979	165.0
5	Farmer	1973	165.3
6	Farmer	1950	165.0
7	Officer at irrigation dept.	1986	165.2
8	Officer at irrigation dept.	1930	165.2
9	Farmer	1960	165.2
10	Farmer	1970	165.3
Adopted HWL for Point 11			165.5
7) Hong Xeng at Dong Deng bridge (Point 8)			
	(Date: 26 October, 1989)		
1	Farming near the river	1983	167.5
2	Farming near the river	1945	167.4
3	Farming near the river	1950	167.3
4	Rice cultivation nearby	1980	167.5
5	Staff of Vientiane Prefecture	1980	167.4
6	Rice cultivation	1986	167.5
7	Farming nearby	1970	167.4
8	Farming nearby	1983	167.3
9	Unemployed	1986	167.3
Adopted HWL for Point 8			167.5

Table 2.7 Vientiane Urban Plan

Mark	Area	Use	Development Method
UAa	Center	Administrative/Business	Reconstruction
UAb	Center	Business	Intensification
UAc	Center	Residential	Intensification
UBa	Peripheral of Center	- (Mixed)	Reconstruction
UBc	Peripheral of Center	- (Mixed)	Intensification
UC	Riverline	Residential	Reconstruction
UD	Suburb	Residential	Intens. and Reconst.
UE	Expansion area	- (Mixed)	-
UEa	Expansion area	Residential	Intensification
UEb	Expansion area	Residential	Intensification
UEc	Expansion area	Residential	Intensification
UF	Isolated area	Residential	Not specified
D	Stockyard	Warehouse	-
I	Industrial area	Factory	-
E	Large scale facility	- (Mixed)	-
T	Transportation area	Factory	-
NE	Special scenery	Factory	No development
NA	Agricultural/Natural	Factory	No development
NF	Paddy field (Reserve)	Factory	No development

Table 2.8 Land Use by Sub-area

Year: 1989 Unit: ha

Sub-area	Residential	Public & Commercial	Industrial	Water	Green	Other	Total
A	60.3		10.8	83.7	295.2		450.0
B	403.3	50.3	3.8		293.6		751.0
C	123.9	36.3		8.2	27.6		196.0
D	111.3	14.1	0.4		118.2		244.0
E	78.0	28.2		5.0	33.8		145.0
F	101.4	4.7		2.0	16.9		125.0
G	27.5	1.1		7.0	19.5		55.1
H	72.8	88.8	0.4	2.8	23.2		188.0
I	88.4	50.4			137.2		276.0
J	160.9	3.9		10.2	137.0		312.0
K	63.2	23.3	2.7	7.4	137.4		234.0
L	161.7	23.2	1.8	7.0	20.0		213.7
M	367.5	44.6	5.0	24.0	233.0	104.8	778.9
N	214.9		9.7	9.0	910.8	244.6	1,389.0
O	18.4				21.6		40.0
P	79.5	30.3		0.4	43.8		154.0
Q	31.4	1.4	3.6		30.5		66.9
Total	2,164.4	400.6	38.2	166.7	2,499.3	349.4	5,618.6

Year: 2020 Unit: ha

Sub-area	Residential	Public & Commercial	Industrial	Water	Green	Other	Total
A	273.2		14.8	35.1	126.9		450.0
B	411.6	50.3	41.3		247.8		751.0
C	113.9	61.1	0.7	12.5	7.8		196.0
D	202.0	19.0	9.0		14.0		244.0
E	88.0	33.3		3.4	20.3		145.0
F	118.3	4.7		2.0			125.0
G	7.1	22.0		11.3	14.7		55.1
H	37.0	130.2	2.0		18.8		188.0
I	141.8	82.2			52.0		276.0
J	188.8	26.1		1.8	95.3		312.0
K	128.1	23.3	7.1	7.6	67.9		234.0
L	130.3	47.1	9.3	7.0	20.0		213.7
M	364.2	47.4	5.5	24.0	233.0	104.8	778.9
N	251.8		9.7	11.4	831.8	284.3	1,389.0
O	35.6				4.4		40.0
P	125.0	26.1	2.5	0.4			154.0
Q	41.6	2.3	5.5		17.5		66.9
Total	2,658.3	575.1	107.4	116.5	1,772.2	389.1	5,618.6

Table 2.9 List of Fish, Water Plant and Water Use

Date ; 26/9/1989

Location No.	Fish	Water Plant	Water Use	
1	A,B,C,D,G,H	B,C,E,I	A	X
2	A,B,C,D,E,F,G,H,U,Z	B,C,E	A	X
3	A,B,C,D,G,H,J,Q	–	AA,B	
4	A,B,C,D,F,H	–	A	
5	A,B,C,D,E,F,G,H	A,B,C,D,E	A,B	
6	A,B,E,F,M	A,B,C	C	
7	H	–	–	
8	A,D,M	B	A	
9	H	–	–	
10	Unknown	–	–	
11	A,C,G,I,J,K,L	B,C,F	AA	X
12	A,B,D,E,F,K,R	–	AA,B	X
13	A,B,C,D,H	A,B,F	A,D	
14	A,E,F,M	G	A,C	
15	A,E,F,M	A,B,G	A,C	
16	H,P,Q	–	–	
17	C,E,H,M	B,C	AA,B,E	X
18	A,B,C,G,H,N	B,C,E,H	A	
19	A,B,C,D,J,K,L,Q,R,S,t,U,V,W,X,Y,Z	B,C,F	AA,E	X
20	A,B,C,D,E,F,G,H,K,L,O,	B,C,E	AA	

Name of Fish

A;Pa Ko
B;Pa Douk
C;Pa Keng
D;Pa Kadout
E;Pa Ninh(Tilapia)
F;Pa Nai(Common Carp)
G;Pa Khao Mong
H;P Sieu
I;Pa Ka
J;Pa Lot
K;Pa Kot
L;Pa Kagnen
M;Pa Salit
N;Yen
O;Pa Pak
P;Pa Kat
Q;Pa Mat
R;Pa Sou
S;Pa Meo

Name of Fish

T;Pa Soua
U;Pa sathong
V;Pa It
W;Pa Kiang
X;Pa Tiok
Y;P khap khong
Z;Pa Sieu Ao

Name of Water Plant

A;Phak Bong(Ipomoea)
B;Phak Top (Eichhornia)
C;Phak Chok (Pistia)
D;Ne(Hydrilla)
E;Ne(Ceratophyllum)
F;Boualuang(Nelumbo)
G;Kolokasia((Colocasia)
H;Chok Noi(Salvinia)
I;Phak Beyen(Jussiaea)

Kind of Water Use

AA; Fishing(Active)
A; Fishing
B; Irregation
C; Cultivation
D; Washing
E; Bathing (on 26.9)
X; Bathing (observed on the other day)

Table 2.10 Assessment of Water Quality

Sampling Point	Class	Fauna species	Water and Water surface Utilization	Note
1	E	6	Fishing	
2	C	10	Fishing	
3	C(D)	8	Fishing(Active), Irrigation	Hong Ke
4	D	6	Fishing	
5	D	8	Fishing, Irrigation	
6	E	5	Cultivation	
7	D	1	-	
8	E	3	Fishing	
9	E	1	-	
10	E	1	-	
11	E(C)	7	Fishing(Active)	Nong Nieng
12	C(C)	7	Fishing (Active), Irrigation	Hong Xeng
13	C	5	Fishing, Washing	
14	E	4	Fishing, Cultivation	
15	D	4	Fishing, Cultivation	
16	E	3	-	
17	D	4	Fishing(Active), Irrigation, Bathing	
18	C	6	Fishing	
19	D	17	Fishing(Active), Bathing	
20	C	11	Fishing(Active)	
Houa Khoua	D	-	-	
Salakham	D	-	-	
Kaolico	A	-	-	

Table 2.11 Comparison of Unit Price

(1 USS = J.Yen 141)

Description	Unit	Suburbs Project			Tha Ngon			Contractor			Assumed		
		F.C. ($)	L.C. ($)	Total ($)	F.C. ($)	L.C. ($)	Total ($)	F.C. ($)	L.C. ($)	Total ($)	F.C. ($)	L.C. ($)	Total ($)
Excavation	m3	1.58	0.04	1.62	2.64	0.70	3.34			3.50	3.41	0.09	3.50
Embankment	m3	4.66	0.19	4.85	1.46	1.66	3.12			5.00	4.80	0.20	5.00
Concrete	m3	88.19	15.20	103.39	93.83	16.17	110.00			95.00	89.56	15.44	105.00
Form	m2	0.70	6.00	6.70	0.99	10.26	11.25			13.00	1.57	13.43	15.00
Reinforcement bar	ton	471.10	39.90	511.00	259.53	73.48	333.01			690.00	578.00	72.00	650.00
Sod facing	m2	1.41	0.04	1.45	0.55	2.00	2.55			-	2.43	0.07	2.50
Laterite Pavement	m3	4.58	0.12	4.70	2.77	3.19	5.96			-	5.85	0.15	6.00
Gravel pavement	m3			-			-			-	1.24	14.66	15.90
Asphalt pavement	m3			-			-			-	40.39	25.98	66.37
Stone masonry t=300 mm	m2			-			-			-	20.00	5.00	25.00
Concrete block masonry t=350 mm	m2			-			-			-	40.00	8.00	48.00
Road w=5,0, t=0,8	m			-			-			-	46.00	2.00	48.00
Bride	m2			-			-			-	1,200.0	220.0	1,420.0
Culvert 2 x 2	m			-			-			-	720.0	340.0	1,060.0
Concrete pipe Dia 800	m	139.79	8.55	148.34			-			-	128.0	105.0	233.0

(as of October 1989)

Table 2.12 Condition of Inundation Damage

Survey Area	Sub-area	No. of Samples (households)	No. of Samples with Inudation Damage (households)	Frequency of Inudation Damage in the Last Year (times)	Average Inudation Depth in the District (cm)	Maximum Inundation Depth in the District (cm)
1	C	21	19	1.48	45	80
2	C	4	3	0.25	20	80
3	C	-	-			
4	C	-	-			
5	C	10	10	3.1	51	50
6	H	13	13	2.25	43	80
7	H	8	8	1	41	50
8	H	38	31	10.5	53	500
9	L	20	20	2.75	75	160
10	G	44	44	7.31	65	150
11	H	18	18	3.61	48	200
12	H	16	16	5.21	64	300
13	H	18	18	3	25	50
14	H	12	8	0.58	84	50
15	L	17	17	12.8	36	50
16	L	14	10	2.21	63	150
17	L	19	11	0.05	13	70
18	L	18	8	15.2	7	20
19	L	10	9	0	41	80
20	L	17	6	0.23	17	70
21	L	26	23	6.61	30	50
22	L	13	13	1.92	29	50
23	L	7	7	0.85	27	50
24	L	-	-	-	-	
25	L	41	34	1.36	30	60
26	M	61	52	7.25	26	140
27	N	20	5	4.72	7	50
28	C	27	17	2.14	24	80
29	D	12	12	11.2	38	80
30	D	13	13	0	33	50
31	A	14	14	0.35	25	70
32	A	15	15	1.46	37	90
33	A	17	12	1.41	28	100
34	A	22	18	5.4	18	50
35	A	28	18	0.85	18	60
36	A	20	18	0.05	1	10
37	A	16	4	3	10	50
38	A	28	15	1.89	14	80
39	M	37	31	0.98	25	80
40	N	20	14	3.2	19	50
41	N	18	13	1.16	20	60
42	N	10		-	57	120
43	I, J	-		0	-	
44	D	4	2	0.75	5	10
45	D	9	9	1.11	28	50
46	P	28	20	2.21	24	70
47	I, J	12	11	7.75	26	50
48	I, J	18	11	4.16	12	50

Table 2.13 Economic Damage Potential for 10-year Storm (1/2)

Year : 1989

Unit: 1,000 Kip

Sub-area	House	Household Article	Shop & Factory	Public Facility	Traffic	Sales	Market	Wage	Daily Life	Health Condition	Crop	Sub-total	Other	Total
A	0	0	0	0	0	0		0	0	0	1,144	1,144	114	1,258
B	7,296	4,104	1,365	47	33	382	175	19	1	327	2,768	16,517	1,652	18,169
C	4,352	2,448	810	11	19	227		11	1	195	0	8,074	807	8,881
D	11,168	6,282	2,100	36	50	588		29	2	501	1,052	21,808	2,181	23,989
E	7,578	4,809	3,018	22	29	723		23	1	391	443	17,037	1,704	18,741
F	2,304	1,296	435	4	10	122		6	0	103	50	4,330	433	4,763
G	9,792	5,508	1,830	15	44	512	414	25	1	439	0	18,580	1,858	20,438
H	31,024	22,008	19,044	34	100	4,327	972	107	5	1,821	0	79,442	7,944	87,386
I	4,370	3,795	4,692	11	8	1,019		19	1	322	1,746	15,983	1,598	17,581
J	8,224	4,626	1,545	55	37	432		21	1	369	786	16,096	1,610	17,706
K	984	600	303	3	4	75	73	3	0	49	967	3,061	306	3,367
L	4,256	2,394	795	11	19	223		11	1	191	0	7,901	790	8,691
M	20,544	11,556	3,855	49	92	1,079	97	53	3	921	3,342	41,591	4,159	45,750
N	5,000	6,500	1,500	10	68	77	1,215	27	0	303	9,993	24,693	2,469	27,162
O	0	0	0	0	0	0		0	0	0	0	0	0	0
P	4,192	2,358	780	1	19	218	360	11	1	188	574	8,702	870	9,572
Q	0	0	0	0	0	0		0	0	0	0	0	0	0
Total	121,084	78,284	42,072	309	532	10,004	3,306	365	18	6,120	22,865	284,959	28,496	313,455

Table 2.13 Economic Damage Potential for 10-year Storm (2/2)

Year : 2020

Unit: 1,000 Kip

Sub-area	House	Household Article	Shop & Factory	Public Facility	Traffic	Sales	Market	Wage	Daily Life	Health Condition	Crop	Sub-total	Other	Total
A	0	0	0	0	0	0	0	0	0	0	18,066	18,066	1,807	19,873
B	348,000	196,000	65,200	509	9,625	18,253	1,897	891	49	15,595	23,248	679,267	67,927	747,194
C	70,296	39,592	13,203	115	1,939	3,696	0	180	10	3,150	0	132,181	13,218	145,399
D	527,177	307,659	129,930	393	14,013	34,016	0	1,414	76	24,638	1,922	1,041,238	104,124	1,145,362
E	261,193	170,491	116,548	238	6,007	27,495	0	809	40	13,910	2,890	599,621	59,962	659,583
F	69,600	39,200	13,040	38	1,927	3,651	0	178	1	3,119	0	130,754	13,075	143,829
G	144,550	125,650	155,120	159	1,691	33,716	4,499	635	27	10,650	0	476,697	47,670	524,367
H	451,725	320,775	276,690	369	9,032	62,895	#####	1,554	74	26,502	0	1,160,179	116,018	1,276,197
I	652,331	463,841	401,184	115	13,009	91,158	0	2,248	106	38,329	7,403	1,669,724	166,972	1,836,696
J	418,607	265,469	164,462	594	10,025	39,522	0	1,250	63	21,561	3,915	925,468	92,547	1,018,015
K	331,605	195,487	87,194	29	8,718	22,503	792	901	48	15,683	0	662,960	66,296	729,256
L	147,028	127,804	157,890	124	1,723	34,318	0	646	27	10,833	0	480,393	48,039	528,432
M	416,904	234,808	78,077	532	11,524	21,858	1,056	1,067	59	18,683	33,527	818,095	81,810	899,905
N	146,278	189,222	43,684	113	12,245	2,254	#####	788	15	8,824	100,154	516,781	51,678	568,459
O	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P	328,936	190,824	77,581	15	8,806	20,505	3,912	876	47	15,365	0	646,867	64,687	711,554
Q	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	4,314,230	2,866,822	######	3,343	110,284	415,840	#####	13,437	642	226,842	191,125	9,958,291	995,829	10,954,120

Table 2.14 Expected Benefit by Sub Area

US$1,000

	Sub-area	2020	2030	2040
Hong Ke System	C, E, F, G, H	1,996	5,117	13,429
Nam Pasak System	L	410	1,063	2,758
Sub Area I	I	310	556	996
Sub Area K	K	200	358	641
Sub Area M	M	532	1,806	6,133
Sub Area J	J	508	907	1,625
Sub Area D	D	330	712	1,539
Sub Area P	P	167	299	536
Sub Area A	A	15	25	46
Sub Area B	B	334	598	1,071

Table 3.1 Development Concept by Stretch

Stretch	Zoning for Drainage	Zoning for Environment	Development concept
Hong Ke (I)	Improvement	Urban green	Improvement of safety and development of green areas corresponding to the urbanization
Khoua Khao (II)	Retarding	Urban scenery	Generation of water space andn development of green areas and amenity water front
Hong Thong (III)	Retarding	Urban scenery	Generation of water space and development of green areas and amenity water front
Nam Pasak (IV)	Improvement	Reconstruction	Regional reconstruction and improvement of sanitary condition.
Nam Pasak (V)	Improvement	Reconstruction Urban green	Regional reconstruction and development
Nam Pasak (VI)	Retention	Rural green	Development of rural green areas coincide with rural area.
Hong Xeng (VII)	Improvement	Rural green	Development of rural green and fishery spots. Conservation of drainage and irrigation function
Wat Tai (VIII)	Retention	Rural green Urban green	Development of green areas coincide with rural area and development of scenery.
Souan Moan (IX)	Retention	Rural green	Development of green areas coincide with rural area.
Souan Moan (X)	Retention	Rural green	Development of green areas coincide with rural area.
Nong Chanh (XI)	Retarding	Urban scenery Water front recreation	Development of multipurpose retarding basin. Development recreation spot.
Nong Duang (XII)	Retarding	Urban green	Development of multipurpose retarding basin and of urban green area.
Nong Bong (XIII)	Retarding	Urban scenery	Creation of amenity water front.

Table 5.1 Summary of the Assessment of Alternative Plans

Alternative No.	Sanitary	Environment			Country Condition		Technical Problem			Equity	Adaptability	Land Use
		Scenery Views	Water Quality	Amenity	Material	Maintenance	Additional Function	Workability	Project Life			
1	B	C	B	B	A	A	C	A	A	A	C	B
2	B	C	C	C	C	B	A	B	B	B	B	A
3	A	B	A	B	B	C	A	B	B	A	C	B
4	A	A	A	A	B	B	A	B	B	B	A	A
5	A	B	A	B	C	C	A	B	B	B	A	A
6	A	A	A	A	C	C	A	C	C	B	A	B
7	C	A	C	A	B	C	A	B	B	B	C	C

A: Superior
B: Fare
C: Inferior

Table 6.1 Assessment of Facility Alternatives (1/2)

Item	Canal, Storage Pond and Retarding Basin				Revetment Works					Bridge					
	Canal (no storage)						Concrete block								
	Single section	Compound section	Storage pond	Retarding basin	No lining	Sod facing	2-D	3-D	Stone masonry	RC Slab	RC T-girder	Steel T-girder	Rigid frame	Steel truss	Wood
Water quality															
Purification function	No	Small	Small	Optical resolution	No	Biological	No	Lose	Biological	-	-	-	-	-	-
	(B)	(B)	(B)	(A)	(B)	(A)	(B)	(C)	(A)	(B)	(B)	(B)	(B)	(B)	(B)
Pollutant load	Decay	No	+ & -	Siltation	Erosion	Erosion	No	No	No	-	-	-	-	-	-
	(C)	(B)	(B)	(A)	(C)	(C)	(B)	(B)	(B)	(B)	(B)	(B)	(B)	(B)	(B)
Fauna	Difficult	Difficult	Difficult	Sufficient space	No	Preferable	Lose	Lose	Preferable	-	-	-	-	-	-
	(C)	(C)	(C)	(A)	(B)	(A)	(C)	(C)	(A)	(B)	(B)	(B)	(B)	(B)	(B)
Flora	Difficult	Sufficient space	Sufficient space	Sufficient space	Preferable	No	Lose	Lose	Preferable	-	-	-	-	-	-
	(C)	(A)	(A)	(A)	(A)	(B)	(C)	(C)	(A)	(B)	(B)	(B)	(B)	(B)	(B)
Maintenance flow	Consume	Require less	Require less	+ & -	Consume	Consume	No	Minimum	Consume	-	-	-	-	-	-
	(C)	(B)	(B)	(B)	(C)	(C)	(B)	(A)	(C)	(B)	(B)	(B)	(B)	(B)	(B)
Amenity															
Scenary view	Not attractive	Possible	Possible	Water surface	Rough	Green	No	Bad	Excellent	No	No	No	No	No	Not attractive
	(C)	(B)	(B)	(A)	(C)	(A)	(B)	(C)	(A)	(B)	(B)	(B)	(B)	(B)	(C)
Recreation opportunity	No	No	No	High	Provided	Provided	Almost none	None	Provided	No	No	No	No	No	No
	(B)	(B)	(B)	(A)	(A)	(A)	(B)	(C)	(A)	(B)	(B)	(B)	(B)	(B)	(B)
Air Temperature	No	No	No	Decrease	Decrease	Decrease	Increase	Increase	No	No	No	No	No	No	No
	(B)	(B)	(B)	(A)	(A)	(A)	(C)	(C)	(B)	(B)	(B)	(B)	(B)	(B)	(B)
Odor	Smell	No	Smell	No	-	-	-	-	-	-	-	-	-	-	-
	(C)	(B)	(B)	(B)	(B)	(B)	(B)	(B)	(B)	(B)	(B)	(B)	(B)	(B)	(B)
Sanitary															
Disease	Stagnation	Dry up	Dry up	No	Possible	Possible	No	None	No	-	-	-	-	-	-
	(C)	(A)	(A)	(B)	(C)	(C)	(B)	(A)	(B)	(B)	(B)	(B)	(B)	(B)	(B)
Coliform contamination	No	No	No	Multiplicate	-	-	-	-	-	-	-	-	-	-	-
	(B)	(B)	(B)	(C)	(B)	(B)	(B)	(B)	(B)	(B)	(B)	(B)	(B)	(B)	(B)
Dust	No	No	No	Absorption	Increase	No	No	No	No	-	-	-	-	-	-
	(B)	(B)	(B)	(A)	(C)	(B)	(B)	(B)	(B)	(B)	(B)	(B)	(B)	(B)	(B)
Garbage disposal	No	No	No	Hesitate	Liable	No	Obvious	Obvious	No	-	-	-	-	-	-
	(B)	(B)	(B)	(A)	(C)	(B)	(C)	(C)	(B)	(B)	(B)	(B)	(B)	(B)	(B)

Note :

No ; The effects of the facility are minor or negligible.

\- ; The effects of the facility are not conceivable.

\+ &- ; The effects of the facility are both positive and negative

Table 6.2 Assessment of Facility Alternatives (2/2)

Item	Gate, Free Overflow Weir and Pump				Inspection Road			Culvert		
	Sluice	Stop log	Free overflow Weir with gate	Pump with gate	Asphalt pavement	Laterite pavement	Gravel pavement	Box culvert	Pipe culvert	Corrugate pipe
Water quality										
Purification function	- (B)	- (B)	- (B)	- (B)	- (B)	- (B)	- (B)	- (B)	- (B)	- (B)
Pollutant load	Flush (A)	Residual (C)	Flush (A)	Flush (A)	No (B)	Erosion (C)	No (B)	- (B)	- (B)	- (B)
Fauna	Shut out (C)	Shut out (C)	Shut out (C)	Shut out (C)	- (B)	- (B)	- (B)	No (B)	Controled (C)	Controled (C)
Flora	Shut out (C)	Shut out (C)	Shut out (C)	Shut out (C)	- (B)	- (B)	- (B)	No (B)	Controled (C)	Controled (C)
Maintenance flow	No (B)	No (B)	No (B)	No (B)	- (B)	- (B)	- (B)	required (C)	Required less (B)	Required less (B)
Amenity										
Scenary view	No (B)	Not attractive (C)	Possible (A)	No (B)	Cleau (A)	No (B)	Attractive (A)	No (B)	No (B)	No (B)
Recreation opportunity	No (B)	No (B)	Possible (A)	No (B)	To be released (A)	Available (B)	Available (B)	- (B)	- (B)	- (B)
Air Temperature	- (B)	- (B)	- (B)	- (B)	Increse (C)	No (B)	No (B)	No (B)	No (B)	No (B)
Odor	- (B)	- (B)	- (B)	- (B)	- (B)	- (B)	- (B)	- (B)	- (B)	- (B)
Sanitary										
Disease	- (B)	- (B)	- (B)	- (B)	- (B)	- (B)	- (B)	- (B)	- (B)	- (B)
Coliform contamination	- (B)	- (B)	- (B)	- (B)	- (B)	- (B)	- (B)	- (B)	- (B)	- (B)
Dust	- (B)	- (B)	- (B)	- (B)	No (B)	Liable (C)	Liable (C)	- (B)	- (B)	- (B)
Garbage disposal	No (B)	Liable (B)	No (B)	No (B)	- (B)	- (B)	- (B)	Hesitate (A)	Hesitate (A)	Hesitate (A)

Note :

No ; The effects of the facility are minor or negligible.

\- ; The effects of the facility are not conceivable.

\+ &- ; The effects of the facility are both positive and negative

Table 6.3 Financial and Economic Cost of Main Work in Hong Ke System
(as of October,1989 price)

	Financial cost				Ecconomic cost		
	F.C. (J.Yen 1,000)	F.C. (US$1,000)	L.C. (US$1,000)	Total (US$1,000)	F.C. (US$1,000)	L.C. (US$1,000)	Total (US$1,000)
1. Direct cost total	704,253	4,995	3,896	8,891	4,630	2,803	7,433
2. Land acquisition cost	0	0	122	122		84	84
3. Government administrarion		0	226	226	0	203	203
4. Enginering service	134,805	956	136	1,092	1,009	136	1,145
5. Contingency	70,425	499	390	889	463	280	743
Total	909,483	6,450	4,747	11,197	6,102	3,506	9,608

Note: O&M equipment cost is excluded in the financial cost

Table 6.4 Economic Cost of Lateral Canal

Unit: US$10^3

	1992 - 2000	2000 - 2020
1. Hong Ke*1		
Target area (ha)	101	9
Annual financial cost	180	23
Annual economic cost	157	20
2. Nam Pasak		
Target area (ha)	29	0
Annual financial cost	111	0
Annual economic cost	97	0
3. Area I		
Target area (ha)	7	81
Annual financial cost	27	127
Annual economic cost	24	111
4. Area K		
Target area (ha)	33	74
Annual financial cost	90	115
Annual economic cost	78	110

*1 In 1991, the following cost is disbursed for construction of 3 km of the model lateral canal in Hong Ke area.

Financial cost	US$1,174 x 10^3
Economic cost	US$1,025 x 10^3

After 1993, the construction cost of remaining area are disbursed as shown in above table.

Table 6.5 Economic Cost and Benefit Stream of Hong Ke System

Unit US$1,000 EIRR = 7.3%

		Construction Cost							
		Main Canal		Lateral Canal		Total	O & M Cost	Benefit	Net Benefit
		F.C.	L.C.	F.C.	L.C.				
1	1991	496	228	0	0	724			-724
2	1992	2,781	1,720	591	434	5,526			-5,526
3	1993	2,825	1,558	90	66	4,587			-4,587
4	1994			90	66	156	111	97	-170
5	1995			90	66	156	113	121	-148
6	1996			90	66	156	115	148	-123
7	1997			90	66	156	117	180	-93
8	1998			90	66	156	119	216	-59
9	1999			90	66	156	120	258	-18
10	2000			11	8	19	121	306	166
11	2001			11	8	19	121	336	196
12	2002			11	8	19	121	369	229
13	2003			11	8	19	121	405	265
14	2004			11	8	19	121	445	305
15	2005			11	8	19	122	489	348
16	2006			11	8	19	122	537	396
17	2007			11	8	19	122	590	449
18	2008			11	8	19	122	648	507
19	2009			11	8	19	123	711	569
20	2010			11	8	19	123	781	639
21	2011			11	8	19	123	858	716
22	2012			11	8	19	123	943	801
23	2013			11	8	19	123	1,035	893
24	2014			11	8	19	124	1,137	994
25	2015			11	8	19	124	1,249	1,106
26	2016			11	8	19	124	1,372	1,229
27	2017			11	8	19	124	1,507	1,364
28	2018			11	8	19	125	1,655	1,511
29	2019			11	8	19	125	1,817	1,673
30	2020			0	0	0	125	1,996	1,871
31	2021			0	0	0	125	2,196	2,071
32	2022			0	0	0	125	2,415	2,290
33	2023			0	0	0	125	2,657	2,532
34	2024			0	0	0	125	2,922	2,797
35	2025			0	0	0	125	3,215	3,090
36	2026			0	0	0	125	3,536	3,411
37	2027			0	0	0	125	3,890	3,765
38	2028			0	0	0	125	4,279	4,154
39	2029			0	0	0	125	4,707	4,582
40	2030			0	0	0	125	5,177	5,052
41	2031			0	0	0	125	5,695	5,570
42	2032			0	0	0	125	6,265	6,140
43	2033			0	0	0	125	6,891	6,766
44	2034			0	0	0	125	7,580	7,455
45	2035			0	0	0	125	8,338	8,213
46	2036			0	0	0	125	9,172	9,047
47	2037			0	0	0	125	10,089	9,964
48	2038			0	0	0	125	11,098	10,973
49	2039			0	0	0	125	12,208	12,083
50	2040			0	0	0	125	13,429	13,304

Table 7.1 Financial and Economic Cost of Main Work in System for Sub-area L (Nam Pasak)
(as of October,1989 price)

	Financial cost				Ecconomic cost		
	F.C. (J.Yen 1,000)	F.C. (US$1,000)	L.C. (US$1,000)	Total (US$1000)	F.C. (US$1000)	L.C. (US$1000)	Total (US$1000)
1. Direct cost total	313,903	2,226	2,440	4,666	1,918	1,668	3,586
2. Land acquisition cost	0	0	226	226		203	203
3. Government administrarion		0	109	109	0	98	98
4. Enginering service	61,617	437	84	521	255	39	294
5. Contingency	31,390	223	244	467	192	167	359
Total	406,910	2,886	3,103	5,989	2,365	2,175	4,540

Note: O&M equipment cost is excluded in the financial cost

Table 7.2 Economic Cost and Benefit Stream of System for Sub-area L (Nam Pasak)

Unit US$1,000 EIRR = 4.2%

		Construction Cost							
		Main Canal		Lateral Canal		Total	O & M	Benefit	Net
		F.C.	L.C.	F.C.	L.C.		Cost		Benefit
1	1991	192	141	0	0	333			-333
2	1992	1,078	1,067	56	41	2,242			-2,242
3	1993	1,095	966	56	41	2,158			-2,158
4	1994			56	41	97	48	3	-142
5	1995			56	41	97	49	5	-141
6	1996			56	41	97	50	8	-139
7	1997			56	41	97	51	11	-137
8	1998			56	41	97	52	15	-134
9	1999			56	41	97	53	20	-130
10	2000			0	0	0	53	27	-26
11	2001			0	0	0	53	34	-19
12	2002			0	0	0	53	39	-14
13	2003			0	0	0	53	44	-9
14	2004			0	0	0	53	50	-3
15	2005			0	0	0	53	57	4
16	2006			0	0	0	53	65	12
17	2007			0	0	0	53	74	21
18	2008			0	0	0	53	85	32
19	2009			0	0	0	53	97	44
20	2010			0	0	0	53	110	57
21	2011			0	0	0	53	126	73
22	2012			0	0	0	53	143	90
23	2013			0	0	0	53	164	111
24	2014			0	0	0	53	186	133
25	2015			0	0	0	53	213	160
26	2016			0	0	0	53	242	189
27	2017			0	0	0	53	277	224
28	2018			0	0	0	53	315	262
29	2019			0	0	0	53	360	307
30	2020			0	0	0	53	410	357
31	2021			0	0	0	53	451	398
32	2022			0	0	0	53	496	443
33	2023			0	0	0	53	546	493
34	2024			0	0	0	53	601	548
35	2025			0	0	0	53	661	608
36	2026			0	0	0	53	727	674
37	2027			0	0	0	53	800	747
38	2028			0	0	0	53	880	827
39	2029			0	0	0	53	968	915
40	2030			0	0	0	53	1,065	1,012
41	2031			0	0	0	53	1,172	1,119
42	2032			0	0	0	53	1,289	1,236
43	2033			0	0	0	53	1,418	1,365
44	2034			0	0	0	53	1,560	1,507
45	2035			0	0	0	53	1,716	1,663
46	2036			0	0	0	53	1,888	1,835
47	2037			0	0	0	53	2,077	2,024
48	2038			0	0	0	53	2,285	2,232
49	2039			0	0	0	53	2,514	2,461
50	2040			0	0	0	53	2,765	2,712

Table 8.1 Financial and Economic Cost of Main Work in System for Sub-area I (Hong Kai Keo)
(as of October,1989 price)

	Financial cost				Ecconomic cost		
	F.C. (J.Yen 1,000)	F.C. (US$1,000)	L.C. (US$1,000)	Total (US$1,000)	F.C. (US$1,000)	L.C. (US$1,000)	Total (US$1,000)
1. Direct cost total	138,575	982	1,039	2,021	933	857	1,790
2. Land acquisition cost	0	0	25	25		11	11
3. Government administrarion		0	47	47	0	50	50
4. Enginering service	27,715	197	38	235	187	34	221
5. Contingency	13,858	98	104	202	93	86	179
Total	180,148	1,277	1,253	2,530	1,213	1,038	2,251

Note: O&M equipment cost is excluded in the financial cost

Table 8.2 Economic Cost and Benefit Stream of System for Sub-area I (Hong Kai Keo)

Unit US$1,000 EIRR = 3.5%

		Construction Cost							
		Main Canal		Lateral Canal		Total	O & M	Benefit	Net
		F.C.	L.C.	F.C.	L.C.		Cost		Benefit
1	1991	99	67	0	0	166			-166
2	1992	1,114	971	14	10	2,109			-2,109
3	1993	0	0	14	10	24	24	3	-45
4	1994			14	10	24	24	6	-42
5	1995			14	10	24	24	9	-39
6	1996			14	10	24	24	14	-34
7	1997			14	10	24	25	19	-30
8	1998			14	10	24	25	26	-23
9	1999			14	10	24	25	33	-16
10	2000			64	47	111	26	42	-95
11	2001			64	47	111	28	46	-93
12	2002			64	47	111	29	51	-89
13	2003			64	47	111	30	57	-84
14	2004			64	47	111	32	63	-80
15	2005			64	47	111	33	69	-75
16	2006			64	47	111	34	77	-68
17	2007			64	47	111	35	85	-61
18	2008			64	47	111	37	94	-54
19	2009			64	47	111	38	103	-46
20	2010			64	47	111	39	114	-36
21	2011			64	47	111	40	126	-25
22	2012			64	47	111	42	140	-13
23	2013			64	47	111	43	154	0
24	2014			64	47	111	44	170	15
25	2015			64	47	111	45	188	32
26	2016			64	47	111	47	208	50
27	2017			64	47	111	48	230	71
28	2018			64	47	111	49	254	94
29	2019			64	47	111	51	281	119
30	2020			0	0	0	51	310	259
31	2021			0	0	0	51	329	278
32	2022			0	0	0	51	349	298
33	2023			0	0	0	51	370	319
34	2024			0	0	0	51	392	341
35	2025			0	0	0	51	415	364
36	2026			0	0	0	51	440	389
37	2027			0	0	0	51	467	416
38	2028			0	0	0	51	495	444
39	2029			0	0	0	51	524	473
40	2030			0	0	0	51	556	505
41	2031			0	0	0	51	589	538
42	2032			0	0	0	51	625	574
43	2033			0	0	0	51	662	611
44	2034			0	0	0	51	702	651
45	2035			0	0	0	51	744	693
46	2036			0	0	0	51	789	738
47	2037			0	0	0	51	836	785
48	2038			0	0	0	51	886	835
49	2039			0	0	0	51	939	888
50	2040			0	0	0	51	996	945

Table 9.1 Financial and Economic Cost of Main Work System for Sub-area K
(as of October,1989 price)

	Financial cost				Ecconomic cost		
	F.C.		L.C.	Total	F.C.	L.C.	Total
	(J.Yen 1000)	(US$1000)	(US$1000)	(US$1000)	(US$1000)	(US$1000)	(US$1000)
1. Direct cost total	36,736	261	214	475	248	176	423
2. Land acquisition cost	0	0		0			0
3. Government administrarion		0	11	11	0	10	10
4. Enginering service	7,050	50	8	58	50	7	57
5. Contingency	3,674	26	22	48	25	18	42
Total	47,459	337	255	593	322	210	532

Note: O&M equipment cost is excluded in the financial cost

Table 9.2 Economic Cost and Benefit Stream System for Sub-area K

Unit US$1,000 EIRR = 3.5%

		Construction Cost							
		Main Canal		Lateral Canal		Total	O & M	Benefit	Net
		F.C.	L.C.	F.C.	L.C.		Cost		Benefit
1	1991	26	14	0	0	40			-40
2	1992	296	196	45	33	570			-570
3	1993	0	0	45	33	78	7	1	-85
4	1994			45	33	78	8	2	-84
5	1995			45	33	78	9	3	-84
6	1996			45	33	78	10	5	-83
7	1997			45	33	78	11	7	-82
8	1998			45	33	78	12	10	-80
9	1999			45	33	78	12	13	-78
10	2000			58	43	100	14	13	-101
11	2001			58	43	100	15	15	-100
12	2002			58	43	100	16	17	-99
13	2003			58	43	100	17	20	-98
14	2004			58	43	100	18	23	-96
15	2005			58	43	100	19	26	-94
16	2006			58	43	100	21	30	-91
17	2007			58	43	100	22	34	-88
18	2008			58	43	100	23	39	-84
19	2009			58	43	100	24	45	-79
20	2010			58	43	100	25	52	-74
21	2011			58	43	100	26	59	-68
22	2012			58	43	100	27	68	-60
23	2013			58	43	100	29	77	-52
24	2014			58	43	100	30	89	-42
25	2015			58	43	100	31	102	-30
26	2016			58	43	100	32	116	-16
27	2017			58	43	100	33	133	0
28	2018			58	43	100	34	153	18
29	2019			58	43	100	36	175	39
30	2020			0	0	0	36	200	164
31	2021			0	0	0	36	212	176
32	2022			0	0	0	36	225	189
33	2023			0	0	0	36	238	203
34	2024			0	0	0	36	253	217
35	2025			0	0	0	36	268	232
36	2026			0	0	0	36	284	248
37	2027			0	0	0	36	301	265
38	2028			0	0	0	36	319	283
39	2029			0	0	0	36	338	302
40	2030			0	0	0	36	358	323
41	2031			0	0	0	36	380	344
42	2032			0	0	0	36	402	367
43	2033			0	0	0	36	427	391
44	2034			0	0	0	36	452	417
45	2035			0	0	0	36	479	444
46	2036			0	0	0	36	508	473
47	2037			0	0	0	36	539	503
48	2038			0	0	0	36	571	535
49	2039			0	0	0	36	605	570
50	2040			0	0	0	36	641	606

Table 10.1 Requird Staff and Labour of Operation and Maintenance

(Yearly basis)

Description	Unit	Q'ty
Director	M/M	12
Chief	M/M	30
Engineer/Officer	M/M	70
Technician	M/M	30
Administrative Staff	M/M	60
Driver (Office)	M/M	40
Foreman	M/day	310
Mechanic	M/day	310
Carpenter	M/day	310
Operator	M/day	270
Driver	M/day	270
Rigger	M/day	310
Skilled Labor	M/day	520
Common Labor	M/day	1,650

Table 10.2 Disbursement Schedule of the Basic Plan
(Current price as of October 1989)

Unit: US$1,000

	1991-1995	1996-2000	2001-2005	2006-2010	2011-2015	2016-2020	Overall Period
Hong-ke system	13,237	1,800	180	180	180	176	15,753
(Hong-ke, Hong Thong,Khoua Khao)							
- Main work	11,929						11,929
- Lateral improvement	1,308	1,800	180	180	180	176	3,824
Nam-pasak system	0	7,526	0	0	0	0	7,526
- Main work		6,593					6,593
- Lateral improvement		933					933
Sub-area I	0	0	3,360	690	690	718	5,458
(Hong Kai Keo)							
- Main work			2,670				2,670
- Lateral improvement			690	690	690	718	2,788
Sub-area K	0	2,430	320	320	320	320	3,710
- Main work		630					630
- Lateral improvement		1,800	320	320	320	320	3,080
Sub-area O	0	0	0	0	5,469	0	5,469
(Hong Xeng)							
- Main work					5,469		5,469
- Lateral improvement							0
Sub-area M	0	0	0	11,522	740	753	13,015
(Wat Tay, Hong Xeng)							
- Main work				10,782			10,782
- Lateral improvement				740	740	753	2,233
Sub-area J	0	0	5,675	770	770	772	7,987
(Hong Xeng)							
- Main work			4,905				4,905
- Lateral improvement			770	770	770	772	3,082
Sub-area D	0	0	4,740	700	700	715	6,855
- Main work			4,040				4,040
- Lateral improvement			700	700	700	715	2,815
Sub-area P	0	0	0	0	840	842	1,682
- Main work							0
- Lateral improvement					840	842	1,682
Sub-area A	0	0	0	0	0	2,395	2,395
(Nong Hay)							
- Main work						2,395	2,395
- Lateral improvement							0
Sub-area B	0	0	0	0	0	5,602	5,602
(Soune Mone)							
- Main work						2,551	2,551
- Lateral improvement						3,051	3,051
Overall Basic Plan	13,237	11,756	14,275	14,182	9,709	12,293	75,452
- Main work	11,929	7,223	11,615	10,782	5,469	4,946	51,964
- Lateral improvement	1,308	4,533	2,660	3,400	4,240	7,347	23,488

Note: Including O&M equipment cost except cost for O&M material and stuff & labour

Table 10.3 Economic Evaluation of the Basic Plan

Unit: US$1,000

	Basic Plan Total (IRR= 6.0%)				Priority Project (IRR = 6.5%)				Sub Area O,M,J,K,P (IRR = 4.9%)				Sub Area A and B (IRR = 4.3%)			
	Cost	O & M cost	Benefit	Net Benefit	Cost	O & M cost	Benefit	Net Benefit	Cost	O & M cost	Benefit	Net Benefit	Cost	O & M cost	Benefit	Net Benefit
1991	729	0	0	-729	729	0	0	-729								
1992	5,566	0	0	-5,566	5,566	0	0	-5,566								
1993	4,573	0	0	-4,573	4,573	0	0	-4,573								
1994	156	112	97	-171	156	112	97	-171								
1995	156	114	121	-149	156	114	121	-149								
1996	489	116	148	-457	489	116	148	-457								
1997	2,559	118	180	-2,497	2,559	118	180	-2,497								
1998	2,475	120	216	-2,379	2,475	120	216	-2,379								
1999	414	175	276	-313	414	175	276	-313								
2000	19	176	336	141	19	176	336	141								
2001	225	176	370	-31	225	176	370	-31								
2002	658	176	408	-426	658	176	408	-426								
2003	2,392	184	450	-2,126	2,392	184	450	-2,126								
2004	307	212	502	-17	307	212	502	-17								
2005	307	217	558	34	307	217	558	34								
2006	2,012	219	623	-1,608	307	219	623	97	1,705	0	0	-1,705				
2007	11,492	223	694	-11,021	307	223	694	164	11,185	0	0	-11,185				
2008	11,242	230	778	-10,694	307	227	774	240	10,935	3	4	-10,934				
2009	966	478	941	-503	307	230	862	325	659	248	79	-828				
2010	966	490	1,093	-363	307	234	961	420	659	256	132	-783				
2011	1,309	502	1,266	-545	307	238	1,073	528	659	264	193	-730	343	0	0	-343
2012	3,378	511	1,465	-2,424	307	240	1,198	651	659	271	267	-663	2,412	0	0	-2,412
2013	3,342	523	1,692	-2,173	307	244	1,337	786	659	279	355	-583	2,376	0	0	-2,376
2014	1,299	590	2,003	114	307	248	1,492	937	659	286	457	-488	333	56	54	-335
2015	1,299	604	2,329	426	307	251	1,668	1,110	659	293	576	-376	333	60	85	-308
2016	1,299	621	2,700	780	307	255	1,863	1,301	659	302	715	-246	333	64	122	-275
2017	1,299	635	3,128	1,194	307	258	2,084	1,519	659	309	878	-90	333	68	166	-235
2018	1,299	652	3,613	1,662	307	263	2,330	1,760	659	317	1,066	90	333	72	217	-188
2019	1,299	666	4,169	2,204	307	266	2,606	2,033	659	324	1,285	302	333	76	278	-131
2020	0	666	4,802	4,136	0	266	2,916	2,650	0	324	1,537	1,213	0	76	349	273
2021	0	666	5,230	4,564	0	266	3,188	2,922	0	324	1,672	1,348	0	76	370	294
2022	0	666	5,698	5,032	0	266	3,485	3,219	0	324	1,821	1,497	0	76	392	316
2023	0	666	6,214	5,548	0	266	3,812	3,546	0	324	1,986	1,662	0	76	416	340
2024	0	666	6,775	6,109	0	266	4,168	3,902	0	324	2,166	1,842	0	76	441	365
2025	0	666	7,391	6,725	0	266	4,559	4,293	0	324	2,365	2,041	0	76	467	391
2026	0	666	8,068	7,402	0	266	4,987	4,721	0	324	2,586	2,262	0	76	495	419
2027	0	666	8,811	8,145	0	266	5,458	5,192	0	324	2,829	2,505	0	76	524	448
2028	0	666	9,626	8,960	0	266	5,973	5,707	0	324	3,098	2,774	0	76	555	479
2029	0	666	10,520	9,854	0	266	6,537	6,271	0	324	3,395	3,071	0	76	588	512
2030	0	666	11,503	10,837	0	266	7,156	6,890	0	324	3,724	3,400	0	76	623	547
2031	0	666	12,584	11,918	0	266	7,835	7,569	0	324	4,088	3,764	0	76	661	585
2032	0	666	13,774	13,108	0	266	8,581	8,315	0	324	4,492	4,168	0	76	701	625
2033	0	666	15,079	14,413	0	266	9,397	9,131	0	324	4,939	4,615	0	76	743	667
2034	0	666	16,519	15,853	0	266	10,294	10,028	0	324	5,437	5,113	0	76	788	712
2035	0	666	18,101	17,435	0	266	11,277	11,011	0	324	5,989	5,665	0	76	835	759
2036	0	666	19,845	19,179	0	266	12,357	12,091	0	324	6,603	6,279	0	76	885	809
2037	0	666	21,763	21,097	0	266	13,540	13,274	0	324	7,285	6,961	0	76	938	862
2038	0	666	23,878	23,212	0	266	14,839	14,573	0	324	8,045	7,721	0	76	994	918
2039	0	666	26,208	25,542	0	266	16,265	15,999	0	324	8,890	8,566	0	76	1,053	977
2040	#####	666	28,780	42,384	-2,096	266	17,830	19,660	-9,323	324	9,833	18,832	-2,851	76	1,117	3,892

FIGURES

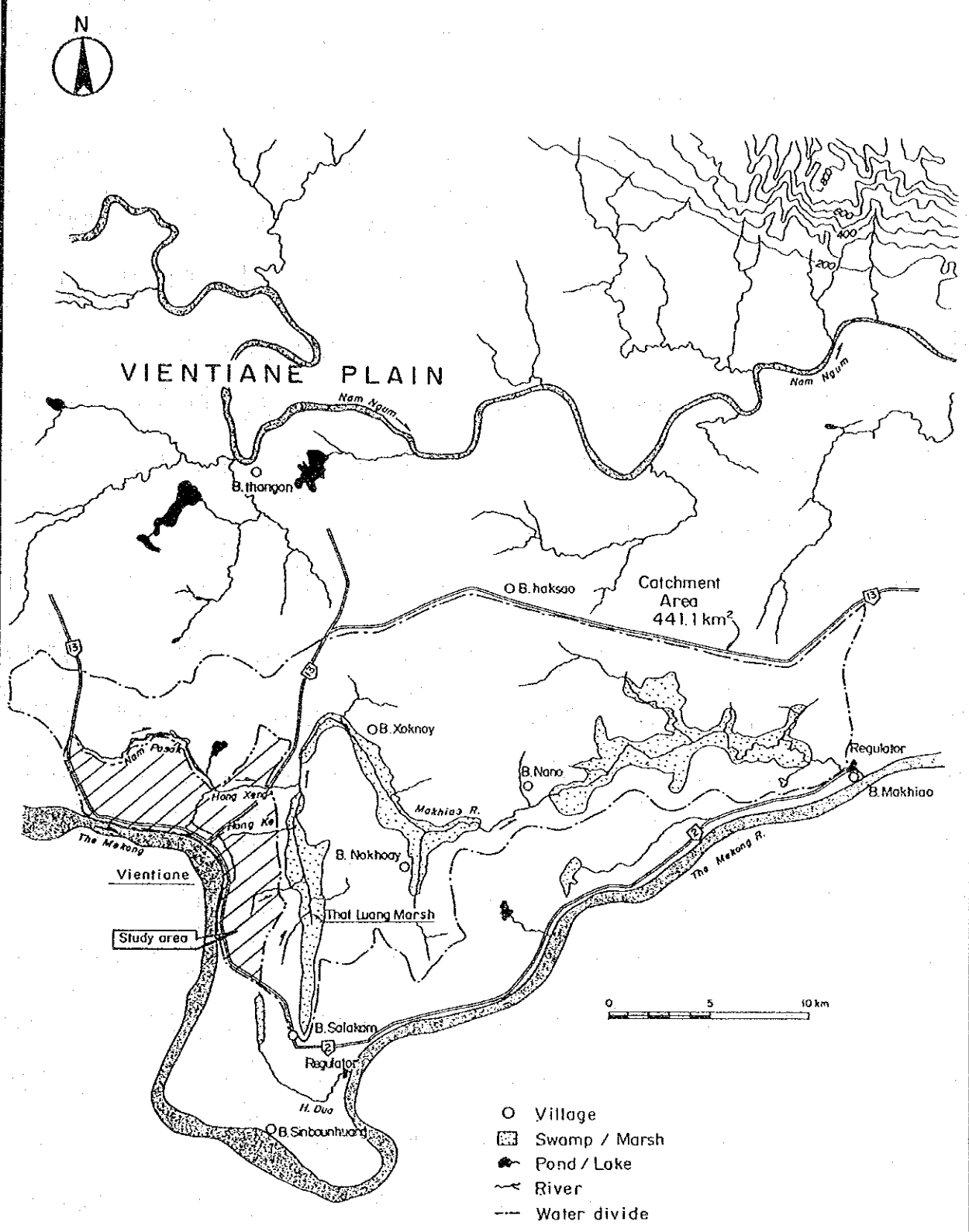

Fig. 2.1 Study Area and Vientiane Plain

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OF DRAINAGE SYSTEM IN VIENTIANE

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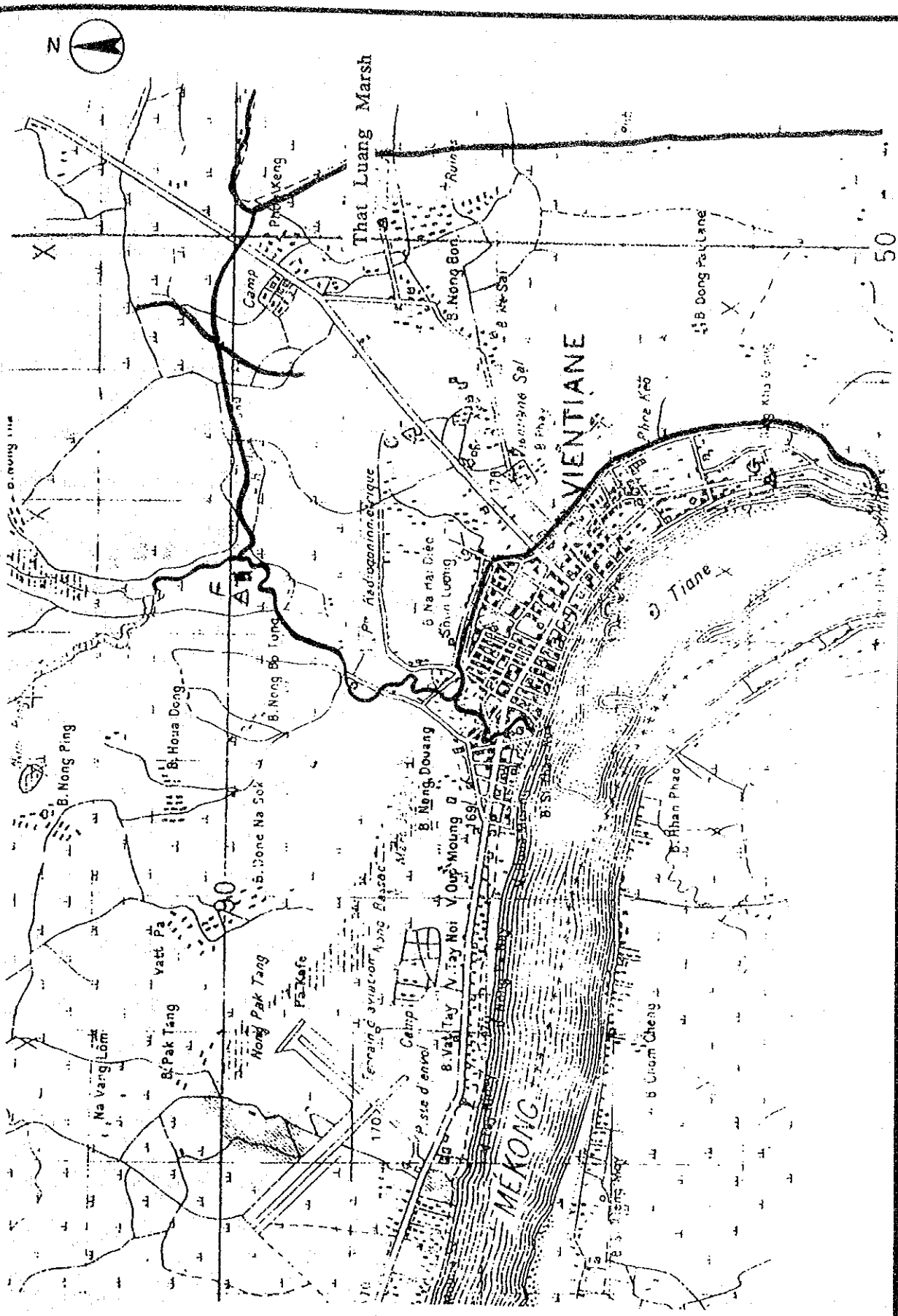

Fig. 2.2 Alignment of River Channels in 1954

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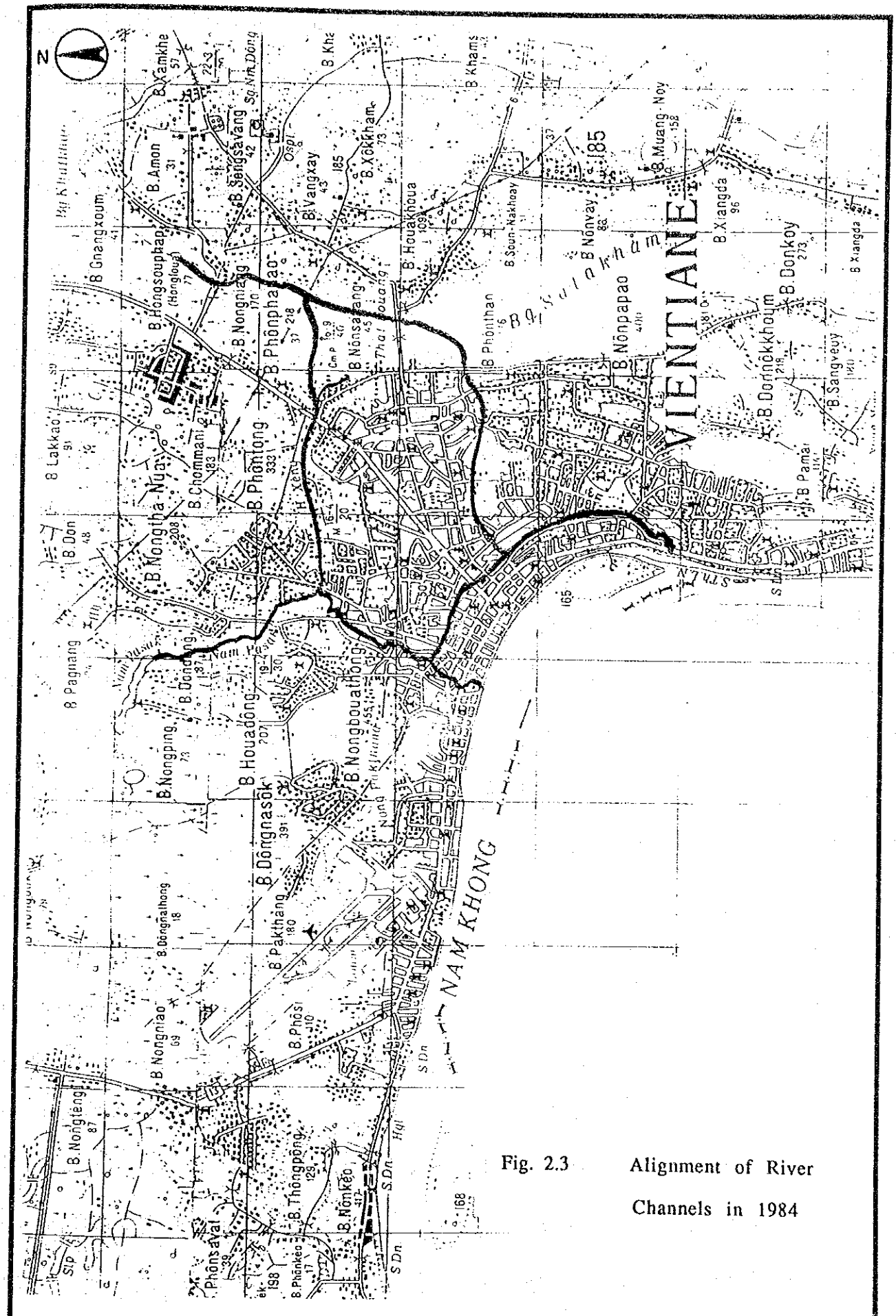

Fig. 2.3 Alignment of River Channels in 1984

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OF DRAINAGE SYSTEM IN VIENTIANE

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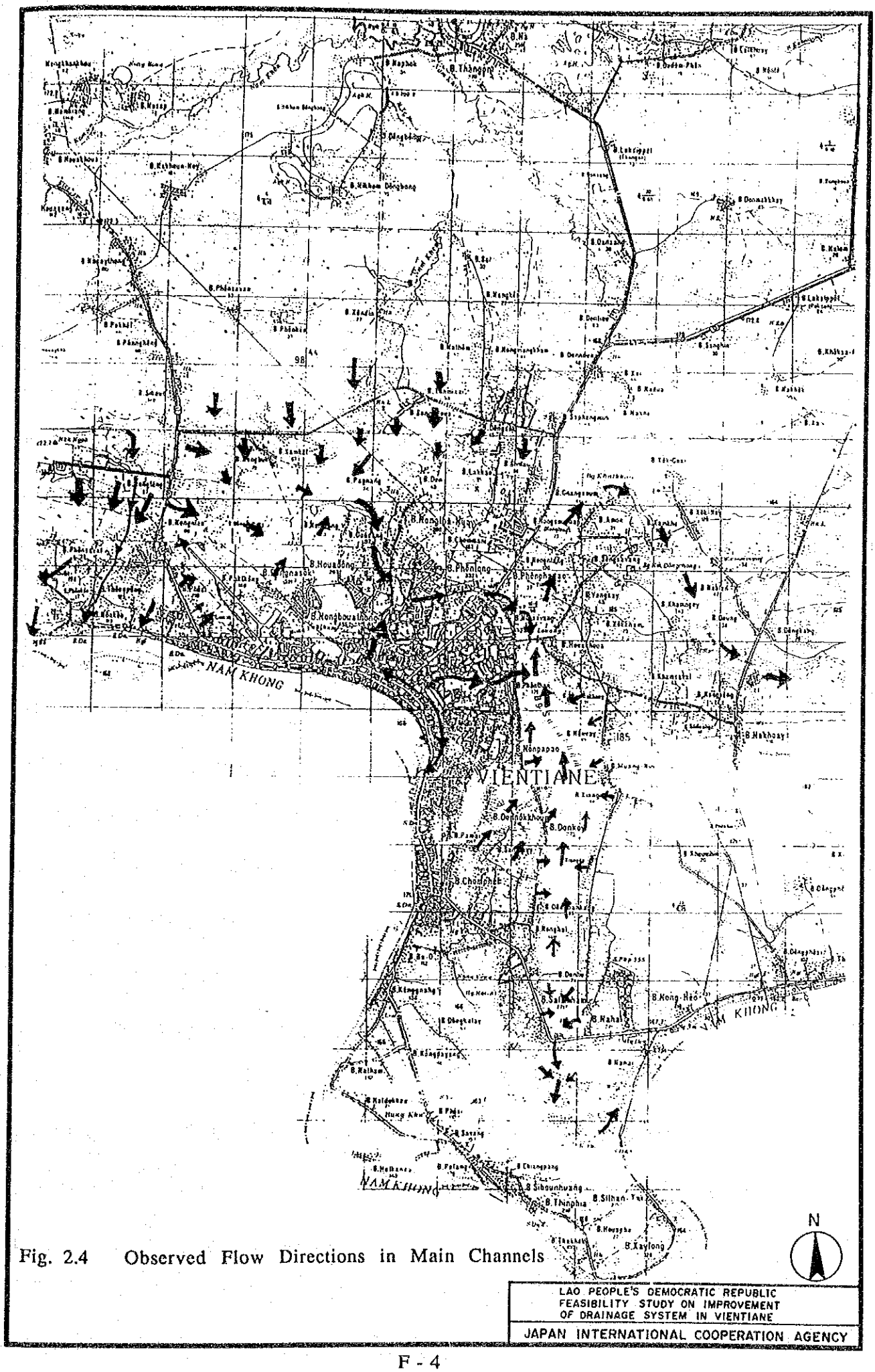

Fig. 2.4 Observed Flow Directions in Main Channels

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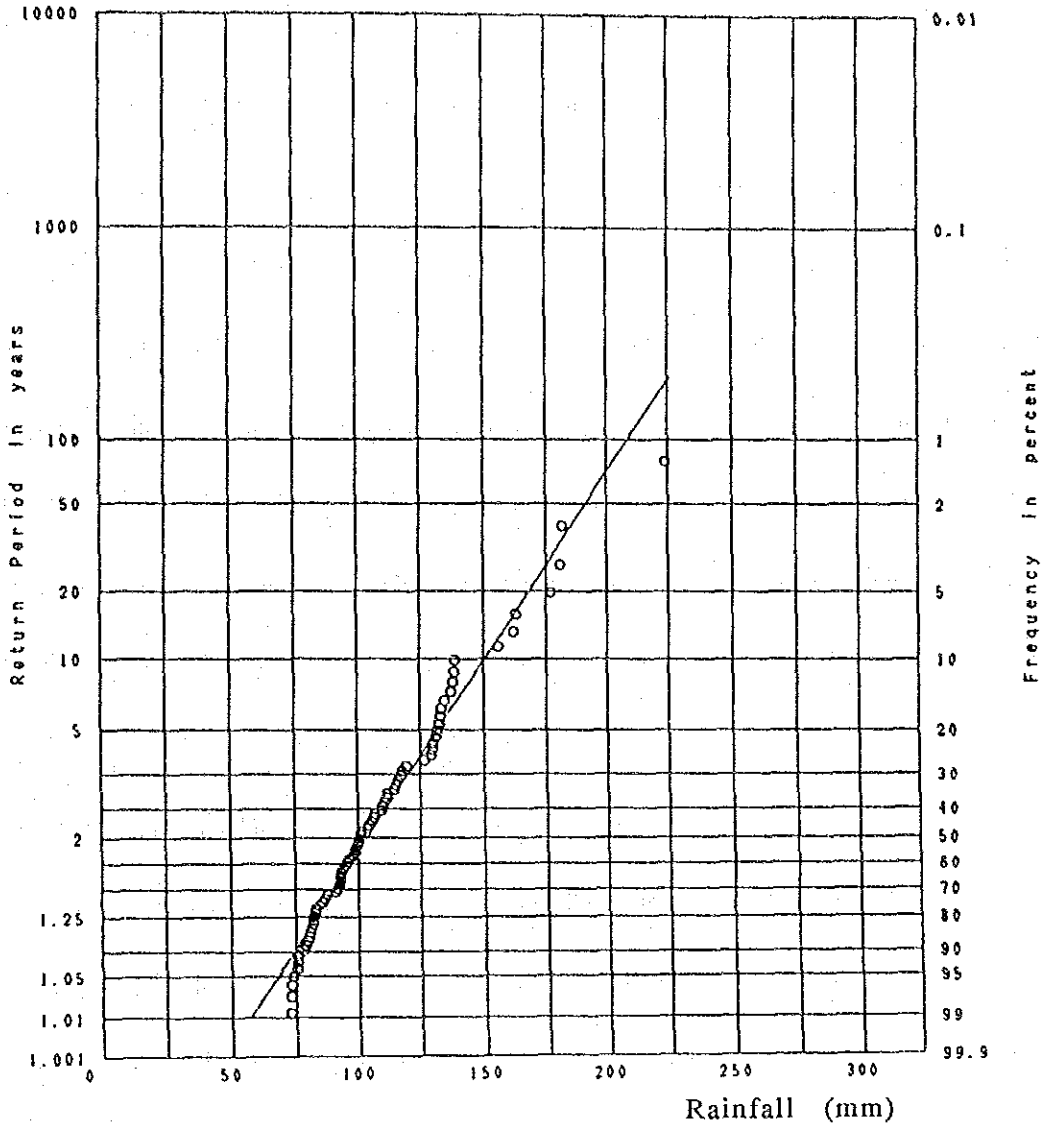

Fig. 2.5 Frequency Curve of Annual Maximum One-Day Storm Rainfall

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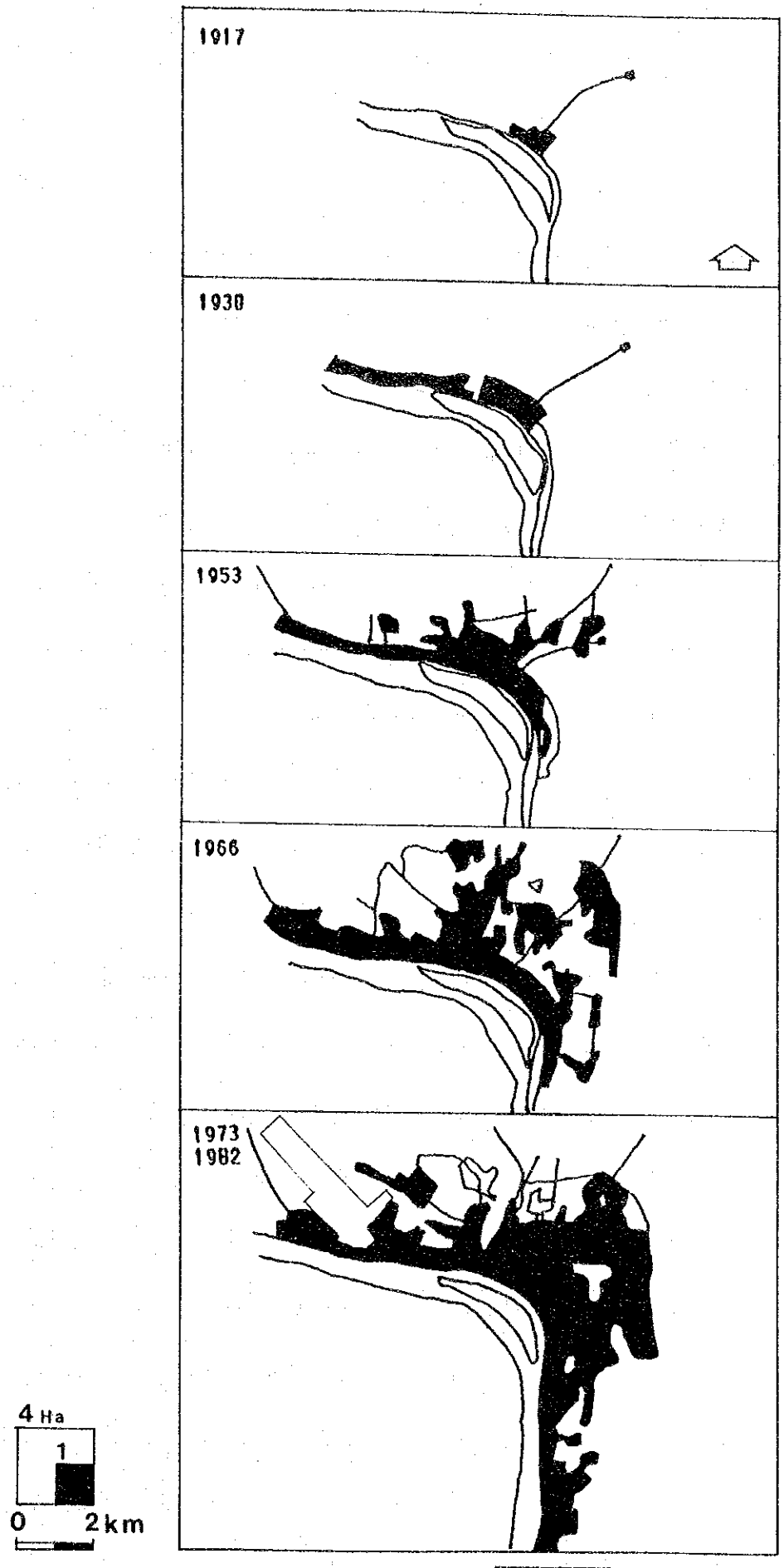

Fig. 2.6 Historical Urbanization at Vientiane (Source: UNDP)

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