

No. 2

JAPAN INTERNATIONAL COOPERATION AGENCY
MINISTRY OF INDUSTRY AND HANDICRAFTS OF
THE GOVERNMENT OF LAO P.D.R.

FEASIBILITY STUDY
ON
THE NAM NGIEP-I HYDROELECTRIC POWER PROJECT
IN
THE LAO PEOPLE'S DEMOCRATIC REPUBLIC

FINAL REPORT : VOLUME 1
MAIN REPORT

FEBRUARY 2000

JICA LIBRARY



J 1155577 (8)

NIPPON KOEI CO., LTD.

M P N
J R
00-007



FEASIBILITY STUDY ON THE NAM NGIEP-I HEP

FINAL REPORT : VOLUME 1

MAIN REPORT

FEBRUARY 2000

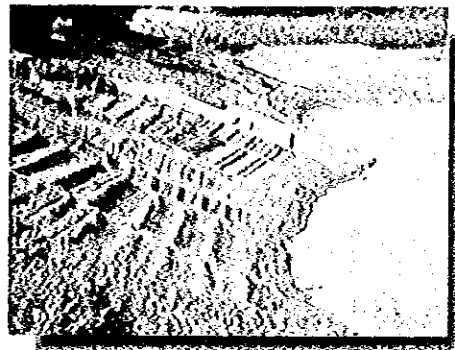
NIPPO



112
643
MPN
IBRARY

JAPAN INTERNATIONAL COOPERATION AGENCY
MINISTRY OF INDUSTRY AND HANDICRAFTS OF
THE GOVERNMENT OF LAO P.D.R.

FEASIBILITY STUDY
ON
THE NAM NGIEP-I HYDROELECTRIC POWER PROJECT
IN
THE LAO PEOPLE'S DEMOCRATIC REPUBLIC



FINAL REPORT : VOLUME 1

MAIN REPORT



FEBRUARY 2000

NIPPON KOEI CO., LTD.



1155577(8)

PREFACE

In response to a request from the Government of the Lao People's Democratic Republic, the Government of Japan decided to conduct the Feasibility Study on the Nam Ngiep-1 Hydroelectric Power Project in the Lao People's Democratic Republic and entrusted the Study to Japan International Cooperation Agency (JICA).

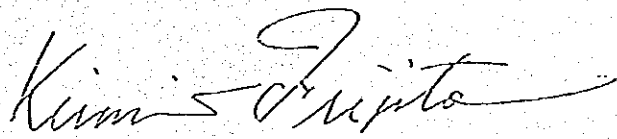
JICA dispatched a study team consisting of personnel of NIPPON KOEI Co., Ltd. led by Mr. Ichiro ARAKI to the Lao People's Democratic Republic, six times during the Study period between July 1998 and February 2000.

The Team held discussions with the officials concerned of the Government of the Lao People's Democratic Republic, and conducted related field surveys. After returning to Japan, the Team conducted further studies and compiled the final results in this report.

I hope this report will contribute to the promotion of the Project and to enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Lao People's Democratic Republic for their close cooperation throughout the study.

February 2000



Kimio FUJITA
President
Japan International Cooperation Agency



NIPPON KOEI CO., LTD.

Consulting Engineers

February 2000

To. Mr. Kimio FUJITA
President
Japan International Cooperation Agency
Tokyo, Japan

Dear Sir,

Letter of Transmittal

We are pleased to submit herewith the Final Report of Feasibility Study on the Nam Ngiep-I Hydroelectric Power Project in the Lao People's Democratic Republic.

Our Nippon Koei had studied it for about 19 months from July 1998 to February 2000 under contract with JICA.

This Final Report deals with the detailed procedure for the development scale justification of the Nam Ngiep-I Hydroelectric Power Project as the first stage of the Feasibility Study. This Project aims to serve the best interests of the Lao P.D.R. by selling power to the neighboring countries through a private enterprise based on the national power policy. Accordingly, during the Study, the environmental impact assessment had been carried out beyond usual view points of the Study in line with JICA's own principles. Precisely, in consideration of the recent worldwide criticism on dam construction, we had tried to find a smooth way to proceed a hydropower project by focussing on environmental issues, especially on social matters of resettlement and opening all studied results and information to public at workshops. We believe that it will take the first step forward a new sense of values from a former out-and-out economic believer of project formation.

We hope this Final Report would help not only to shift smoothly to the next stage for the Feasibility Study on the Nam Ngiep-I Hydroelectric Power Project but also to provide further similar projects with useful information.

The Final Report consists of seven (7) volumes, Main Report, Executive Summary and five (5) volumes of Supporting Report. Main Report covers all the study results including the hydropower planning procedure and the summary of natural and social environmental issues. Executive Summary presents main outputs of the Study. Supporting Reports give the detailed information, data and analysis to Main Report, such as (i) First Environmental Impact Assessment Report, (ii) Preliminary Environmental Management/Monitoring Plan, (iii) Preliminary Resettlement Plan, (iv) Sub-Contractor's Field Investigation Report, and (v) Records during Field Investigations.

We wish to take this opportunity to express sincere gratitude to your Agency and the Environmental Assessment Committee for the Study. We also wish to express our deep gratitude to the Government of Lao P.D.R., the Embassy of Japan in Vientiane, the JICA Laos Office for close cooperation and assistance extended to our Study Team during field investigations and studies in Lao P.D.R.

Sincerely yours,

Ichiro ARAKI, Team Leader

Feasibility Study on the Nam Ngiep-I
Hydroelectric Power Project
Nippon Koei Co., Ltd.



Nippon Koei Co., Ltd. Consulting Administration International Division
Registered in England and Japan No. 958024
Registered Office: 2-5 Kojimachi, Chiyoda-ku, Tokyo

SUMMARY

CONCLUSIONS AND RECOMMENDATIONS

1. MILLENNIUM DAM

On one hand, some advanced countries lost significance in the dam development, and on the other hand it is a fact that some developing countries need it as a tool for their national development. Accordingly, we had provided them not only financial aid but also the intellectual assistance to judge the priority of development from the environmental standpoint. The judgements were on the basis of understandable national development policy on national interests from the other countries by an effective utilization of rich water resources under the best geopolitical advantages.

As a conclusion of the above, the Study Team proposes to construct "the Millennium Dam" at the end of the Study. We named a dam of the Nam Ngiep-I HEPP as "the Millennium Dam" on ground of our oath to recover "the silent rivers" in the next century, not by the reason of our memorial to propose it at the end of this century.

Therefore, in order to that the proposal of "the Millennium Dam" may be worthy for coming ages, the detailed procedures to reach the conclusion were shown in the report hereinafter.

The conclusion reached both to minimization of environmental impacts at the extent, and realization of an economic-viable and financially attractive development, is the universal truth for the coming hydropower development. Consequently, the alternative with FSL at EL.320m is proposed to select the most promising development scheme for the Project.

This conclusion was made on the recent worldwide circumstance and with understanding that the development should be made on the international rule even in the developing countries. However, on the other hand, there is a different recognition that it is still permissible greatly for the developing countries to give national developments the highest priority in order to maximize their own benefits.

The Study has not been carried out in line with the theme of choice between "Environmental Conservation" and "Promotion of National Development". But, the same will probably come to the main theme by shaping up of the Project. The scale of the Project, which constructs the permanent structure, is determined based on the sense of value at that time. Especially, for the Project likely to be implemented by IPP, the minimization of risks is a key factor for determination of the development scale.

Therefore, the extent and scopes for further investigation and study should not be limited only for the medium scale development of FSL.320m.

2. PROJECT EVALUATION

Today's world has been continuously trying to cope with them. The modern civilization, which applied to natural science, was developed with the technology to control nature. However, in the society of high technological principles, which is ruled by this civilization, nature philosophy contrary to human is only resulted. Therefore, as an environmental destruction of present society is led by this nature philosophy, a doubt and a regret against to this nature philosophy have led an effort to create a symbiotic relationship between human and nature. These recent tendencies require us to show various evaluation criteria for a dam project implementation.

Under the viewpoint mentioned above, the general evaluation to be carried out by all persons at any positions under various evaluation criteria is indispensable for the dam development alternatives with priority on the environmental study. Therefore, the Study Team recommended the most attractive alternative as a conclusion of evaluation results by proposing seven (7) items of design criteria as shown below, which are expected to raise various discussions among GOL, JICA, village people and NGOs.

No.	Evaluation Category	Evaluation Criteria	Evaluation Results
1.	Natural Environment Evaluation	E.C. on the assumption that the existing natural, developed-natural and artificial environments should be preserved or improved.	Impacts on Natural Environment will become large as increasing dam scale, until a failure of the environmental preservation
2.	Social Environment Evaluation	E.C. on the assumption that people and social system surround them should be preserved and improved.	Impacts on Social Environment will become large as increasing dam scale, but, Social system can be kept safety by changing slowly.
3.	Economic Evaluation	E.C. on the assumption that the economic feasibility shall be judged by avoid cost of thermal generation.	Mathematical evaluation can be done with economical index: B/C, B-C, and EIRR; however, only a validity of hydropower can be evaluated.
4.	Financial Evaluation	E.C. on the assumption that the benefit by electricity sales shall cover all investment, under a good enterprise as IPP.	Same as Item No.3, however, evaluation is based on several assumptions such as BOOT composition, fund procure, electricity sale cost, and commencement day of commercial operation.
5.	Technical Evaluation (Dam Construction)	Technical evaluation criteria for a high dam construction.	A Large-scale dam is technically restricted to construct. The highest record of dam construction is 180m, that of project design is 220m.
6.	Evaluation on EAC & Workshops	E.C. judged from opinion, suggestion and questionnaire results at EAC/Workshop.	Evaluation is based on individual extent of interest and understanding on participants, and on their positions.
7.	Evaluation on Japan's Mekong River Develop. Plan	E.C. judged from the viewpoint of stance in official development aid of Japan	Aid policy in peace, development, environment preservation is essential for evaluation.

Note: E.C means Environmental Criteria.

The Study Team recommended the most attractive alternative, the medium-scale dam development with FSL.320m, as a conclusion of evaluation results by proposing seven (7) items of design criteria as shown below:

No.	Evaluation Category	General Evaluation Results	
		Medium-Scale (FSL.320m)	Large-Scale (FSL.360m)
1.	Natural Environment Evaluation	O	Δ
2.	Social Environment Evaluation	O	Δ
3.	Economic Evaluation	Δ	O
4.	Financial Evaluation	Δ	O
5.	Technical Evaluation(Dam Construction)	O	O
6.	Evaluation on EAC & Workshops	O	Δ
7.	Evaluation on Japan's Mekong River Basin Development Plan	O	O
8.	General Evaluation Results	O	Δ

Note: O : Recommended alternative to develop.
 Δ : Recommended alternative not to develop compared with other one.

The various reasons that the medium-scale dam alternative have been selected as the most recommendable one by the Study Team were epitomized by the following four (4) reasons:

- (i) Evaluation results of the social environmental aspects: This alternative will save the Thaviang Sub-District, where is expected of the future development due to not only a geographic advantage but also the recent regional development projects for extension of both a national highway and a rural electrification.
- (ii) Evaluation results of the preliminary resettlement plan: This alternative will save the population being resettled forcibly as less as possible due to avoiding inundation of the Thaviang Sub-District.
- (iii) Evaluation results of economic and financial analysis: This alternative will clear the critical economic index for IPP projects, even the Study Team's evaluation criteria thinks a great deal of evaluation results both on the social and natural environmental aspects.
- (iv) Evaluation results of General and Site Workshops: This alternative was selected under deep consideration of the evaluation results by local peoples and local governments through both General and Site Workshops during the field investigations.

Accordingly, at the following two points, the Nam Ngiép-I HEPP is expected to set as a high valuation on dam developments in the world not only by peoples in Lao PDR but also by both local and international NGOs, as well as international financing agencies being willing to invest in positively based on the comprehensive development intention:

- (i) The project might become a pathfinder of the advanced development procedure selecting a project scheme based on the EIA results at the preliminary F/S stage of hydroelectric power project, and
- (ii) The Project will save the reservoir area of 74km², the dam height of 40m, the construction cost of US\$118mil., and resettlement population of 3,000, instead of lost values at the install capacity of 94MW, the annual energy of 556GWh, and B-C(current value) of US\$80mil.

HYDROPOWER PLAN

3. OBJECTIVES OF THE PROJECT

In line with the Lao National Policy for increasing in earning from sales of electricity to abroad by the development of abundant domestic hydroelectric resources, The Nam Ngiep-1 HEPP is recommended to develop for export of clean, stable and economic electricity to Thailand to meet the growing demand.

The Project will not only attain conventional hydropower benefits, but also contribute to (i) expansion of irrigable area around the proposed reservoir, (ii) rural electrification, (iii) improvement of downstream river-navigation condition, and (iv) accessibility among Bolikhamxay Province, Xaysonmoun Special Zone and Xieng Khouang Province with a transporting system in the reservoir.

4. DEVELOPMENT TYPE AND SCALE OF THE PROJECT

The project development scale was optimized not only taking into consideration economic and financial attractiveness but also making comprehensive assessment of environmental impacts in and around the Project area. Negative impacts and indirect benefits, which are difficult to quantify, were relatively evaluated through value judgement based on the specific evaluation criteria. Collateral solutions or set-off effects to the negative impacts as well as the value or point judgements for the indirect benefits are summarized in the attached tables below:

Quantified Environmental Impacts

No.	Natural-Social Environmental Impacts	Collateral Solution
1.	Inundation of villages	Supply of equal-scaled resettlement facilities
2.	Peoples' mental burden for resettlement (*1)	Monetary support such as outfit allowance for resettlement and guarantee fund for villager's living after movement at a decent-life level for several years.
3.	Water level fluctuation at downstream due to discharge from power station	Provision of re-regulation pond for stabilization of water level
4.	Decreasing fishes at downstream reach	Promotion and construction of facilities for fishery
5.	River shore erosion at downstream reach	River protective works
6.	Tentative water pollution by hydrogen sulfide from the submerged forest	Provision of public wells for downstream villages
7.	Destruction (damage) of peoples' production due to construction	Compensation and relocation
8.	Sedimentation at upstream end of reservoir (*2)	Heightening river bank when actually required
Note (*1)	As the result of EIA, it was revealed that the present infrastructures in the Project area are not satisfactory to the villagers and local market is much stagnant. Judging from the above, even the scale of resettlement become large, the consensus of the people will be positive against the resettlement, if a meticulous welfare is provided to them with well-supply of local electrification, medical facilities, schools, public wells, etc., supply of equal-sized farmland, technical guidance for agriculture and stockbreeding, provision of industrial promotion center in the resettlement land, etc.	
Note (*2)	Judging from the state of sedimentation measured for the existing Nam Ngum reservoir, prospective sedimentation at the upstream end of the Nam Ngiep-1 HEPP reservoir is deemed to be negligible small.	

Interpretation for Impacts not Quantified

No.	Evaluation
1.	Mental-burden of the highland people in the form of changing living circumstances due to resettlement is considered to be set off by the contribution to the nation with the decreasing shifting cultivation and guarantee of their lives with well-supplied resettlement facilities and support.
2.	Declined CO ₂ purification effect in the river basin due to vanishing forest is considered to set off by the amount of CO ₂ emission, which is expected to decrease by hydropower development instead of thermal plant construction.
3.	Noise, dust, water pollution, etc during construction will be restricted and minimized by applying careful construction control in conformity with the local environmental rules and regulations in Lao PDR.
4.	In the tropical country, influence of the discharge for power generation, which will negatively affect on an adequate water temperature for irrigation, will be negligible small.

The conclusion reached that the minimization of the environmental impacts at the extent of an economic-viable and financially attractive development is the universal truth for the coming hydropower development. Consequently, the alternative with FSL at EL.320m was selected as the most promising development scheme for the Project. The principal project features are as shown in the table below:

Proposed Principal Project Features

Structure	Parameter	Unit	FSL.320m
Reservoir	Catchment area at dam site	km ²	3,700
	Annual basin rainfall	mm	2,470
	Annual mean runoff	m ³ /s	162.3
	Annual mean runoff	mill. m ³	5,118
	Average run-off coefficient	-	0.56
	Probable max. flood, PMF	m ³ /s	15,900
	Mean annual sediment flow	t/km ² /yr	413.4
	Reservoir area at FSL	km ²	73.9
	Gross & effective storage volume	10 ⁶ m ³	2,279, 1,779
	Min. operation level (MOL)	EL.m	284
	Draw-down	m	36
Dam	Dam type	-	CFRD
	Dam height & crest length	m	157, 524
	Dam volume	10 ⁶ m ³	6.9
	Dam crest level	EL.m	325
Spillway	Spillway crest level	EL.m	306.5
	Design flood capacity	m ³ /s	8,730 (Q=10,000yr)
Waterway	Design discharge	m ³ /s	221
	Headrace tunnel diameter & length	m	9.0, 420
Power Plant	Powerhouse type & size	Surface type	L58mxW31mxH58m
	Design flood discharge	m ³ /s	4,519 (Q=100yr)
	Rated head	m	131.8
	Type of turbine	-	Vertical Francis
	Plant capacity & nos. of unit	MW	240=2nos@120
Re-regulation Structure	Annual energy	GWh	1,349
	Max. pond level	EL.m	173
	Required storage capacity	mill. m ³	4.7
	Design flood discharge	m ³ /s	4,519 (Q=100yr)

5. FARMLANDS AND VILLAGES IN RESERVOIR AREA

The area of cultivating lands and number of villages as shown below will be inundated by the proposed reservoir of FSL320m. However, most of the villages and paddy fields of Thaviang

Sub-District except B.Pou in the upper reservoir area will be released from inundation. Name of the affected villages are as listed below:

Inundating Lands & Number of Villages

No.	Affected Item	Extent
1	Paddy Field	361 ha
2	Dry Field	114 ha
3	Village	5 nos.

Name of Affected Villages

No.	Name of Village	Area	EL. (m)
1	B. Pou	Upper Reservoir	319
2	B. Houaypamon	Lower Reservoir	275
3	B. Namyouk	Lower Reservoir	271
4	B. Soppouh	Lower Reservoir	261
5	B. Sopyouk	Lower Reservoir	245

Meanwhile, B.Pou will be relocated in the near future by a national plan irrespective to the Project to the area along National Route-4 where will not be affected by inundation.

6. POWER PEAK TIME DURATION

Since EGAT is hoping for the time being to purchase from the most IPP Projects in Lao PDR the intermediate peaking power, the similar peak time duration of 16-hour is applied in this moment for the study of the Nam Ngiep-1 HEPP. However, as the daily peak demand in Thailand is trending sharp year by year, it is expected that EGAT will require in the near future power purchase from Lao PDR for peak demand. If EGAT accepts 8-hour or less peaking operation, the Project becomes drastically attractive.

7. RE-REGULATION FOR DOWNSTREAM FLOW

The maximum discharge to be released from the power plant will be about 220m³/s. According to the operation rule proposed by EGAT, a power generation will be interrupted daily for several hours and entirely on Sunday and Thai national holidays, thus, the water level at downstream of the dam will be fluctuated largely with dangerous ranges to the riparian peoples. To minimize the influence by plant discharge to the downstream river corridor, a discharge regulation facility will be constructed at 5km downstream of the proposed main damsite.

8. CAPITAL COST OF THE PROJECT

The total capital cost of the Nam Ngiep-1 HEPP was estimated at US\$345.9 million, expressed at mid-1999 price level. The total capital cost makes a unit cost of 1,440US\$/kW with installed capacity of 240MW. The total cost for the intentional environmental impact mitigation measures was estimated at US\$21.1 million, which is equivalent to 6.0% of the total capital cost of the Project. Preliminary cost breakdown of the Project is shown in the tables below:

No.	Particular		Unit	EL.320m
1.	Direct Const. Cost (Civil)	-	mill.US\$	161.8
2.	Direct Const. Cost (M & E)	-	mill.US\$	120.4
3.	Direct Const. Cost (Preparatory works)	-	mill.US\$	11.2
4.	Total Direct Construction Cost	(1+2+3)	mill.US\$	293.4
5.	Environmental Impact Mitigation Cost	-	mill.US\$	21.1
6.	Engineering Service Cost	-	5%	15.7

No.	Particular		Unit	EL.320m
7.	Administration Cost	-	5%	15.7
8.	Total Capital Cost for EIRR	(4+5+6+7)	mill.US\$	345.9
9.	Price Escalation	(4)x7.5%	0%	22.0
10.	Physical Contingency	(1+3)x10%		17.3
11.	Tax and Duties	-		0.0
12.	Land Acquisition	-		0.0
13.	Total Project cost (for FIRR)	-	mill.US\$	385.2

9. PROJECT BENEFITS

Project benefits other than income from electricity sales are summarized in the table below:

No.	New Economic Opportunities	Economic Effect
1.	Creation of reservoir	Flood regulation effect to downstream reach by reservoir storage function and prospective enlargement of irrigable area around reservoir
2.	Navigation in reservoir	Economical interconnection of Xieng Khouang Province and Bolikhamxay Province (*1) and prospective tourism development (*2)
3.	Fishery in reservoir (*3)	Stabilization of catch of fish and prospective development of rural socio-economy
4.	Increasing job opportunity by Project	Increasing people's living standard with more labor income
5.	Resettlement of highland people	Decreasing the are of shifting cultivation
6.	Technical guidance for agriculture and stockbreeding (*3)	Modernization of rural agriculture and stockbreeding
7.	Rural electrification by power supply from Project	Notable improvement in living circumstances and prospective rural industrial development
8.	Macro economic impact derived from Project	Decreasing poverty and regional economic activation
(*1)	Economic interconnection of both provinces, Xieng Khouang and Bolikhamxay will give impacts to the economic activities in the remote Xieng Khouang Province, which were not briskly due to poor transportation condition and security problem of National Road Nos. 4 and 7.	
(*2)	Assuming from the trend of national economic expansion to the Southern region, as well as the recent inroads of tourism into the areas near the existing Nam Ngum reservoir, it is also presumed that development of tourism will be expected for the areas around the reservoir soon after the completion of the Project. Especially the Thaviang Sub-District, from its topographic advantage with widely developed flat land along the reservoir, has a high possibility of tourism development as resort area.	
(*3)	By the construction of a rural industrial promotion center in the main resettlement area, technical guidance will be provided to the resettlement people dispatching several foreign experts for the respective sector.	

10. FINANCIAL VIABILITY

An independent BOT power development company is assumed in the model and the debt-equity ratio of 65-35 is used, assuming a joint venture between GOL and a consortium of private sectors. The GOL would be responsible for 25% of equity investment, and the GOL equity is assumed to come from an international soft loan. An initial tariff of 6.6 cents/kWh in 2011, the date of commissioning, is assumed as levelised tariff and will increase with an annual escalation of 2.5 %. The expected loan terms are given below. The financial IRR obtained for FSL.320m Alternative is 12.8% as FIRR on Project and annual net benefit (NPV) is assumed to be US\$79.8million (NPV).

Source	Interest (%)	Grace Period (years)	Maturity (years)	Commitment Fec (%)	Front-end Fee (%)
1. OECF	3.3	5	20	0.0	0.0
2. JCB	8.5	3	8	0.5	1.0
3. ADB	8.5	3	15	1.0	1.0
4. IFC	0.0	0	0	0.0	0.0
5. TCB	10.0	3	8	1.0	1.0

Note: OECF : Overseas Economic Corporation Fund
 JCB : Japanese commercial banks
 ADB : Asian Development Bank
 IFC : International Finance Corporation
 TCB : Thai Commercial Bank

Financial steadiness against prospective risks involved in the project is favorable as shown in the table below, except the return on project is somewhat sensitive to the decrease in total energy sales:

No.	Risk Analysis	FSL.320m	FSL.360m
1.	Base Case	12.8%	13.7%
2.	10% Increase in Investment Cost	11.6%	12.5%
3.	10% Decrease in Total Energy Sales	11.4%	12.3%

ENVIRONMENTAL IMPACT ASSESSMENT

11. IMPACTS IN THE DOWNSTREAM AREA

Both the proposed FSL alternatives EL.360m and EL.320m have the same dam site. Consequently, the environmental impacts in the downstream area are very similar and do not provide a significant basis for differentiating the two (2) alternatives from the environmental point of view.

12. RESERVOIR AREA AND FOREST

The large-scale dam alternative (FSL.360m) will inundate exactly not only twice more land (14,820ha) than the medium-scale alternative (FSL.320m, 7,390ha), but also three (3) times more cultivated land (950ha compared to 310ha). Almost 10,000ha of forest, representing a potential timber volume of 290,000m³ are also flooded by FSL.360m, against only half of these values for FSL.320m.

13. WATERQUALITY IN THE RESERVOIR

The clearing of reservoir is efficient to reduce the duration of low water quality. However, the clearing of the forest in the vast Nam Ngiep reservoir of 74km² may require an immeasurable long time and huge cost. Therefore, it seems not economical and realistic.

The improvement of the low-water quality at the downstream river stretch will have to be

planned with some re-aeration facilities.

14. SEQUESTERING LOSS OF CARBON

With the flooding of the forest, Laos will lose a potential for sequestering the carbon, resulting eventually in a higher contribution to global warming. It represents a loss for a potential selling of carbon credits to any industrialized nations. Based on a forest growth of 2 to 3 m³/ha/year, the loss may be estimated at US\$180,000-270,000/year for FSL.360m and at US\$88,000-130,000/year for FSL.320m.

15. DRAW-DOWN AREA CULTIVATION

During operation, the water level of the reservoir will fluctuate, exposing draw-down areas which may be developed for agriculture or grazing. For rice production, the land must be exposed around 5 months. FSL.320m offers almost twice more areas for rice cultivation than FSL.360m: almost 2,000ha against 1,000ha. Only a part of this area is suitable for rice culture when considering soil quality and local topography.

16. WATER QUALITY IN MEDIUM AND LONG TERM

The residence time of water into the reservoir is about 13 months for FSL.360m and only 3.6 months for FSL.320m. This short residence time combined with a limited inflow of Phosphorus from the watershed leads to the conclusion that there should be no problem of water quality in the medium and long term. After the impoundment, as the intense decay of organic matter in the water consumes all the dissolved oxygen, it is anticipated that the water will recover a reasonable level of oxygen after only 5 to 6 years for FSL.360m and after only 2 years for FSL.320m.

17. WATER QUALITY IN SHORT TERM

Because of its depth, the reservoir will probably be stratified, with a 15-20m depth layer of well aerated water over a deeper water body of colder and anoxic water. Turn over may occur during the cold season as observed in the Nam Ngum reservoir, but its magnitude has still to be assessed. As the water intake is located most of the year below 20m from the surface, it is anticipated a release of low quality water in the downstream river, with impacts on aquatic life and population. To mitigate this impact, appropriate facilities as multi level intake or downstream re-aeration structure may be studied in a further investigation.

18. RE-REGULATION FOR DOWNSTREAM

A re-regulation facility will be constructed below the tailrace channel to regulate the flow over

24 hours, to avoid daily changes in river flow which could have resulted in hazards for the population and excessive erosion of the riverbed.

The average monthly flow will be significantly changed at the downstream area: the dry season flow will be increased 3 times and the wet season flow reduced by 50% from present situation.

19. IMPACTS OF ACCESS ROAD AND TRANSMISSION LINE

Impacts on land at downstream will be limited to land acquisition for only 10km of access road and 110km of transmission line. Compensation for the loss of land will be provided to the concerned population. Impact is the same for both alternatives.

20. ENVIRONMENTAL MANAGEMENT PLAN

To mitigate the impacts during construction, filling stage of the reservoir and operation stages, a program of activity has been prepared in the Environmental Management Plan (EMP). The constitution of an Environmental Management Unit (EMU) is also proposed.

PRELIMINARY RESETTLEMENT PLAN

21. POSSIBLE INVOLUNTARY RESETTLEMENT

According to the socioeconomic surveys of the Project area conducted December 1998 through March 1999, overall, including both Upstream and Downstream areas of the proposed dam site, nearly 2,000 households and 12,000 persons may be affected to one degree or another by the Project. About 660 households and 5,000 persons in 14 villages are in the Upper Reservoir and another 200 households and 1,200 persons in 4 villages the Lower Reservoir could potentially be affected by involuntary resettlement. For Downstream area about 1,300 households and 6,800 people in 15 villages would be affected through changes in the Nam Ngiep River flow and water.

22. FSL.360M ALTERNATIVE

While not all villages within the proposed reservoir area would be submerged even by FSL.360m, their rice lands are all situated along the Nam Ngiep River and its territories at low levels. So it can be assumed that virtually all the villages would require resettlement, if FSL.360m is chosen for implementation. Generally speaking, mitigation includes minimizing resettlement to the extent possible, carrying out an international standard of resettlement planning and implementation if unavoidable, and fair compensation for the displaced population.

23. FSL.320M ALTERNATIVE

The recommended design mitigation at this time is to consider the medium-scale dam alternative. The initial thinking was that lowering the FSL to EL 320m would reduce the number of affected villages down to 5 villages. There is not enough information at this time, however, to determine what the amount of backwater effect would be, i.e., how much higher the water at the back of the reservoir will be than at the front end. Two (2) meters would be assumed, including a safety margin. Therefore, consideration of the backwater effect indicates that EL.318m might be necessary to protect the majority of irrigated paddy land belonging to the Upper Reservoir villages, nearly 300ha of the total reservoir paddy land. This FSL.318m dam would more surely reduce the affected population down to 260 households and about 1,600 people.

24. PREPARATION OF FULL RESETTLEMENT ACTION PLAN

The Preliminary Resettlement Plan (PRP) is prepared without the final design of the Project having been decided. Once the alternative is selected, a full Environmental Impact Assessment (EIA) and Social Impact Assessment (SIA) will be required by internationally accepted guidelines, as well as preparation of a full Resettlement Action Plan (RAP) and a Social Action Plan (SAP) for mitigating other social impacts. During preparation of a draft RAP, the following studies will take place:

- (i) Socio-Cultural Assessment of Resettlement and Host Communities (Part of SIA),
- (ii) Preparation of a Public Consultation Framework,
- (iii) Capacity Assessment of Resettlement Sites,
- (iv) Backwater and Sedimentation Modeling,
- (v) Archeological Review and Field Survey, and
- (vi) Technical Resources explored and detailed TOR for development of Livelihood Packages prepared.

**FEASIBILITY STUDY
ON
THE NAM NGIEP-I HYDROELECTRIC POWER PROJECT
IN
THE LAO PEOPLE'S DEMOCRATIC REPUBLIC
FINAL REPORT**

COMPOSITION OF REPORTS

Volume 1	Main Report
Volume 2	Executive Summary
Volume 3	Supporting Report (I) : First Environmental Impact Assessment Report
Volume 4	Supporting Report (II) : Preliminary Environmental Management Plan
Volume 5	Supporting Report (III) : Preliminary Resettlement Plan
Volume 6	Supporting Report (IV) : Sub-Contractor's Field Investigation Report
Volume 7	Supporting Report (V) : Records during Field Investigations

Front Cover Photos		
Downstream Scenery of the Nam Ngiep River	Site Workshop under the Lao & Japanese National Flags	Vegetable Gardens along lower banks of the Nam Ngiep River
Hmong's National Costume at Site Workshop	Ceremony "Bassii" at General Workshop	Site Workshop at Thaviang Sub-district

VOLUME 1 : MAIN REPORT

TABLE OF CONTENTS

Preface	
Letter of Transmittal	
Location of Project Area	
Main Abbreviation	
	Page
SUMMARY	S - 1
1. INTRODUCTION	
1.1 Conclusions and Recommendations.....	1 - 1
1.2 Background of Study	1 - 2
1.3 Purpose of Study.....	1 - 3
1.4 Work Progress of Study.....	1 - 4
1.5 Composition of Study Reports.....	1 - 7
2. GEOPHYSICAL SURVEY	
2.1 General.....	2 - 1
2.2 GPS Survey in Proposed Reservoir	2 - 2
2.2.1 General.....	2 - 2
2.2.2 GPS Survey.....	2 - 4
2.2.3 Ground Leveling Survey.....	2 - 5
2.2.4 Level Differences between GPS Survey & Read on Maps	2 - 6
2.3 Ground Survey at Thaviang Sub-District	2 - 6

2.3.1	General.....	2 - 6
2.3.2	Preparatory Works.....	2 - 7
2.3.3	Field Survey Works.....	2 - 7
2.3.4	Result of Field Survey.....	2 - 8
3.	GEOLOGICAL SURVEY	
3.1	General.....	3 - 1
3.1.1	Geological Data Collection.....	3 - 1
3.1.2	Geological Structures of Indochina.....	3 - 1
3.1.3	Geological Structures of Nam Ngiep Basin.....	3 - 4
3.2	Geology around Proposed Reservoir.....	3 - 5
3.2.1	Upstream Area of Reservoir.....	3 - 5
3.2.2	Downstream Area of Reservoir.....	3 - 5
3.3	Geology at Dam Site.....	3 - 6
3.3.1	General.....	3 - 6
3.3.2	Geological Distribution.....	3 - 6
3.3.3	Geological Structure.....	3 - 13
3.3.4	Lithology.....	3 - 13
3.3.5	Strength and Water Tightness of Dam Foundation Rocks.....	3 - 15
3.3.6	Geology around Re-Regulating Weir Site.....	3 - 15
3.4	Seismicity.....	3 - 16
3.5	Construction Material.....	3 - 16
3.5.1	Strength of Rock.....	3 - 16
3.5.2	Quarry Sites.....	3 - 17
3.5.3	Fill Material.....	3 - 19
4.	METEOROLOGICAL & HYDROLOGICAL SURVEY	
4.1	General.....	4 - 1
4.2	Meteorological & Hydrological Observation.....	4 - 1
4.2.1	General.....	4 - 1
4.2.2	Installation of Meteorological Observation Equipment.....	4 - 3
4.2.3	Installation of Hydrological Observation Equipment.....	4 - 5
4.3	Collection of Meteorological & Hydrological Data.....	4 - 8
4.3.1	General.....	4 - 8
4.3.2	Meteorological Data.....	4 - 8
4.3.3	Hydrological Data.....	4 - 11
4.4	Evaluation of Meteorological & Hydrological Data.....	4 - 16
4.4.1	Meteorological Data.....	4 - 16
4.4.2	Hydrological Data.....	4 - 17
4.5	Review and Evaluation on Long-term Monthly Mean Inflow at Dam Site.....	4 - 19
4.5.1	Review of Previous Hydrological Studies.....	4 - 19
4.5.2	Review Results on Monthly Mean Inflows Estimates.....	4 - 22
4.5.3	Preliminary Evaluation.....	4 - 24
4.6	Review on Flood Discharge.....	4 - 25
4.6.1	Estimate at Pre-F/S.....	4 - 25
4.6.2	Review on Estimate.....	4 - 25
5.	POWER MARKET SURVEY	
5.1	General.....	5 - 1

5.2	Power Market in Greater Mekong Sub-Region	5 - 1
5.3	Power Market in Lao PDR	5 - 2
5.3.1	General.....	5 - 2
5.3.2	IPP Governmental Agencies.....	5 - 3
5.3.3	Forecast of Electricity Demand in Lao PDR.....	5 - 3
5.3.4	Candidate Projects for Power Export from Lao PDR.....	5 - 7
5.3.5	Transmission System Development	5 - 9
5.3.6	Impact of Asian Financial Crisis	5 - 13
5.4	Power Market in Thailand	5 - 13
5.4.1	Potential of Power Resources in Thailand.....	5 - 13
5.4.2	Forecast of Electricity Demand in Thailand.....	5 - 14
5.4.3	Power Import Plan of Thailand.....	5 - 19
5.4.4	Reassessment of Economic Growth in the Wake of Currency Crisis	5 - 20
5.5	Power Market in Vietnam	5 - 22
5.5.1	General.....	5 - 22
5.5.2	Structure of Power Sector.....	5 - 24
5.5.3	Potential of Power Resources in Vietnam	5 - 24
5.5.4	Power Development Program in Vietnam.....	5 - 26
5.5.5	Power Import Plan of Vietnam.....	5 - 30
5.6	IPP Business Approach.....	5 - 32
5.6.1	IPPs in Thailand.....	5 - 32
5.6.2	IPPs in Vietnam	5 - 34
5.6.3	New IPP Business Approach after Economic Crisis	5 - 36
6.	HYDROPOWER PLAN	
6.1	General.....	6 - 1
6.2	Reservoir Operation	6 - 1
6.2.1	Purpose of Reservoir Operation Study	6 - 1
6.2.2	Conditions for Determination of Optimum Reservoir Operation Model	6 - 2
6.2.3	Simulation of Reservoir Operation.....	6 - 3
6.2.4	Computation of Power Output.....	6 - 3
6.3	Study of Hydropower Plan	6 - 4
6.3.1	Basic Considerations for Project Power Development.....	6 - 4
6.3.2	Confirmation of Basic Parameters.....	6 - 5
6.3.3	Comparative Dam Scheme and Layout	6 - 15
6.3.4	Run-of-River Type Alternative and Development Scale.....	6 - 19
6.4	Construction Cost Estimate & Economic Evaluation of Environmental Impacts	6 - 20
6.4.1	Conditions for Project Cost Estimate	6 - 20
6.4.2	Estimate of Construction Work Quantities.....	6 - 20
6.4.3	Estimate of Construction Unit Prices	6 - 21
6.4.4	Cost Estimate other than Direct Construction Cost.....	6 - 21
6.4.5	Economical Evaluation of Natural and Social Environmental Impacts ..	6 - 23
6.5	Economic and Financial Evaluation Criteria.....	6 - 32
6.5.1	Approach to Project Economic and Financial Evaluation.....	6 - 32
6.5.2	Parameters for Project Evaluation	6 - 32
6.5.3	Valuation of Cost.....	6 - 33
6.5.4	Valuation of Benefits.....	6 - 33
6.6	Economic Evaluation	6 - 34
6.6.1	General.....	6 - 34

6.6.2	Parameters for Economic Analysis.....	6 - 35
6.6.3	Economic Analysis Using Avoided Cost	6 - 35
6.6.4	Risk Analysis.....	6 - 36
6.7	Financial Evaluation	6 - 36
6.7.1	General.....	6 - 36
6.7.2	Assumptions for Financial Analysis.....	6 - 37
6.7.3	Benefits Assumed for Financial Analysis.....	6 - 39
6.7.4	Financial Evaluation of FSL.320m Alternative.....	6 - 39
6.7.5	Financial Evaluation of FSL.360m Alternative.....	6 - 41
6.7.6	Sensitivity Analysis for Both Alternatives	6 - 41
6.7.7	Conclusions	6 - 42
7.	SUMMARY OF FIRST EIA REPORT	
7.1	General.....	7 - 1
7.2	Institutional and Legal Framework.....	7 - 1
7.2.1	Government Institutions	7 - 1
7.2.2	Policy and Legal Context	7 - 2
7.3	Baseline Information on Present Conditions.....	7 - 3
7.3.1	Typology of Project Area	7 - 3
7.3.2	Landscape, Geology, Minerals and Soils	7 - 3
7.3.3	Climate and Hydrology.....	7 - 3
7.3.4	Water Quality.....	7 - 5
7.3.5	Aquatic Ecology and Fisheries.....	7 - 8
7.3.6	Vegetation and Wildlife.....	7 - 10
7.4	Impact Analysis and Mitigation Measures	7 - 19
7.4.1	Environmental Impacts Screening.....	7 - 19
7.4.2	Impacts During Construction Phase	7 - 19
7.4.3	Impacts During Filling Phase	7 - 22
7.4.4	Impacts During Operation Phase in Inundation Zone	7 - 27
7.4.5	Impacts During Operation Phase in Downstream Area.....	7 - 36
7.4.6	Environmental Comparison between Alternatives	7 - 43
7.4.7	Conclusions	7 - 43
7.5	Environmental Management and Monitoring Plan (EMP).....	7 - 47
7.5.1	Objectives of the Plan.....	7 - 47
7.5.2	Institutional Organization and Responsibilities.....	7 - 47
7.5.3	Environmental Measures and Estimated Cost	7 - 48
7.5.4	Implementation Schedule of Environmental Measures.....	7 - 48
7.6	Summary of Preliminary Resettlement Plan (PRP).....	7 - 53
7.6.1	Proposed Reservoir Area	7 - 53
7.6.2	Resettlement Impacts of Reservoir Inundation.....	7 - 56
7.6.3	Development of Draft RAP and Final RAP	7 - 61
7.6.4	Resettlement Action Plan (RAP).....	7 - 64
7.6.5	Nam Ngum Watershed Management planning.....	7 - 68
7.6.6	Conclusions	7 - 71
8.	PRELIMINARY DESIGN	
8.1	General.....	8 - 1
8.2	Overall Project Layout	8 - 2
8.2.1	General Layout	8 - 2

8.2.2	Temporary Facilities.....	8 - 2
8.2.3	Construction Access Road.....	8 - 2
8.3	Preliminary Design of Major Structures.....	8 - 7
8.3.1	Design Flood Discharges.....	8 - 7
8.3.2	Reservoir Operation Levels.....	8 - 7
8.3.3	Main Dam.....	8 - 8
8.3.4	Spillway.....	8 - 13
8.3.5	Outlet Works.....	8 - 16
8.3.6	Intake Structure and Power Waterway.....	8 - 16
8.3.7	Power Station.....	8 - 17
8.3.8	Re-Regulation Facilities.....	8 - 22
9.	GENERAL PROJECT EVALUATION	
9.1	General.....	9 - 1
9.2	General Project Evaluation Results.....	9 - 1
9.2.1	Definition of Evaluation Criteria.....	9 - 1
9.2.2	General Project Evaluation by Study Team.....	9 - 2
9.2.3	Natural Environment Evaluation Results.....	9 - 3
9.2.4	Social Environment Evaluation Results.....	9 - 4
9.2.5	Economic Evaluation Results.....	9 - 5
9.2.6	Financial Evaluation Results.....	9 - 6
9.2.7	Technical Evaluation.....	9 - 6
9.2.8	Evaluation Results on EAC & General/Site Workshops.....	9 - 8
9.2.9	Evaluation Results on Mekong River Basin Development Plans.....	9 - 9
10.	PROJECT IMPLEMENTATION	
10.1	Feasibility Study for Next Stage.....	10 - 1
10.1.1	General.....	10 - 1
10.1.2	Field Investigation.....	10 - 1
10.1.3	F/S Grade Design Works.....	10 - 2
10.2	Project Implementation Schedule.....	10 - 3
10.2.1	Implementation Procedure.....	10 - 3
10.2.2	Procurement Plan.....	10 - 5
10.2.3	Construct Package.....	10 - 8
11.	RECORDS ON WORK PROCESS	
11.1	Environmental Assessment Committee (EAC).....	11 - 1
11.1.1	Background and AIM of EAC.....	11 - 1
11.1.2	Execution of 1st EAC Meeting.....	11 - 2
11.1.3	Execution of 2nd EAC Meeting.....	11 - 5
11.1.4	Execution of 3rd EAC Meeting.....	11 - 9
11.2	General Workshop.....	11 - 13
11.2.1	General.....	11 - 13
11.2.2	1st General Workshop.....	11 - 13
11.2.3	2nd General Workshop.....	11 - 18
11.2.4	3rd General Workshop.....	11 - 23
11.3	Site Workshop.....	11 - 28
11.3.1	Background and Subjects.....	11 - 28
11.3.2	1st Site Workshop.....	11 - 28

11.3.3	2nd Site Workshop	11 - 30
11.3.4	3rd Site Workshop	11 - 32
11.4	EIA Survey by Sub-Contractor.....	11 - 37
11.4.1	Work Items of EIA Survey	11 - 37
11.4.2	Bidding Procedure of the Works	11 - 37
11.4.3	Supervision of the Works	11 - 39
11.5	Transfer of Knowledge to Counterparts	11 - 42
11.5.1	General.....	11 - 42
11.5.2	Natural and Social Environmental Survey	11 - 42
11.5.3	Geophysical Survey	11 - 42
11.5.4	Geological Survey	11 - 43
11.5.5	Hydrological Survey	11 - 44
11.5.6	JICA Counterpart Training.....	11 - 44
11.6	Site Photographs	11 - 45
11.7	JICA Study Team Members	11 - 50
11.8	Contents of Supporting Reports	11 - 53

LIST OF TABLES

Table 1.1	Salient Features of Recommended Scheme in Pre-F/S.....	1 - 3
Table 1.2	Submitted Study Reports	1 - 6
Table 1.3	Composition of Study Reports.....	1 - 7
Table 2.2.1	Feature of Geophysical Survey	2 - 2
Table 2.2.2	Comparison between Execution Plan and Actual Works	2 - 4
Table 2.2.3	Given Points for GPS Survey.....	2 - 4
Table 2.2.4	Base Points of GPS Survey	2 - 4
Table 2.2.5	River Water Levels Observed	2 - 4
Table 2.2.6	Time Schedule of GPS Survey.....	2 - 4
Table 2.2.7	Villages Selected for Ground Leveling Survey	2 - 5
Table 2.2.8	Time Schedule for Ground Leveling Survey	2 - 6
Table 2.2.9	Discrepancy of Elevations between Survey Result & Existing Map....	2 - 6
Table 2.3.1	Work Schedule of Geophysical Survey	2 - 7
Table 3.1.1	Geological Data Collection.....	3 - 1
Table 3.5.1	Result of Franklin Test made in Pre-F/S.....	3 - 17
Table 4.2.1	Newly Installed Hydrological Observation Stations.....	4 - 3
Table 4.2.2	Rainfall Observation Data measured by the Study Team.....	4 - 4
Table 4.2.3	Total Length of Installed Water-Level Staff.....	4 - 5
Table 4.2.4	Result of Discharge Measurement.....	4 - 6
Table 4.3.1	Collected Meteorological and Hydrological Data	4 - 7
Table 4.3.2	List of Observation Station	4 - 11
Table 4.3.3	Watershed Areas of Major Hydrological Sites	4 - 11
Table 4.3.4	Difference of the Watershed Area at Muangmai Station.....	4 - 14
Table 4.4.1	Mean Annual Basin Precipitation in Nam Ngiep at B.Muangmai.....	4 - 16
Table 4.4.2	Min. W.L. Difference between Pakxan and B.Muangmai(1988-1993)	4 - 17
Table 4.4.3	Number of Discharge Measurements.....	4 - 18
Table 4.4.4	Comparison of Mean Annual Precipitation & Runoff at B.Muangmai	4 - 19
Table 4.5.1	Hydrological Date of Nam Ngiep Dam Site	4 - 20
Table 4.5.2	Estimated Mean Annual Precipitation and B.Muangmai (1962-1991)	4 - 21

Table 4.5.3	Estimated Mean Annual Runoff at Dam Site (1966-1995)	4 - 21
Table 4.5.4	Comparison of Catchment Area at Dam Site and B.Muangmai	4 - 22
Table 4.5.5	Estimated Mean Annual Precipitation and Runoff at Dam Site	4 - 23
Table 4.5.6	Estimated Mean Annual Precipitation and Runoff at B.Muangmai	4 - 23
Table 4.5.7	Comparison of Estimated Annual Average Runoff at B.Muangmai	4 - 23
Table 4.5.8	Adapted Catchment Area at Dam Site and B.Muangmai	4 - 24
Table 4.6.1	Probable Floods at Major Points in Nam Ngiep Basin	4 - 25
Table 5.3.1	Energy Generation and Trade Balance in Lao PDR	5 - 6
Table 5.3.2	Energy Consumption Forecast in Lao PDR up to 2010.....	5 - 7
Table 5.3.3	Present IPP Projects in Lao PDR	5 - 8
Table 5.3.4	Comparison between Gener. Cost in Thai & Proposed Tariff of Lao ..	5 - 9
Table 5.3.5	Connecting S.S for Export Power to Thai from Existing P.S in Lao....	5 - 10
Table 5.4.1	Existing Power Plants in Thailand.....	5 - 14
Table 5.4.2	Peak Demand Under PDP 99-01.....	5 - 17
Table 5.4.3	EGAT Averaged Generation Requirements	5 - 17
Table 5.4.4	EGAT Generation Requirements.....	5 - 18
Table 5.4.5	Power Capacity Increase in Thailand (1999-2011).....	5 - 20
Table 5.4.6	Key Economical Indicators in Thailand	5 - 22
Table 5.5.1	Electricity Generating by Region in 1996	5 - 26
Table 5.5.2	Vietnam's Existing Power Generation Facilities in 1999.....	5 - 27
Table 5.5.3	Electricity Demand for 1995-1999	5 - 27
Table 5.5.4	Transmission and Distribution Facilities	5 - 29
Table 5.5.5	Electricity Generation Demand Forecasts (2000-2020).....	5 - 29
Table 5.5.6	GDP Growth under the 3 Growth Scenarios.....	5 - 29
Table 5.5.7	New Generating Source Capacity by 2020	5 - 30
Table 5.6.1	IPPs in Vientiane (as of end 1999)	5 - 35
Table 6.2.1	Input and Output Data for Reservoir Operation	6 - 3
Table 6.3.1	Division of Nam Ngiep River Slopes	6 - 5
Table 6.3.2	Topographic Conditions at 3-Alternative Dam Sites.....	6 - 5
Table 6.3.3	Modification of Storage Capacity based on Survey at Thaviang	6 - 7
Table 6.3.4	Estimate of Sediment Volume	6 - 7
Table 6.3.5	States of Inundation at Respective Elevation.....	6 - 9
Table 6.3.6	Electricity Price(Tariff) of Nam Ngum 1 HEPP.....	6 - 14
Table 6.3.7	Monthly Discharge on the Nam Ngiep Rive at Damsite	6 - 15
Table 6.3.8	Configuration of Dam Type Alternatives (1st Phase).....	6 - 16
Table 6.3.9	1st Economic Comparison of Alternative Dam Type Schemes	6 - 16
Table 6.3.10	2nd Economic Comparison of Alternative Dam Type Schemes	6 - 17
Table 6.3.11	3rd Economic Comparison of Alternative Dam Type Schemes.....	6 - 18
Table 6.3.12	Configuration of Run-of-River Type Alternatives	6 - 19
Table 6.3.13	Economic Comparison of Alternative Run-of-River Type Schemes ...	6 - 19
Table 6.4.1	Construction Work Quantities	6 - 20
Table 6.4.2	Contract Unit Prices of Major Civil Works at Various ICB Projects...	6 - 21
Table 6.4.3	Assumed Power Losses of Hydropower Plant.....	6 - 22
Table 6.4.4	Collateral Solutions for Quantitatively Evaluated Impacts	6 - 22
Table 6.4.5	Interpretation for Specific Benefits out of Income from Electricity....	6 - 24
Table 6.4.6	Project Features for Alternative FSLs.....	6 - 25
Table 6.4.7	Hydraulic Characteristics & Structural Dimensions.....	6 - 26
Table 6.4.8	Construction Work Quantities	6 - 27
Table 6.4.9	Construction Cost (1/2).....	6 - 28

Table 6.4.10	Construction Cost (2/2).....	6 - 29
Table 6.4.11	Construction Cost and Annual Costs of Alternative Thermal Plant.....	6 - 30
Table 6.4.12	Hydropower Potential at Different FSLs.....	6 - 31
Table 6.6.1	Parameters for Economic Analysis.....	6 - 35
Table 6.6.2	Assumed Power Losses for Thermal Power Plant.....	6 - 36
Table 6.6.3	Results of Risk Analysis.....	6 - 36
Table 6.7.1	Project Cost Disbursement Schedule.....	6 - 37
Table 6.7.2	Working Capital.....	6 - 37
Table 6.7.3	Power Generation and Sales Schedule(GWh/year).....	6 - 37
Table 6.7.4	Financing Terms.....	6 - 38
Table 6.7.5	Initial Assumptions in Financial Analysis.....	6 - 38
Table 6.7.6	Primary Levelised Energy Tariff at Current Price.....	6 - 39
Table 6.7.7	Tariff Comparison.....	6 - 39
Table 6.7.8	Disbursement of Project Cost.....	6 - 40
Table 6.7.9	Results of Sensitivity Analysis.....	6 - 41
Table 7.3.1	Average Monthly Rainfall Average in Project Area.....	7 - 5
Table 7.3.2	River Flow at Dam Site.....	7 - 5
Table 7.3.3	Results of Water Quality Monitoring.....	7 - 8
Table 7.3.4	Distribution of Biodiversity.....	7 - 9
Table 7.3.5	Degradation of Land Systems.....	7 - 14
Table 7.3.6	Mammals and Reptiles observed having Conservation Significance... ..	7 - 18
Table 7.4.1	Summary of Impacts in Downstream Area and Construction Zones	7 - 20
Table 7.4.2	Summary of Impacts in Inundation Zone and Catchment Area.....	7 - 21
Table 7.4.3	Change in Flow during Filling with 20 m ³ /s Riparian Release.....	7 - 22
Table 7.4.4	Distribution of Land Use in Inundation Zone.....	7 - 23
Table 7.4.5	Estimated Biomass in Reservoir Area.....	7 - 26
Table 7.4.6	Potential Maximum Reduction of Biomass in Reservoir Area.....	7 - 26
Table 7.4.7	Distribution of Maximum Draw-Down in Reservoir.....	7 - 31
Table 7.4.8	Availability of Draw-Down Area.....	7 - 31
Table 7.4.9	Comparison of Alternatives.....	7 - 44
Table 7.5.1	Environmental Measures and Estimated Cost (1/2).....	7 - 50
Table 7.5.2	Environmental Measures and Estimated Cost (2/2).....	7 - 51
Table 7.5.3	Implementation Schedule of Environmental Measures.....	7 - 52
Table 7.6.1	Numbers of HH & Population in Reservoir Area & D/D of Dam.....	7 - 59
Table 7.6.2	Preliminary Construction and Resettlement Task Schedule.....	7 - 62
Table 7.6.3	Cost Estimate of Preparatory PRP Studies.....	7 - 63
Table 7.6.4	Preliminary Summary of Resettlement Cost.....	7 - 68
Table 8.1.1	Final Salient Features of Promising Scheme.....	8 - 1
Table 8.2.1	Existing Road Conditions between Pakxan and Dam Site.....	8 - 7
Table 8.3.1	Flood Discharge at Dam Site.....	8 - 7
Table 8.3.2	Reservoir Water Levels for each Alternative.....	8 - 8
Table 8.3.3	Partial List of CFRD H>100m after 1980.....	8 - 10
Table 8.3.4	Instrumentation for Main Dam.....	8 - 12
Table 8.3.5	Major Dimension of River Diversion Tunnel.....	8 - 13
Table 8.3.6	Major Dimensions of Intake and Headrace Tunnel.....	8 - 17
Table 8.3.7	Major Dimensions of Power Station.....	8 - 18
Table 8.3.8	Preliminary Sizing for Nam Ngiep-I Powerhouse.....	8 - 19
Table 9.2.1	Definition of Evaluation Criteria.....	9 - 2
Table 9.2.2	General Evaluation Results by Study Team.....	9 - 2

Table 9.2.3	Economic Comparison of Alternative Dam Type Schemes	9 - 5
Table 9.2.4	Results of Financial Evaluation	9 - 6
Table 9.2.5	Typical Dam Project of CFRD	9 - 7
Table 9.2.6	Major Dam Features	9 - 7
Table 9.2.7	Technical Comparison among Alternatives.....	9 - 7
Table 9.2.8	Major Opinion at EAC and General/Site Workshops.....	9 - 8
Table 10.1	Implementation Schedule in Four Stages	10 - 3
Table 10.2	Time Schedule for Pre-Construction Activities.....	10 - 4
Table 10.3	Construction time Schedule for Major Works.....	10 - 5
Table 10.4	Contents of Field Survey before Detailed Design	10 - 6
Table 11.1.1	List of EAC Members and Advisor	11 - 2
Table 11.1.2	Attendance List of 1st Environmental Assessment Committee.....	11 - 3
Table 11.1.3	Execution Programs of 1st Environmental Assessment Committee....	11 - 3
Table 11.1.4	Attendance List of 2nd Environmental Assessment Committee	11 - 6
Table 11.1.5	Execution Programs of 2nd Environmental Assessment Committee ...	11 - 6
Table 11.1.6	Attendance List of 3rd Environmental Assessment Committee.....	11 - 10
Table 11.1.7	Execution Programs of 3rd Environmental Assessment Committee....	11 - 10
Table 11.2.1	Outline of the 1st General Workshop	11 - 14
Table 11.2.2	Outline of the 2nd General Workshop	11 - 19
Table 11.2.3	Outline of the 3rd General Workshop.....	11 - 24
Table 11.3.1	Places for 1st Site Workshop	11 - 29
Table 11.3.2	Preparatory Schedule for 1st Site Workshop.....	11 - 29
Table 11.3.3	Preparatory Schedule for 2nd Site Workshop.....	11 - 31
Table 11.3.4	Sites for the 3rd Site Workshop	11 - 34
Table 11.3.5	Preparatory Schedule for 3rd Site Workshop	11 - 34
Table 11.7.1	Description of Work for Team Members by Position	11 - 50
Table 11.7.2	Executed Staffing Schedule	11 - 52

LIST OF FIGURES

Figure 1.1	Project General Layout	1 - 8
Figure 1.2	Overall Work Flow	1 - 9
Figure 2.2.1	Survey Area Map	2 - 3
Figure 2.3.1	Inundation Area Map of Cultivation Land at FSL.320m.....	2 - 9
Figure 2.3.2	Inundation Area Map of Cultivation Land at FSL.360m.....	2 - 10
Figure 3.1.1	Geological Map of Indochina	3 - 2
Figure 3.1.2	Geological Map in Nam Ngiep Basin.....	3 - 3
Figure 3.3.1	Geological Map at Dam Site.....	3 - 7
Figure 3.3.2	Geological Plan at Dam Site.....	3 - 8
Figure 3.3.3	Geological Profile along Dam Axis.....	3 - 9
Figure 3.3.4	Geological Profile along River Diversion Tunnel	3 - 10
Figure 3.3.5	Geological Profile along Spillway Cuteway.....	3 - 11
Figure 3.3.6	Geological Profile along Headrace Tunnel.....	3 - 12
Figure 3.3.7	Sketch of Conglomerate Cliff.....	3 - 14
Figure 3.5.1	Prospective Sites for Quarry	3 - 18
Figure 4.2.1	Hydro-Meteorological Observation Gauge Stations.....	4 - 2
Figure 4.2.2	Rainfall Observation Data measured by Study Team.....	4 - 4
Figure 4.2.3	H-Q Relation Curves.....	4 - 7

Figure 4.2.4	Rainfall & Water Level Dam measured by Study Team	4 - 8
Figure 4.3.1	Monthly Rainfall Average (mm) at Muangmai Rain-Gauge Station....	4 - 10
Figure 4.3.2	Topographic Map of Watershed Area of Nam Ngiep Basin.....	4 - 12
Figure 4.3.3	Watershed Areas of Major Hydrological Sites	4 - 13
Figure 4.3.4	Daily Discharge Fluctuation at Muangmai (1988-1993).....	4 - 15
Figure 5.3.1	Organization Chart of Principal GOL Agencies involved in IPP	5 - 4
Figure 5.3.2	IPP Project Implementation Process in Lao PDR.....	5 - 5
Figure 5.3.3	Future National Grid Line of Lao PDR for 500kV Power Export.....	5 - 11
Figure 5.3.4	Tentative Route of 500kV Line (B.Nabong S.S & Pakxan G.S).....	5 - 12
Figure 5.4.1	Monthly Trends in Peak Demand (FY1997-FY1999).....	5 - 15
Figure 5.4.2	Daily Load Curves on Peak Day for Past 10 years in Thailand.....	5 - 16
Figure 5.4.3	Comparison of 3 Scenarios and Actual Demand for Monthly Peak....	5 - 19
Figure 5.5.1	Characteristics of Vietnam's Power System.....	5 - 26
Figure 5.5.2	Location Map of Existing Power Station and T/L System	5 - 28
Figure 6.3.1	Alternative Dam Sites on Nam Ngiep River.....	6 - 6
Figure 6.3.2	Area-Capacity Curve of Nam Ngiep Reservoir	6 - 8
Figure 6.3.3	Topographic Limitation for FSL.....	6 - 10
Figure 6.3.4	Reservoir Profile at Different FSL.....	6 - 11
Figure 6.3.5	Rural Electrification Plan.....	6 - 13
Figure 6.3.6	Duration Curve for 30Years at Damsite	6 - 14
Figure 6.3.7	Results of 1st Economic Comparison.....	6 - 16
Figure 6.3.8	Results of 2nd Economic Comparison.....	6 - 18
Figure 6.7.1	Revenue Components of FSL.320m Alternative	6 - 41
Figure 7.3.1	Typology of Project Area.....	7 - 4
Figure 7.3.2	Total/Controlled Nam Ngiep Catchment.....	7 - 6
Figure 7.3.3	Location of Water Sampling.....	7 - 7
Figure 7.3.4	Land System in Nam Ngiep Catchment.....	7 - 12
Figure 7.3.5	Land Cover in Nam Ngiep Catchment.....	7 - 13
Figure 7.3.6	Potential for Development in Catchment Area.....	7 - 15
Figure 7.3.7	Areas of Special Interest for Wildlife	7 - 17
Figure 7.4.1	Land Use in Reservoir Area (FSL.360m).....	7 - 24
Figure 7.4.2	Land Use in Reservoir Area (FSL.320m).....	7 - 25
Figure 7.4.3	Intensity of Water Quality Problems	7 - 28
Figure 7.4.4	Draw-Down Areas (FSL.360m).....	7 - 29
Figure 7.4.5	Draw-Down Areas (FSL.320m).....	7 - 30
Figure 7.4.6	Vollenweider Phosphorus Model.....	7 - 33
Figure 7.4.7	Variation of Thermocline Level (FSL.360m).....	7 - 34
Figure 7.4.8	Variation of Thermocline Level (FSL.320m).....	7 - 35
Figure 7.4.9	Change in Flow at Dam Site (in m ³ /s)	7 - 37
Figure 7.4.10	Change in Flow at Dam Site (in %).....	7 - 38
Figure 7.4.11	Change in Flow at Muangmai (in m ³ /s).....	7 - 39
Figure 7.4.12	Change in Flow at Muangmai (in %).....	7 - 40
Figure 7.4.13	Change in Flow at Mekong Confluence (in m ³ /s).....	7 - 41
Figure 7.4.14	Change in Flow at Mekong Confluence (in %)	7 - 42
Figure 7.4.15	Hydropower Efficiency Rations with Inund. Area & Reset. People	7 - 45
Figure 7.5.1	Tentative Possible Organization Diagram	7 - 49
Figure 7.6.1	Boundary Orientation Map	7 - 54
Figure 7.6.2	Planned Road Upgrading Map in Xaysomboon	7 - 55
Figure 7.6.3	Reservoir Area Overview Map.....	7 - 57

Figure 7.6.4	Downstream Villages Overview Map.....	7 - 58
Figure 7.6.5	Land Use in the Thaviang Sub-District	7 - 60
Figure 7.6.6	Potential Resettlement Sites.....	7 - 65
Figure 8.2.1	Dam Site Layout Plan (FSL.EL.320m).....	8 - 3
Figure 8.2.2	Dam Site Layout Plan (FSL.EL.360m).....	8 - 4
Figure 8.2.3	Temporary Facilities and Access Road.....	8 - 5
Figure 8.2.4	Route of Access Road to Dam Site.....	8 - 6
Figure 8.3.1	Typical Dam Section and Profile along Dam Axis (FSL.EL.320m).....	8 - 9
Figure 8.3.2	River Diversion Tunnel, Profile (FSL.EL.320m)	8 - 14
Figure 8.3.3	Spillway, Profile (FSL.EL.320m).....	8 - 15
Figure 8.3.4	Intake and Headrace Tunnel, Profile (FSL.EL.320m).....	8 - 17
Figure 8.3.5	Powerhouse, Profile and Section (FSL.EL.320m).....	8 - 20
Figure 8.3.6	Tentative Operation Rule of Re-regulation Pond	8 - 23
Figure 8.3.7	Re-regulation Dam.....	8 - 24
Figure 8.3.8	Area and Storage Curves of Re-regulation Pond.....	8 - 25
Figure 9.2.1	Results of Economic Comparison.....	9 - 5
Figure 9.2.2	Financial Evaluation (FSL.320m).....	9 - 6
Figure 10.1	Tentative Work Schedule for 2nd Survey Stage.....	10 - 1
Figure 10.2	Time Schedule for Pre-Construction Stage.....	10 - 5
Figure 10.3	Tentative Construction Time Schedule.....	10 - 9

ABBREVIATIONS

Lao PDR agencies

EDL	Electricite du Laos
GOL	Government of Lao PDR
HPO	Hydropower Office (Department of Electricity, MIH)
LWU	Lao Women's Union
MAF	Ministry of Agriculture and Forestry
MIH	Ministry of Industry and Handicrafts
MOH	Ministry of Health
STEA (former STENO)	Science, Technology and Environ. Agencies (Organization)

Foreign organizations

ADB	Asian Development Bank
GOJ	Government of Japan
IUCN	World Conservation Union (Switzerland)
JICA	Japan International Cooperation Agency (Japan)
NTEC	Nam Theun 2 Electricity Company
OECF (JBIC)	Overseas Economic and Cooperation Fund (Japan) Note: Changed organization to JBIC (Japan Bank for International Cooperation) on October 1, 1999.
UNDP	United Nations Development Program
WCS	The Wildlife Conservation Society (New-York)
WHO	World Health Organization

Others

B.	"Ban" Village in Laotian language
BOT	Built-Operate-Transfer
BOOT	Built-Own-Operate-Transfer
CFRD	Concrete Faced Rockfill Dam
EAC	Environmental Assessment Committee
EIA	Environmental Impact Assessment
EMMP	Environmental Management & Monitoring Plan
F/S	Feasibility Study
GPS	Global Positioning System
HEPP	Hydroelectric Power Project
ICB	International Competitive Bidding
IEE	Initial Environmental Examination
IPP	Independent Power Producer
LCB	Local Competitive Bidding
MOU	Minutes of Understanding
NBCA	National Biodiversity Conservation Area
NGOs	Non Governmental Organizations
NK-NBCA	Nam Khading Protected Area
PKK-NBCA	Phou Khao Khouai Protected Area
PPA	Power Purchase Agreement
SPP	Small Power Producer
RAP	Resettlement Action Plan
S/W	Scope of Works
TOR	Terms of Reference

Unit

EL () m	Meters above Sea Level
US\$	US Dollar
K.	Kip in Lao PDR
Bht.	Baht in Thailand
MW	Mega Watt (one million watt)
GWh	Giga Watt Hour (one billion watt hour)
B-C, B/C	B: Benefit and C: Cost
EIRR, FIRR	Economic/Financial Internal Rate of Return