SAMBOR PROJECT REPORT

Lower Mekong River Basin

Volume I

GENERAL REPORT (1)

OVERSEAS TECHNICAL COOPERATION AGENCY

GOVERNMENT OF JAPAN

JUNE 1969

SAMBOR PROJECT REPORT

The Sambor Project Report consists of the following eight volumes:

Volume I	General Report (1)
Volume II	General Report (2) — Sambor with Nam Ngum and Pa Mong
Volume III	Dam and Hydroelectric Power — Supplementary Material to Volume I
Volume IV	Irrigation and Agriculture — Supplementary Material to Volume I
Volume V	Navigation — Supplementary Material to Volume I
Volume VI	Fishery — Supplementary Material to Volume I
Volume VII	Basic Data — Appendix (1) to Volume III
Volume VIII	Drill Hole Logs — Appendix (2) to Volumes III and V

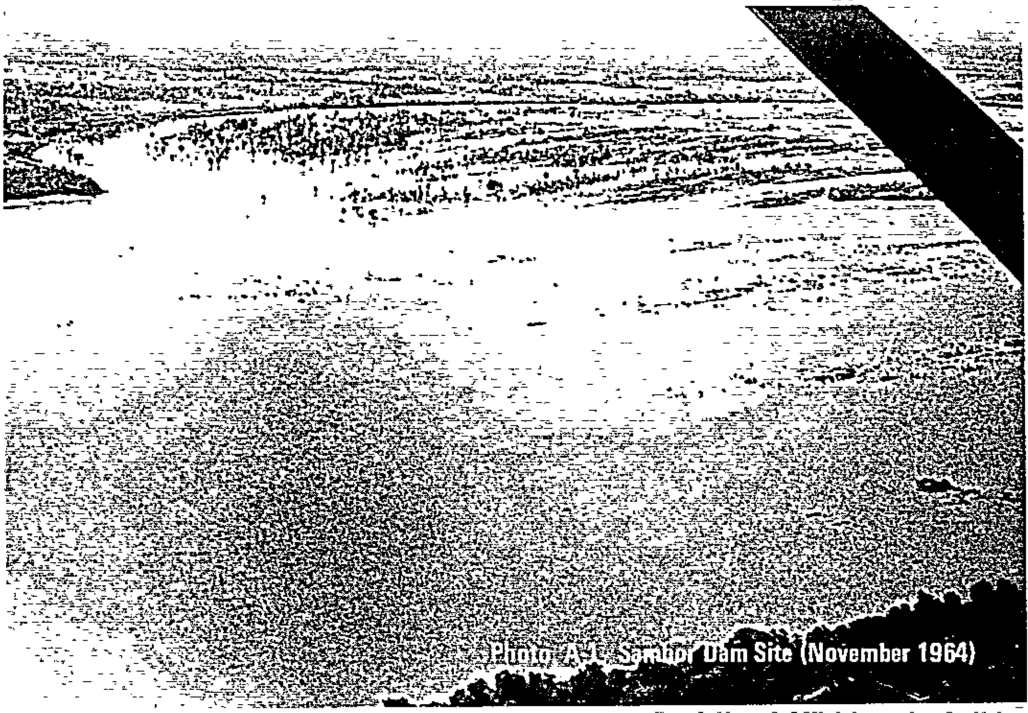


Photo. A-1. Sambor Dam Site (November 1964)

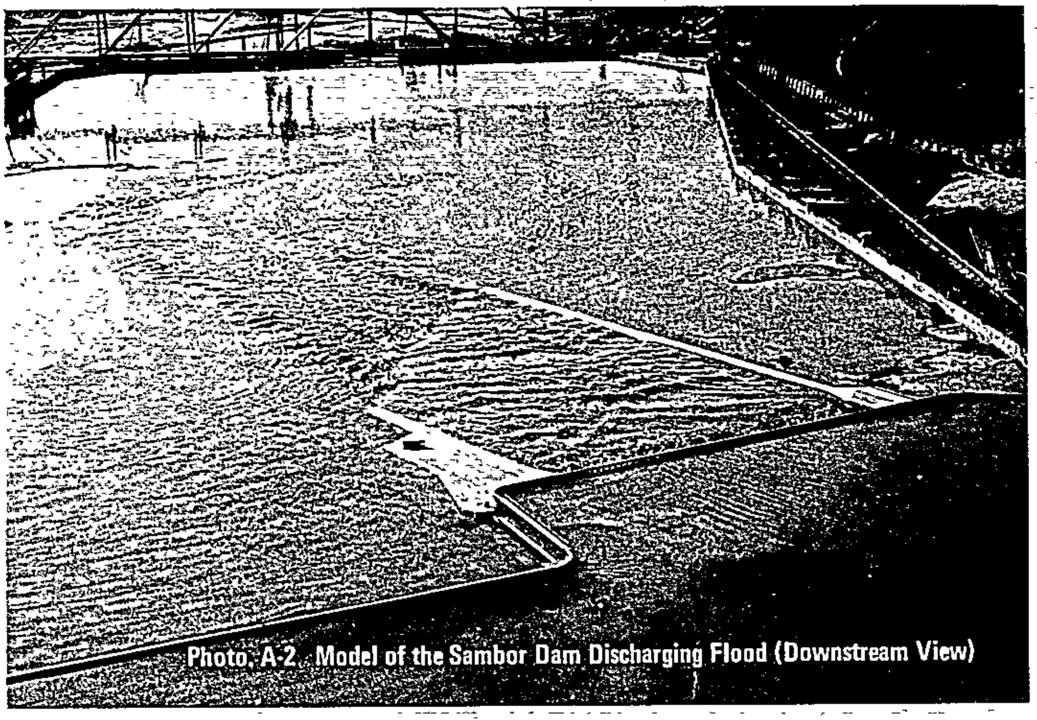
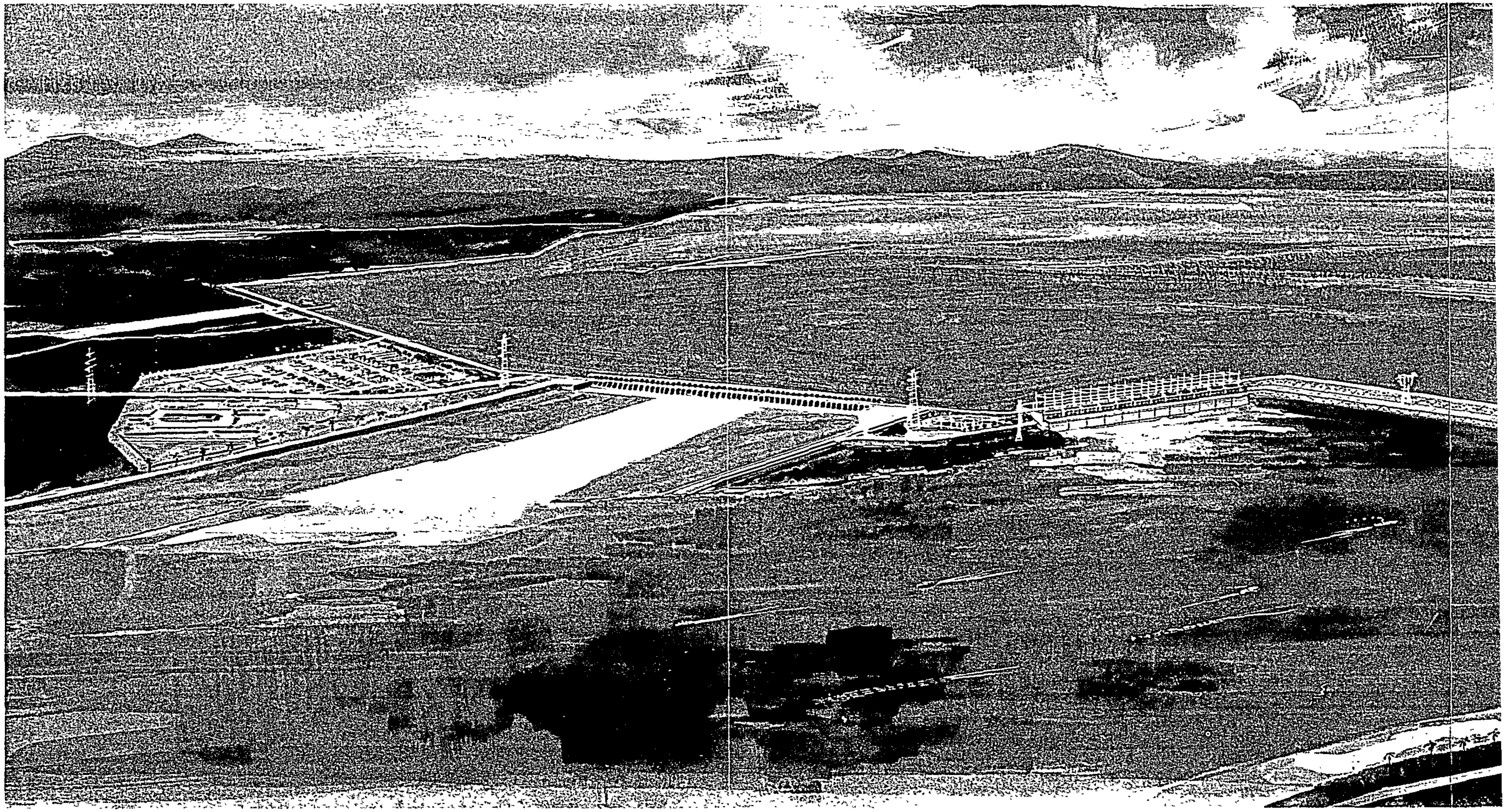
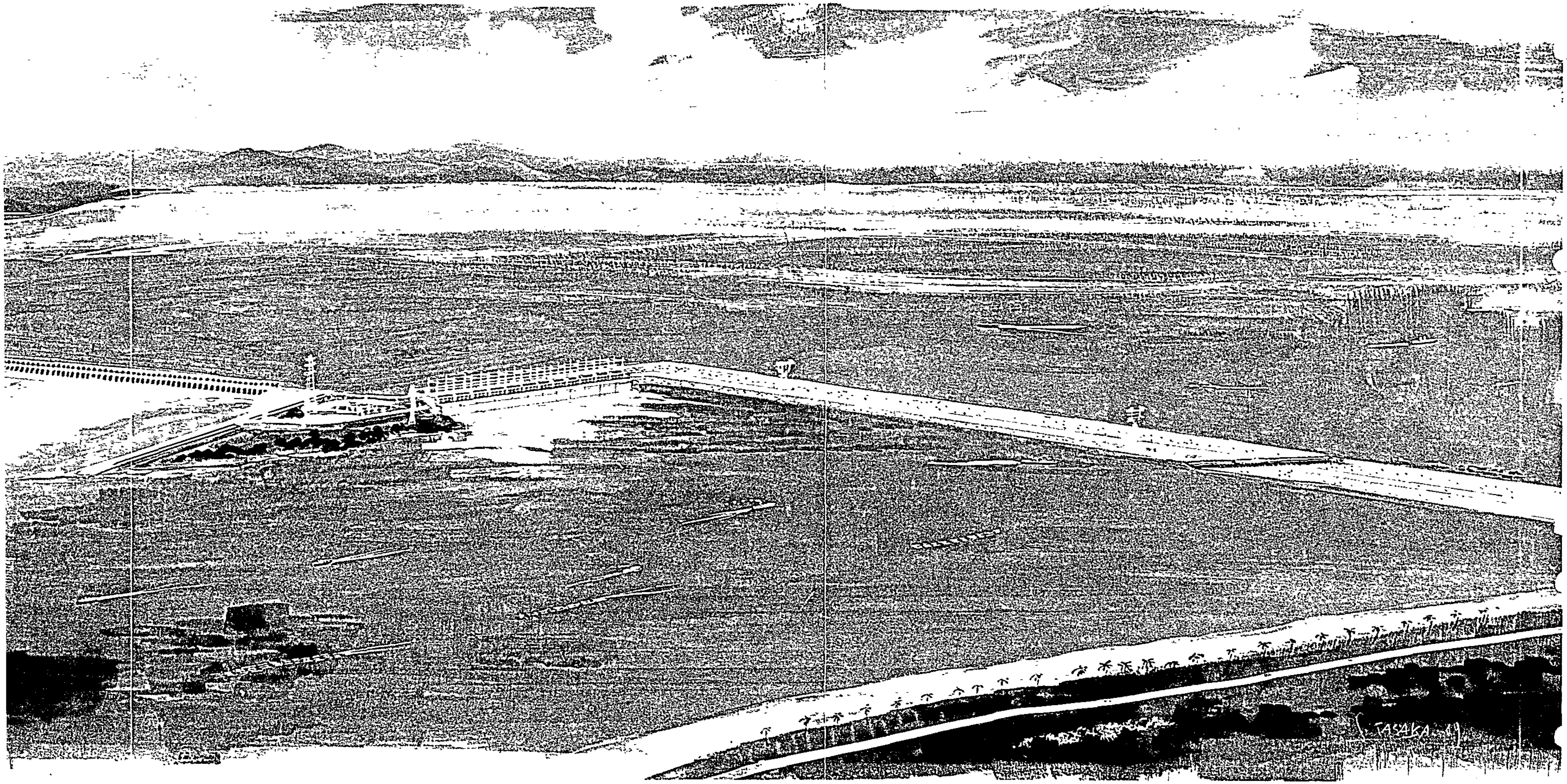


Photo. A-2. Model of the Sambor Dam Discharging Flood (Downstream View)





Aerial View of the Projected Sambor Dam

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PREFACE

The Government of Japan, at the request of the Committee for Coordination of Investigations of the Lower Mekong River Basin, expressed its intention to undertake a comprehensive investigation of the Sambor Project at the Seventeenth Session of the Committee and in December 1962, entrusted this task to the Overseas Technical Cooperation Agency (OTCA) which is an executing agency of the Government of Japan.

The OTCA decided to organize a survey team to implement the investigations and studies both at the Project sites and in Japan with the cooperation of government organizations, consultants firms and research institutions concerned.

The general management of these works was assumed by Mr. Goro Inouye, Director of the OTCA. The first and second teams were headed by Mr. Motonaga Ohto, Executive Director of the OTCA, and the third, fourth and fifth teams by Dr. Koichi Aki, Advisor to the OTCA.

The field investigations were carried out during the four-year period from January 1963 to March 1967 mainly within the Project area, i.e., the Kratie Province of Cambodia. Some of the investigations related to navigation and power markets were carried out in areas extending outside the Project area as well as in the neighboring countries of Laos, Thailand and Vietnam.

Subsequently, the planning, design calculation, analysis and review with regard to the Project were performed in Japan, and compiled into the present Report which consists of the following eight volumes:

Volume I	General Report (1)		
Volume II	General Report (2): Sambor with Nam Ngum and Pa Mong		
Volume III	Supplementary material to Volume I:		Dam and Hydroelectric Power
Volume IV	"	"	: Irrigation and Agriculture
Volume V	"	"	: Navigation
Volume VI	"	"	: Fishery
Volume VII	Appendix (1) to Volume III		: Basic Data
Volume VIII	Appendix (2) to Vol. III and Vol. V		: Drill Hole Logs

As is summarized at the outset of the Volume I, the Sambor Project is a multipurpose development project for hydroelectric power, agriculture and navigation. The Report concludes that the Project as such is feasible from technical, economic and financial points of view, and recommends its early execution for the economic development in the Lower Mekong River Basin.

Finally, on behalf of the OTCA, I take this opportunity to express my hearty gratitude to the U.N. Special Organizations the Mekong Committee, the Royal Governments of Cambodia, Laos, Thailand and the Government of Republic of Vietnam for their kind cooperation and assistance.

June, 1969

Shinichi Shibusawa
Director General
Overseas Technical Cooperation Agency
Tokyo, Japan

LETTER OF TRANSMITTAL

Mr. Shinichi Shibusawa, Director General
Overseas Technical Cooperation Agency,
Tokyo

Dear Sir,

I have the great pleasure of submitting herewith to you the Feasibility Report on the Comprehensive Development Project at the Sambor site on the Mekong River in Cambodia.

The Sambor Project, one key factor in the comprehensive development of the Mekong, aims at fulfilling general electric demand and promotion of industries through effective use of hydroelectric power, extension and stabilization of agricultural production, improvement of navigation, downstream from the Sambor site, as well as preservation or increase in fishery resources in the area.

The development of the Mekong is a prerequisite for the future economic and social development of the riparian countries in the Lower Mekong River Basin. Surveys and planning for the Mekong development have therefore been promoted for a long time by the Division of Water Resources Development of ECAFE and the Committee for Coordination of Investigations of the Lower Mekong River Basin (Mekong Committee).

At the 14th Session of the Mekong Committee held in Bangkok in May 1961, the Government of Japan expressed its intention to conduct a survey of the Sambor Project which was accepted by the Mekong Committee.

Thereafter, the preliminary survey and comprehensive investigations in five phases have been conducted up to 1967. These investigations were carried out mainly by engineers of the Electric Power Development Co.; Ltd. (EPDC) which was responsible for the power aspect; Sanyu Consultants International, Ltd. responsible for the agricultural aspect and Japan Port Consultants, Ltd. responsible for the navigation aspect, with the coordination of the Overseas Technical Cooperation Agency (OTCA).

In 1968 discussions were held between the OTCA and the Mekong Secretariat, Division of Water Resources Development (ECAFE) and the Royal Government of Cambodia with respect to the survey's findings, and it was agreed that the Sambor Project Report would consist of the General Reports and detailed reports dealing with the Dam and Power, Irrigation and Agriculture, Navigation and Fishery. These reports are hereby submitted.

The expenses required for the field survey and the preparation of the report, amounting to the equivalent of about $800,000 were borne by the Government of Japan. The total amount of money spent for the overall investigations including contributions from the Royal Government of Cambodia, Australia and other countries amounted to more than $1,100,000.

The Sambor Project, located in the lowermost reaches of the Mekong Mainstream, when completed will greatly benefit the economic and social development of the downstream areas. The project has a close interrelationship with the upstream projects of the Pa Mong, The Nam Ngum, the Stung Treng, etc. with regard to scale, timing and economy of development. Of these upstream projects, the scale of the Stung Treng Project has not been determined. The present report therefore deals with two cases, i.e., the case wherein the project is treated as an isolated project, and the case wherein the effects of the upstream projects, the Pa Mong and the Nam Ngum are taken into account.

The Outline of the Sambor Project is as described below:

The Sambor Dam site, some 500 km upstream from the estuary of the Mekong, is located on the Mekong Mainstream about 15 km upstream of Kratie – one of major towns in central Cambodia. The proposed dam will be a combination type of rock-fill, earth-fill and concrete dam with a total crest length of about 30 km and a height of 54 m in the river section.

In regard to the power aspect, the total installed capacity will be 875 MW and the annual energy output will be 7,000 million kWh. When the upstream projects are completed, the total installed capacity will be increased to 2,100 MW and the annual energy output will be nearly doubled to 14,100 million kWh. Power thus generated will be supplied to Phnom Penh and Sihanouk Ville in Cambodia and to Saigon in Vietnam through extra high tension transmission lines of 345 kV.

In regard to the agricultural aspect, irrigation improvement utilizing water supplied from the regulated discharge through the Sambor Dam and other sources will increase the total arable land from the present 12,469 ha to 34,000 ha and the planting area from 16,980 ha to 60,739 ha, with the annual net income per ha of each farming household also rising to a level 3.82 times size of the present one.

The Sambor Project will become even more advantageous when large-scale irrigation in the Deltaic Area is made possible by the combination of the Sambor power and the increase in the dry season discharge downstream of the Sambor Dam which will be attained upon completion of the Pa Mong Project.

As for navigation, the construction of the inclined passage facility of three lines, the increase in the dry season discharge due to the dam operation and the dredging of shallow sections of the river will make it possible for vessels presently plying only downstream of Kratie to serve as far upstream as Stung Treng throughout the year.

For the purpose of preservation and increase of fishery resources, a design for fish ladders is included in the present report.

The construction cost of the Sambor Project excluding the fishery aspect amounts to an equivalent of approximately $358 million in the case of the isolated project and an equivalent of approximately $478 million when the upstream projects are taken into consideration.

In order to finance the construction of the project, financial aid from cooperating countries will have to be sought in addition to long-term low-interest loans from international financing organizations.

As detailed in the report, the Sambor Project promises immense direct and indirect benefits which technically and economically justify its construction, even as an isolated project, when funding and other conditions are satisfied.

The construction of the Sambor Project is not simply very desirable but rather it is absolutely essential as it is the key to great economic and social benefits for all the riparian countries.

On this occasion, I wish to express my sincere thanks to all who extended their valuable assistance in the preparation of the Present Report. My appreciation also goes to the Royal Government of Cambodia and other riparian countries, ECAFE, the Mekong Committee, and the Embassies of Japan which extended unlimited cooperation in the execution of the field surveys. I sincerely hope that the development of the four riparian countries can be quickly begun through the early completion of the Sambor Project.

Yours respectfully,

May 28, 1969

Goro Inouye
Director of OTCA
in Charge of Sambor Project

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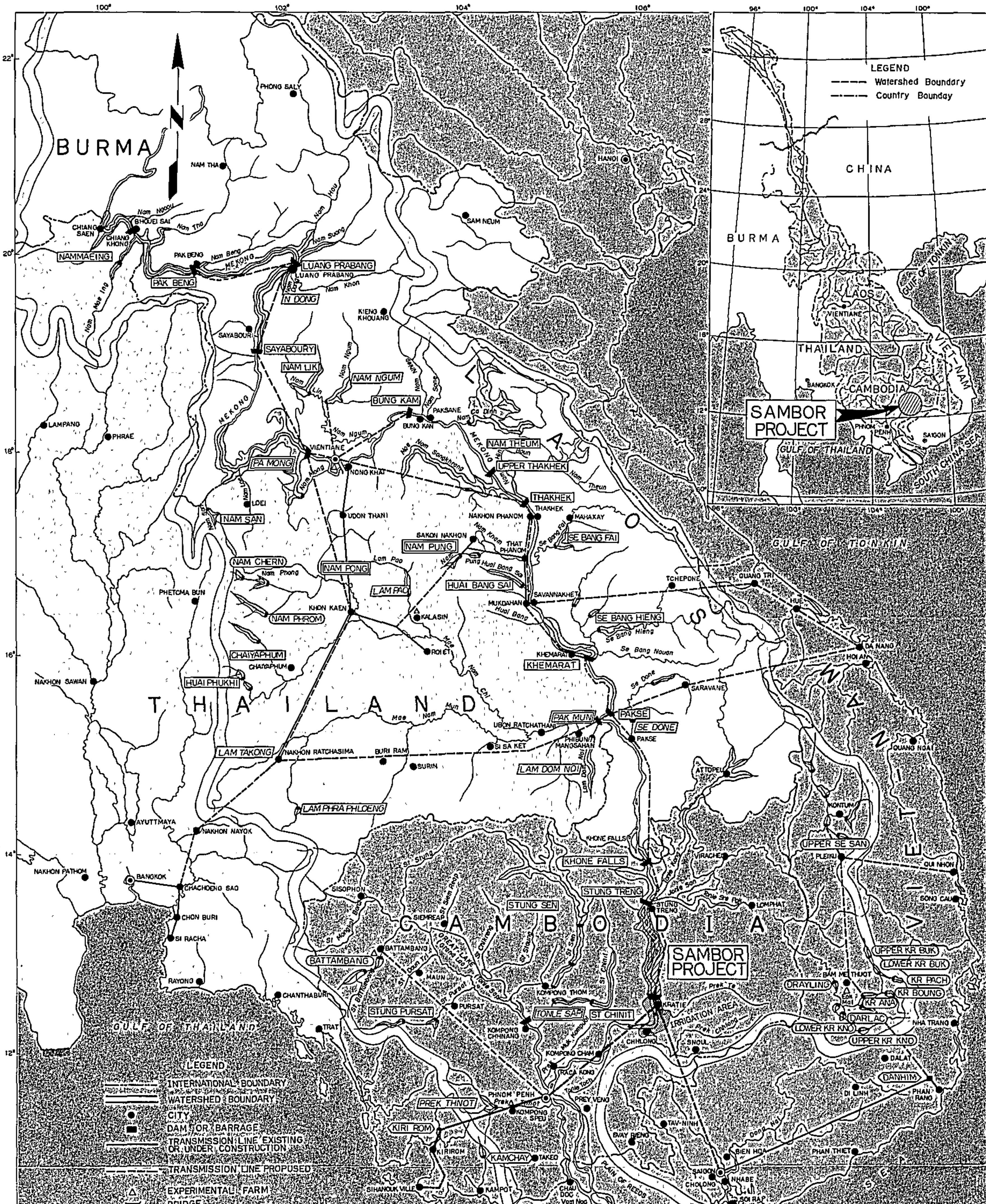
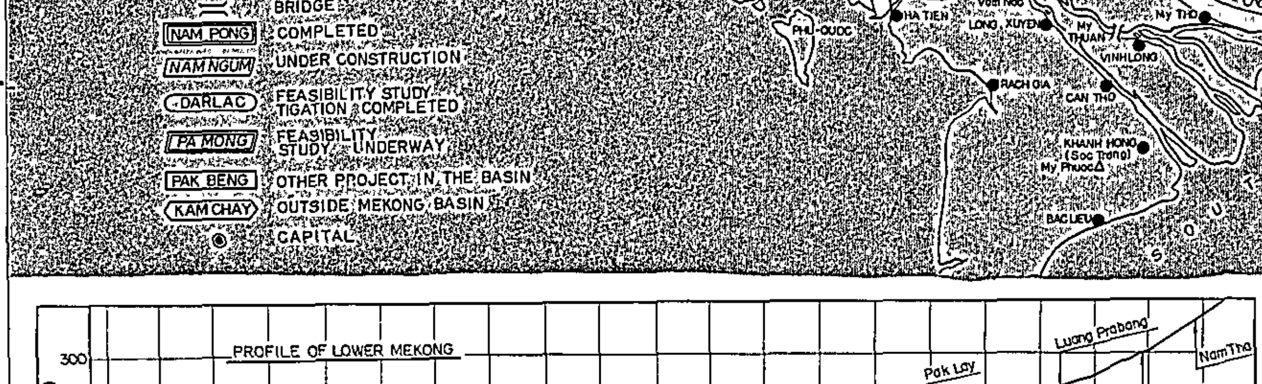
UNITS AND CONVERSIONS

mm ········ millimeter	kg ········ kilogram
cm ········ centimeter	ton ········ metric ton
m ········ meter	m/sec ········ meter per second
km ········ kilometer	kW ········ kilowatt
sq.mm ········ square millimeter	MW ········ megawatt
sq.cm ········ square centimeter	kV ········ kilovolt
sq.m ········ square meter	kVA ········ kilovolt-ampere
sq.km ········ square kilometer	kWh ········ kilowatt-hour
ha ········ hectare	mill ········ U.S. mill
cu.m ········ cubic meter	$ ········ U.S. dollar
cu.ms ········ cubic meter per second	p.p.m. ········ parts per million
cu.ms/day ········ cubic meter per second per day	EL ········ the height above mean sea level
gr ········ gram	°C ········ centigrade

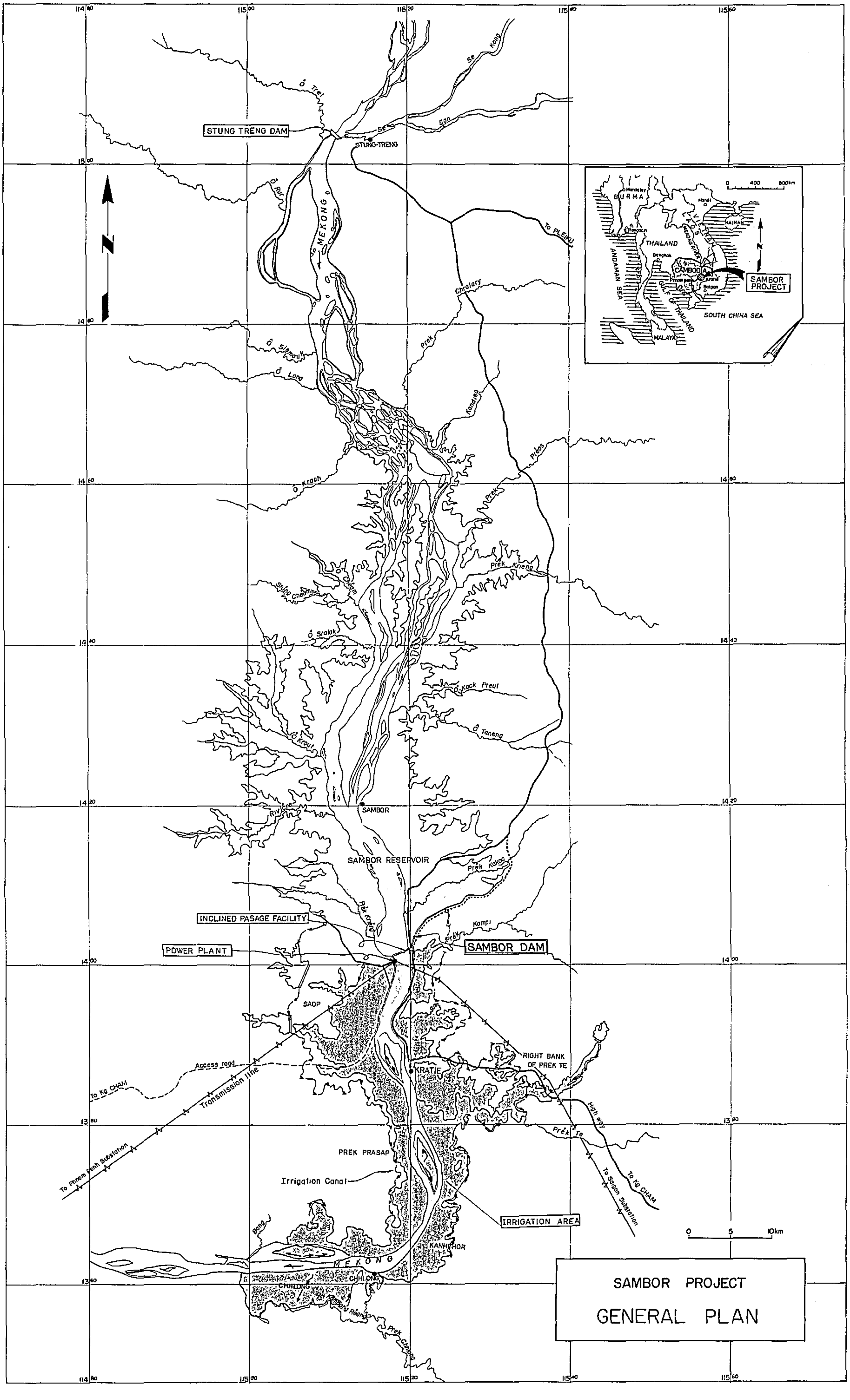
1 m	39.37 inches	3.2808 feet
1 km	0.6214 mile	3,280.8 feet
1 n.m.	(1 nautical mile)	1,852 m
1 sq.m	1.196 sq.yards	10.764 sq.feet
1 sq.km	100 hectares	247.1 acres
1 ha	10,000 sq.m	2,471 acres
1 cu.m	1,000 liters	35.31 cu.feet
1 kg	2.2046 pounds	
1 ton	1,000 kilogram	2,204.6 pounds
1 cu.ms	35.31 cu.ft/sec	
°C	5/9 (°F-32°)	





This map was prepared with reference to the basin map of the Mekong Committee's Annual Report 1967 and the boundaries shown hereon do not imply official endorsement or acceptance by the United Nations.

Key and Location Map


SAMBOR PROJECT
GENERAL PLAN
STUNG TRENG DAM
STUNG-TRENG
MEKONG
To PLEIKU
SAMBOR
SAMBOR RESERVOIR
INCLINED PASAGE FACILITY
POWER PLANT
SAMBOR DAM
SAOP
KRATIE
RIGHT BANK OF PREK TE
Access road
To Kg CHAM
Transmission line
To Phnom Penh Substation
High way
To Saigon Substation
PREK PRASAP
Irrigation Canal
IRRIGATION AREA
KANHCHOR
CHHLONG
Se Kong
Se San
Ô Trel
Ô Rur
Ô Siemouk
Ô Long
Ô Krach
Prek Chralary
Prek Kandieng
Prek Preas
Prek Krieng
Ô Sralak
Ô Kack Preul
Ô Taneng
Ô Krout
Prek Kakoo
Kampi
Prek Krieng
Prek Te
Bang
Prek Chhlong
0 5 10km
SOUTH CHINA SEA
SAMBOR PROJECT
THAILAND
BURMA
ANDAMAN SEA
GULF OF THAILAND
MALAYA
HAINAN
CAMBODIA
0 400 800km

The Mekong in Cambodia

Photo. B-1 Inundation of Mekong Delta (March 1962)

Photo. B-2 Inundation in the Downstream Area of the Dam Site (March 1962)

Photo. B-3 Quatre Bras (Downstream View)

Photo. B-4 Mekong and Tonle Sap (Upstream View)

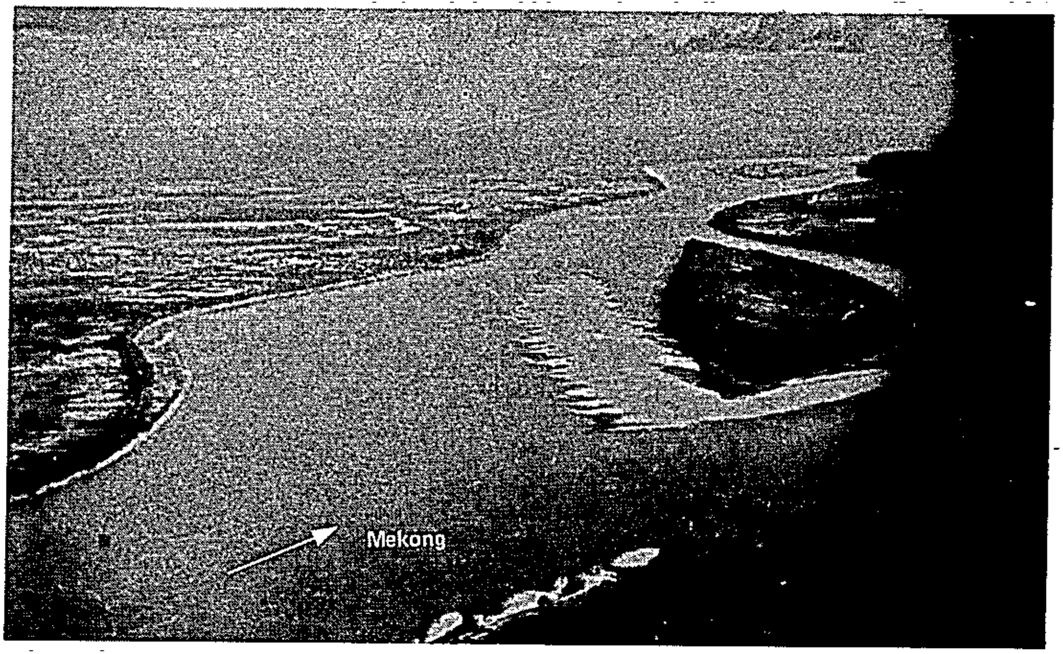


Photo. B-5 Island in front of Kratie (December 1964)

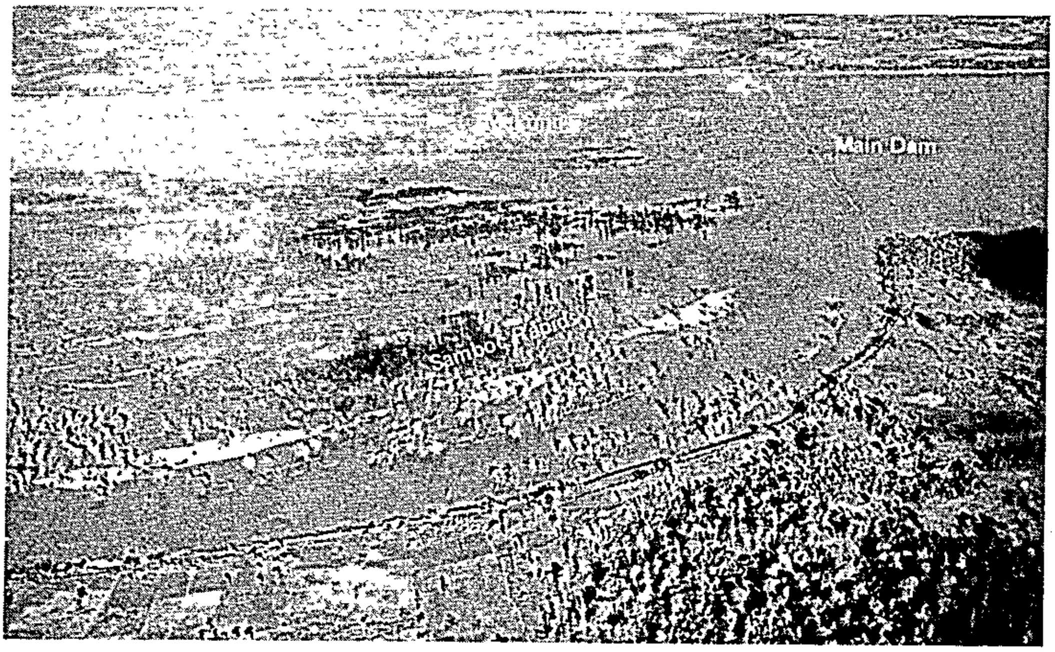


Photo. B-6 Sambor Dam Site (December 1964)

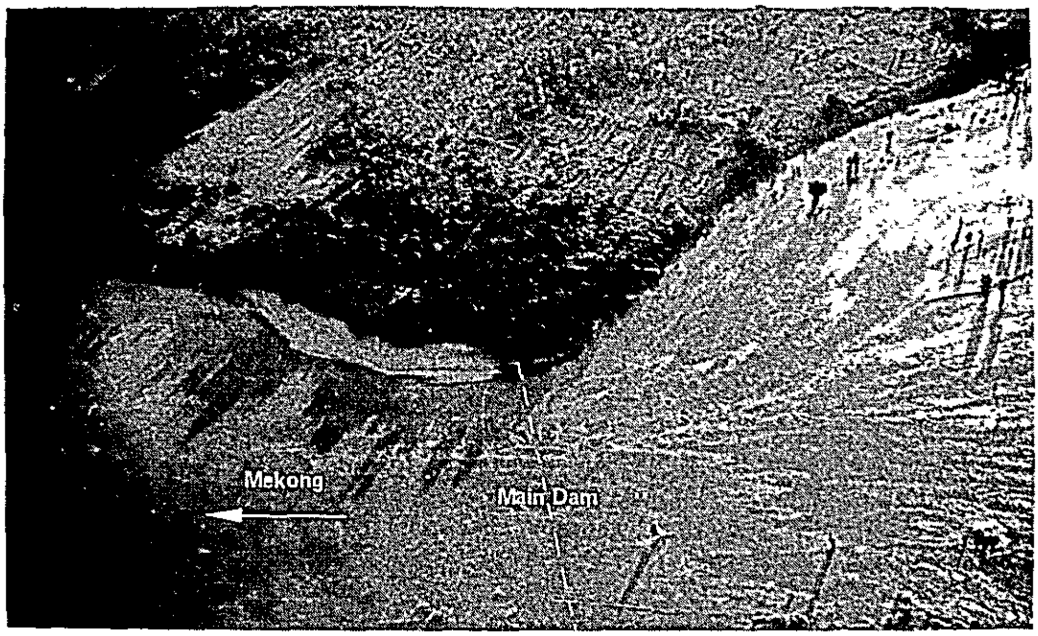


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Photo. B-8 Samboc Rapids (December 1964)

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Photo. B-10 Mekong between Sambor and Stung Treng

Photo. B-11 Confluence of Mekong and Se San at Stung Treng

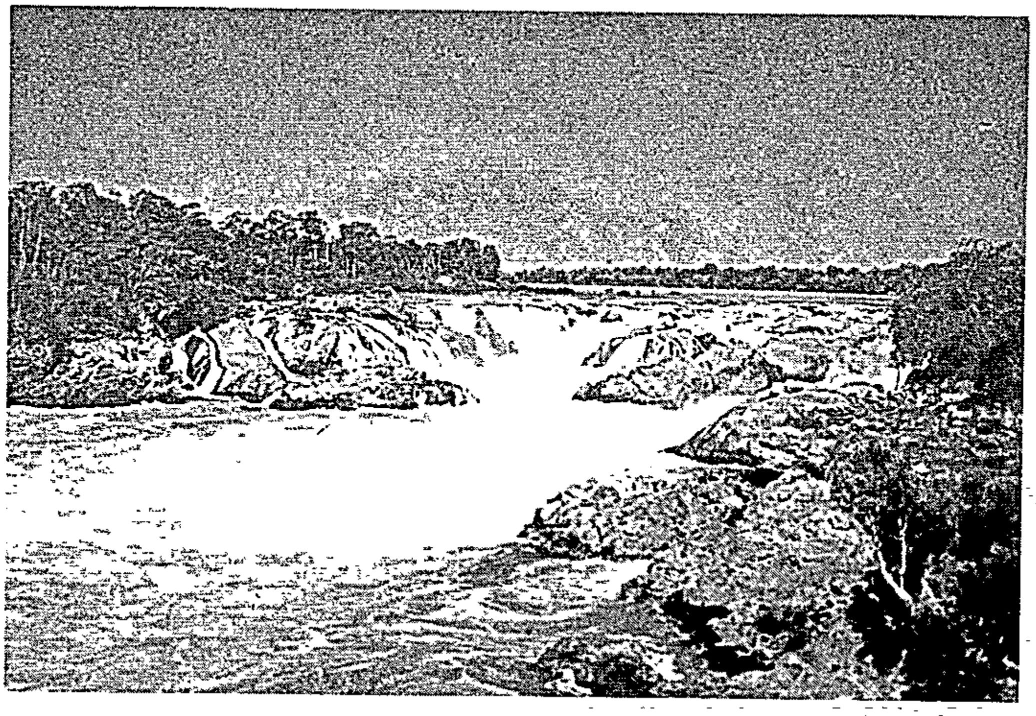


Photo. B-12 Part of the Kohn Falls (December 1964)

Technical Cooperation and Investigation

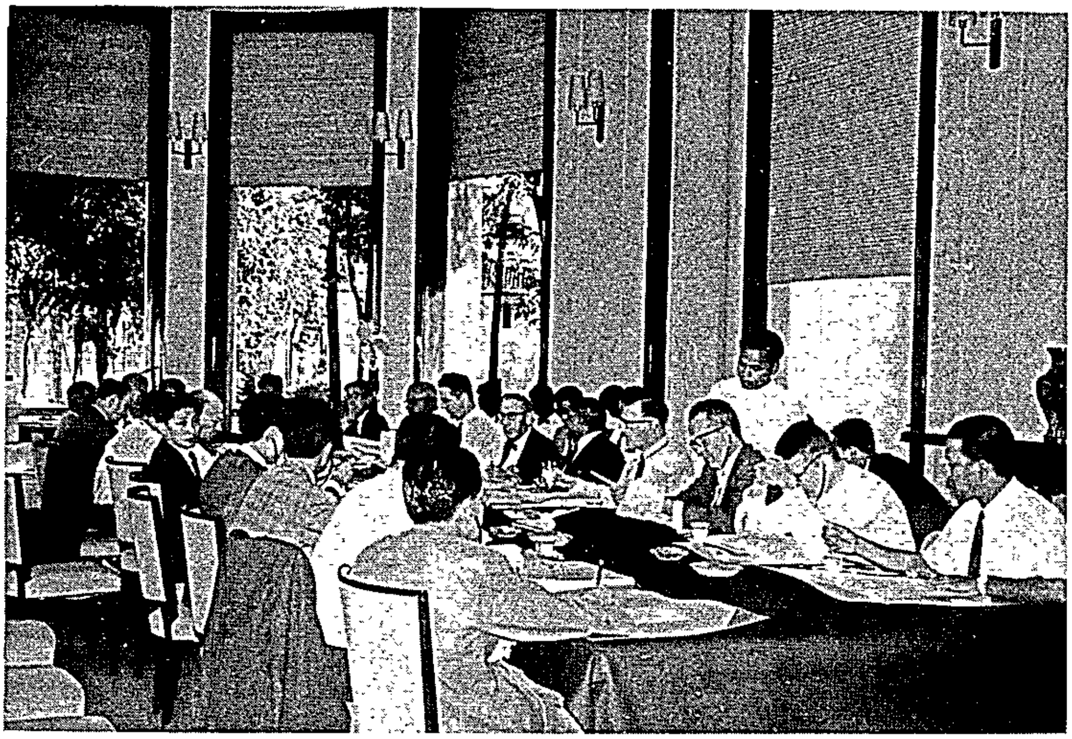


Photo. C-1 Sambor Project Technical Meeting at Phnom Penh

Photo. C-2 Sambor Dam Site Field Investigation

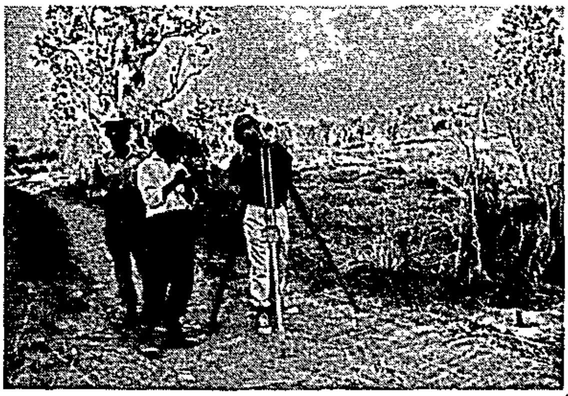


Photo. C-3 Field Survey in the Project Area

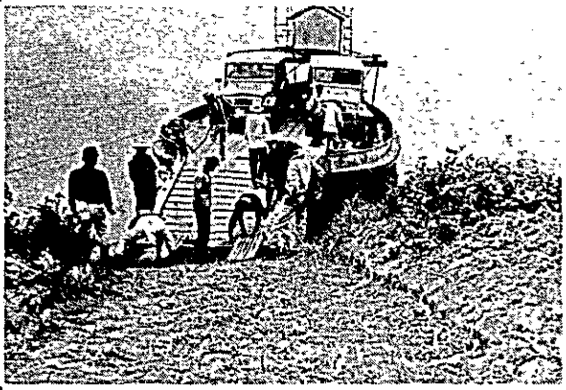


Photo. C-5 Crossing the Mekong

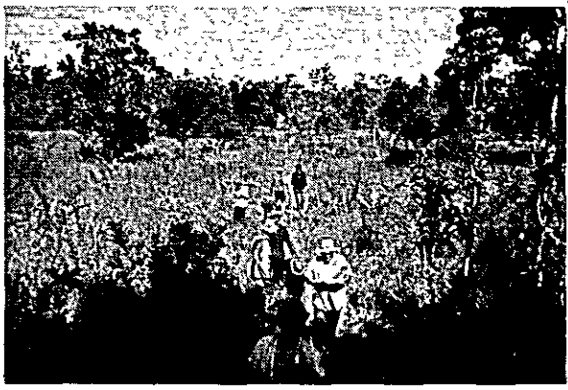
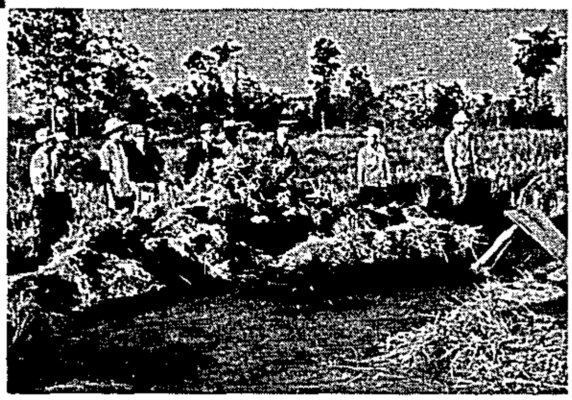


Photo. C-4 Sambor Dam Site Field Survey



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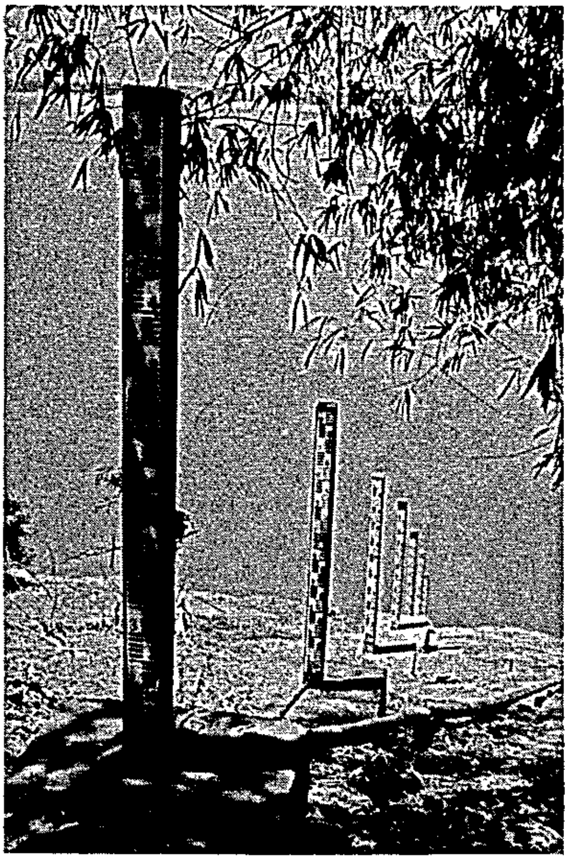

Photo. C-9 Gauging Station at Phnom Samboc (Left Bank)

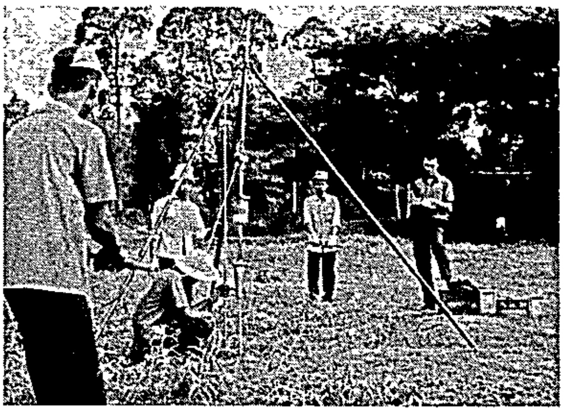

Photo. C-8 Soil Penetration Test for Power Transmission Tower Foundation

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Dam and Hydroelectric Power

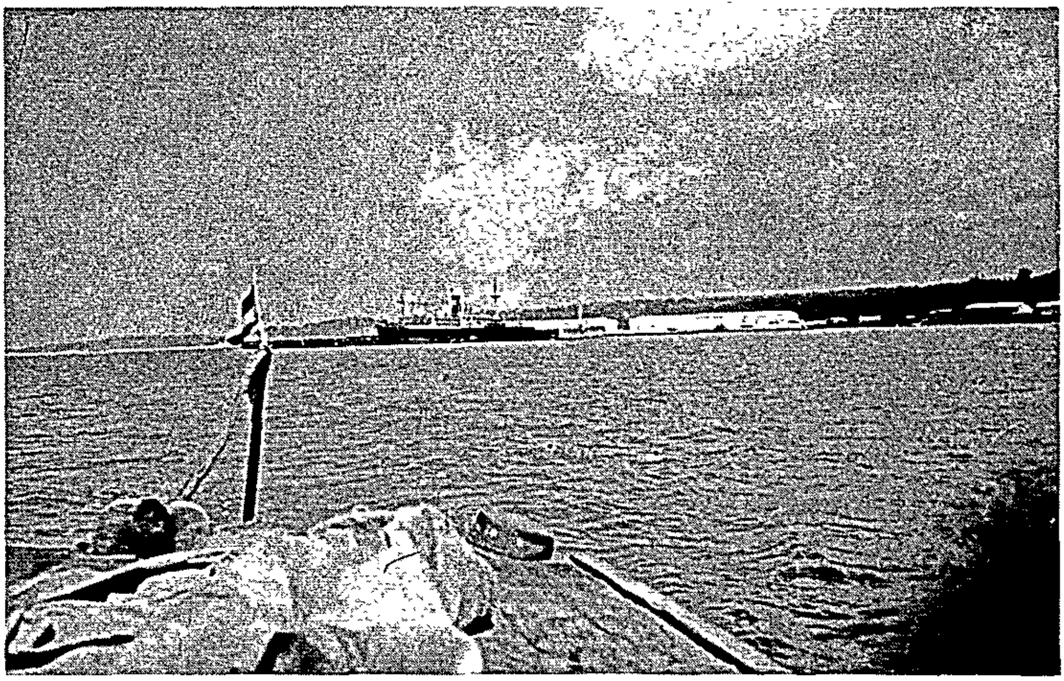


Photo. H-1 Port of Sihanouk Ville

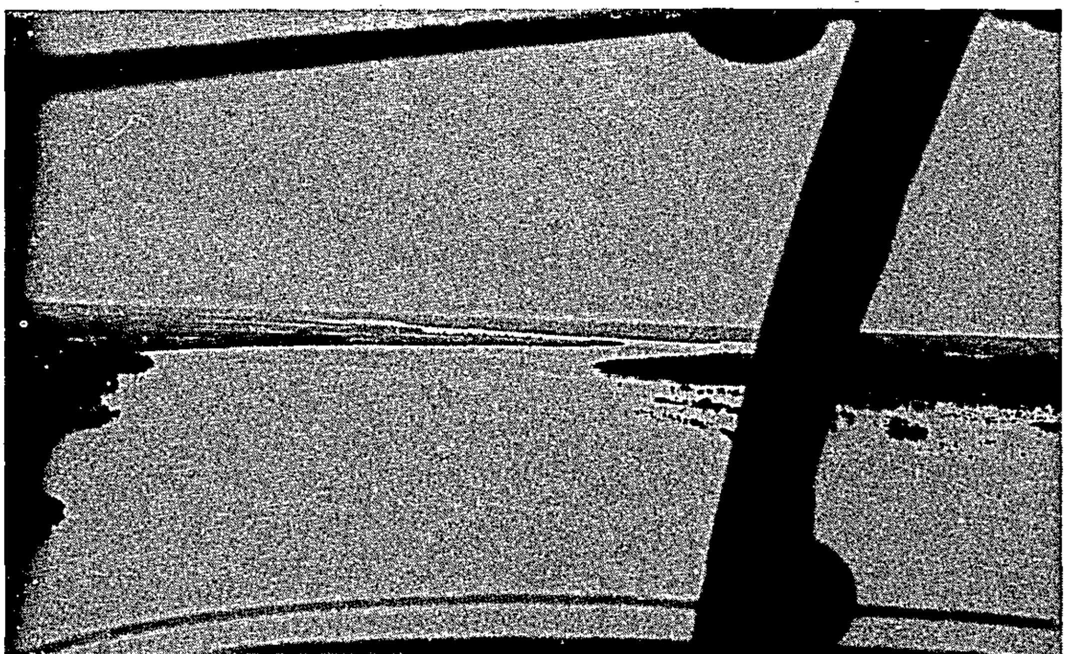


Photo. H-2 Sambor Dam Site (Downstream View) (September 1962)

Agriculture

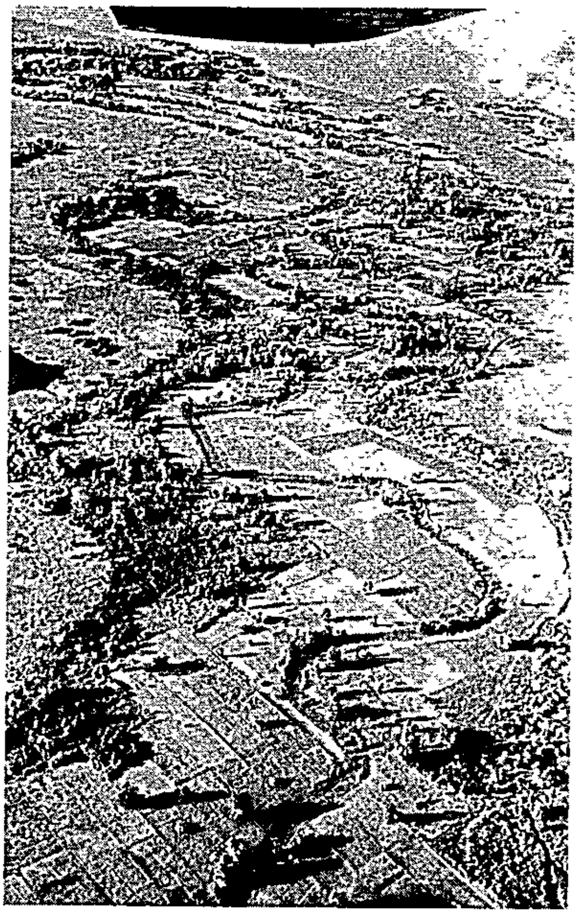


Photo. H-3 Typical Cultivated Land

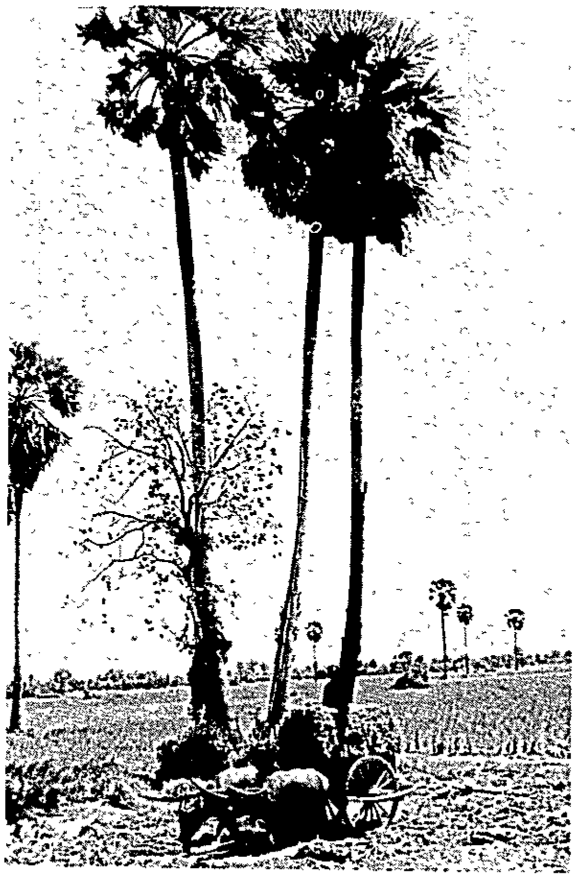


Photo. H-4 Paddy Field in the Dry Season

Navigation

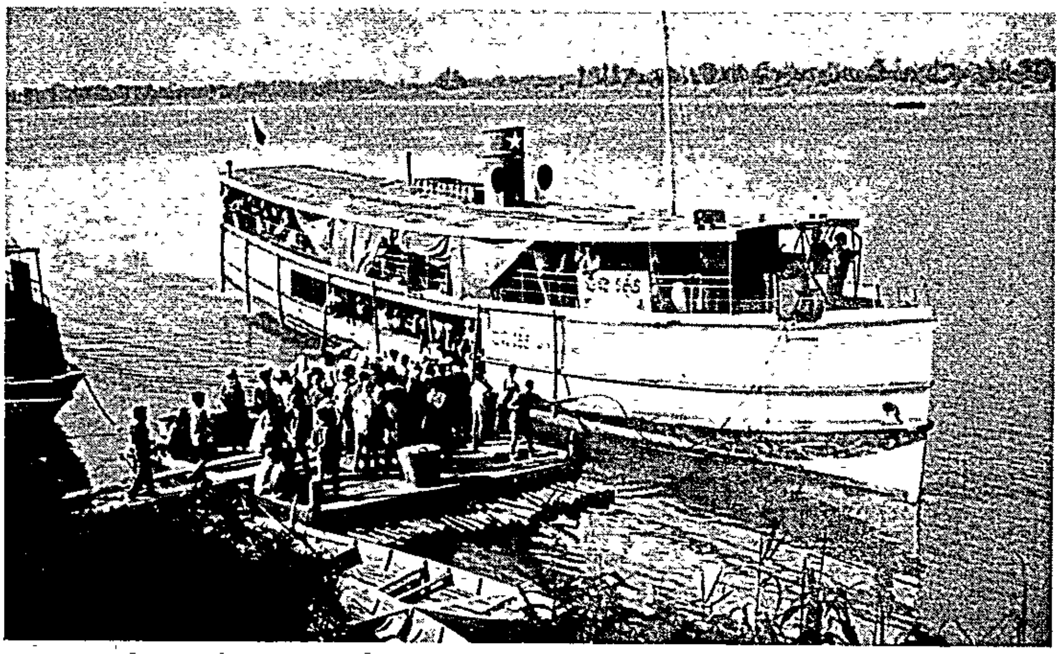


Photo. H-5 Inter-water Liner at Kratie Port

Fishery

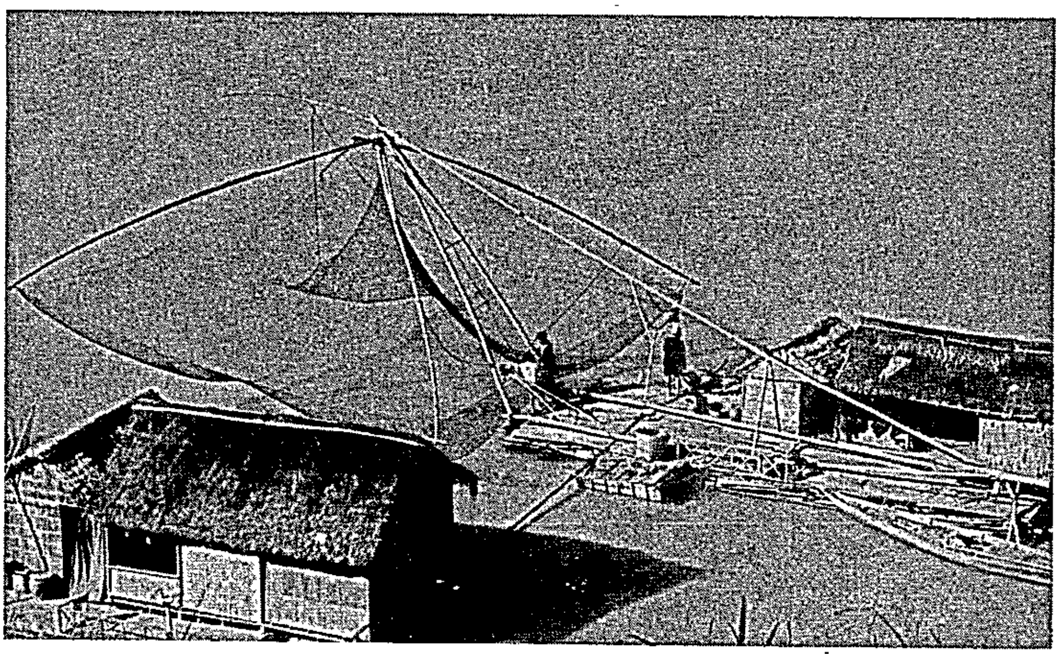


Photo. H-6 Mekong Fishery

MAIN FEATURES OF THE PROJECT

TOTAL CONSTRUCTION COST of the PROJECT	$358.0 million
in which FOREIGN CURRENCY	$256.5 million
DOMESTIC CURRENCY	$101.5 million

A. Power and Dam Sector

1.	Location	15 km Upstream of Kratie, Cambodia
2.	Catchment Area	646,000 sq.km
3.	Annual Inflow	446,000 million cu.m (average 14,000 cu.ms)
4.	Design Flood	90,000 cu.ms
5.	Reservoir	
	Max. High Water Level	EL 42 m
	Normal High Water Level	EL 40 m
	Reservoir Surface Area	1,157 sq.km
	Reservoir Storage Capacity	10,000 million cu.m
	Effective Storage Capacity	2,050 million cu.m
	Available Draw-down	2 m
6.	Dam	
	Type	Combined Dam of Earth-fill, Rock-fill, and Concrete
	Elevation of Crest	EL 44 m
	Height of Dam	54 m
	Crest Length	Total 30.7 km:
		Earth-fill 26.1 km
		Rock-fill 2.4 km
		Others (Top of Spillway and Powerhouse) 2.2 km
	Slope of Upstream Face	1:2.0 - 2.5 (Rock-fill), 1:3.0 (Earth-fill)
	Slope of Downstream Face	1:1.5 - 1.3 (Rock-fill), 1:2.5 (Earth-fill)
	Volume Earth-fill	17.2 million cu.m
	Rock-fill	8.7 million cu.m

Concrete	Refer Spillway and Power Plant

7. Spillway

Type	Overflow Type with Roller Gates
Energy Dissipator	Horizontal Apron
Capacity	90,000 cu.ms at Flood Water Level EL 42 m
Length	1,471 m (Net Length: 1,003 m Effective Length: 795 m)
Crest Road Width	6 m
Concrete Volume	900,000 cu.m
Gate	14 m (H) x 15 m (W) Roller Gates, 53 gates

8. Power Plant

Type	Outdoor
Final Dimension of House	485 m (L) x 30 m (W) x 31 m (H)
Concrete Volume	1.5 million cu.m

9. Power Generation and Consumption Pattern

Installed Capacity	875 MW
Firm Output	473 MW
Dependable Firm Peak Output	637 MW
Annual Energy Output	7 billion kWh
Firm Energy	4.1 billion kWh
Secondary Energy	2.9 billion kWh

Power Consumption Pattern (in which Type I is the most recommended)

Type I
1) General Demand
2) Power-oriented Industries including Aluminum Refining

Type II
1) General Demand
2) Power-oriented Industries excluding Aluminum Refining and its Related Industries

Type III General Demand

10. Power Generation Facilities

Unit Capacity	125,000 kW
Number of Units Installed	7
Room Provided for Additional Installation of Unit	5 Turbine Rooms and Draft Tubes
Turbine	
Type	Vertical Shaft Kaplan Type
Rated Head	19.7 m
Max. Discharge	775 cu.ms
Rated Output	128,000 kW
Number of Units Installed	7
Generator	
Type	Three-phase Synchronous Generator, Vertical Shaft Rotating Field Enclosed Type
Capacity	140,000 kVA
Voltage	15,400 V
Frequency	50 c/s
Power Factor	89%
Number of Units Installed	7

11. Transformer

Type	Three-phase, Outdoor, Forced Oil, Forced Air-cooled Type
Capacity	140,000 kVA
Voltage	15,400 V/345,000 V
Frequency	50 c/s
Number of Units	7

12. Transmission Line

Location	Sambor-Phnom Penh	P. Penh-Sihanouk Ville	Sambor-Saigon
Distance	190 km	160 km	230 km
Number of Circuits	2 cct	2 cct	1 cct
Voltage	345 kV	345 kV	345 kV
Conductor	410 sq.mm ACSR x 2	ditto	ditto

13. Substation

Location	Phnom Penh	Sihanouk Ville	Saigon
Secondary Voltage	115 kV	115 kV	220 kV
Capacity	100 MVA (100 x 1)	600 MVA (120 x 5)	360 MVA (120 x 3)

14. Telecommunication Equipment

Powerline Carrier Telephone and VHF Radio Telephone

15. Construction Cost (excluding interest during construction)

Reservoir and Dam	$104.3 million
Power Station	$165.4 million
Transmission Line and Substation	$48.4 million
Total	$318.1 million

in which

Foreign Currency	$236.6 million
Domestic Currency	$81.5 million

16. Construction Period in Development of Type I Power Consumption Pattern:

First Stage:	1970 - 1977	Completion of Dam, Installation of 625 MW and Beginning of Operation
Second Stage:	1979 - 1980	Additional Installation of 125 MW
	1983	Additional Installation of 125 MW

17. Economic Evaluation and Financial Analysis

Type I Power Consumption Pattern	4.4%
Type II Power Consumption Pattern	5.3%
Type III Power Consumption Pattern	5.3%

Financial analysis are made by changing the rate of interest corresponding to the objects, where the interest during construction is also included in the cost.

MAIN FEATURES OF THE PROJECT

TOTAL CONSTRUCTION COST of the PROJECT	$358.0 million
in which FOREIGN CURRENCY	$256.5 million
DOMESTIC CURRENCY	$101.5 million

B. Agricultural Sector

1. Scale of Development

Irrigation Area	34,000 ha (Paddy Field – 58%, Upland Field – 42%)
Drainage Improvement Area	2,845 ha
Total Planting Area	60,739 ha (including 1,957 ha for Cultivation of Feed)
Number of Farming Households	8,500 (including 2,000 Households expected to settle from Farmland to be submerged under the reservoir)

2. Water Requirement and Facilities

Water Requirement	468 million cu.m
	Sambor Reservoir – 238 million cu.m Other Sources – 230 million cu.m
Division of Area	12 Districts
Length of Irrigation Canal	557 km
Length of Drainage Canal	31 km
Pumping Station	27 Stations
Irrigation Pumping Stations	23 (6,900 kW)
Drainage Pumping Stations	4 (1,900 kW)
Total Power Required	8,800 kW
Reservoir	3 Reservoirs
Effective Storage Capacity	35 million cu.m
Dam Embankment Volume	783 million cu.m
Lakes and Ponds with Gates	8 provided with 10 Gates
Colmatage Method	To be practised at 8 Places
	Canal length – 8.6 km

	Experimental Farm	To be established at 2 Places
3.	Construction Cost	
	Foreign Currency	$17.04 million
	Domestic Currency	$17.86 million
	Total	$34.90 million
4.	Construction Period	1970 - 1979
5.	Economic Evaluation and Financial Analysis	
	Averaged Internal Rate of Return	7.9%

Financial analysis are made by changing the rate of interest corresponding to the objects, where the interest during construction is also included in the cost.

MAIN FEATURES OF THE PROJECT

TOTAL CONSTRUCTION COST of the PROJECT	$358.0 million
in which FOREIGN CURRENCY	$256.5 million
DOMESTIC CURRENCY	$101.5 million

C. Navigation Sector

1. Inclined Passage Facilities

Location	Component Part of Rock-fill Dam near the Left Bank
Specifications	1 Line for Rafts 2 Lines for medium-sized Vessels (30 to 50 tons) Length - 855 m Gradient – 1/11 Volume of Embankment – 820,000 cu.m

2. Dredging

Location	Shoals 3 km on the Downstream of the Inclined Passage Facilities
Designed Channel Width and River Bed Elevation	45 m, EL + 3.5 m
Rock Excavation	95,000 cu.m
Location	Shoals existing at a Point 25 km, and Those between 7 and 14 km Downstream of Stung Treng
Designed Channel Width and River Bed Elevation	60 m, EL +34.4 m
Dredging	570,000 cu.m

3. Construction Cost (excluding interest during construction)

Foreign Currency	$2.95 million
Domestic Currency	$2.08 million
Total	$5.03 million

4. Construction Period

1976 - 1977	1 Line for Rafts
1988	1 Line for Medium-sized Vessels
1993	1 Line for Medium-sized Vessels

5. Economic Evaluation and Financial Analysis
Internal Rate of Return 5.2%

Financial analysis are made bychanging the rate of interest corresponding to the objects, where the interest during construction is also included in the cost.

CHAPTER A. INTRODUCTION

CHAPTER A. INTRODUCTION

A-1 Authorization

The development of the Mekong has long been desired as prerequisite of the future economic development of the four countries of Cambodia, Laos, Thailand and Republic of Vietnam in the Lower Mekong River Basin. Surveys and investigations were carried out to date for early materialization of development plans as described below.

(1) Since 1951, the Division of Water Resource Development, ECAFE, carried out a series of reconnaissance in the Lower Mekong River Basin. At its 13th session held in March 1957, ECAFE adopted a recommendation calling for the establishment of an international organization which would seek the development of water resources of the basin, and in response thereto, the governments of the four riparian countries, Cambodia, Vietnam, Laos and Thailand, jointly established, in October of the same year, the Committee for Coordination of Investigations of the Lower Mekong River Basin (hereafter referred to as the "Mekong Committee"). The Mekong Committee was assigned the task of promoting and coordinating water resources development projects including hydropower, navigation, flood control, irrigation and other associated purposes.

(2) At the Special Session of the Mekong Committee held in December 1958, Japan together with the United States, France, Australia, expressed her intention and readiness to extend her cooperation in the investigations of the Lower Mekong River Basin. Successively, Japan conducted reconnaissance of major tributaries for a two-year period commencing in 1959, and submitted to the Committee a report in September 1961 which served as the guidepost for future tributary development.

(3) In parallel with the tributary development scheme, the Mekong Committee had been hoping for the promotion of the multipurpose development of the Mekong Mainstream involving five projects of Pa Mong, Khemarat, Khone Falls, Sambor and Tonle Sap. The Government of Japan expressed its intention to conduct the preliminary survey of the Sambor Project at the 14th session of the Committee held in Bangkok in May 1961, which the Committee accepted.

(4) During the period from 1961 to 1967, the Government of Japan conducted three preliminary surveys and five detailed surveys. The task of conducting detailed survey teams was entrusted to the Overseas Technical Cooperation Agency (OTCA) which is the executing agency of the Government of Japan. Field investigations were carried out by survey teams composed mainly of engineers of three consultants each engaged in their respective specialized fields; Electric Power Development Co., Ltd. (EPDC), being charged with the dam, power installation and transmission, Sanyu Consultants International, Ltd., with agriculture and Japan Port Consultants, Ltd., with navigation.

(5) The field investigations were completed in 1967, and final reports for each aspect were completed in July of the same year. However, it was agreed that these final reports should be rearranged and supplemented. Following the discussions made in July 1968 between the Japanese Survey Team, and the Mekong Secretariat, Division of Water Resources Development (ECAFE) and the authorities of the Royal Government of Cambodia, it was agreed that the rearrangement of final reports and the preparation of the present General Report, which is a comprehensive text compiled from data and information contained in the final reports, would be completed in June 1969 and submitted to the Mekong Committee by the Government of Japan.

A-2 Object and Scope of the Report

A-2-1 Object of the Report

(1) While the per capita power consumption in the Lower Mekong River Basin is still low as compared with other parts of the world, development of the basin is largely hampered at present due to poor transportation systems. It is expected, however, that the progress of the mainstream development and the resultant supply of abundant and inexpensive power would amply meet the potential demand, inviting a rapid increase of general power demand, and would also serve as an incentive to the establishment of aluminum refining industry and other chemical industries. Furthermore, construction of the dam, which will include an inclined passage facility for navigation and river bed dredging, will increase the river runoff in the dry season,

contributing largely to the development of agriculture and making navigation possible over a 680 km course from the estuary of the Mekong River to Stung Treng.

(2) For the realization of these benefits, in the 2nd Five-Year Plan drawn up by the Mekong Committee for the period from 1964 to 1968, it is recommended that priority be given to the completion of feasibility studies of three mainstream projects, i.e., Sambor, Pa Mong and Tonle Sap, which would be the basis for negotiating loans to finance the cost of the projects.

(3) The Sambor Project has a number of advantages particularly with respect to location, reservoir area and construction cost. Since the Sambor Project is located at about the center of Cambodia and the reservoir area will be confined within Cambodian territory, this will greatly facilitate the implementation of the project. Its estimated construction cost is smaller than that required for the other two mainstream projects. Completion of this project will undoubtedly bring about immense benefits that will stimulate the economic development of this area. In the power aspect, the installed capacity of 875 MW and the annual output of 7,000,000 MWh will not only promote the introduction and establishment of power-oriented industries, but also meet the growth of other industrial, residential and general demands. In the agricultural and navigation aspects, reclamation of 34,000 ha of irrigated farm land and improvement of navigation between Kratie and Stung Treng can be realized. Other benefits, whether material or immaterial, that may be derived from the above-mentioned direct effects, would be invaluable for the desired economic development.

(4) This report has been prepared, in view of these advantages and benefits, to justify the technical and economic feasibility of the Sambor Project. It is hoped that this report will provide the Government of Cambodia with the basic data with which to approach international financing organization with the cooperation of the Mekong Committee.

A-2-2 Scope of the Report

(1) Commencement of the Sambor Project investigations by the Japanese Survey Team coincided with that of the investigations of the upstream Pa Mong Project undertaken by the USBR and the Nam Ngum Project which is now under construction. As a consequence, it was rather difficult, during the course of studies, to obtain discharge data of these upstream projects. In the present report, therefore, the Sambor Project, is treated as an isolated project, and though due consideration has been given to the addition of capacity by the regulated discharge from the upstream dams, emphasis has been placed on studies in which the regulated discharge from the proposed upstream projects has been disregarded.

(2) Nevertheless, the estimated effective storage capacity of upstream reservoirs upon completion of the Pa Mong and Nam Ngum Projects will be approximately 80 billion cu.m which will make possible the control of flood discharges. It is expected that the increase in the discharge in the downstream area resulting from the construction of the two upstream projects will largely enhance the benefits of the Sambor Projects. Studies have therefore been made, as annexed hereto, on Volume II, taking 250 m as the normal high water level of the Pa Mong Reservoir.

A-3 Investigations

A-3-1 Preliminary Survey

(1) Preliminary surveys in earlier stages included geological survey by the Australian Survey Team, aerial mapping by the Canadian Team as well as hydrological survey conducted by the United States Team. These surveys were succeeded by the Japanese Team following the decision adopted at the 14th session of the Mekong Committee held in May 1961.

(2) For the execution of preliminary survey, a survey team headed by Mr. Goro Inouye, then Chairman of the Board of Chubu Electric Power Co., Inc., was organized. The survey team was sent to Cambodia to conduct field investigations on three occasions from October to November 1961, January to March 1962, and September 1962. The team made technical and economic studies of the hydroelectric, irrigation, navigation improvement and industrial aspects of the Sambor Project, and established the fundamental principles to be adopted for the project, and further laid down basic plans for the execution of detailed surveys to be successively carried out. Results of these preliminary surveys were compiled into "Report on Preliminary

Investigations for Development of the Lower Mekong River Basin, Cambodia" which was submitted to the Mekong Committee in October 1962 by the Government of Japan.

A-3-2 Detailed Survey

(1) Based on data and information contained in the above-mentioned report, the Mekong Committee requested the Government of Japan for further cooperation in the project, which led to the execution of a series of detailed surveys commencing in 1963.

The first phase detailed survey was conducted from January to March 1963, followed by the second phase detailed survey during the period from October 1963 to January 1964. The survey team was headed by Mr. Motonaga Ohto, executive Director of OTCA, and comprised experts from a number of organizations. EPDC was charged with the dam, generation, and transmission aspect; Ministry of Agriculture and Forestry with agricultural aspect; Japan Port Consultants, Ltd. with navigation improvement aspect; and Overseas Electrical Industry Survey Institute, Inc. with power market aspect.

(2) A survey team was organized which was headed by Dr. Koichi Aki, Advisor to OTCA, and composed of engineers of the above-mentioned firms and additional experts from Sanyu Consultants International, Ltd., for the third phase detailed survey which was carried out in the wet season of 1964 (September–October) and in the dry season of 1964–65 (November 1964–February 1965). This was the final field survey covering all aspects excluding agriculture and irrigation. The survey on fisheries was conducted also in 1965 by Dr. Yoshikazu Shiraishi who is chief of Nikko Branch of the Fresh Water Research Laboratory in Ministry of Agriculture and Forestry of Japan.

(3) With respect to the agricultural aspect, the fourth and fifth phase survey teams were dispatched to Cambodia for the final field survey which was carried out over two periods, i.e., in the wet season of 1965 (August–September) and in the dry season of 1966–67 (December 1966–March 1967), respectively. These surveys were conducted in parallel with the aerial mapping undertaken by the Royal Government of Cambodia in the proposed agricultural development areas.

Further, engineers of EPDC were dispatched to Cambodia through OTCA during the period from February to March 1967 to conduct supplementary power market studies.

A-3-3 Final Report

(1) EPDC, Sanyu Consultants International, Japan Port Consultants and Japan Economic Engineering Consultants conducted analysis and review of result and data obtained by the field surveys, and completed in July 1967 the final reports covering the aspects they were entrusted with.

(2) The Pa Mong-Sambor joint Meetings were held by the Mekong Committee in May and December 1966, in April 1967, and in March 1968. The purpose of the meetings was to discuss and coordinate the joint technical problems of both projects between the Sambor Team of OTCA and the Pa Mong Team of USBR. In compiling the feasibility report of the Sambor Project, various useful references were obtained from the result of the meetings.

(3) Later in July 1968, discussions were held in Bangkok and Phnom Penh between OTCA, the Mekong Secretariat, Water Resources Development Division of ECAFE and the Royal Government of Cambodia to review and determine the details of the Sambor Project, with the attendance of the USBR Pa Mong Team as an observer.

(4) This led to the understanding that the minutes of discussions would be reviewed and studied by each consultant for rearrangement and supplementation of their final reports. In addition, EPDC was entrusted by OTCA to prepare a General Report which should give a comprehensive description covering all aspects of the project.

These final reports and the General Report were completed in June 1969, and are hereby presented to the Mekong Committee.

A-4 Acknowledgement

Deep gratitude is hereby expressed to the ECAFE, the Mekong Committee, the Royal Governments of Cambodia, Laos, Thailand, and the Government of Republic of Vietnam and other organizations concerned who have freely extended cooperation and provided various facilities and valuable data and information to the Japanese Survey Team, as well as to the USBR team whose goodwill and cooperation displayed through the Sambor-Pa Mong Joint Meeting are highly appreciated.

It is earnestly hoped that this Project Report will play an important role in the implementation of the Sambor Project by the Mekong Committee and the Royal Government of Cambodia.

CHAPTER B. CONCLUSIONS AND RECOMMENDATIONS

CHAPTER B. CONCLUSIONS AND RECOMMENDATIONS

B-1 Conclusions

The Sambor Project is a multipurpose development scheme for power, navigational and agricultural development in the Lower Mekong River Basin. The percentages of the construction cost of each aspect to the total cost are 89% for power including the dam, 1% for navigation and 10% for agriculture. Thus, power constitutes the major part of the project. The principal conclusions resulting from the field surveys as well as studies and analyses made in Japan are summarized below.

(1) The Sambor Project is feasible from the economic and technical point of view, and is recommended that the project be implemented as early as practicable when the required conditions can be satisfied.

(2) The Sambor Project will create large direct benefits and also immeasurable indirect benefits such as providing more employment opportunities, promotion or improvement of related industries, education and culture, etc.

(3) The accumulation of internal reserve will amount to approximately $380 million to $440 million in the power and navigation sectors over a 50-year period after the completion of project, and a net income of about $138 million to $140 million will be realized from the agricultural sector, if the required conditions and financial program can be satisfactory fulfilled.

(4) Getting implementation financing for the Sambor Project seems to be relatively easy compared with other mainstream projects such as the Pa Mong and the Stung Treng, because the net construction cost is estimated as $358 million which is about one-third that of the other projects.

(5) The Sambor Power Plant will be able to supply electric power at a relatively low cost with a maximum capacity of 875 MW and an average annual energy of seven billion kWh.

The general demand of Cambodia and Vietnam will be met sufficiently by approximately one-third of the energy as firm power at a cost of 9 mills/kWh for a long period of time.

About one-third of the energy is to be delivered to the aluminum industry as firm power at a cost of 2.5 mills/kWh at the receiving end of the primary substation, and the remaining energy (approx. one-third of the energy) as secondary energy to the other power-oriented industries at a cost of 2 mills/kWh, when the Type I power consumption pattern is adopted as a development scheme.

Therefore, firm power can be supplied approximately at an average cost of 5.7 mills/kWh when the required conditions can be satisfied.

B-1-1 Growth of General Demand and Necessity for Early Development of the Sambor Project

(1) At present, Cambodia has an installed capacity of approximately 45 MW and Vietnam an installed capacity of about 285 MW. There is a shortage of power supply capacity to meet demand for power in both countries. The charge for electric service currently in force in Phnom Penh and Saigon, where electricity is supplied at the lowest rate, is as high as 60 to 70 mills/kWh. The annual growth of general demand in these countries during the past 10 years average 10% and 11% respectively. Therefore, if abundant and inexpensive power becomes available, it would not only satisfy potential demand but also create new demands causing a fast growth in the demand for power.

(2) If the transmission lines from the Sambor Power Plant are connected with the existing systems linking to Phnom Penh, Sihanouk Ville, Saigon, and Cholong, and if independent systems (privately operated power plants) are to be interconnected with such power systems, 73% to 78% of power demand of the two countries will be concentrated in the said power systems. The total power demand in the two countries is expected to reach 576 MW (Cambodia–121 MW, Vietnam–455 MW) in 1978 when the power plant is to be commissioned, and 1,520 MW in 1988 (Cambodia–346 MW, Vietnam–1,174 MW).

(3) Cambodia plans to develop 197 MW from nine projects and Vietnam 454 MW from six projects. Thus, development of a 240 MW is planned for completion by 1977. The commissioning of the Sambor Project, even if construction progresses smoothly, will be in 1978. If all these projects are developed as scheduled, it is likely that the demand and supply balance will be maintained until 1976, but in 1977 there will arise a deficiency in supply of 170 MW against a maximum demand of 590 MW in Vietnam, necessitating the construction of a thermal plant to cover the shortage. Six of these projects (three each in the two countries) are scheduled after 1978 to generate 73 MW in Cambodia and 262 MW in Vietnam. In the two countries, a deficiency of 56 MW is expected against the demand increment of 164 MW in 1980. In 1988, the deficiency will increase to 656 MW against the demand increment of 991 MW. Therefore, completion of all projects, including the above-mentioned six, will not provide sufficient power to satisfy the deficiency which will range from 30% to 70% of the total demand increment.

(4) The deficiency of supply will gradually increase after 1980 requiring a large-scale power development. The Sambor Project has the benefit over other mainstream projects because (a) its development will be facilitated as its site is located at about the center of Cambodia, (b) its reservoir area will be confined within Cambodian territory, (c) its submerged area including farm land will be smaller than that of other mainstream projects, (d) its estimated cost is about one-third of that of the Pa Mong and Stung Treng Projects, and (e) it will provide power for general demand at a low rate of about 9 mills/kWh, delivered at the primary substation.

B-1-2 Necessity and Feasibility of Inducing Power-Oriented Industries

(1) Power generation of the Sambor Project has been designed to satisfy 60% of the increment of general demand until the maximum output of 875 MW is attained. Therefore, if the power is consumed solely by the general demand, it will take about 13 years before the Sambor Project enters the stage of full load operation provided that it is commissioned in 1978. This calls for the inducement of power-oriented industries which would serve the purpose of effective utilization of power for the purpose of early economic development of the Lower Mekong River Basin.

(2) Power-oriented industries suitable for inducement into the Lower Mekong River Basin include aluminum refining industry, caustic soda industry, calcium carbide industry, ferro-silicon industry, silicon carbide industry and vinyl chloride industry. For the aluminum refining industry, the Sambor Project can supply firm energy at the prevailing international rate of 2.5 mills/kWh. For the other power-oriented industries, the Sambor Project can provide secondary energy at approximately 2 mills/kWh. It may be added that Sihanouk Ville, Saigon and Phnom Penh are all port cities with suitable conditions for the establishment of these power-oriented industries.

B-1-3 Power Generation Program

(1) Comparative studies were made on geological and topographical conditions of the four alternative sites located between the Samboc Rapids and a point about 6 km downstream, which led to the selection of the dam site proposed in this report.

(2) A fill-type dam has been adopted in consideration of various factors including the diversion and care of the river, geology, topography, availability and transportation of embankment materials. Structures such as the powerhouse and the spillway will be built on highland on the right bank. The dam will be a rock-fill structure in the river section and earth-fill structures on both wings adjoining it. The normal high water surface level of the reservoir has been designed to be 40 m in consideration of the tailrace water level of the proposed Stung Treng Project to be constructed upstream of the Sambor Project. The total storage capacity will be 10 billion cu.m, but this will not provide any flood control capacity since the storage capacity is only 2.2% of the average annual discharge of 446 billion cu.m at the dam site (average for period 1933 to 1965). The dam will be 54 m high and have a crest length (including the intake) of 30.7 km. The draw-down of the reservoir has been designed to be 2 m in consideration of the influence to navigation and irrigation. The effective storage capacity, therefore, will be 2,050 million cu.m. Construction of the dam including powerhouse and spillway is technically feasible, and there are no problems in the transportation of machines and equipment, availability of construction materials, foundation treatment, and diversion and care of the river.

(3) In determining the scale of power development, studies were made on the combined hydro and thermal operation which is designed to firm up secondary hydro energy and on the hydro generation only to supply firm energy. This led to the conclusion that an output of about 900 MW would be most optimum for either case. The unit capacity of the generator has been selected to be 125 MW at a rated head of 19.7 m and maximum discharge of 775 cu.ms. The total installed capacity is assumed to be 875 MW (125 MW x 7 units).

If Type I is employed as a pattern of consuming electric power, five units of turbines and generators are to be installed in the first stage, while two units installed in the second stage. When the upstream projects are completed, fluctuations of the flow will be mild. In anticipation of this situation, five additional bays will be constructed in the first stage. The five bays for the future extension and the two bays for the second stage will be utilized as diversion channels during construction. In the design of the units, consideration has been made to increase the capacity of a unit to be installed in the first and second stages up to 200 MW by adjusting the vanes.

(4) It is anticipated that before completion of the Sambor Project a 110 kV line connecting Phnom Penh and Sihanouk Ville, and a 220 kV line between Saigon, Da Nhim and Don Nhoi will be constructed creating 220 kV and 66 kV systems. It is therefore planned to build primary substations in the suburbs of Phnom Penh, Sihanouk Ville and Saigon to receive power from the Sambor Project. Two circuit of 345 kV lines are to be constructed between Sambor and Phnom Penh (190 km) and Sihanouk Ville (160 km), on the assumption to supply power to power-oriented industries, and a single-circuit 345 kV line Sambor and Saigon (230 km).

(5) Among the mainstream projects, the Sambor Project is located in the lowermost reaches Due consideration was therefore given to create no excessive variation of the river water level that may be caused by the powerhouse operation. The fluctuation of water level at Kratie will be held within 1 m, which is expected to cause no adverse effect on the water level at Phnom Penh.

B-1-4 Navigation Program

(1) Navigation on the Mekong is quite active in the section downstream of Kratie. Upstream of Kratie, however, navigation is obstructed at many places including the Samboc Rapids. When these obstacles are submerged by the dam and appropriate navigation facilities are provided, the navigable distance will extend to 680 km from the estuary of the Mekong up to Stung Treng. This will largely contribute not only to the future economic development of the lower basin but also to the development of upstream areas.

(2) Comparative study was made on a number of navigation programs with attention directed to the rate of population growth in the four riparian countries, estimated transport demand, cost, etc. As a result, the conclusion reached was that the construction of inclined passage facility would be the best to attain the desired thoroughfare for vessels that navigate upstream beyond the dam and vice versa. The inclined passage facility will consist of one line for passing raft and two for medium-sized boats of 30 tons to 150 tons. The one line for passing raft should be constructed, and completed simultaneously with the dam, and the two for medium-sized boats are to be constructed corresponding to the increase in the volume of traffic.

(3) For smooth and uninterrupted navigation, it will be necessary to dredge some sections of the river channel. Dredging should be carried out over a 3 km distance in the downstream direction from the downstream end of inclined passage facility to maintain a minimum effective channel width of 45 m with a water depth of 2 m at a minimum flow of 1,350 cu.ms after completion of the dam. Dredging should also be carried out in shoals existing near the extreme end of the reservoir backwater, i.e., in sections about 7 km to 14 km and 25 km downstream of Stung Treng, so that an effective channel width of 60 m may be maintained. These dredging works will greatly improve the dry season navigation between Kratie and Stung Treng and will also make it possible for vessels presently plying between Kratie and the estuary to serve as far upstream as Stung Treng.

(4) The dredging work mentioned above entails no technical problems and can be executed without difficulty. A navigation lock and canal will be required at Sambor in the future when the construction of upstream dams is completed. Considering the volume of traffic estimated for the project period, construction of a canal which requires large capital investment is not economic. In this report, therefore, no consideration has been given to the canal construction. (See Vol. II, Chapter K)

B-1-5 Agricultural Program

(1) Agriculture in Cambodia occupies an important position as the country's basic industry. It has been proven in many developing countries that economic development can be put on the right track only when priority is given to the development of agriculture over other industries. Cambodia is no exception in this respect and agriculture constitutes an important part of the Sambor Project, too.

(2) In order to delineate the agricultural development area, investigations were conducted in the 69,000 ha of land which extends downstream of the dam site to the boundary of Kratie Province at an elevation lower than the reservoir low water level of 38 m. Investigations revealed that 34,000 ha would be technically and economically suitable for agricultural development.

(3) Crops presently cultivated in the proposed agricultural development area include rice, maize, green pea, peanut, sesame, tobacco and others. Crops recommended for cultivation in the area are mainly rice and maize.

(4) The total water requirement upon completion of the program is 468 million cu.m of which 238 million cu.m will be supplied from the Sambor Reservoir and 230 million cu.m from the Mekong Mainstream and tributaries as well as lakes and swamps. Due to limitations imposed by topography and cost, only 45% of the development area will be covered by the network of pump irrigation system. It is considered suitable to divide the area into 12 districts by the difference in irrigation and drainage systems and farm management, and to promote the development in a manner that best suits each district.

(5) Completion of this program will increase the total arable land from the present 12,469 ha to 34,000 ha (2.73 times) and the planting area from 16,980 ha to 60,739 ha (3.58 times). Number of farming households in the area is about 6,500 at present. When 2,000 households now in the area to be submerged under the reservoir will have settled in the development area, the total number of farming households will be 8,500. Upon completion of the program, each farming household is expected to enjoy an increase of arable and planting areas from the present 1.93 ha to 4 ha (2.1 times) and from 2.62 ha to 7.15 ha (2.73 times) respectively. The annual net income per ha of each farming household will also rise from $47.5 to $181.4 (3.82 times). It is therefore believed that farm management in the area will become economically attractive.

(6) Flood protection and drainage are factors that can not be neglected within the agricultural development. At the present stage, however, an attempt to provide the entire development area with flood protection and drainage systems cannot be justified, and should await the completion of the flood control scheme of the Mekong Mainstream to be realized by the construction of upstream reservoirs. In the program under consideration, therefore, the drainage improvement is planned to be effected only in 2,845 ha whose topography will allow simple facilities including drainage pumps and dikes to produce sufficient effect. The *colmatage* method, which has been practised on a limited scale, will be introduced on a large scale.

B-1-6 Work Schedule

(1) Assuming that all prerequisite conditions and arrangements including the approval of the Mekong Committee, pledges of international financing organizations to finance the cost, preparation of detailed designs and bid documents, award of contracts to civil contractors and equipment suppliers could be obtained and completed within a couple of years from the present and that preparatory construction work including transport roads, access roads, construction camp and other structures could commence in or around 1970, the project could be completed in or around 1978 with the construction period taken into account. With respect to the powerhouse, spillway, transmission lines and dam, construction of the former three structures is assumed to commence in 1973 and that of the dam in 1974. Five turbines and generators will be installed in the first stage and the two additional units will be installed in stages corresponding to the growth of demand with target completion time in 1983.

(2) As regards the inclined passage facility for navigation, preparations for constructing one line for timber raft will be started three years prior to the completion of the dam, to be followed by the actual construction work which will commence one and half years before completion of the dam. The remaining two lines will be constructed to meet the estimated increase in transport load, i.e., one in 1988 and the second in 1993. One year will be required to construct each line.

(3) The agricultural development program has been prepared by dividing the entire development area into 12 districts. Actual work, however, will be carried out after dividing the area into 17 work districts so that the annual cost will become approximately equal. The period required for the development of each work district will be about two years, and a total of 10 years from 1970 to 1979 has been scheduled as the develop-period.

B-1-7 Estimated Cost

(1) The total estimated cost of the Sambor Project including power, navigation and irrigation amounts to $358 million, of which $256.5 million is foreign currency, and the remaining $101.5 million is local currency. The cost required for the first stage development assumed to be completed in 1978 is $322.5 million, of which $231.3 million is required in foreign currency and the remaining $91.2 million in local currency.

Breakdown of the costs is tabulated below.

(Unit: Million dollars)

(Item)	(Total Cost)			(Total Cost for First Stage)		
	Total	Foreign currency	Local currency	Total	Foreign currency	Local currency
Power	318.1	236.6	81.5	292.5	216.2	76.3
Navigation	5.0	2.9	2.1	3.8	2.2	1.6
Subtotal	323.1	239.5	83.6	296.3	218.4	77.9
Agriculture	34.9	17.0	17.9	26.2	12.9	13.3
Grand Total	358.0	256.5	101.5	322.5	231.3	91.2

[As for fishery see B-2, (5)]

(2) The above table covers, all costs for preparatory constructions, civil engineering works, machines and equipment, construction materials, transportation, engineering, and contingencies, but exclude interest during the construciton and the administrative costs of the executing agency of the project. (As for interest during construction, see Chapter K, K-4, of Vol. III)

B-1-8 Economic Soundness

(1) In planning the power supply program, the following three types of load combinations were studied, which revealed that the internal rate of return for power is 4.4% in case of Type I and 5.3% in both cases of Types II and III.

Type I : General demand and power-oriented industries with the aluminum refining industry as the major component (aluminum refining, calcium carbide, caustic soda, vinyl chloride, ferro-silicon and silicon carbide)

Type II : General demand and industries (calcium carbide, caustic soda, and vinyl chloride)

Type III: General demand only

Types II and III would take a longer time before the full load operation is attained, and would also invite dump power rate of 30% and 34% respectively as against 15% for Type I. Type I is therefore recommended for the early economic development and effective utilization of power.

(2) The internal rate of return method has been employed at the request of the Mekong Committee. It should be noted, however, that this method is effective only if there are competitive and optional projects. In the case of the Sambor Project, no such projects can be considered to exist since its implementation is easier than any of the upstream projects with respect to cost and other aspects. The method therefore is considered to serve only as a supplementary means to justify the economic soundness of the project.

(3) The calculated internal rate of return of 4.4% is not very high. It should be noted, however, that large-scale power development schemes in developing countries generally produce a low internal rate of return because of the long period required for load to build up to full load operation.

(4) Upon completion of the Pa Mong Project which is under study and the Nam Ngum Project which is under construction, the regulated discharge from these projects will enable the addition of capacity of the Sambor Project to a ultimate installed capacity of 2,100 MW. This increase will naturally be accompanied by a rise of internal rate of return to 6% to 8%. Therefore, the project feasibility can be readily established when studied solely from the standpoint of internal rate of return.

(5) The feasibility of the project has been studied on the basis of comprehensive judgement of the technical and economic soundness given above as well as the financial soundness that is described in Chapter B-1-9, which led to the conclusion that the Sambor Project is feasible in every aspect though its internal rate of return would not exceed 4.4% at the outset.

(6) The internal rate of return of the navigation aspect is about 5.2%. Since the absolute cost required for navigation improvement which is less than 2% of the total project cost, it is assumed to be absorbed into the internal rate of return of power as a part of the cost of the dam. Evaluation of navigation improvement must be also made in the light of the secondary benefits it will create for forestry development in areas upstream of Kraite as well as the development of forestry and mineral resources in Laotian territory in the future.

(7) The internal rate of return of agriculture is 7.9%, and this is on the international level. However, the benefits created by the agricultural development program cannot be directly appropriated to debt financing. Therefore, in negotiating possible loans from international financing organizations, efforts should be directed to securing loans at an interest rate far lower than the expected internal rate of return.

B-1-9 Financial Soundness

(1) Separate financial programs for power and navigation and for agriculture have been prepared for the following reasons.

a) Time of benefits from power and navigation do not coincide with that from agricultural development.

b) Benefits from agricultural development cannot always be appropriated to debt financing.

c) Agricultural development has more opportunity to be financed by soft loans than industrial development.

For the financing of the project, it was assumed that all foreign currency would be raised in the form of loans outside of Cambodia, but for domestic currency the following two cases were assumed : (Case 1) total amount is to be borne by the national treasury of the Royal Government of Cambodia, and (Case 2) half of the amount is to be borne by the national treasury and the remaining half is to be raised from domestic financing institutions.

As for interest rate and term of repayment, an anticipated amount of loans from each of various international financing insitutions and other foreign financing institutions for the power and navigation aspects were first assumed, then the weighted mean of the current interest rate charged by these financial institutions were calculated, and the overall interest charge and term of repayment for the first and second stages of construction were obtained.

The results are as follows:

Case 1:	Interest charge	–	First stage	4%
			Second stage	6.2%
	Repayment period	–	First stage	25 years after start of its operation
			Second stage	18 years after start of its operation

Case 2:	Interest charge —	First stage	4%
		Second stage	5.9%
	Repayment period —	First stage	28 years after start of its operation
		Second stage	18 years after start of its operation

For agriculture the interest charge is 3.5%, and repayment period is 20 years.

(2) Results of calculation based on the above condition for power and navigation indicates that the cash balance takes a favorable turn from the eighth year after start-up for Case 1 and also for Case 2. After all borrowings, including both foreign and domestic, are completely redeemed, and if governmental contribution is set aside, the accrued reserve which is net income and depreciation reserve will amount in 50 years after start-up to $550 million for Case 1 and $490 million for Case 2. After deducting costs for replacement, the accrued reserve will amount to $440 million for Case 1 and $380 million for Case 2.

(3) For agriculture, the principal and interest of both foreign and domestic borrowings will amount to $44.06 million for Case 1 and $48.73 million for Case 2. On the other hand, the net income of the farmers in the 50 years after the creation of the initial benefit is estimated to amount to $186.9 million. In the case of agriculture source of funds for repayment may not necessarily be collected from farmers, but judging from the above earnings the net income in terms of national economy in 50 years will be $143 million for Case 1 and $138 million for Case 2.

(4) The burden on the treasury of the Royal Government of Cambodia in the 10 years after of construction of the Sambor Project will be $10,490,000 per year on the average and $16,400,000 in the maximum years for Case 1, and $6,012,000 per year on the average and $8,200,000 in the maximum years for Case 2. Under the Second Five-Year Program of the Royal Government of Cambodia, the GNP in 1972, the last year of the Five-Year Program, is estimated at 39.1 billion Riel ($1,120 million), and if it is assumed that the GNP will continue to increase at an annual rate of 5% thereafter, the ratio of the burden to the treasury of the Royal Government of Cambodia will be around 0.7% to 0.8% of the GNP for Case 1, and 0.4% to 0.5% for Case 2, which is considered to be an amount that seems to be shouldered by the state treasury. As a result of the above study, it is concluded that the Sambor Project is financially feasible if the required conditions can be satisfied.

B-2 Recommendations

Based on the conclusions given above, the following recommendations are made.

(1) The Sambor Project is technically, economically and financially feasible, even if developed as an isolated project. The project is of a suitable scale from the standpoint of the economy of Cambodia and Vietnam since its construction cost is about one-third of that of the Pa Mong Project and the Stung Treng Project. It is therefore recommended that every effort be made for its early development so that the basis for economic and industrial development may be established in the two countries.

Upon completion of the upstream Pa Mong Project and the Nam Ngum Project, the regulated discharge from those project will enable the Sambor Project to increase its ultimate installed capacity to more than 2,000 MW which will result in an immense increase in energy output. It is therefore recommended that social and economic development be initiated at an early stage to create environments in which power from the Sambor Project can be utilized to the fullest extent.

(2) Since the introduction of aluminum refining industry and other power-oriented industries is one of the important controlling factors to the successful development of the project, concerted efforts should be made to attract power-oriented industries into the area. Studies on the possibility of establishment of power-oriented industries should be made also as early as possible.

(3) In order that the benefits of agricultural development may be realized at an early stage, it is recommended that experimental and demonstration farms be established to provide technical training and guidance in improvement of irrigation and drainage technique, and to disseminate information in farming technique and plant breeding.

(4) In order to enhance to the fullest extent the benefits of navigation improvement, it is desirable to prepare an industrial development plan of the Stung Treng District and to conduct investigations of unexploited natural resources of the Lower Mekong River Basin.

(5) The tributaries of the Mekong, those which join the mainstream near Stung Treng, particularly the Se San, Se Kong, and the Sre Pok, and the adjoining inundated forests and swamps seems to be excellent breeding grounds for fish in the wet season. The Sambor Reservoir is expected to play an important role in the preservation and production of fish resources, but it is unknown yet whether the catches in downstream waters will be affected by the construction of a dam. Taking into account fish migration, the present study includes fish ladders which are estimated to cost approximately $5 million. It is recommended that fishery studies be carried out to establish appropriate measures for the preservation and production of fishes.

(6) Before construction of the project may begin, the following supplementary investigations will be necessary in order to prepare the detailed designs.

a. Study of the probable maximum flood by meteorological data, and the method and influence of flood control operation.

b. Detailed study on the construction of the rock-fill dam in the river channel section.

c. Geological investigation of the former river bed.

d. Geological survey of foundations of supporting structures for the transmission line to be built on soft ground along the proposed route.

e. Sounding of shallow water and geological investigation in the neighborhood of Stung Treng.

f. Detailed land classification study in the proposed irrigation development area, and study on construction, maintenance and management of hydraulic structures.

g. Study of socio-economic influence of the Sambor Project upon the projected area or Cambodia and Vietnam.

CHAPTER C. OBJECT AND SCOPE OF THE PROJECT

CHAPTER C. OBJECT AND SCOPE OF THE PROJECT

C-1 Object of the Project

C-1-1 Present Condition and Existing Problems

(1) The Mekong River originates in the Tibetan mountains, flows through the China mainland, enters Laos and forms the boundary between Laos and Thailand until it drains through Cambodia and the delta in Vietnam and finally empties into the China Sea. It has a total length of 4,200 km and a catchment area of 795,000 sq.km. The catchment area being in the monsoon zone is distinctly divided into two seasons, the wet season from May to November during which period rainfall is concentrated and the dry season with extremely little precipitation.

(2) The Mekong River has close bearing on the industrial and economic activity of the riparian countries. Major cities and villages are found along the river, and water traffic between these cities and villages is active. Between the estuary of the Mekong and Kratie, river transportation is far more active than overland transportation because the river is the safest, most convenient and economical means of transporting passengers, agricultural and forestry products, daily necessities and other cargoes. Upstream of Kratie, however, navigation is hampered by the Samboc Rapids, Khone Falls, the Khemarat Rapids and other obstacles. Difficulty of water transportation to the middle and upper reaches are retarding the exploitation of rich forest resources in the upstream areas and mineral resources in Laos which include gold, silver, lead, zinc, limestone, gypsum, rock-salt, etc.

(3) Major products of Cambodia are rice, maize, fish and rubber. Export of these major products has served to improve the country's balance of payment position which is in a fairly satisfactory state. However, the country is far behind in the development of irrigation and drainage facilities. In the dry season, therefore, virtually no crops are cultivated, retarding the increase of agricultural production. In the project area, foods are supplied from other districts of the country.

In Vietnam, the once rice exporting country known as the "Granary of Asia," production seems to have drastically dropped resulting in the import of foods

The annual population growth rate in these two countries is about 3%. If the population continues to expand at this rate, both countries will have a population twice the present size in 20 to 25 years. It is imperative for these countries to promote industrial development based on increased food production, whereby the living standard of the people may be improved by increased national production and the national economy may be put on a firm basis. Investigations revealed that for the realization of these purposes, industrial production should be increased at an annual rate of 6% to 7%.

(4) With respect to power supply that supports the national economy and industrial production, it is found that consumption in the areas is considerably low compared with other parts of the world. This is due primarily to the prevailing shortage of supply capacity as well as to the high charges for service currently in force. In areas around Phnom Penh and Saigon, capital cities of the two countries, electricity is supplied at an average rate of 60 to 70 mills/kWh. A large potential demand therefore exists. However, the annual growth rate of general demand has been more than 10% during the past 10 years, and if abundant and low-cost power becomes available, it would not only satisfy the potenitial demand but also accelerate the growth of demand which will reach five to seven times the present level. Investigations revealed that the maximum demand in about 20 to 25 years, will become 470 MW to 770 MW in Cambodia and 1,575 MW to 2,400 MW in Vietnam, or a combined demand of about 2,045 MW to 3,170 MW in the two countries. This indicates that a large deficiency of supply capability will occur each year after 1980 even if all the proposed national power projects are completed as scheduled.

C-1-2 Object of the Sambor Project and Necessity for Its Implementation

(1) The most pressing needs of the two countries are large-scale agricultural development by securing increased flow in the dry season and construction of irrigation and drainage facilities, exploitation of

1/ *Economic and Social Aspects of Lower Mekong Development*, January 1962, by Gilbert F. White natural resources and promotion of local industries through improvement of navigation, promotion of industrialization by large-scale power development, and resulting improvement of the living standards of the people. As a means of satisfying these needs, a solution is the construction of a large multipurpose dam on the Mekong Mainstream.

(2) The Sambor Project is a multipurpose development scheme intended to satisfy these needs and includes power, navigation and agricultural development. In view of its location and capital requirement, it is judged that the project is most optimum to meet the present needs.

The Mekong Mainstream Projects include the Pa Mong and the Stung Treng Projects besides the Sambor Project. The first two projects have larger potentials and are expected to create substantial benefits including flood protection in the Mekong Delta, but the required investment for their development amounts to more than twice of that of the Sambor Project. The Sambor Project, whose reservoir storage capacity is smaller, will not create such benefits as flood protection and large-scale agricultural development in the delta while it would remain to be an isolated project. However, the merits of the project is that it is located at about the center of Cambodia, its reservoir area is confined within Cambodian territory, and the loss of farm land due to immersion in the reservoir is small.

Economic development and modernization of industry in the two countries will be largely enhanced by the development of the project, which will lay the basis for the establishment of power-oriented industries that require large bulk power, satisfy general power demands, improve navigation up to Stung Treng, and enable the reclamation of farm lands in areas downstream of the dam. And upon completion of the two upstream project, which will result in an increased dry season discharge in the downstream areas, the installed capacity of the Sambor Power Plant can be increased to more than 2,000 MW, and large-scale agricultural development covering an area of about 1,000,000 ha or more in the delta will become possible.

In view of these advantages and benefits, the Sambor Project would have to be given priority over other mainstream projects.

C-2 Scope of the Project

C-2-1 Isolated Project

As mentioned above, the upstream projects, when constructed, will greatly add to the economic benefits of the Sambor Project. At present, however, these upstream projects are still in the planning stage and their basic engineering data are not available. In the present study, therefore, the Sambor Project is treated as an isolated project.

A study of the Sambor Project taking into consideration the influence of the Pa Mong and the Nam Ngum Projects is attached to this report as Volume II.

C-2-2 Scope of the Project

(1) Power Development Program: The scale of the dam and powerhouse has been determined on the basis of the discharge data for the 33-year period from 1933 to 1965 which has been made available by the Mekong Committee. Due attention was given so that the backwater will not have an adverse influence to the tailrace water level of the proposed upstream Stung Treng Project.

In the demand forecast, it is assumed that the Sambor Project will satisfy general demands in both Cambodia and Vietnam, and also meet 60% of the increment of demand in and after 1978 when there will arise a deficiency of supply capability. Establishment of power-oriented industries is to be planned centering on the aluminum refining industry with an annual production of 125,000 tons. After comparative studies on the possible location of the industry, including Saigon and Phnom Penh, it was judged that Sihanouk Ville seems to be the most suitable site.

The power transmission program of the project has been prepared with Phnom Penh, Sihanouk Ville and Saigon as load centers, and interconnection with upstream projects has not been considered.

(2) Navigation Program: In the navigation program, account is taken of the estimated transport demand that may arise in the next 20 to 25 years when the population of the riparian countries is estimated to double, and the limit of navigable water to Stung Treng where the extreme backwater of the Sambor Reservoir is to reach.

When the proposed upstream dams are completed in the future to make navigation possible from the esturay of the Mekong to Vientiane (Laos), the construction of locks will be necessary at Sambor. This, however, is not included in this report of Isolated Project because the time of completion of the upstream dams is unknown yet. (As for locks, see Vol.II, Chapter K)

(3) Irrigation Program: The irrigation program for agricultural development has been prepared after investigation of 69,000 ha of land extending downstream to the boundary of Kratie Province, where gravity irrigation is possible by the Sambor Reservoir. As a result of topographical and soil survey conducted in this area, 34,000 ha has been designated as the proposed irrigation development area.

The number of farming households in the development area is set at 8,500, of which 2,000 would be the settlers that migrate from the farm land to be submerged under the reservoir.

Completion of the upstream dams will make it possible to control flood discharge of the Mekong and also increase dry season flow, whereby large-scale agricultural development will become possible in the downstream areas and in the delta. In this report, however, study of this large-scale agricultural development is not included. (See Vol. II)

CHAPTER D. DESCRIPTION OF THE PROJECT

CHAPTER D. DESCRIPTION OF THE PROJECT

D-1 Power Development Program

D-1-1 Demand Estimate

D-1-1-1 Present Status

According to the December 1967 issue of the "Mekong Committee Statistical Bulletin," the power demand and supply in Cambodia and Vietnam is as follows.

As of 1965, Cambodia had an installed capacity of 45 MW and an annual output of 85,000 MWh, while Vietnam had an installed capacity of 285 MW and an annual output of 522,000 MWh. In the same year, energy consumption in the two countries was 63,000 MWh and 430,000 MWh respectively.

The per capita consumption is 10.3 kWh per annum in Cambodia and 26.7 kWh per annum in Vietnam, which is lower than the level in other countries with approximately the same national income. One of the causes of this low consumption is the absolute shortage of supply capacity in the two countries, and the other is that superannuated steam or diesel generators, constituting most of the power installations in Cambodia and more than half in Vietnam, invite high power costs, as reflected in the rate of 60 to 70 mills/kWh enforced in Phnom Penh and Saigon-Cholon Districts where electricity is the cheapest. It follows that there exists a substantial potential demand in both countries.

Despite their unfavorable conditions, the annual load growth during the 10-year period since 1956 has been 10% in Cambodia and 10.8% in Vietnam. It is therefore expected that when abundant and inexpensive power becomes available in the future, it will not only satisfy the potential demand but also serve to create new demands causing a large growth of demand for power. Particularly in Cambodia, where development of the national economy and modernization of industries are progressing through the Second Five-Year Plan (1968-72) which was implemented following the First Five-Year Plan, a fast growth is expected in the demand for power to sustain the new economic pattern.

The power demand in Cambodia is comprised of 75% for lighting and 25% for motive power, and that in Vietnam is 66% for lighting and 34% for motive power. About 80% of the total demand in Cambodia is concentrated in the Phnom Penh-Kandal District. Similarly, about 85% of the total demand in Vietnam is found in the Saigon-Cholon District.

D-1-1-2 Electric Power Industries

In Cambodia, 56% of the power installations are owned by electric power industries and the remaining 44% is owned by private industries. About 90% of the power installations of the electric power industries is owned by Eléctricité du Cambodge (EDC) whose service area covers entire Cambodia, excluding Battambang District, and the remaining 10% is shared between a private enterprise in Battambang (CIE) and provincial and village management. In Vietnam, approximately 88% of power installations belongs to electric power industries and the remaining 12% is owned by private industries. About 56% of the installations of the electric power industries is owned by Eléctricité du Vietnam (EDV) whose major power plant is the Da Nhim Hydro-Power Station (160 MW). The remainder is operated by the five private enterprises (CEE, UNEDI, SCEE, SIPEA, and SAER) as well as by local entities. Details of the existing power installations in the two countries are given in Table D-1.

D-1-1-3 Supply Area of the Sambor Power System

With the exception of the 220 kV transmission line (200 km) that connects the Da Nhim Power Plant and Saigon-Cholon District, there is no extensive and full-scale transmission system in the two countries. Isolated plants are found in major cities, towns and villages of both countries. As stated before, about 80% and 85%, respectively, of the total demand of the two countries are concentrated in the Phnom Penh-Kandal District and in the Saigon-Cholon District.

Table D-1 Power Installations in Cambodia and Vietnam by District and Enterprise

District	Operating Agency	Installed Capacity (MW)	Percentage (%)
Cambodia (As of 1963)			
Phnom Penh - Kandal	EDC	23.3	42.0
Sihanouk Ville	Provincial management	0.6	1.1
Battambang	CIE	1.1	2.0
Monopolies	EDC	4.0	10.7
Monopolies	Village management		
Subtotal (Electric utility industries)		30.9	55.8
Phnom Penh - Kandal	Private plants	19.0	34.5
Other districts	"	5.3	9.7
Subtotal (Private plants)		24.3	44.2
Grand Total		55.2 1/	100
Vietnam (As of 1965)			
Saigon - Cholon, Dalat	EDV	200.8	56.0
" "	CEE	88.1	24.6
Mekong Delta	SCEE	4.3	1.3
Central District	SIPEA	11.0	3.1
Southwestern District	SAER	5.1	1.4
Southeastern Coastal Area	UNEDI	2.2	0.6
Villages (about 60)	Village management	4.2	1.2
Subtotal (Electric utility industries)		315.7	88.3
Textile industries	Private plants	42.9	11.7
Grand Total		358.6 1/	100

When the following transmission lines are constructed in the two countries, cities and isolated local plants will be gradually connected to these transmission lines. Further, expansion of power supply capacity and transmission network is expected to be accompanied by the gradual absorption of private power installations into these transmission lines.

Note: 1/ The figures are taken from the data pressented by EDC and EDV, *Electricite Renseignements Statistiques.*
But it is 37 MW of Cambodia in 1963 and 285 MW of Vietnam in 1965 according to the Statistical Bulletin of Mekong Committee in Dec. 1967.

Transmission Line	Voltage (V)	Starting Year of Operation
(1) Cambodia		
Phnom Penh-Kirirom	110	1967
Phnom Penh-Prek Thnot-Sihanouk Ville	110	1969
Phnom Penh-Takeo-Kampot-Kamchy	110	1971
Phnom Penh-Pursat-Battambang	110	1973
(2) Vietnam		
Da Nhim-Pan-Nha Trang	220	1968
Saigon-My Tho-Tan An	110	1968

Power from Sambor will be supplied to the interconnected system extending to Phnom Penh-Sihanouk Ville District and Saigon-Cholon District.

D-1-1-4 Estimate of General Demand

(1) Method Employed: Investigations of past power demands during the period from 1956 to 1965 have disclosed that general demand recorded an annual growth rate of 10% and 10.8% respectively in Cambodia and Vietnam. In this report, the median of the values obtained by the following two methods has been adopted as the estimated demand. These two methods are the analytical method in which the demands estimated for each year by district and uses are summed up, and the overall method in which the demand for each year is calculated from elastic value of demand against gross national product.

The annual growth rate attained by these methods is tabulated below.

Period	Growth Rate
1965 – 1985	10% – 17%
1986 – 2000	9% – 11%

The demand in the interconnected Sambor Power System is also estimated to occupy 72.5% to 78.0% of the total power demand during the period from 1978 to 1998.

Table D-2 Estimated National Demand at Consuming End

		1963	1970	1975	1980	1985	1990	1995	2000
Cambodia									
Annual energy requirement	(10^6 kWh)	86	260	460	800	1,360	2,290	3,780	6,150
Growth rate	(%)	-	17.1	12.1	11.7	11.2	10.9	10.4	10.3
Peak load	(MW)	-	60	100	175	295	470	770	1,270
Vietnam									
Annual energy requirement	(10^6kWh)	455	1,250	2,100	3,400	5,400	8,350	12,800	19,600
Growth rate	(%)	-	15.6	10.9	10.2	9.6	9.1	8.9	8.8
Peak load	(MW)	-	240	410	655	1,030	1,575	2,400	3,630

(2) Estimated National Demand: The maximum demand and annual energy requirement at the consuming end (including private plants) in the two countries are given in Table D-2 which has been prepared on the basis of the above estimate.

It is estimated that the overall losses will drop to 12% to 17% by the extension and improvement of transmission and distribution networks, and that the annual load factor will increase to 52%- 55% in Cambodia and 59% - 61% in Vietnam by development of secondary industries, and by connection of private power installations with the interconnected power system as well as by the increased use of air-conditioning equipment resulting from the rise of living standards.

(3) Estimated Demand in the Interconnected Sambor Power System: The estimated maximum demand and annual energy demand at the generating end in the Interconnected Sambor Power System, taking into account the above-mentioned demand ratio, overall losses and annual load factor, are given in Table D-3.

The maximum demand is estimated to be 576 MW in 1978, 1,520 MW in 1988 and 3,718 MW in 1998, and the annual energy demand is estimated to be 2,922,000 MWh in 1978, 7,828,000 MWh in 1988 and 19,430,000 MWh in 1998.

TableD-3 Estimated Demand of Sambor Interconnected System (at generating end)

		1978	1983	1988	1993	1998
Cambodia						
Annual energy requirement	(10^6kWh)	557	954	1,638	2,790	4,330
Peak load	(MW)	121	204	346	582	898
Vietnam						
Annual energy requirement	(10^6kWh)	2,365	3,850	6,190	9,950	15,100
Peak load	(MW)	455	738	1,174	1,875	2,820
Total						
Annual energy requirement	(10^6kWh)	2,922	4,804	7,828	12,740	19,430
Peak load	(MW)	576	942	1,520	2,457	3,718
Growth rate of peak load	(%)	-	10.4	10.0	9.9	8.7

D-1-1-5 Supply and Demand Balance and Load Distribution Ratio of General Demand

(1) Existing Development Project: As indicated in Table D-4 which gives the existing development projects in the two countries, Cambodia has nine projects from which 197 MW is expected to be generated by 1982, and Vietnam has six projects which are expected to generate 454 MW by 1985. Table D-5 prepared on the basis of the above values indicates that a balance of supply and demand will be maintained until 1976, but there will emerge in 1977 a shortage of 170 MW in maximum demand and about 1,135,000 MWh in energy demand in Vietnam. This shortage would have to be covered by the construction of a new thermal power plant of 175 MW capacity.

(2) Supply and Demand Balance: Power from these existing development projects will not be sufficient to satisfy the estimated demand in and after 1980. About 30% to 70% of the supply deficiency will be against the increment of demand. (See Table D-6) This deficiency can be met by the commissioning the Sambor Project in 1978.

(3) Load Distribution Ratio of Sambor Project: It is advisable that the load distribution ratio of the Sambor Project be set at a value higher than the above deficiency rate to avoid shortage of supply capability that may be caused by the delayed completion of the existing development projects. In the present study, therefore, the ratio of the Sambor Project for general demand has been set at 60% of the demand increment.

Table D-4 Existing Power Development Project

District	River	Max. output (MW)	Annual energy output (MWh)	Target completion year
Cambodia				
Kirirom No. 1 unit	Kompong Som	10	50,000	1967
Prek Thnot	Mekong tributary	18	40,000	1969
Kirirom No. 2 unit	Kompong Som	21	93,000	1970
Kam Chay	Prek Tuk	50	250,000	1971
Battambang No. 1 unit	Stung Sanke	20	80,000	1973
Maun	Stung Daum Tri	5	30,000	1976
Stung Pursat	"	21	120,000	1978
Battambang No. 2 unit	Stung Sanke	7	35,000	1980
Upper Kam Chay	Prek Tuk	45	210,000	1982
Subtotal		191	908,000	
Vietnam				
Drayling	Srepok	12	-	1968
Tri An	Don Nai	100	440,000	1972
Da Nhim No. 3 unit	"	80	-	1978
Da Nhim No. 4 unit	"	80	942,000	1982
Lagna	"	102	-	1985
Da Nhim No. 2 unit	"	80	491,000	-
Subtotal		454	-	
Grand Total		651	-	

D-1-1-6 Introduction of Power-Oriented Industries

(1) Necessity for Inducing Power-Oriented Industries: The power output of a project can be most economically determined based on the characteristics of the river runoff. In the case of the Sambor Project, the installed capacity has been set at 875 MW for reasons given later.

If power from Sambor is allocated only to general demand, it will take about 13 years before the demand will build up to full load operation and during the intermediate period, there will be a large surplus of energy. From the standpoint of effective utilization of water resources and promotion of industrial and economic development of the Lower Mekong River Basin, it is advisable to establish power oriented industries promoting export of products and to anticipate secondary benefits by the introduction of related industries as components of the said industries. The demand estimate for the Sambor Project, therefore, includes the establishment of power-oriented industries in addition to power supply to general demands.

(2) Power-Oriented Industries: The desirable types of power-oriented industries to be introduced include aluminum refining which will be the key industry that demands firm energy supply, and a number of other industries including soda, carbide, ferro-silicon, silicon carbide and vinyl chloride industries which will be able to consume secondary power.

(3) Conditions for Industrial Development: In Cambodia and Vietnam, great efforts are being directed toward industrialization along with the promotion of agricultural production. The fundemental problem for the desired industrial development is the lack of funds and technique. Disregarding these handicap, both countries can be compared with other parts of the world with respect to area and geographical location, though they may not have abundant natural resources. By the willingness and diligence inherent to the people, the prospects of industrialization will become much brighter if they are provided with financial and technical assistance.

(4) Proposed Site of Power-Oriented Industries: Since the aluminum refining industry (which will be the key industry) and other power-oriented industries that operate on secondary power are equally dependent on import for the supply of raw materials, it is advisable that they be established near port facilities. As the sites for such industries, Phnom Penh, Sihanouk Ville and Saigon may be considered.

Of these three cities, Phnom Penh would not be considered to be a suitable site for the aluminum refining industry since it is a river port and no large vessels can be mored. The other two cities have almost same conditions with respect to port facilities, availability of water supply and other environmental conditions. If the prerequisite

Table D-5 Supply and Demand Balance in 1977

(a) Power

Unit: MW

		Cambodia	Vietnam
Maximum available output of existing projects	Hydropower	-	140
	Thermal power	52	185
	Total (A)	52	325
Maximum available output	(B)	106	95
Total maximum available output	(C) = (A) + (B)	158	420
Maximum demand	(D)	150	590
Supply deficiency	(C) – (D))	8	(–) 170

(b) Energy

Unit: MW

		Cambodia	Vietnam
Annual available energy of existing projects	Hydropower	-	900,000
	Thermal power	235,000	515,000
	Total (A)	235,000	1,415,000
Annual available energy	(B)	490,000	450,000
Total annual available energy	(C) = (A) + (B)	725,000	1,865,000
Annual energy demand	(D)	725,000	3,000,000
Energy deficiency	(C) – (D)	0	(–) 1,135,000

Note: (1) 15% is deducted from the maximum output of hydropower in consideration of decrease in output in the dry season and the multipurpose operation of dam.

(2) 5% is deducted from the maximum output of thermal power for station use.

(3) In calculating the available energy, 10% surplus was deducted from the output.

assumption is that the power-oriented industries be established in one country, that is, Cambodia, then Sihanouk Ville may be considered for the aluminum refining and carbide industries, and Phnom Penh for some industries using electric furnaces.

D-1-1-7 Power Consumption Program

(1) Load Combination: The Sambor Project, when completed, will have seven 125 MW units to produce a maximum output of 875 MW and an average annual energy output of 7,000,000 MWh. For the distribution of the power and energy which will become available, the following three patterns of load combination were studied.

Type I : General demand and demands by power-oriented industries (aluminum refining, caustic soda, vinyl chloride, calcium carbide, ferro-silicon, and silicon carbide)

Type II : General demand and demands by industries whose production is intended for consumption in the project area (caustic soda, vinyl chloride, calcium carbide)

Type III: General demand only.

(2) Supply Capacity Required to Meet Increment of Demand after 1978: The required supply capacity at the generating end to satisfy the increment of demand after 1978 in the interconnected Sambor Power System and the required capability of the Sambor Project which will supply 60% of the increment are as follows: (See also Table D-6)

Year	Total		Sambor	
	Power (MW)	Energy (MWh)	Power (MW)	Energy (MWh)
1978	47	247,000	28	147,000
1980	164	828,000	98	516,000
1985	608	3,068,000	365	1,918,000
1990	1,289	6,513,000	769	4,042,000

Table D-6 Supply and Demand Balance of Maximum Demand of Increment of Demand in Sambor Interconnected System after 1978.

(Unit MW)

		1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Cambodia Installed Capacity													
Increment of Demand	(A_1)	12	25	39	56	75	95	119	143	172	202	237	285
Stung Pursat		21	21	21	21	21	21	21	21	21	21	21	21
Battambang II		-	-	7	7	7	7	7	7	7	7	7	7
Upper Kam Chay		-	-	-	-	45	45	45	45	45	45	45	45
Total	(B_1)	21	21	28	28	73	73	73	73	73	73	73	73
Deficiency of Capacity	$(C_1) = (B_1) - (A_1)$	9	(-)4	(-)11	(-)28	2	(-)22	(-)46	(-)70	(-)99	(-)129	(-)164	(-)212
Vietnam Installed Capacity													
Increment of Demand	(A_2)	35	75	125	180	248	318	388	465	555	650	754	853
Da Nhim III		80	80	80	80	80	80	80	80	80	80	80	80
Da Nhim IV		-	-	-	-	80	80	80	80	80	80	80	80
Lagna		-	-	-	-	-	-	-	102	102	102	102	102
Total	(B_2)	80	80	80	80	160	160	160	262	262	262	262	262
Deficiency of Capacity	$(C_2) = (B_2) - (A_2)$	45	5	(-)45	(-)100	(-)88	(-)158	(-)228	(-)203	(-)293	(-)388	(-)492	(-)591
Total Increment of Demand	(ΣA)	47	100	164	236	323	413	507	608	727	852	991	1,138
Installed Capacity	(ΣB)	101	101	108	108	233	233	233	335	335	335	335	335
Deficiency of Capacity	$(\Sigma C) = (\Sigma B) - (\Sigma A)$	54	1	(-)56	(-)128	(-)90	(-)180	(-)274	(-)273	(-)392	(-)517	(-)656	(-)803
Deficiency Rate of Capacity	$(D) = (\Sigma C)/(\Sigma A) \times 100\%$	115	1	34	55	28	44	54	45	54	60	66	71

(3). Power Allocation to Power-Oriented Industries: The Sambor Project, when completed, will have seven 125 MW units or a total installed capacity of 875 MW which will produce 7,000,000 MWh annually. Discharge data covering the past 33 years indicate that the output will drop to 473 MW in the critical hydro period. It is therefore considered proper, in the light of the nature of the respective demands, to allocate firm energy of 473 MW to general demand at first, with second priority given to the aluminum refining industry, and to supply the secondary energy to other power-oriented industries.

With respect to the production capacity of these power-oriented industries, the aluminum refining industry will have to be of an optimum economic size compatible with recent international trends of the industry, and also other industries are to be established at a scale suitable for supply to the project area. The power allocation of annual production and unit energy requirement of each industry have been studied and planned as follows:

General demand	390 MW
Aluminum refining	250 "
Caustic soda	60 "
Vinyl chloride	16 "
Calcium carbide	103 "
Ferro-silicon	28 "
Silicon carbide	28 "
Total	875 MW

	Annual production (10^3 t/yr)	Unit energy requirement (kWh/t)
Aluminum refining	125	16,100
Vinyl chloride	125	1,000
Caustic soda	123	3,700
Calcium carbide	52	3,150
Ferro-silicon	20	10,000
Silicon carbide	17	10,000

The annual production given above is applicable to Type I load combination. In Type II load combination, aluminum refining, ferro-silicon, silicon carbide is excluded from the power consumption program, and the output of the calcium carbide industry will be decreased to about one-third of the above value.

(4) Power Consumption Program and Capacity Addition Schedule: Based on the conditions given above, the power consumption program and the capacity addition schedule have been studied with respect to each type of load combination.

(a) Type I: The total installed capacity of 875 MW will be developed by 1983, and the available energy at the generating end will reach 7,000,000 MWh after 1986. Surplus energy of 1,028,000 MWh will be deducted from this 7,000,000 MWh, and the remainder of 5,972,000 MWh will be supplied to load centers. The energy delivered at load centers will be 5,731,000 MWh, after deducting transmission loss of 4%.

Power allocation to power-oriented industries will be held constant after 1978, while the general demand will grow year after year. After 1986, the power allocation ratio of general demand, aluminum refining industry and other industries will become approximately equal, each being about one-third of the total demand. Allocation of power in 1978 and after 1986 is given in Table D-7.

The scheduling of capacity addition will be as given in the table which follows.

Start of Operation	Installed Capacity
1978	125 MW x 5 units
1981	125 MW x 1 unit
1984	125 MW x 1 unit
Total	875 MW (7 units)

Table D-7 Allocation of Power (Type I)

		1978					after 1986				
No. of Generators	(Unit)	5					7				
Maximum Output	(MW)	625					875				
Available Energy	(10^6kWh)	5,377					7,000				
Surplus Energy	(10^6kWh)	1,311					1,031				
Surplus Ratio	(%)	24.4					14 7				
		Generating End		Consuming End			Generating End		Consuming End		
		Power (MW)	Energy (10^6kWh)	Power (MW)	Energy (10^6kWh)	Load Factor (%)	Power (MW)	Energy (10^6kWh)	Power (MW)	Energy (10^6kWh)	Load Factor(%)
General Demand		28	147	27	141	60	390	2,050	374	1,968	60
Aluminum Refining Industry		250	2,100	240	2,016	96	250	2,100	240	2,016	96
Other Industries		235	1,819	226	1,747	88	235	1,819	226	1,747	88
Caustic Soda		60	504	58	484	96	60	504	58	484	96
Vinyl Chloride		16	130	15	125	93	16	130	15	125	93
Calcium Carbide		103	793	99	761	88	103	793	99	761	88
Ferro-silicon		28	211	27	203	86	28	211	27	203	86
Silicon Carbide		28	181	27	174	74	28	181	27	174	74
Total		513	4,066	493	3,904	90	875	5,969	840	5,731	78

Note Total loss between the generating and consuming end is 4%.

(b) Type II: In 1978, the project is to be commissioned with an installed capacity of 250 MW which will produce 2,190,000,000 MWh annually. The estimated demand will be 28 MW for general demand and 115 MW for power-oriented industries, totaling 143 MW. The energy requirement will be 1,077,000 MWh. Hence, surplus energy will be 1,113,000 MWh which is 51% of the available energy. Full load operation with an installed capacity of 875 MW will not be possible until after 1990 when the energy demand at the generating end will be 4,925,000 MWh. At this stage there will be 2,075,000 MWh of surplus power which is 30% of the available energy. The power allocation in 1978 and after 1990 are given in Table D-8.

Capacity addition schedule will be as indicated in the table which follows.

Start of Operation	Installed Capacity
1978	125 MW x 2 units
1981	125 MW x 1 unit
1983	125 MW x 1 unit
1985	125 MW x 1 unit
1987	125 MW x 1 unit
1989	125 MW x 1 unit
Total	875 MW (7 units)

(c) Type III: In case of Type III, full capacity operation can be attained after 1991 when the energy demand at the generating end will be 4,600,000 MWh. This creates 2,400,000 MWh of surplus energy which is 34% of the available energy.

The capacity addition schedule is to start-up No. 1 generator in 1978 and No. 7 unit in 1990, which means that one unit will be added every two years.

The demand growth and supply capability by load and district in Types I, II and III are illustrated in Fig. D-1.

D-1-1-8 Findings

As mentioned before, introduction of power-oriented industries is strongly recommended for the early economic development of the Lower Mekong River Basin and for the effective utilization of power to be produced by the project which will require a huge capital investment.

Though three power consumption programs have been studied Type I load combination is recommended as the most desirable consumption program.

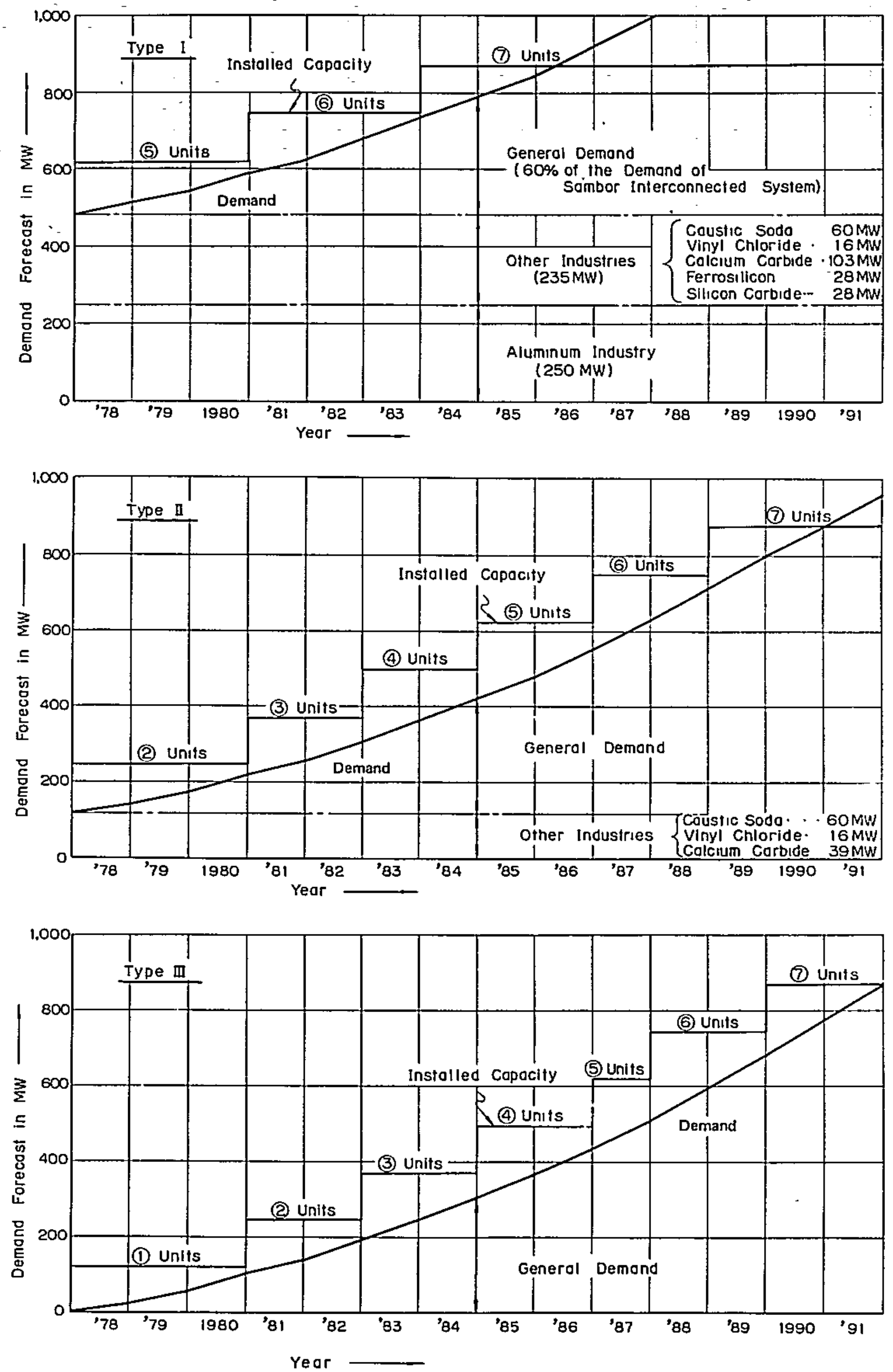
Table D-8 Allocation of Power (Type II)

		1978	from 1990
No of Generators	(Unit)	2	7
Maximum Output	(MW)	250	875
Available Energy	(10^6kWh)	2,190	7,000
Surplus Energy	(10^6kWh)	1,113	2,075
Surplus Ratio	(%)	50.8	29 6

	1978 Generating End		1978 Consuming End			from 1990 Generating End		from 1990 Consuming End		
	Power (kW)	Energy (10^6kWh)	Power (kW)	Energy (10^6kWh)	Load Factor(%)	Power (kW)	Energy (10^6kWh)	Power (kW)	Energy (10^6kWh)	Load Factor(%)
General Demand	28	147	27	141	60	760	3,995	730	3,835	60
Aluminum Refining Industry	115	930	110	893	92	115	930	110	893	92
Other Industries:										
Caustic Soda	60	504	58	484	96	60	504	58	484	96
Vinyl Chloride	16	130	15	125	93	16	130	15	125	93
Calcium Carbide	39	296	37	284	87	39	296	37	284	87
Total	143	1,077	137	1,034	86	875	4,925	840	4,728	64

Note Total loss between the generating and consuming end is 4%.

Fig. D-1 Demand Forecast at Generating End and Capacity Installations Schedule



D-1-2 Description of the Project Area

D-1-2-1 Topography

The Mekong is a narrow river in the upstream reaches and becomes wider in the downstream basin. The total catchment area of the river is 800 thousand sq.km. The Mekong, after passing through China and Burma, flows into Laos and changes its course to the right at a point near 18O° N Lat. and flows in an easterly direction. Up to this point, the river flows through a narrow valley, and after passing Pa Mong, it enters a wide expansive flat valley called the Vientiane Plain on the northern side and the Korat Plateau on the southern side of the river. As the river reaches the foot of the Annam Ranges, it turns to the south and flows through undulating land where the Annam Ranges approaches the left bank and the eastern ridge of the Korat Plateau extends to the right bank. A number of rapids and the well-known Khone Falls are found in this section, but the river gradient is generally gentle. On entering Cambodian territory, it flows through an extensive plain which is inundated in the wet season. At Phnom Penh, it is joined by the Tonle Sap that drains Great Lake, and forms the huge Mekong Delta before emptying into the China Sea. (See Fig. Key and Location Map)

In the proposed Sambor Reservoir area, it is joined by the Se Khong, the Se San and the Sre Pok on the left bank near Stung Treng, and descends southwards for about 100 km until it reaches the Samboc Rapids. Between Stung Treng and the Samboc Rapids, the river flows gently through rolling land where the river width at places is very wide. Downstream of Samboc Village the river narrows to 2.5 km-4.0 km, and further to 2.0 km just downstream of the rapids which is the proposed site of the Sambor Dam.

D-1-2-2 Geology

The mountainous areas in northern Laos within the Mekong Basin are formed chiefly of crystalline rocks of the Archaeozoic Era, the Pelaeozoic Era and the Mesozoic Era. The Korat Plateau is composed of gently sloping undulated sandstone formation of the Mesozoic Era. Eruption of basalt and andesite that intrude the Mesozoic Formation is often observed in the Annam Ranges. Diluvial and alluvial formations are widely distributed throughout the downstream areas.

The geology of the reservoir area is Indosinian Formation consisting of shale, sandstone, fine mudstone or alternate layers of these rocks, which are overlain by fine alluvial soil and residual soil produced by weathering. Except for the surface soils, these soils are generally compact and firmly bonded to the bedrock. Faults are not highly developed, and the fluctuated zone is considered to have sufficient water-tightness since cobble stones in the fault zones are cemented by clayey and silty materials.

On the right bank of the dam site, there is a former river bed about 2 km long. Deposit in the former river bed is comparatively water-tight and is considered to provide a sufficient sound foundation for the dam.

D-1-2-3 Climate

The Mekong Basin is located within the tropical and subtropical monsoon zone, and rainfall varies by the topography of each district. Generally speaking, however, the wet season coincides with the period of the southwesterly monsoon winds and the dry season with the period of the northeasterly monsoon. Typhoons that occasionally attack the Indo-Chinese Peninsula during September and October bring about much rain in the mountain area near the Annam Ranges and cause flooding of the basin.

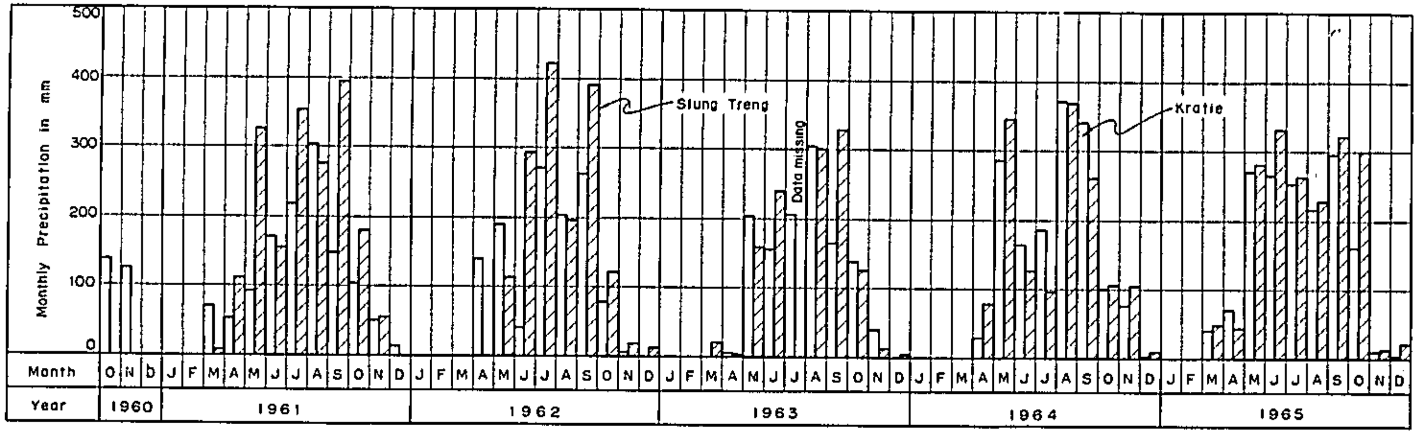
Precipitation records reveal that the annual average rainfall is 1,200 mm at Kratie and 1,600 mm at Stung Treng (See Fig.D-2). With respect to evaporation, no appreciable difference is observed between the districts, and the average annual value is approximately 5.6 mm per day (See Fig. D-2).

Wind blows from the southwest during June to August, and from the northeast during December to February. The wind velocity ranges from 1.5 m to 2.5 m per sec., but at time of typhoon or thunderstorm, it often registers 25 m to 40 m per sec.

Fig. D-2 shows the daily wind movement of each year which is larger in the dry season and decreases gradually towards the wet season. Thunderstorms occur rather frequently. On an average, they occur 90 times a year in Saigon, and 140 to 180 times in Phnom Penh.

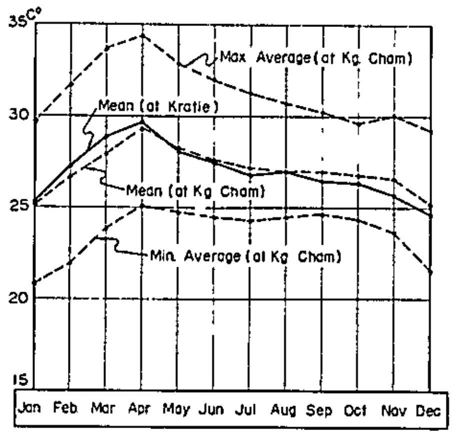
Fig. D-2 Weather Data

(a) Monthly Precipitation at Kratié and Stung Treng in Cambodia



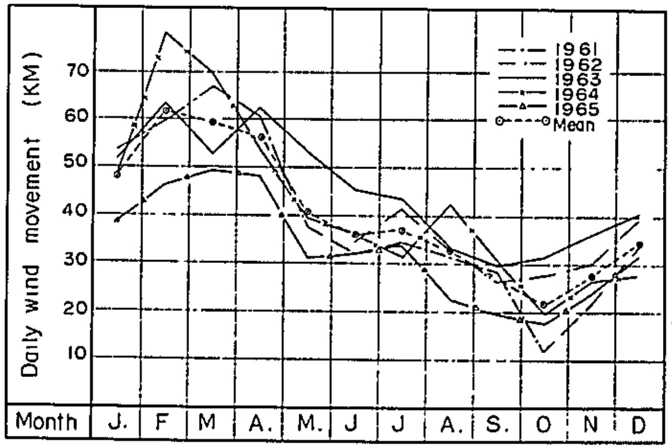
Source. Hydrological Data Mekong River Basin Cambodia 1960, 1961 Harza Eng
Lower Mekong Hydrologic Year Book 1962 ~ 1965

(b) Seasonal Variation of Temperature



NOTE Kratie, 11 Years Average
Kg Cham; 4~5 Years Average (Jan 1960 ~ Aug 1964)

(c) Daily Wind Movement at Stung Treng



D-1-2-4 River Runoff

The annual discharge of the Mekong River at Kratie (catchment area: 646,000 sq.km) ranges from 343 billion cu.m to 546 billion cu.m. The average annual discharge during the 33 years from 1933 is 446 billion cu.m. The discharge starts to increase in June, and reaches the maximum in September (average of 33 years: 40,500 cu.ms) and drops to the minimum in April (average of 33 years: 2,000 cu.ms) (See Table D-9 (1), (2)).

The maximum daily discharge recorded in the past is 66,700 cu.ms (September 3, 1939) and the minimum recorded is 1,250 cu.ms (April 17, 1960). The design flood discharge at the dam site has been set at 90,000 cu.ms This was determined by first obtaining the flood discharges having a return period of 10,000 years from past flood records using Log.-Normal Distribution Method, Gumbel Method and Hazen-Foster Method (type 3), and adjusting the value thus obtained taking into account the maximum flood discharges recorded in the rivers in Southeast Asian countries.

D-1-2-5 Sedimentation

The sedimentation at the dam site has been estimated to be 169 million tons per year and 200 cu.m per 100 sq.km from the values of suspended sediments measured at Stung Treng and Phnom Penh.

The trap efficiency of the reservoir is assumed to be 50% since the reservoir volume is quite small compared with the river discharge. Study of the storage capacity after 50 years of operation revealed that the sedimentation will have little effect on power generation. The problem of reduction in effective storage capacity was therefore disregarded in the study of power generation.

D-1-3 Reservoir

D-1-3-1 Location and Size of Reservoir

Comparative studies were made of four alternative dam axes proposed within a 6 km distance downstream of the Samboc Rapids, which led to the conclusion that the axis shown in Fig. D-3 (Line C') is most suitable. The area capacity curve to be considered in relation to the above dam axis is shown in Fig. D-4. The normal high water level of the reservoir has been set at EL 40 m in consideration of the Stung Treng Project to be developed upstream of Sambor.

The effective draw-down has been designed to be 2 m in view of the irrigation intake level in the proposed irrigation area as well as for navigation improvement.

As a result, the total storage capacity has been set at 10,000 million cu.m and the effective storage capacity at 2,050 million cu.m, which is 2% to 3% and 0.5%, respectively, of the annual discharge.

D-1-3-2 Reservoir Operation

Since the reservoir storage capacity is small, as mentioned in Chapter D-1-3-1, regulation of discharge can be done only during the several months in the dry season. The power plant will be similar to a run-of-river plant It has been determined that the control of discharge from the reservoir would be based on the dry season average daily discharge (discharge for power generation) which has been set at 2,775 cu.ms for wet year 2,300 cu.ms for medium hydro-year and 1,860 cu.ms for dry year.

In other words, the discharge at Kratie during the 33-year period from 1933 was divided into the following three groups by the dry season discharge (January to May), and models were prepared for each group with the lower limit of monthly discharge taken as the rated discharge.

A.	Wet year:	2 years (1938-39)
B.	Medium hydro-year:	15 years (1936, 1940-51, 1962, 1965)
C.	Dry year:	16 years (1933-35, 1937, 1952-61, 1963-64)

Further, a mass curve was prepared excluding net evaporation, precipitation correction factors given in Table D-10 and irrigation water requir ement given in Table D-11, and from the mass curve the available discharge for power generation with effective storage capacity of 2,050 million cu.m was obtained(See Fig. D-5).

Table D-9 (1) Discharge Data at Kratie (1933 – 1965) 1/

Month / Year	Jan	Feb.	Mar	Apr.	May	Jun	Jul.	Aug	Sep.	Oct.	Nov.	Dec.	Annual Runoff (10^6cu m)	Annual Average
1933	2,600	1,800	1,300	1,290	1,620	5,630	19,430	34,290	30,430	20,320	12,190	4,910	358,958	11,318
34	2,930	2,210	1,790	1,470	2,620	5,000	22,430	39,950	44,550	30,210	12,070	5,950	452,451	14,265
35	3,460	2,300	1,810	1,590	2,990	10,490	26,320	32,780	33,910	30,740	21,150	7,880	463,478	14,618
36	3,860	2,740	2,210	2,080	2,970	9,470	25,750	34,830	38,880	15,190	6,040	3,800	390,554	12,318
37	2,800	2,030	1,780	1,540	4,060	12,590	31,580	49,500	55,660	24,620	11,090	6,460	538,081	16,977
38	4,440	3,420	2,770	3,160	4,230	16,850	29,080	33,420	35,460	35,990	13,990	8,440	505,341	15,938
39	4,580	3,110	2,560	2,610	4,540	15,950	26,620	45,730	47,430	33,270	12,680	6,860	543,932	17,162
40	4,020	2,980	2,350	2,180	3,150	12,520	34,750	49,930	60,260	20,830	8,230	5,120	544,895	17,193
1941	3,710	2,990	2,470	2,240	3,540	13,990	27,120	44,600	39,250	31,070	17,220	7,620	517,454	16,318
42	4,180	3,050	2,270	2,280	4,090	11,670	29,180	42,170	39,820	22,020	13,400	5,860	475,455	14,999
43	3,810	2,670	2,400	2,790	3,360	14,850	24,580	35,510	44,550	26,190	12,460	5,280	470,804	14,871
44	3,820	3,020	2,320	2,070	3,460	8,150	21,520	39,150	29,070	25,070	14,150	7,300	420,989	13,258
45	4,200	3,030	2,470	2,200	4,760	17,270	28,070	30,770	43,850	19,330	10,450	6,100	454,857	14,375
46	4,010	2,680	2,090	1,890	4,550	15,390	23,400	35,990	46,530	25,900	12,290	6,160	477,190	15,073
47	3,900	3,000	2,130	2,260	6,420	11,620	32,850	37,910	45,860	23,090	10,500	5,420	488,528	15,413
48	3,670	2,700	2,090	2,180	4,520	12,820	24,490	36,870	49,620	27,220	13,110	6,810	491,248	15,508
49	4,020	2,990	2,300	2,080	3,770	4,690	13,670	34,420	43,100	30,640	16,710	8,380	440,163	13,898
50	4,700	3,040	2,190	1,920	2,890	11,360	25,250	36,000	38,350	32,200	17,940	7,800	485,066	15,303
1951	4,040	3,100	2,080	2,030	3,700	14,480	22,810	36,400	34,440	23,720	12,460	6,210	436,912	13,789
52	3,070	1,960	1,760	1,720	3,200	7,210	18,810	44,450	46,700	30,810	12,260	4,260	465,596	14,684
53	2,080	1,920	1,630	1,620	5,110	14,630	20,350	33,100	33,690	20,770	10,490	5,070	395,666	12,504
54	2,850	1,890	1,510	1,700	3,170	9,080	11,300	22,580	37,160	23,560	10,570	4,770	343,016	10,845
55	3,120	2,240	1,870	2,060	2,560	7,960	20,290	25,380	30,230	17,090	11,430	7,690	348,325	10,993
56	3,960	2,510	1,930	1,990	5,550	11,980	20,990	39,340	41,350	18,430	8,940	3,740	424,483	13,393
57	3,430	2,540	1,970	2,000	2,650	10,000	22,680	24,730	34,840	27,680	10,220	5,090	390,388	12,319
58	3,350	2,510	1,920	1,730	2,160	9,390	20,810	25,080	42,720	19,780	8,730	3,750	374,078	11,828
59	2,180	1,950	1,730	1,650	2,210	6,360	11,920	26,130	37,300	24,030	10,040	4,160	342,843	10,805
60	2,880	2,300	1,830	1,360	1,800	6,320	13,550	39,540	36,120	28,390	11,380	5,830	400,017	12,608
1961	3,280	2,390	2,000	1,970	3,940	16,180	28,200	40,040	49,790	39,370	13,270	6,450	546,481	17,240
62	4,170	3,140	2,500	2,170	3,690	14,610	25,230	37,660	36,410	24,660	11,310	5,240	451,043	14,236
63	3,180	2,370	2,030	1,760	1,850	9,760	21,990	41,600	36,660	21,750	13,660	6,720	431,472	13,611
64	3,690	2,520	1,970	1,850	4,230	9,380	19,330	27,360	37,900	31,850	15,690	7,410	430,982	13,598
65	4,000	2,890	2,240	1,980	2,620	17,900	26,700	28,600	32,500	16,200	12,500	6,040	407,000	12,848
Average	3,580	2,610	2,070	1,980	3,520	11,380	23,370	35,930	40,450	25,250	12,380	6,020	445,720	14,065

1/ Provided by the Mekong Secretariat in Apr 1967

Table D-9 (2) Discharge Data at Kratie (1924 – 1965)1/

Year \ Month	Jan	Feb.	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Runoff (10^6cu m)	Annual Average
1924	-	-	-	1,969	2,824	11,166	27,402	54,466	35,621	19,938	12,951	6,087	456,489	19,158
25	3,395	2,446	2,074	1,939	3,075	10,004	27,206	32,280	44,628	17,520	8,102	4,822	415,602	13,124
26	3,243	2,692	2,158	2,015	1,953	6,733	19,649	39,151	33,398	26,209	12,599	7,077	414,752	13,073
27	4,223	2,707	2,426	2,449	3,658	14,165	20,218	42,601	27,881	29,858	11,897	6,043	460,805	14,511
28	3,574	2,500	2,245	2,953	4,471	17,480	29,495	34,027	33,826	19,593	8,457	4,742	431,701	13,614
29	3,076	2,293	1,987	2,067	2,843	11,189	29,685	47,071	46,041	27,082	9,715	5,537	498,552	15,716
30	3,486	2,502	2,158	2,117	4,142	11,434	28,017	39,082	56,229	24,393	10,010	5,589	499,101	15,763
1931	3,509	2,404	2,054	2,122	2,925	6,040	12,832	31,373	32,631	24,097	7,728	4,326	348,843	11,003
32	2,745	2,128	1,770	1,861	2,341	6,593	23,433	26,566	33,839	26,168	11,853	6,079	381,651	12,115
33	3,381	2,505	1,777	1,603	2,099	6,244	19,441	34,287	30,430	20,316	12,185	4,910	367,765	11,598
34	2,932	2,206	1,787	1,473	2,619	5,000	22,433	39,948	44,550	30,206	12,067	5,954	452,452	14,265
35	3,464	2,296	1,813	1,592	2,994	10,486	26,324	32,784	33,913	30,742	21,147	7,876	463,479	14,619
36	3,864	2,742	2,207	2,075	2,965	9,474	25,745	34,826	38,883	15,194	6,040	3,800	390,555	12,318
37	2,798	2,025	1,780	1,543	4,058	12,589	31,584	49,500	55,660	24,616	11,089	6,460	538,082	16,975
38	4,440	3,418	2,767	3,164	4,231	16,849	29,077	33,416	35,463	35,994	13,990	8,436	505,343	15,937
39	4,578	3,106	2,564	2,612	4,537	15,946	26,619	44,819	47,580	32,400	12,677	6,887	539,649	17,027
40	4,015	2,983	2,345	2,182	3,148	12,518	34,752	47,600	55,173	20,832	8,230	5,122	525,470	16,575
1941	3,706	2,994	2,466	2,243	3,543	13,992	27,119	44,603	39,250	31,071	17,223	7,621	517,456	16,319
42	4,180	3,050	2,268	2,278	4,087	11,666	29,181	42,168	39,823	22,019	13,395	5,861	475,454	14,998
43	3,805	2,674	2,401	2,789	3,355	14,852	24,577	35,513	44,553	26,187	12,455	5,284	470,804	14,870
44	3,823	3,023	2,317	2,066	3,463	8,145	21,523	39,145	29,070	25,071	14,150	7,302	420,989	13,258
45	4,198	3,027	2,464	2,264	4,763	17,274	28,065	30,774	43,850	19,332	10,445	6,096	455,000	14,379
46	4,007	2,684	2,086	1,888	4,551	15,386	23,397	35,987	46,533	25,903	12,294	6,161	477,190	15,073
47	3,899	2,995	2,132	2,262	6,421	11,618	32,852	37,910	45,857	23,090	10,497	5,418	488,528	15,413
48	3,671	2,698	2,091	2,179	4,515	12,817	24,494	36,871	49,623	27,216	13,110	6,808	491,249	15,508
49	4,022	2,993	2,295	2,270	4,204	6,719	13,948	34,416	43,103	30,642	16,710	8,383	447,818	14,142
50	4,704	3,043	2,189	1,921	2,890	11,357	25,252	36,000	38,350	32,197	17,940	7,800	485,070	15,304
1951	4,043	3,099	2,082	2,026	3,700	14,477	22,813	36,403	34,443	23,716	12,439	6,208	436,911	13,789
52	3,070	1,961	1,762	1,718	3,203	7,211	18,810	44,445	46,697	30,813	13,620	5,030	471,347	14,862
53	2,770	2,206	1,828	1,833	4,577	14,630	20,345	33,100	33,687	20,771	10,492	5,098	399,530	12,611
54	3,159	2,110	1,689	1,967	3,853	10,398	13,219	25,416	41,887	26,758	10,970	5,019	386,056	12,204
55	3,124	2,237	1,869	2,038	2,589	8,152	20,285	25,378	30,233	17,091	11,432	7,688	423,795	11,010
56	4,035	2,506	1,934	1,991	5,551	11,980	20,992	39,341	41,350	18,431	9,032	4,578	427,160	16,852
57	3,420	2,600	2,093	2,103	3,056	10,013	22,684	24,733	34,844	27,683	10,221	5,085	383,152	12,378
58	3,345	2,510	1,919	1,733	2,163	9,386	20,809	25,077	42,717	19,780	8,729	4,431	375,881	11,883
59	2,383	1,945	1,730	1,648	2,205	6,360	11,915	26,128	37,304	24,029	10,042	4,161	342,504	10,821
60	2,878	2,296	1,827	1,357	1,799	6,318	13,545	39,539	36,117	28,394	11,381	5,827	400,019	12,607
1961	3,284	2,388	2,004	1,972	3,935	16,183	28,200	40,039	49,790	39,371	13,273	6,445	546,482	17,240
62	4,165	3,137	2,503	2,166	3,692	14,612	25,232	37,658	36,408	24,662	11,309	5,241	451,045	14,232
63	3,181	2,372	1,929	1,757	1,848	9,763	21,985	41,603	36,657	21,745	13,655	6,775	431,345	13,593
64	3,689	2,520	1,965	1,854	4,225	9,375	19,329	27,358	37,897	31,845	15,690	7,414	431,055	13,597
65	4,015	2,890	2,243	1,980	2,623	17,890	26,674	28,629	32,463	16,158	12,483	6,040	406,360	12,841
Average	3,593	2,608	2,096	2,049	3,469	11,297	23,742	36,429	39,958	24,813	11,994	5,881	446,012	14,105

1/ Provided by Mekong Secretariat in Sept 1968

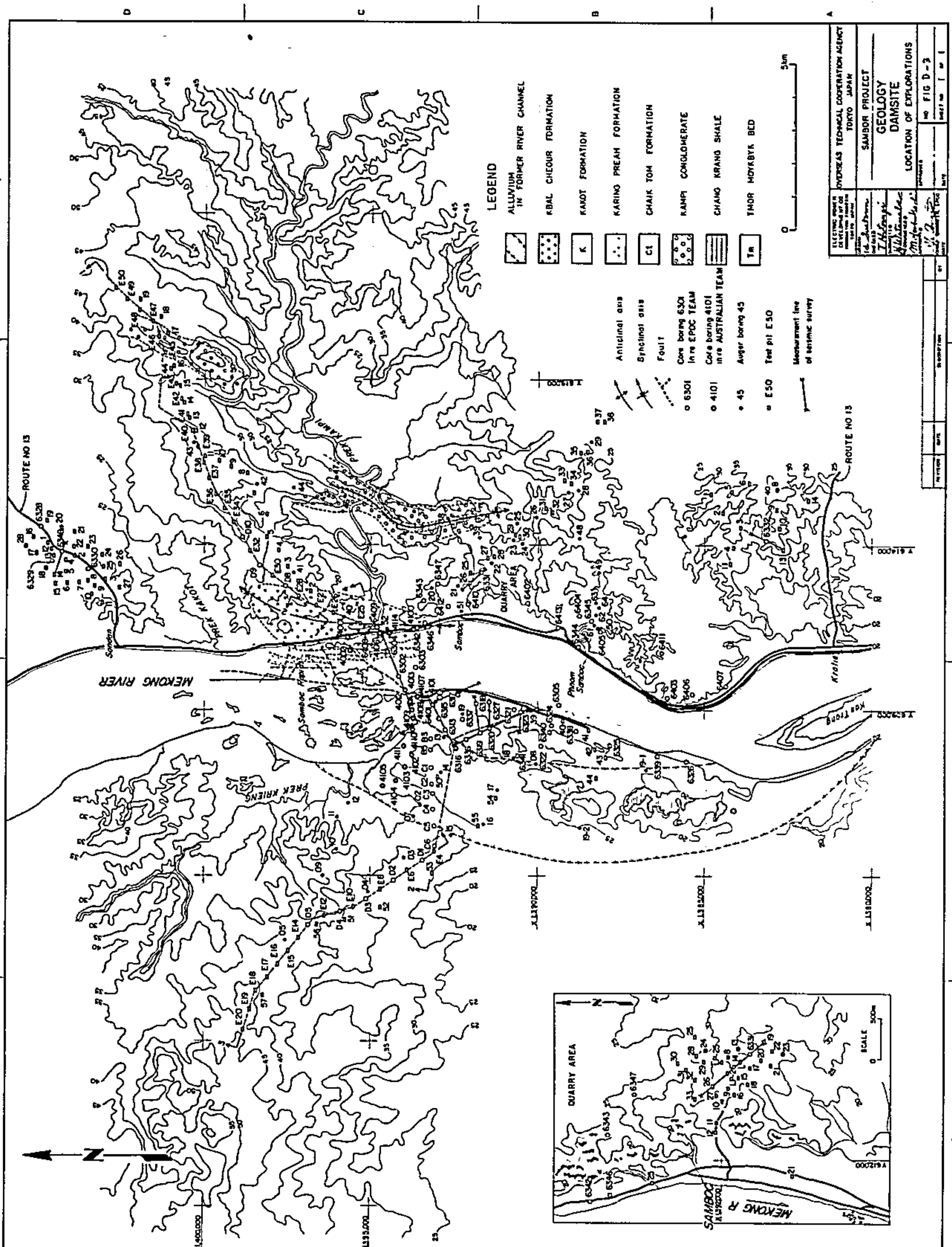

LEGEND
ALLUVIUM IN FORMER RIVER CHANNEL
KBAL CHEOUR FORMATION
KAKOT FORMATION
KARING PREAH FORMATION
CHAIK TOM FORMATION
KAMPI CONGLOMERATE
CHANG KRANG SHALE
THOR MOYKBYK BED
Anticlinal axis
Synclinal axis
Fault
Core boring 6301 in re EPDC TEAM
Core boring 4101 in re AUSTRALIAN TEAM
Auger boring 45
Test pit E50
Measurement line of seismic survey
5km
OVERSEAS TECHNICAL COOPERATION AGENCY TOKYO JAPAN
SAMBOR PROJECT
GEOLOGY
DAMSITE
LOCATION OF EXPLORATIONS
FIG D-3
MEKONG RIVER
PREK KRIENG
PREK KAKOT
ROUTE NO 13
QUARRY AREA
MEKONG R
SAMBOC
Kratie

Fig. D-4 Revised Area Capacity Curve of Sambor Reservoir

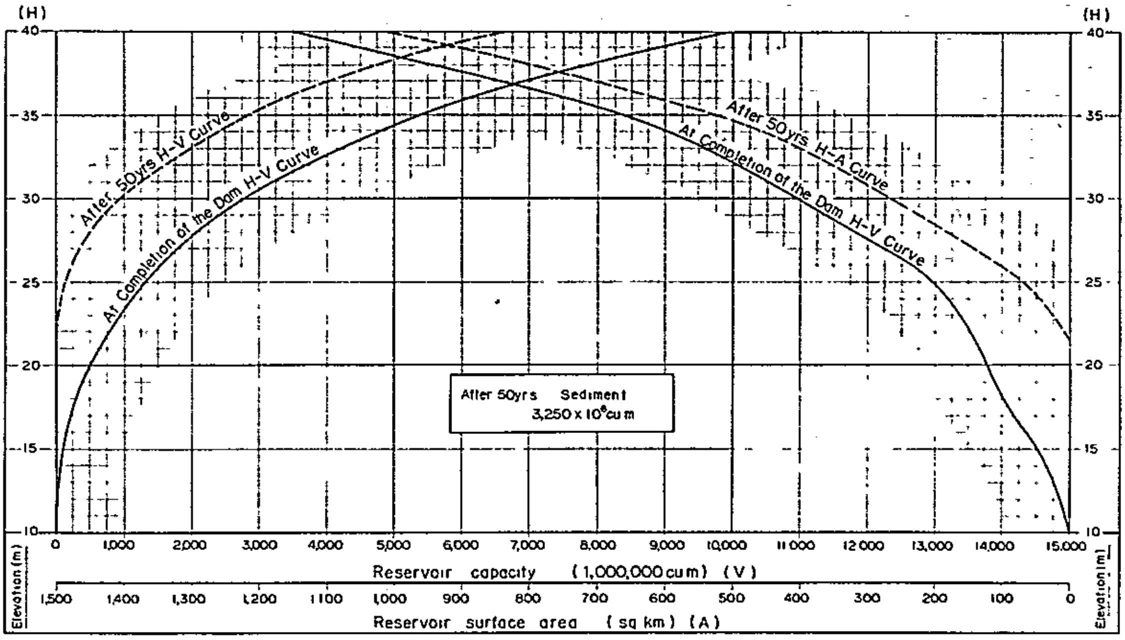
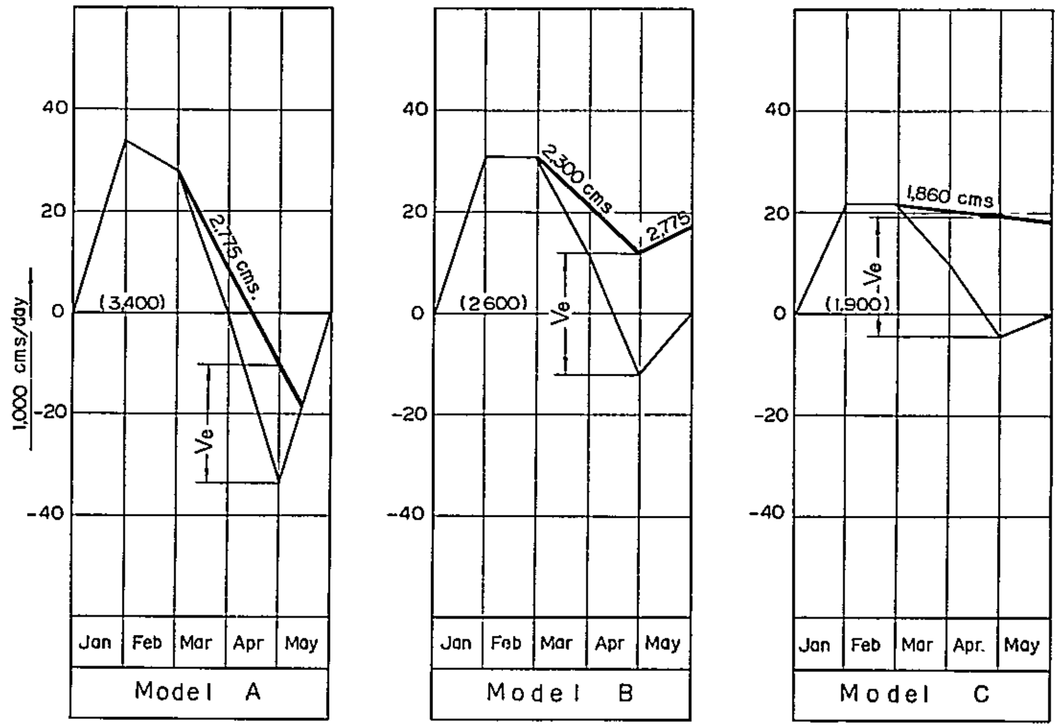


Fig. D-5 Mass Curve of Sambor Reservoir



Ve . Effective Storage Capacity (cms)

Table D-10 Net Evaporation-Precipitation Correction Factors

	Month	Jan.	Feb.	Mar.	Apr	May	Jun.	Jul.	Aug.	Sept.	Oct	Nov	Dec.	Total
(1)	Precipitation (mm)	0	0	22	59	207	159	226	279	232	120	52	3	1,359
(2)	Temperature (°C)	25.3	27.3	28.9	29.7	28.1	27.5	26.8	27.0	26.5	26.4	25.7	24.7	
(3)	Consumptive Use of Native Vegetation (mm)	103	99	117	119	121	117	119	117	109	109	101	101	1,332
(4)	Precipitation Consumed (mm)	0	0	22	59	121	117	119	117	109	90	52	3	809
(5)	Evaporation (mm)	134	149	161	162	138	108	95	81	81	102	102	114	1,427
(6)	Net Correction Factors (mm)	(-) 134	(-) 149	(-) 139	(-) 103	(-) 17	(+) 9	(+) 24	(+) 36	(+) 28	(-) 12	(-) 50	(-) 111	(-) 618

Note (1) Monthly average Precipitation at Kratie (1960-65)
(2) Monthly Average Temperature at Kratie
(3) Calculated by Blaney-Criddle Formula
(6) (+) indicates the amount of holding
(-) indicates the amount of loss

Table D-11 Monthly Supplemental Water for Irrigation from Sambor Reservoir

Month	Supplemental Water (cu.ms)	Month	Supplemental Water (cu.ms)
Jan.	20	Jul.	1
Feb.	21	Aug.	3
Mar.	9	Sep.	2
Apr.	4	Oct.	3
May	-	Nov.	7
June	4	Dec.	18

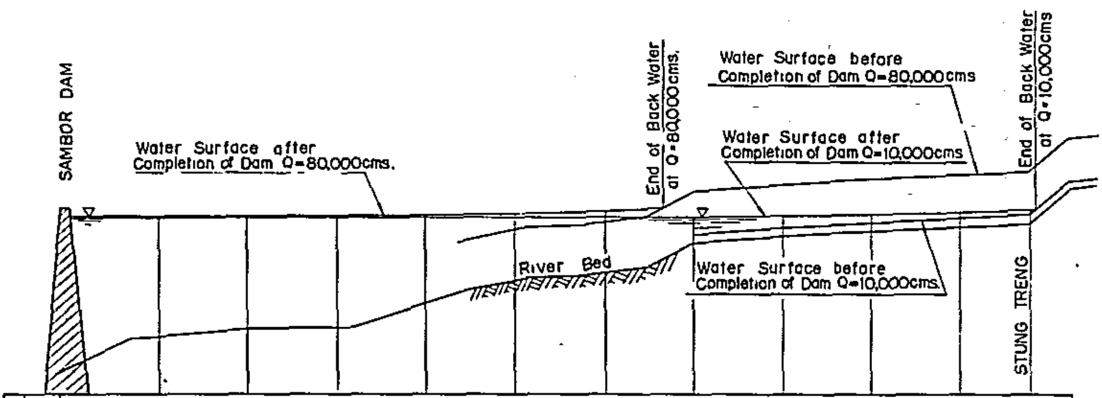
D-1-3-3 Water Level Fluctuation Upstream and Downstream of Dam

As mentioned in Chapter D-1-6-1, the spillway has an effective width of 795 m and will be provided with 53 roller gates (each gate 15 m wide and 14 m high). The spillway will release flood discharge not exceeding 70,000 cu.ms maintaining the water level at EL 40 m. As shown in Fig. D-6 which indicates the results of studies of the possible backwater effects at time of normal or flood water level, there will be very little influence on the tailwater level of the Stung Treng Project.

If power generation is conducted by controlling releases from the reservoir as mentioned in Chapter D-1-3-2, the water level of the reservoir would occasionally drop 20 cm to 50 cm below the lower limit of 38 m as indicated in Fig. D-10, on the basis of the discharge data for 33 years from 1933. This, however, will not have adverse influence on navigation and irrigation because of its low probability of occurrence.

With respect to the downstream water level, it has been determined that the minimum discharge to be maintained is 1,350 cu.ms (average minimum monthly discharge during 33 years: 1,360 cu.ms), irrespective of power load. In order to minimize the fluctuation in water level due to daily load fluctuations, operation shall be carried out within a range of minimum discharge of 1,350 + α cu.ms and maximum discharge of 2,250 + α cu.ms. Therefore, the daily fluctuation of water level downstream of the powerhouse will be held within 1.0 m which is tolerable when compared with the maximum daily water level fluctuation of 1.8 m observed near Kratie at time of flood discharge.

Fig. D-6 Sambor Reservoir Profile



									(End of Back Water)					
Water Level	80,000 cms	41.0	41.1	41.1	41.2	41.4	41.8	42.7	43.3					
Water Level	10,000 cms	40.0	40.0	40.0	40.0	40.0	40.0	40.0		40.1	40.4	40.8	41.2	41.8
River Bed Elev (m)		6.0	13.0	15.0	15.0	20.8	25.8	27.5		34.5	36.0	37.0	38.0	38.5
Total Distance (m)		0	10,000	20,000	30,000	40,000	50,000	60,000		70,000	80,000	90,000	100,000	108,000
Distance (m)		0	10,000	10,000	10,000	10,000	10,000	10,000		10,000	10,000	10,000	10,000	8,000
NO		0	1	2	3	4	5	6		7	8	9	10	11

D-1-4 Power Generation Program

D-1-4-1 Scale of Power Generation

The optimum installed capacity of the Sambor Project, without the flow regulation of the upstream projects, has been determined to be 875 MW consisting of seven 125 MW units.

In reaching the above value, studies were made of two cases. One is the combined operation of thermal and hydropower to firm up secondary energy resulting from seasonal variation of discharge and the other is to utilize firm energy only by hydropower. Studies revealed that in the former case, the cost per kWh becomes the lowest by a combination of about 900 MW of hydropower and about 400 MW of thermal power, and in the latter case, the cost becomes the lowest by hydropower of about 900 MW. Therefore, the installed capacity has been determined at 875 kW, assuming that 125 MW generating units would be installed as described in Chapter D-1-4-2.

When the upstream projects are completed and it becomes possible to enlarge the capacity of the Sambor Project, the number of turbines and generators is to be increased to 12 units, for which five rooms for additional installation are provided in the plant foundation.

The reservoir capacity of the proposed major upstream projects is given below.

Nam Ngum:	5 x 10^9 cu.m
Pak Beng:	20 x 10^9 cu.m
Pa Mong:	75 x 10^9 cu.m
Stung Treng:	60 x 10^9 cu.m
Total	160 x 10^9 cu.m

When these upstream reservoirs are completed and systematically controlled, they will undoubtedly improve the runoff condition of the Mekong, and will make available at the Sambor Project an estimated discharge of 7,000 cu.ms to 9,000 cu.ms during the dry season. If additional units are to be installed as mentioned in Chapter D-1-4-2 (maximum discharge: 775 cu.ms) to make use of this water, a total of 12 units will be required. The installed capacity, then, will be 125 MW x 7 unit = 875 MW plus 200 MW x 5 units = 1,000 MW (at a rated head of 30 m), totaling 1,875 MW. Further, if the 125 MW units are replaced in the future by 200 MW units, it will be ultimately possible to have an installed capacityof 200 MW x 12 units = 2,400 MW.

In this study it is assumed that Type I power consumption pattern will be adopted. In the first stage of construction, therefore, five units will be installed and the foundation for the remaining future seven units will be constructed simultaneously. The foundations for the future units will be utilized as temporary diversion conduits during construction of the dam.

D-1-4-2 Capacity of Turbine and Generator

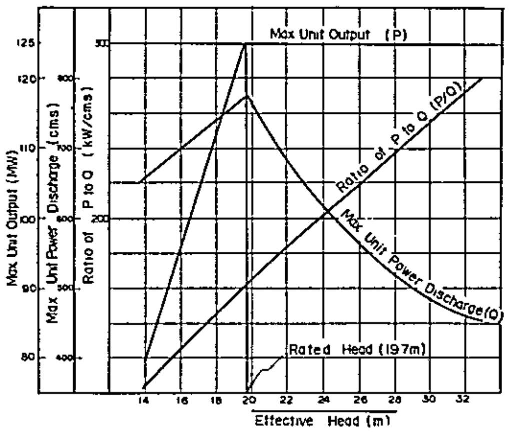
It has been determined that each of the turbines and generators should have the following capacity.

Turbine capacity:	128 MW 1/
Rated head:	19.7 m
Maximum discharge:	775 cu.ms
Generator output:	125 MW
Generator capacity:	140 MVA (power factor: 89%)

In determining the above capacity, considerations were given to the variation of cost resulting from the number of units to be installed, the influence of operation suspension due to accident or repair and maintenance on the entire power system, and the technical limits particularly in the manufacture of turbines.

The maximum output, the maximum unit power, discharge and the ratio of output to discharge against the effective head mentioned above are shown in Fig. D-7.

Fig. D-7 P-H-Q and P/Q Curve



D-1-4-3 Available Power and Energy

Assuming that the installed capacity is 875 MW and the power plant is operated according to the rule mentioned in Chapter D-1-3-2, the available power and energy will be 473 to 875 MW and 6,400 million to 7,500 million kWh respectively (average: 7,000 million kWh). The annual firm energy will be 4,100 million kWh. The firm power of 473 MW has been determined on the basis of the discharge in the critical period (May 1960). Another factor imposing restriction on the power consumption program is the decrease in output due to loss of head by the water level rise downstream of the dam at time of flood discharge (the maximum gross head is 32.5 m in the dry season and the minimum gross head at time of flood discharge is 15.5 m).

Note: 1/ The turbine will be of a design to operate under an effective head of 15.5 m to 32.0 m. If the rated head is changed to 30 m by adjusting turbine vanes, the maximum unit output could become 200 MW.

With respect to the former factor, that is, the decrease of discharge in the dry season, a larger output is possible at time of peak load by controlled operation of the reservoir. But the drop in output due to the head loss cannot be compensated unless more generating units are installed. On the basis of the 33 years runoff data beginning from 1933, some of the average monthly output will be less than 800 MW in the wet season for a period of six months during the said 33 years for the reason stated above. On the basis of the past maximum monthly average discharge of 60,260 cu.ms in September 1940, the output would be 713 MW, and on the basis of the past maximum daily flood discharge of 66,700 cu.ms in September 1939, the output drops to 637 MW. (See Figs. D-8, 9, 10)

D-1-5 Transmission Program

D-1-5-1 Supply Area

Power will be transmitted to the load centers of Phnom Penh, Sihanouk Ville and Saigon. The estimated load in Sihanouk Ville where power-oriented industries are proposed to be established is 485 MW at the generating end, and that in Phnom Penh and Saigon where general demands will be the major load is 90 MW and 300 MW respectively, at the generating end.

It is assumed that by the time the Sambor Project is commissioned, the transmission line voltage will be 110 kV in Phnom Penh, and 220 kV between Da Nhim Power Plant, Dong Nhai Power Plant and Saigon. The Sambor Project is planned to be connected to these systems.

D-1-5-2 Transmission Voltage and Number of Circuits

The transmission voltage has been designed to be 345 kV and the number of circuits to be two for the line between Sambor, Phnom Penh and Sihanouk Ville, and one circuit between Sambor and Saigon.

If future interconnection with the proposed upstream projects is taken into consideration, construction of 400 V transmission system is desirable. At the present stage, however, nothing is known of their timing of development and state of power current. The transmission program has, therefore, been prepared without taking into consideration the proposed upstream projects, as shown in Table D-12. Though single circuit lines were considered sufficient, double circuits of 345 kV lines are planned, between Sambor, Phnom Penh and Sihanouk Ville since high reliability will be required for the aluminum refining industry assumed to be established in Sihanouk Ville, and a single circuit 345 kV line is planned between Sambor and Saigon. (See Fig. D-11)

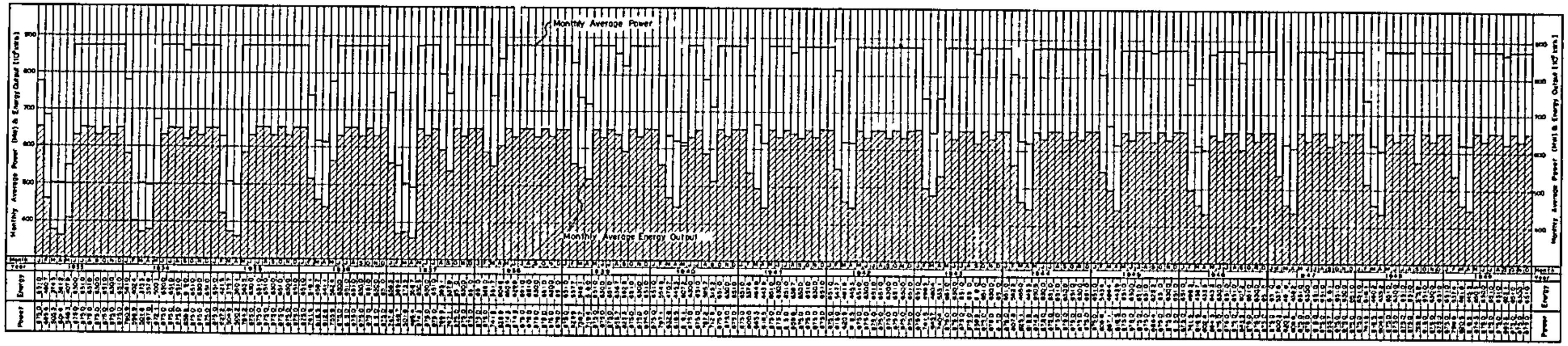
Table D-12 Transmission Voltage and Number of Circuits

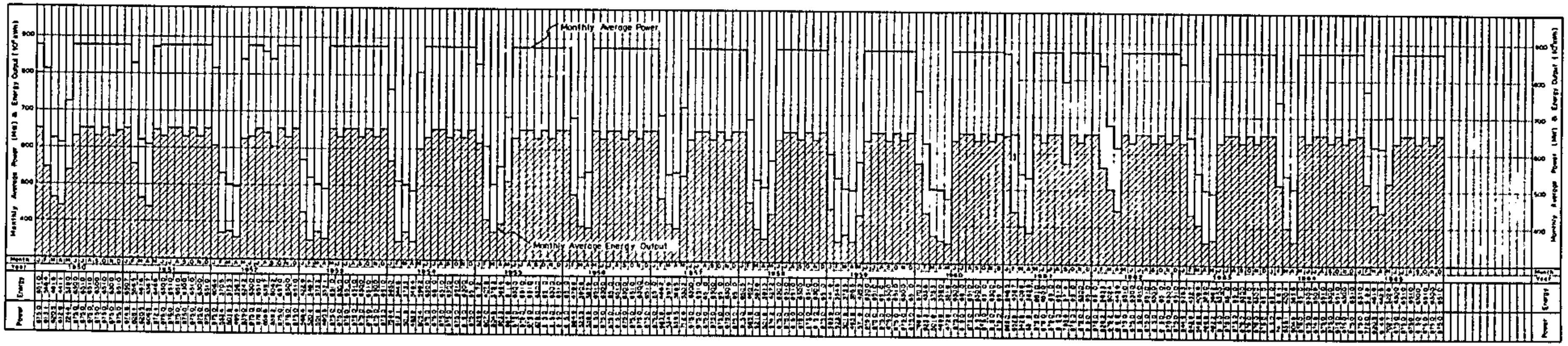
	Sambor to Phnom Penh	Phnom Penh to Sihanouk Ville	Sambor to Saigon
Distance	190 km	160 km	230 km
Load	575 MW	485 MW	300 MW
Voltage & circuit	1 cct, 480 kV 2 cct, 339 kV 3 cct, 279 kV	1 cct, 441 kV 2 cct, 312 kV 3 cct, 255 kV	1 cct, 347 kV 2 cct, 246 kV 3 cct, 200 kV

D-1-5-3 Substation

Primary substations are planned to be built in Phnom Penh, Sihanouk Ville and Saigon for connection with the existing transmission lines. The high-tension side of the transformer will be connected to the 345 kV system, and the low-tension side to the 110 kV system in Phnom Penh and Sihanouk Ville and to the 220 kV system in Saigon. The capacity of the substations has been designed to be one 100 MVA unit at Phnom Penh, five 120 MVA units at Sihanouk Ville, and three 120 MVA units at Saigon. (See Fig. D-11)

Fig. D-8 Monthly Average Power Output and Energy





NOTE The figures from 1934 to 1965 were based on runoff data of Kratie provided by the Mekong Secretariat in Apr 1967
The figures in 1933 are corrected based on the data revised by the Mekong Secretariat in Sept 1968

Fig. D-9 Inflow and Outflow

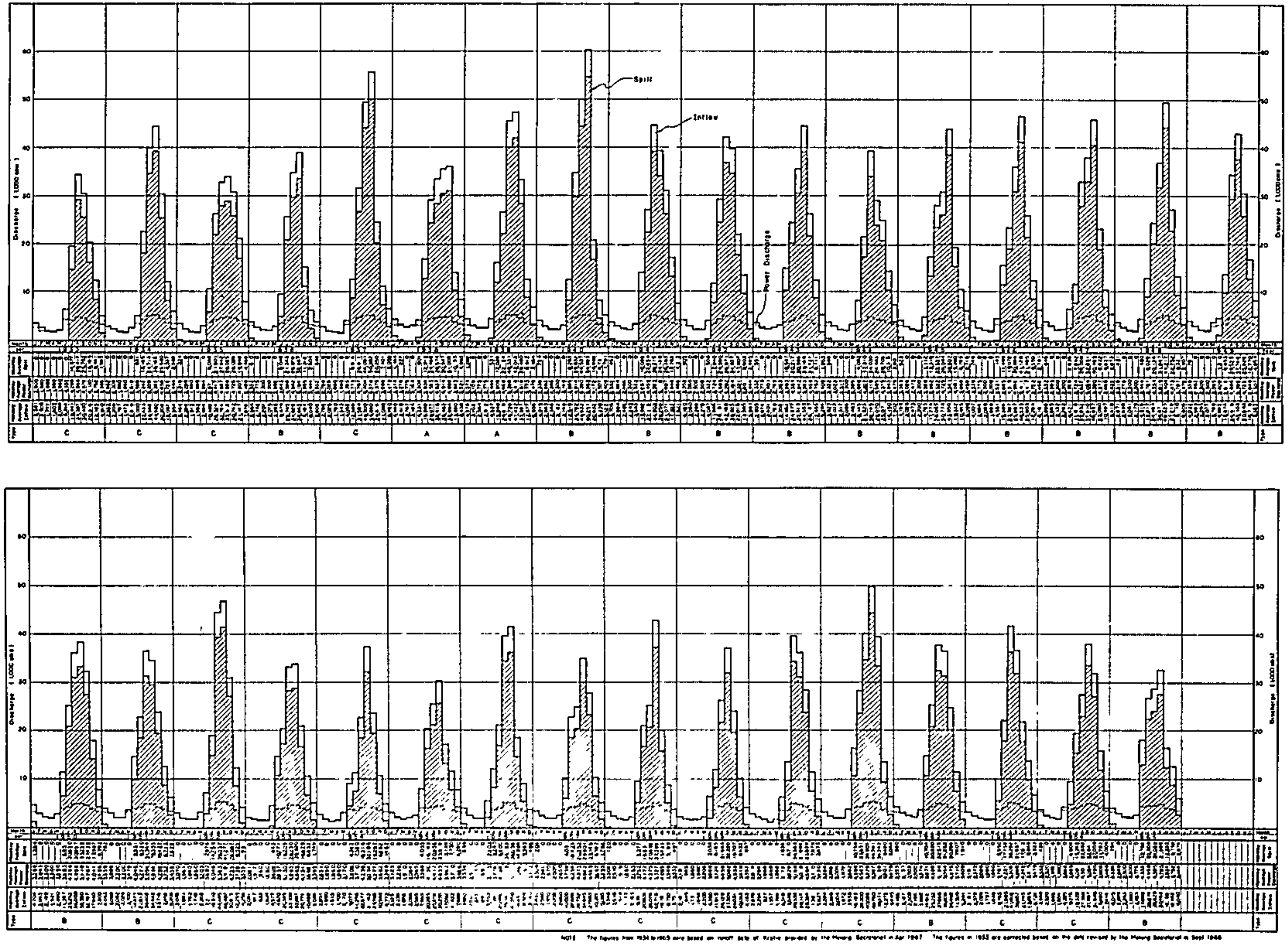
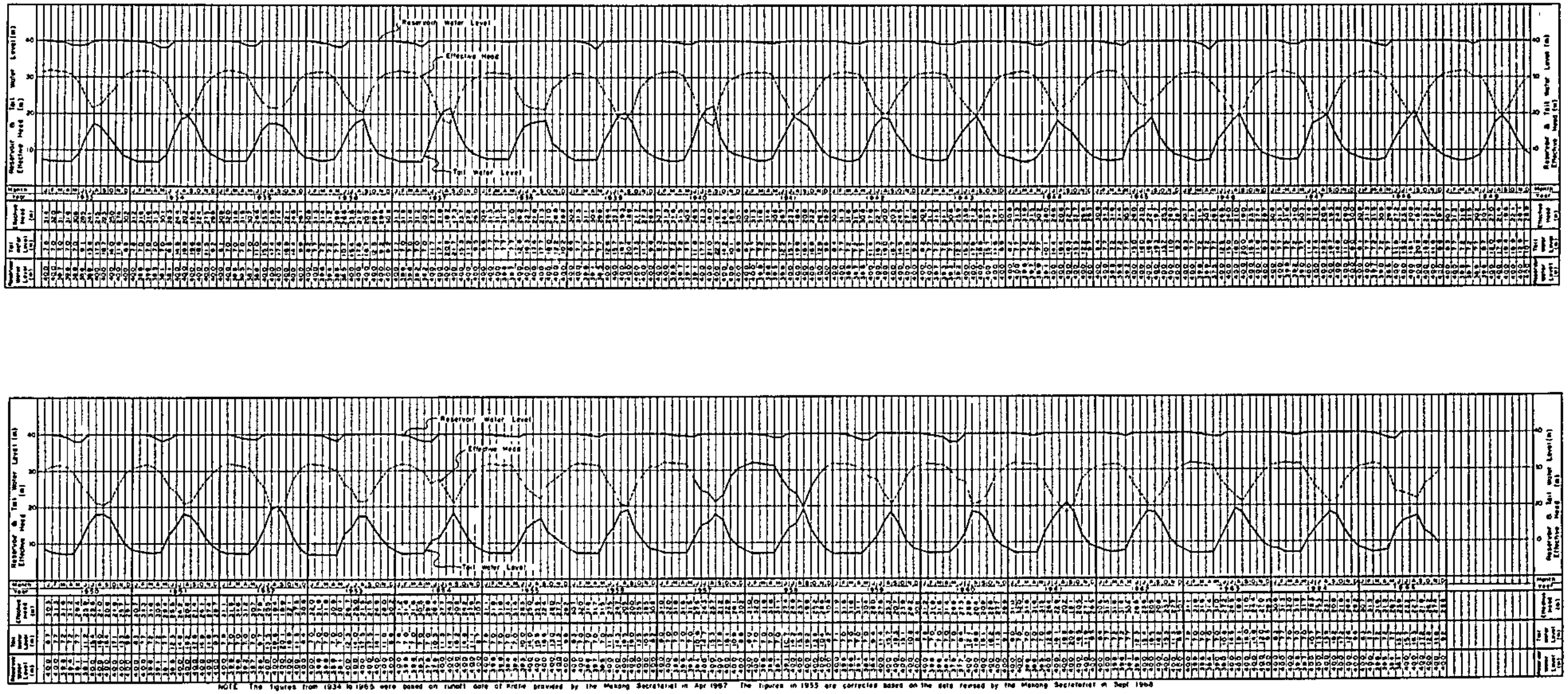
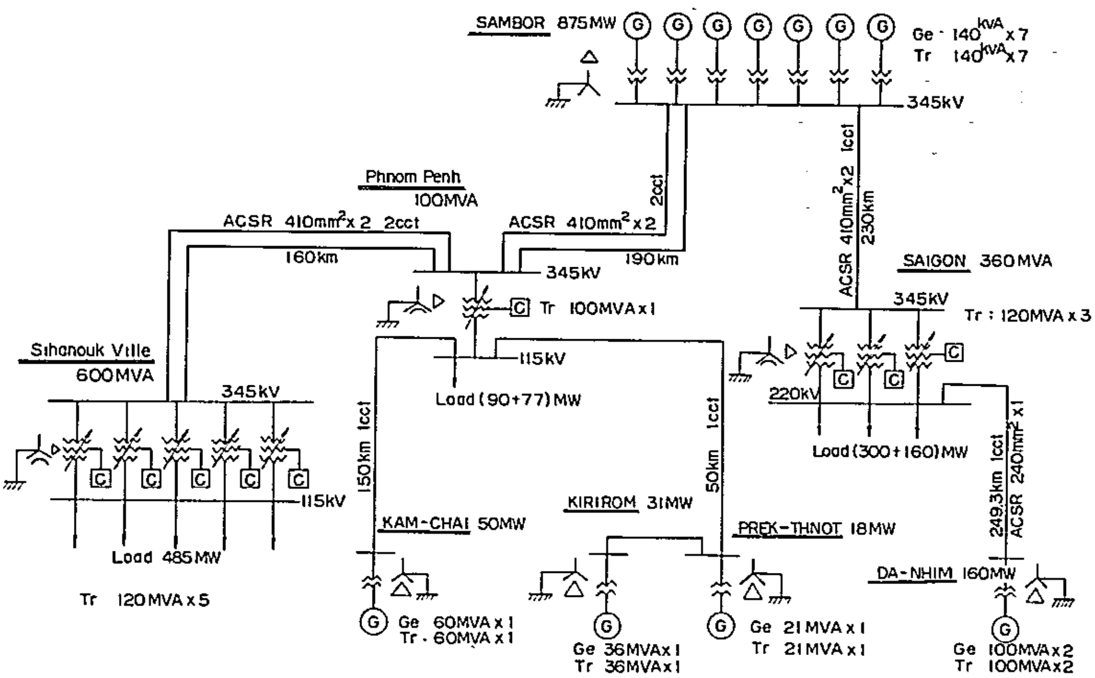


Fig. D-10 Reservoir and Tailwater Levels



NOTE The figures from 1934 to 1965 were based on runoff data of Kratie provided by the Mekong Secretariat in Apr 1967 The figures in 1953 are corrected based on the data revised by the Mekong Secretariat in Sept 1968

Fig. D-11 Transmission System Diagram



D-1-5-4 Telecommunication Facilities

For load dispatching and maintenance, the power line carrier-communication system is planned to be established between the powerhouse and the substations, and also mobile radio telephones will be provided.

D-1-6 Main Structures

D-1-6-1 Dam and Spillway

As shown in Fig. General Plan, the dam will be constructed immediately upstream of the confluence of the Prek Kampi and the Mekong Mainstream. Its total length including the intake is 30.7 km which is described below.

(From the right bank)	Earth-fill dam:	11,730 m	
	Spillway (concrete):	1,471 m	
	Intake (concrete):	763 m	
	Rock-fill dam (in the river bed):	2,350 m	
	Earth-fill dam:	14,350 m	
	Total:	30,664 m	(See Dwg. 1, 2)

The crest elevation will be EL 44 m, and the maximum height of the dam will be EL 54 m in the rock-fill section. The crest width will be 10 m in the rock-fill and earth-fill sections, and 6.0 m and 6.6 m in the concrete sections.

The dam volume will be as follows:

Earth-fill dam on the left bank:	9,020,000 cu.m
Rock-fill dam:	8,720,000 cu.m
Earth-fill dam on the right bank:	8,160,000 cu.m
Concrete (spillway only, excluding intake):	900,000 cu.m

The crest elevation of the overflow spillway is EL 26 m. The spillway will be controlled by 53 double roller gates, each 14 m high and 15 m wide. The design flood discharge is 90,000 cu.ms, which if released through the spillway with all gates fully opened raise the overflow water level to EL 42 m.

D-1-6-2 Intake and Powerhouse

If Type I load combination recommended for the power consumption program is adopted, five units of turbines and generators would have to be installed in the first stage, followed by the addition of two units in the second stage. The installed capacity at the final stage would then be 125 MW x 7 units = 875 MW.

However, if the influence of proposed upstream projects is taken into account, the scale of the power installation would be as mentioned in Chapter D-1-4-1, 200 MW x 12 units. It is therefore planned to construct the intake and the foundation of the powerhouse for 12 units in the first stage, and to utilize the bays for the future of seven units as temporary diversion conduits during construction of the dam.

The dimension of the powerhouse is as follows.

Length :	560 m (240 m in the first stage; 320 m upon installation of two additional generators)
Width :	45 m

The estimated volume of concrete is 1,331,000 cu.m. (See Dwg. 3)

Specifications of equipment to be installed are as follows.

Turbine:	Type	Vertical-shaft Kaplan Turbine
	Output	128 MW
	Number of units	7 (5 units to be installed in the first stage)
	Effective head	15.5 m to 32.0 m
	Discharge	775 cu.ms (at rated head of 19.7 m)
Generator:	3-phase, alternating synchronous	
	Capacity	140 MVA
	Frequency	50 c/s
	Voltage	15,400 V
	Power factor	0.89
	Number of units	7 (5 units to be installed in the first stage)
Transformer:	Outdoor type, 3-phase forced oil air-cooled transformer	
	Capacity	140 MVA
	Frequency	50 c/s
	Voltage	Primary – 15,400 V
		Secondary – 345,000 V
	Number of units	7 (5 units to be installed in the first stage)

D-1-6-3 Transmission Line and Primary Substation

Power generated at the Sambor Project will be transmitted to Phnom Penh, Sihanouk Ville and Saigon through two routes, i.e., Sambor to Sihanouk Ville via Phnom Penh and Sambor to Saigon. The following is an outline of the two routes. (See Dwg. 4)

Sambor to Phnom Penh:	190 km, 345 kV, 1 cct x 2 routes
Phnom Penh to Sihanouk Ville:	160 km, 345 kV, 1 cct x 2 routes
Sambor to Saigon:	230 km, 345 kV, 1 cct

Conductors for both routes will be 410 sq.mm ACSR x 2 (Al 26/4.5 mm, St 7/3.5 mm) supported by steel towers.

Outline of primary substations to be established in the three cities is given below.

Table D-13 Outline of Primary Substations

	Phnom Penh	Sihanouk Ville	Saigon
Load	90 MW	485 MW	300 MW
Secondary voltage	115 kV	115 kV	220 kV
Capacity	100 MVA x 1	120 MVA x 5	120 MVA x 3

D-2 Navigation Program

D-2-1 Present Status of Transportation

D-2-1-1 General Conditions

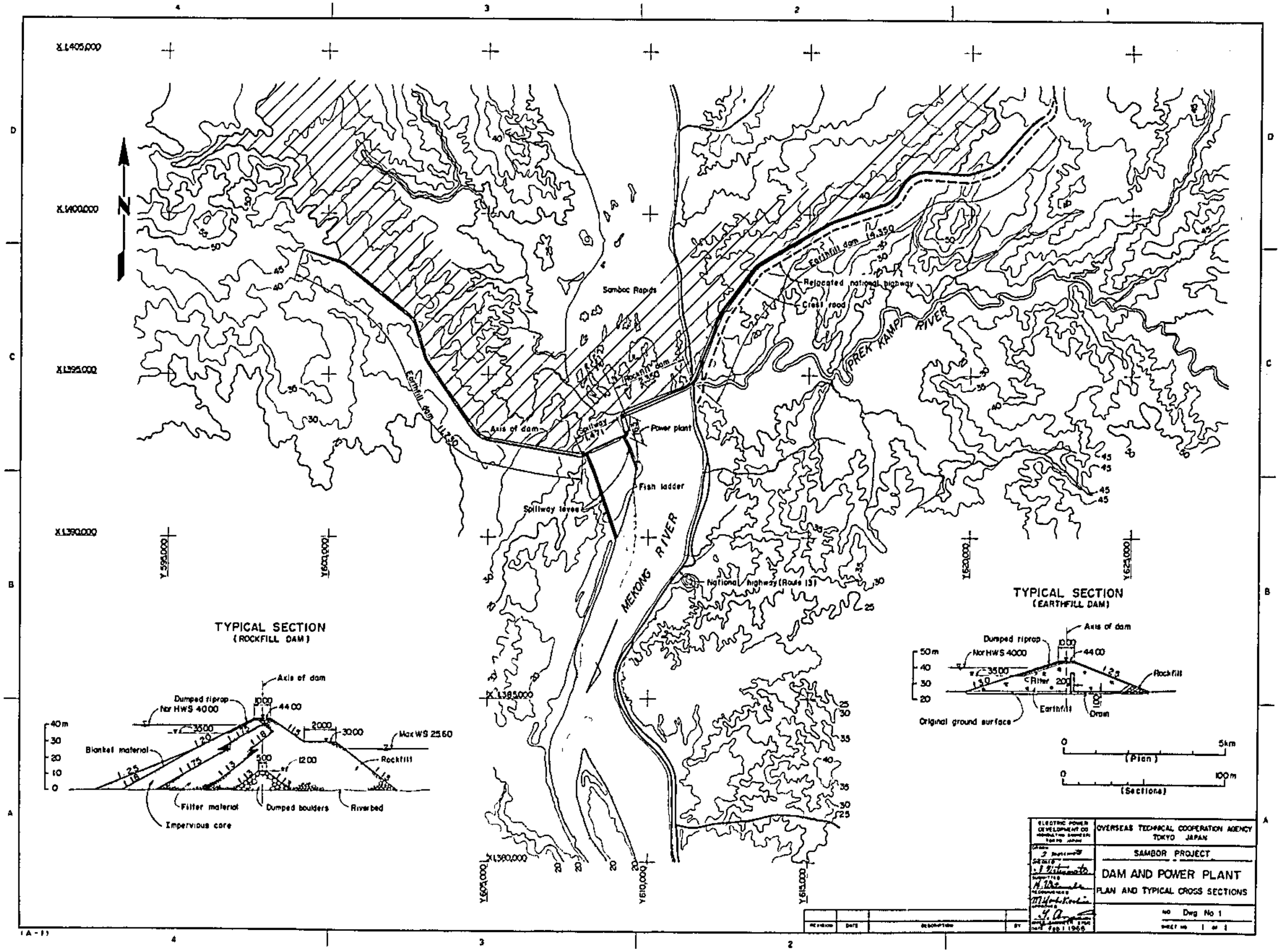
The population of Cambodia as of 1965 was 6,115,000, and the population density was 33.8 persons per sq.km. The total area of the country is 181,000 sq.km. The annual growth rate of population during the past 10 years was a little more than 3%.

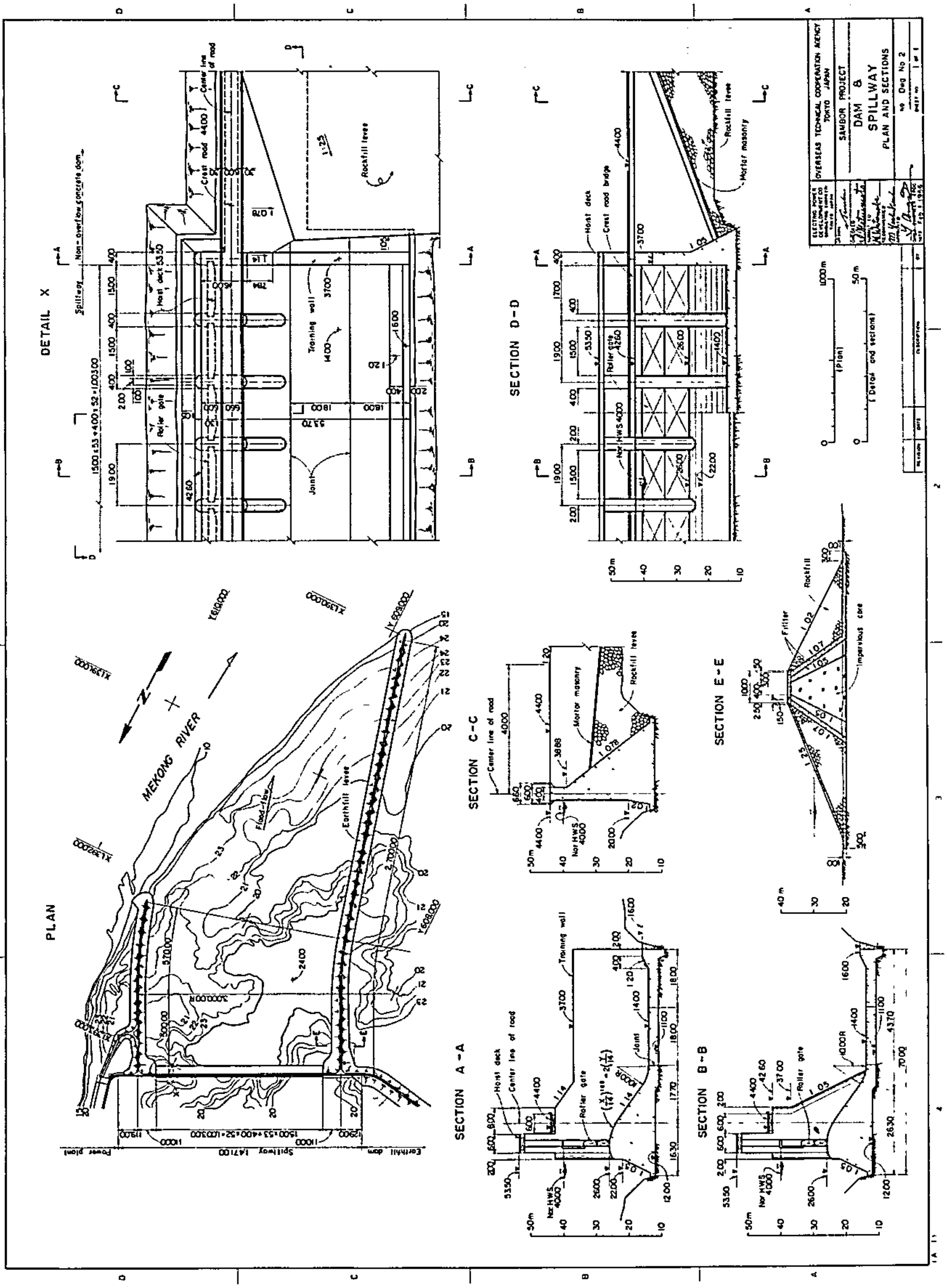
The area upstream of Kratie is less developed than other parts of the country and has a smaller population density. (See Table D-14)

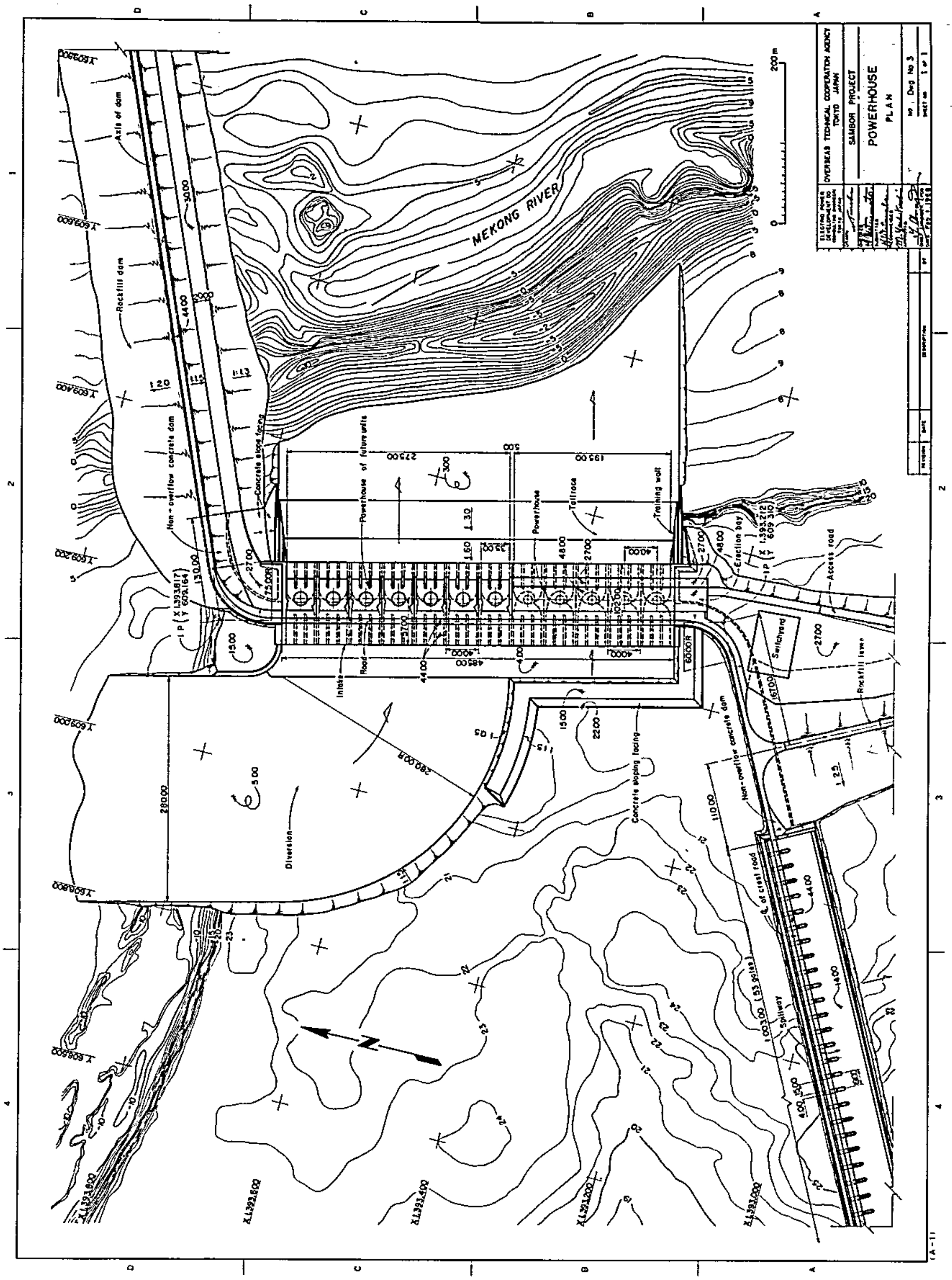
Table D-14 Population and Population Density of Development Area (1962)

	Area (sq.km)	Population (persons)	Population Density (persons/sq.km)
Kratie	11,094.1	126,231	11.4
Stung Treng	11,092.0	34,508	3.1
Rattanakiri	10,732.3	49,340	4.6
(Reference Data)			
Phnom Penh	46.0	403,500	8,771.7
Kompong Cham	9,798.7	819,223	83.6
Total Cambodia	181,035.0	5,740,115	31.7

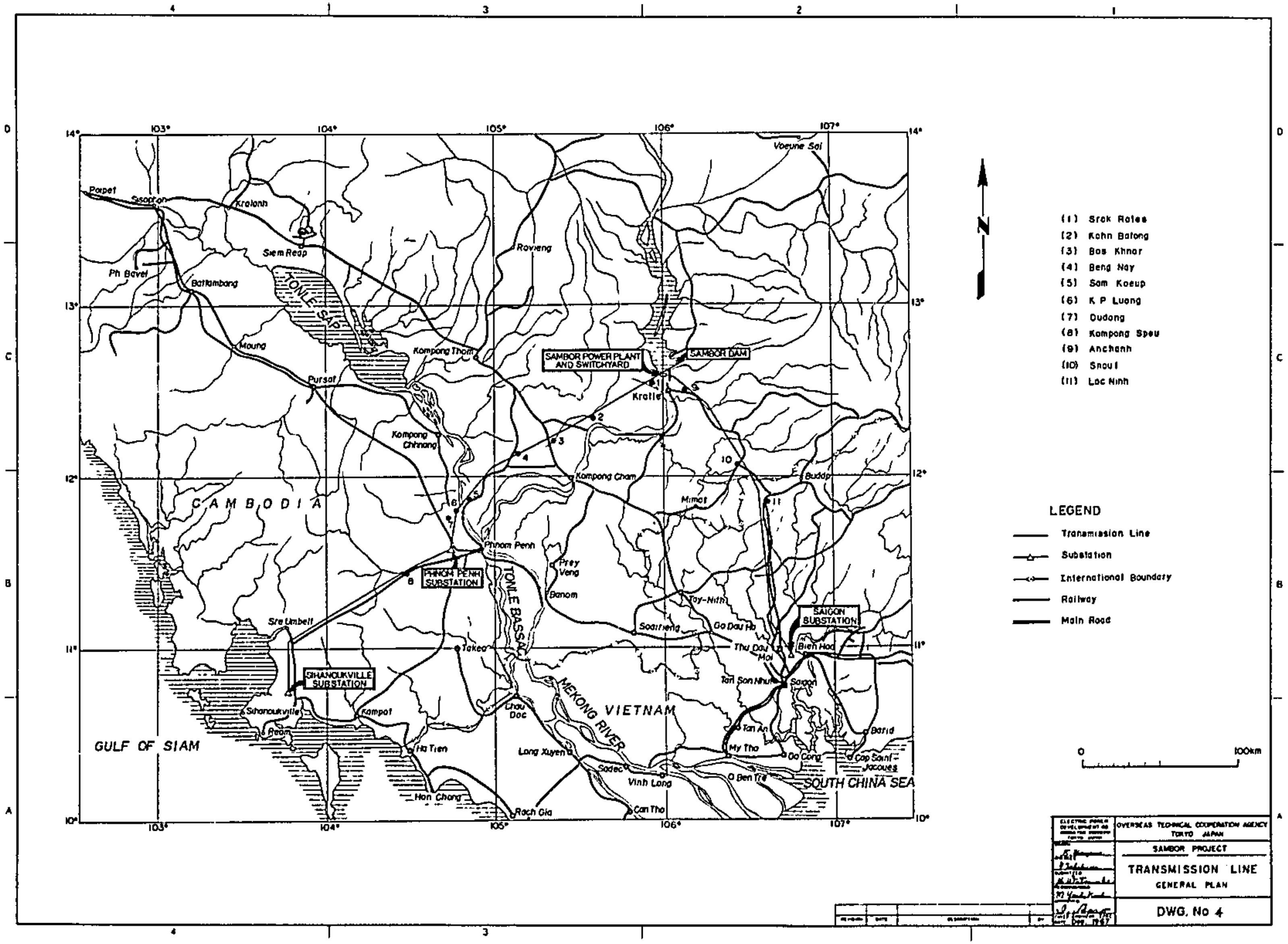
The main industry of Cambodia is agriculture, followed by forestry and fishery. Although the processing of agricultural, forestry and fishery products constitutes the major part of the manufacturing industries, establishment of textile industry, cement industry, paper manufacturing industry, etc., is in progress in recent years. The country seems to be relatively poor in mineral resources which have not been exploited.


TYPICAL SECTION
(ROCKFILL DAM)
Axis of dam
Dumped riprap
Nor HWS 40.00
Blanket material
Filter material
Impervious core
Dumped boulders
Riverbed
Rockfill
Max WS 25.60
TYPICAL SECTION
(EARTHFILL DAM)
Dumped riprap
Nor HWS 40.00
Filter
Earthfill
Drain
Rockfill
Original ground surface
(Plan)
(Sections)
Sambor Rapids
Relocated national highway
Crest road
Earthfill dam
Rockfill dam
Axis of dam
Spillway
Power plant
Fish ladder
Spillway levee
MEKONG RIVER
PREK KAMPI RIVER
National highway (Route 13)
OVERSEAS TECHNICAL COOPERATION AGENCY TOKYO JAPAN
ELECTRIC POWER DEVELOPMENT CO.
SAMBOR PROJECT
DAM AND POWER PLANT
PLAN AND TYPICAL CROSS SECTIONS
Dwg No 1


OVERSEAS TECHNICAL COOPERATION AGENCY TOKYO JAPAN
SAMBOR PROJECT
DAM & SPILLWAY
PLAN AND SECTIONS
PLAN
MEKONG RIVER
DETAIL X
SECTION D-D
SECTION C-C
SECTION E-E
SECTION A-A
SECTION B-B
Earthfill levee
Rockfill levee
Mortar masonry
Training wall
Roller gate
Hoist deck
Crest road bridge
Impervious core
Rockfill
Filter



OVERSEAS TECHNICAL COOPERATION AGENCY TOKYO JAPAN
SAMBOR PROJECT
POWERHOUSE
PLAN
MEKONG RIVER
Axis of dam
Rockfill dam
Non-overflow concrete dam
Concrete slope facing
Powerhouse of future units
Powerhouse
Tailrace
Training wall
Erection bay
Access road
Switchyard
Rockfill levee
Inlake
Road
Diversion
Concrete sloping facing
Spillway
200 m



(1) Srok Roles
(2) Kohn Batong
(3) Bos Khnor
(4) Beng Nay
(5) Som Koeup
(6) K P Luong
(7) Oudong
(8) Kompong Speu
(9) Anchanh
(10) Snoul
(11) Loc Ninh
LEGEND
Transmission Line
Substation
International Boundary
Railway
Main Road
0
100km
SAMBOR POWER PLANT AND SWITCHYARD
SAMBOR DAM
PHNOM PENH SUBSTATION
SIHANOUKVILLE SUBSTATION
SAIGON SUBSTATION
CAMBODIA
VIETNAM
TONLE SAP
TONLE BASSAC
MEKONG RIVER
GULF OF SIAM
SOUTH CHINA SEA
Poipet
Sisophon
Krolanh
Siem Reap
Ph Bavel
Battambang
Moung
Pursat
Kompong Thom
Kompong Chhnang
Rovieng
Voeune Sai
Kratie
Kompong Cham
Phnom Penh
Prey Veng
Banom
Takeo
Sre Umbell
Sihanoukville
Ream
Kampot
Ha Tien
Hon Chong
Rach Gia
Chau Doc
Long Xuyen
Sadec
Vinh Long
Can Tho
Ben Tre
My Tho
Tan An
Go Cong
Cap Saint-Jacques
Barid
Saigon
Tan Son Nhut
Bien Hoa
Thu Dau Mot
Go Dau Ha
Tay-Ninh
Soaitieng
Mimot
Buddp
OVERSEAS TECHNICAL COOPERATION AGENCY TOKYO JAPAN
SAMBOR PROJECT
TRANSMISSION LINE
GENERAL PLAN
DWG. No 4

Various products are shipped by water to consumer cities including Phnom Penh and other cities. Export goods are mostly shipped from Phnom Penh, but some are shipped from Sihanouk Ville and Kompong Cham.

Table D-15 shows the major export goods of Cambodia.

Table D-15 Major Export Goods of Cambodia (1966)

	Quantity (1,000 tons)	Export Value (Million Riels)
Rice	190.10	846
Maize	133.42	285
Natural rubber	50.78	885
Pepper	1.48	59
Ginned kapok	11.74	99
Fishery commodities	1.62	6
Live animals	6.40	39
Soybeans.	0.67	3
Sesame	4.79	32
Lumber	81.17	58
Total	482.17	2,312

Source: *Statistical Bulletin*, Mekong Committee, Dec. 1967
Note. Total import is 3,888 million Riels and total export is 2,356 million Riels

In the southwestern part of the country where no navigable rivers are found, overland transportation is the only means of communication. But, in other parts of the country along the Mekong, movement of commodities and passengers resorts predominantly to the water transportation on the Mekong. As of 1964, the total number and tonnage of registered vessels including junks (16 tons or more), steel boats, steam launches, self-propelling vessels, motor-boats, etc. were about 3,000 and 132,000 tons, respectively.

D-2-1-2 Description of the Mekong

The elevation of major cities along the Mekong and the distance to these cities from the Mekong estuary are in Table D-16 and Key and Location Map. The average gradient of the Mekong is gentle, but in certain sections including Samboc and Khone, navigation is impossible due to rapids.

Table D-16 Gradient of the Mekong in the Lower Reaches

City	Distance from Estuary (km)	Elevation (m)	Average Gradient
Phnom Penh	332	11	1/30,000
Kratie	547	22	1/19,500
Stung Treng	680	50	1/4,700
Pakse	891	100	1/4,200
Savanakhet	1,148	140	1/6,400
Vientiane	1,606	175	1/13,000

The fluctuation of water level in the dry and flood seasons as shown in Table D-17, ranges from about 9 m to 17 m between Phnom Penh and Stung Treng. This water level fluctuation is causing extreme inconvenience to passenger and cargo transportation.

Table D-17 Water level Fluctuation of the Mekong

(Unit: m)

	1961			1962		
	Maximum	Minimum	Difference	Maximum	Minimum	Difference
Stung Treng	48.3	38.2	10.1	47.3	38.4	8.9
Kratie	21.3	4.0	17.3	19.8	4.2	15.6
Kompong Cham	14.5	1.3	13.2	13.7	1.1	12.6
Phnom Penh	10.0	0.7	9.3	9.2	0.7	8.5

Note: Values are height above mean sea level at Hatien (Observation by the Royal Government of Cambodia).

The water depth ranges from 5 m to 7 m between the Mekong estuary and Phnom Penh (the maximum draft of vessels which can navigate the river at high water is restricted to 4.1 m in April and 5.1 m in September at the estuary). Between Phnom Penh and Kompong Cham, navigation of 3,000 ton vessels is possible since the water depth is comparatively deep, between 10 m to 25 m in certain sections. In the dry season, from Kompong Cham to Kratie, vessels up to 200 ton only can navigate the river since the water depth is less than 3 m in some sections, and from Kratie to Samboc the water depth does not exceed 2 m in many sections and navigation is possible only by small boats. Upstream of Sambor, navigation is possible only for rafts due to the Samboc Rapids.

The velocity of flow at Stung Treng, Kratie and Kompong Cham ranges from 0.2 to 0.5 m per sec. in the dry season and from 1.6 to 1.7 m per sec. (3 to 4 m per sec. at the center of stream) in the wet season. At Phnom Penh, an average velocity of 2.3 m per sec. (3.34 m per sec. at the center of stream) was observed in August 1961 when 50,000 cu.ms discharge was recorded. Navigation of small boats is therefore nearly impossible during the wet season.

D-2-1-3 Navigation on the Mekong

Vessels of 3,000 tons are servicing between Phnom Penh and the Mekong estuary at present. The total number of ocean-going vessels that call at Phnom Penh is 500 to 600 per year, and the tonnage of export-import cargoes handled at Phnom Penh in and around 1960 was 700,000 tons to 850,000 tons.

In the upstream section between Phnom Penh and Kratie, water traffic consists of passenger boats, barges, fishing boats and rafts. Ferryboats are in service at points where major trunk roads cross the Mekong.

Passengers boats in service are of 10 tons to 150 tons which can accommodate 50 to 200 passengers. The daily number of service and the time required for passenger boats plying between Phnom Penh and upstream ports are given below (as of 1963).

From Phom Penh to Kratie:	3 services (ports of call – 10 to 15), 14 to 16 hrs.
From Phom Penh to Kompong Cham:	4 services (ports of call – 9 to 25), 9 to 10 hrs.
From Phom Penh to Raca Kong:	3 services
From Kratie to Phnom Penh:	3 services, 12 to 14 hrs.
From Kratie to Kompong Cham:	4 services (ports of call – 10 to 30), 7 to 9 hrs. (11 hrs. for upward-bound service from Kompong Cham to Kratie)
From Kratie to the opposite bank:	15 to 20 services.

These passenger boats are servicing at 50% to 70% of their capacity on week days, and this rate is considered to increase by 1.5 to 2.0 times on Sundays and holidays.

Per capita fares are as given below.

Phnom Penh to Kompong Cham:	20 Riels, (5 to 7 Riels per bag of rice)
Phnom Penh to Kratie:	45 Riels, (7 to 15 Riels per bag of rice)
Kompong Cham to Kratie:	30 Riels, (6 to 10 Riels per bag of rice)

These rates are much lower than bus fares which are 50 Riels for a trip from Phnom Penh to Kompong Cham, 120 Riels from Phom Penh to Kratie (Bus fare between Kratie and Stung Treng is 60 Riels).

Barges are used for the transportation of rice and other agricultural products as well as charcoal. They range from 50 tons to 500 tons in size; for rice transportation, 350 to 500 ton barges are used, and for charcoal transportation, 40 tons to 100 tons are used. Production of rice and charcoal in areas upstream of Phnom Penh are given in Tables D-18 and D-19.

Table D-18 Production of Rice (1965)

Production Center	Output (tons)	Ratio to National Total (%)
Kompong Cham	247,000	9.8
Kratie	23,000	0.9
Stung Treng	5,000	0.2
Cambodian Total	2,500,000	

Table D-19 Production of Charcoal (1962)

Production Center	Output (tons)	Ratio to National Total (%)
Chhlong	3,562	27.4
Snuol	360	2.8
Kratie (Left bank)	2,230	17.2
Kratie (Right bank)	2,248	17.3
Cambodian Total	13,000	

The freight rate charged to these products is 8 to 10 Riels per bag of rice and 12 Riels per bag of maize between Kompong Cham and Phnom Penh, and 10 to 17 Riels per 60 kg charcoal box between Kratie and Phnom Penh. The cargo handling charge imposed on one bag of rice is 2 to 5 Riels.

Compared with the charge by trucks, the above freight for rice is cheaper by 30% to 60%. These barges descend the Mekong towed by tugboats, and the time required for them to sail from Kratie to Phnom Penh is 5 to 7 days in the wet season and about 20 days in the dry season.

Kratie and Stung Treng Districts produce about 15% of the nation's total lumber output (See Table D-20). Logs produced in these districts are formed into rafts at Stung Treng, Kratie, Tone Bet as well as in the upper reaches of the Se Kong and the Se San, and floated down to Phnom Penh.

A number of rafts, each measuring 8 m to 12 m wide and 10 m to 15 m long, are tied together having a total length of about 50 m to 90 m, and descend the Mekong with the river current in the wet season and by tugboats in the dry season. Time required for them to arrive at Phnom Penh is 10 to 15 days in the wet season and 4 to 5 days in the dry season.

With respect to mooring facilities, Phnom Penh Port has two berths of reinforced concrete and four steel pontoons for ocean-going vessels, and 24 pontoons for vessels servicing inland waters; Kompong Cham has four pontoons; and Kratie has four small pontoons. At most of the river ports where passenger boats call, simple pontoons are provided, and ferryboats are employed at some ports. Facilities at these river ports are rather inefficient.

Table D-20 Production of Lumber (1962)

Production Center	Production (cu.m)	Ratio to National Total (%)
Chhlong	3,821	1.9
Snuol	8,753	4.4
Kratie (Left bank)	6,598	3.3
Kratie (Right bank)	6,287	3.2
Stung Treng	2,877	1.5
Total	28,336	14.3
Cambodian Total	198,300	

D-2-2 Navigation Program

D-2-2-1 Target Period and Scope of the Program

The navigation program has been prepared on the basis of the estimated demand for the future 20 to 25 years when the population is expected to double.

Upon completion of the Sambor Dam, navigation will become possible as far upstream as Stung Treng. However, navigation further upstream must await the completion of upstream dams including the Stung Treng Dam. Since no firm program has been established of these upstream projects, the present program has been prepared for the distance between the Mekong estuary and Stung Treng, without considering the upstream course where the backwater of the Sambor Dam will not reach.

D-2-2-2 Estimate of Transport Load

It is estimated that the number of passengers and volume of goods that will pass over the Sambor Dam in the target period would be as follows.

Passengers:	200,000 persons (upward and downward bound combined)
Daily necessities and sundries:	54,000 tons (upward bound)
Lumber:	56,000 tons (downward bound)
Charcoal:	5,000 tons (downward bound)
Others:	5,000 tons (downward bound)

It is further estimated, as shown in Table D-21, that in the target period, the population will increase by 2 times in urban areas and by 1.5 times in other districts.

Table D-21 Estimated Population at Time of Completion of the Program

Province and City	Population (persons)
Kratie Province	190,000
Kratie City	(23,000)
Stung Treng Province	52,000
Stung Treng City	(7,000)
Ratanakiri Province	75,000
Total	317,000

According to this estimate the population of Kratie City will be 80% of the present population of Kompong Cham City and that of Stung Treng City will be 60% of the present population of Kratie City. Further, the population of Stung Treng Province and Ratanakiri Province combined is estimated to be approximately equal to the present population of Kratie Province.

From these assumptive figures, it has been inferred that the number of passengers passing over the dam would be 200,000 or 60% to 80% of the total passengers of 300,000 that embark or disembark at Kratie at present.

The daily necessities required by the estimated population of 127,000 in the hinterland of Stung Treng Port in 1988 has been estimated to range from 50,000 tons to 76,000 tons on the basis of the present annual per capita consumption of daily necessities in Cambodia which is 0.24 tons to 0.35 tons, an annual growth rate of consumption of 4.4%, and that the living standard in areas upstream of Kratie would be two-third of the nation's average. Of the estimated total quantity of daily necessities, 85% or 43,000 tons to 65,000 tons, average 54,000 tons, are estimated to be conveyed to consuming areas by water transport.

The quantity of timbers to be transported to the downstream is estimated to increase sharply to about 56,000 tons along with the rise in the living standard of the people and improvement of navigation.

The annual charcoal production in Stung Treng District is about 20 tons at present. This low production is because the output is consumed within the district due to the lack of means of transportation. Charcoal production, however, is expected to sharply increase up to about 5,000 tons annually when water transport between Stung Treng and the downstream reaches becomes possible since the district is rich in forestry resources.

In addition to the above, an annual volume of traffic of 5,000 tons has been taken into account for rubber, zircon, bamboo, fruits, dried fish and other products.

Trend of growth of passenger and commodity traffic are shown in Fig. D-12.

D-2-2-3 Navigation after Completion of the Sambor Reservoir

When the Sambor Reservoir is completed, the daily discharge downstream of the dam in the dry season will increase to between 1,860 cu.ms and 2,775 cu.ms. However, since the reservoir would be operated corresponding to demand for power, the off-peak discharge will drop to 1,350 cu.ms. Though the water level downstream of the dam will increase to some extent, no appreciable benefits can be anticipated (the minimum daily discharge of the dry season records 1,250 cu.ms) by the construction of the dam. The swift current in the wet season and insufficient water depth in the dry season which restricts navigation to ships of draft up to 1.5 m will not be solved.

Types of vessels and navigable period are given in Table D-22.

Fig. D-12 Increasing Curve of Cargo and Passenger

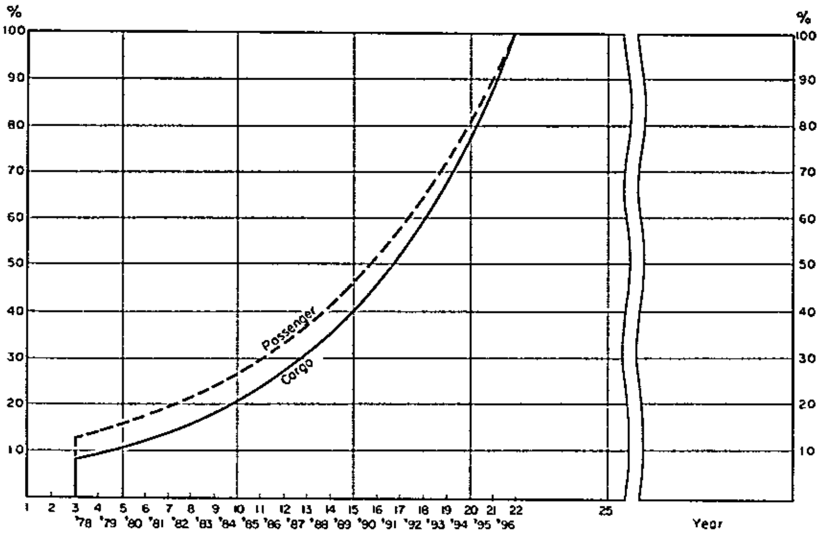


Table D-22 Types of Vessels and Navigable Period

	Passenger boats (120 tons)	Small boats (up to 5 tons)	Rafts
Upper limit of discharge	50,000 cu.ms	25,000 cu.ms	40,000 cu.ms
Lower limit of discharge	4,000 cu.ms	1,350 cu.ms	1,350 cu.ms
Navigable period	10.5 to 11.5 months	8 to 9 months	9 to 10 months

Even if restrictions are placed on navigation for the reasons mentioned above, it would still be necessary to dredge 3 km in the downstream direction from the downstream end of the dam.

D-2-2-4 Type and Number of Vessels Passing the Dam

Construction of the Sambor Dam is not expected to invite any appreciable changes, in the type and number of vessels navigating the river. Traffic that will pass over the Sambor Dam include passenger boats, barges, fishing boats, tugboats and rafts. It is probable that speedcrafts and hovercrafts may be introduced for navigation on the Mekong. (See Table D-23)

Table D-23 Outline of Vessels

Type	Displacement (ton)	Length (m)	Beam (m)	Draft (m)	Remarks
Passenger boat	110 to 120	About 32	6.3 to 6.6	2.75	
Speedcraft	12	16.3	5.8	2.0	Capacity: 30 passengers Speed: 65 to 70 km/hr
Barge	100 to 200	20 to 25		1.3 to 1.5	
Hovercraft		7 to 12 dia.			15 m x 8 m in case of rectangular type
Raft		100 (composed of 5 to 7 units of 10 to 15 m)	8 to 12	1.5 to 2	

The number of vessels that pass over the dam per day (one way) is estimated to be 18 on the average and 25 at the maximum. This volume of traffic is based on the estimated tonnage of goods of 66,000 tons, including lumber and on the estimated number of passengers which is 100,000. (See Chapter D-2-2-2) To handle this volume of traffic it was assumed that each passenger boat would carry 60 passengers and 2 tons of goods, a barge would carry 50 tons of cargo, and each unit of raft would be 80 tons of lumber, and seven other types of vessels per day were added and seasonal variation of traffic was taken into account.

D-2-2-5 Passage of Traffic Upstream and Downstream of the Dam

Passage of traffic upstream and downstream of the dam is to be effectuated by the construction of an inclined passage facility. Compared with navigation canal with locks, this method incurs less cost but has smaller capacity. The capacity of the proposed inclined passage facility, however, is sufficient to handle the estimated volume of traffic in Chapter D-2-2-4. It is estimated that a total of 75 minutes which includes 10 min. for preparation, 23 min. to 27 min. for a return passage plus an allowance, would be sufficient for one reciprocal operation of the inclined passage facility. It follows that if the number of vessels that pass over the dam is 18 to 25 (one way), a total of 23 to 32 hrs. of operation per day would be required. This indicates that the proposed construction of three lines is sufficient.

In the present program, the inclined passage facility is planned to be constructed in three stages as indicated below corresponding to the increase in the estimated volume of traffic. (See Fig. D-12)

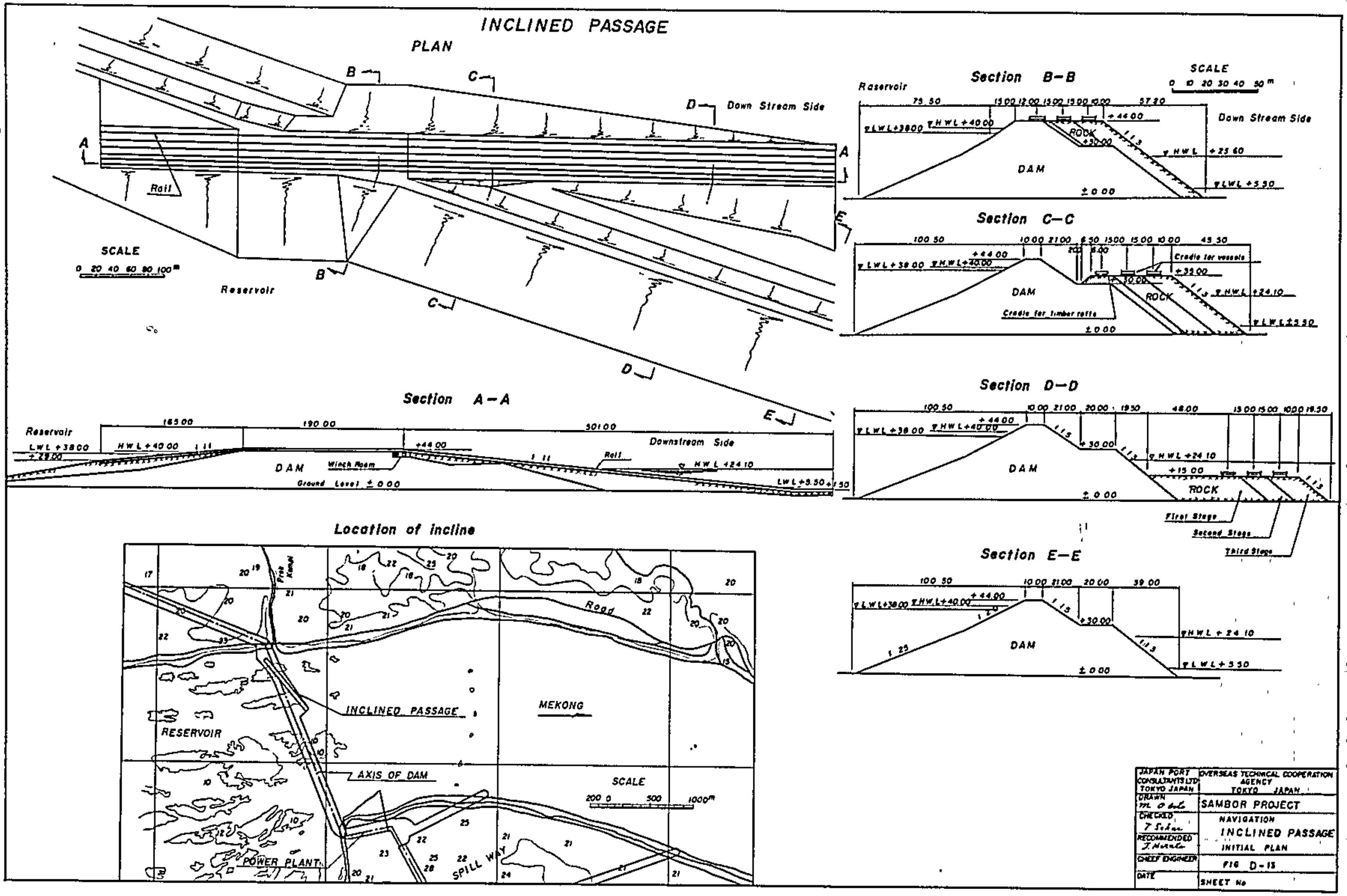
First stage:	1 line for rafts (to be concurrently used for vessels)
Second stage (start operation in the 11th year after completion of first stage):	1 line for medium-sized vessels
Third stage (start operation in the 16th year after completion of first stage):	1 line for medium-sizeed vessels

It is estimated that vessels navigating the Mekong will increase in number and become large in size after completion of dams upstream of Stung Treng. Then a navigation canal with locks would become necessary. (See Vol. II, Chapter K)

D-2-3 Major Structures

D-2-3-1 Outline of Inclined Passage Facility

Location:	On the rock-fill dam, towards the left bank (See Fig. D-13), angle of intersection with dam axis is 18°
Embankment volume:	820,000 cu.m
Machine space:	900 sq.m
Inclined Passage:	3 lines (1 for rafts, 2 for medium-sized vessels; of 30 to 150 tons) Gradient 1/11 Length 855 m Rail 70 kg (4 for each line)
Cradle:	1 for each line for medium-sized vessels 10 for rafts (connected by chain)



INCLINED PASSAGE
PLAN
Down Stream Side
Reservoir
Rail
SCALE
0 20 40 60 80 100m
Section A-A
Reservoir
LWL +38.00
+28.00
HWL +40.00
165.00
190.00
501.00
+44.00
Downstream Side
Rail
HWL +24.10
LWL +5.50
1:11
DAM
Winch Room
Ground Level ±0.00
Section B-B
SCALE
0 10 20 30 40 50m
Reservoir
73.50
15.00 12.00 15.00 15.00 10.00
57.20
LWL +38.00
HWL +40.00
+44.00
ROCK
+30.00
1:1.5
HWL +25.60
LWL +5.50
DAM
±0.00
Down Stream Side
Section C-C
100.50
10.00 21.00 6.50 15.00 15.00 10.00
45.50
+44.00
LWL +38.00
HWL +40.00
Cradle for vessels
+32.00
+30.00
HWL +24.10
LWL +5.50
ROCK
DAM
Cradle for timber rafts
±0.00
Section D-D
100.50
10.00 21.00 20.00 19.50
48.00
15.00 15.00 10.00 19.50
+44.00
LWL +38.00
HWL +40.00
+30.00
HWL +24.10
+15.00
ROCK
DAM
±0.00
1:1.5
First Stage
Second Stage
Third Stage
Section E-E
100.50
10.00 21.00 20.00
39.00
+44.00
LWL +38.00
HWL +40.00
+30.00
HWL +24.10
LWL +5.50
1:1.5
1:25
DAM
±0.00
Location of incline
Road
MEKONG
INCLINED PASSAGE
AXIS OF DAM
RESERVOIR
POWER PLANT
SPILL WAY
SCALE
200 0 500 1000m
JAPAN PORT CONSULTANTS LTD TOKYO JAPAN
OVERSEAS TECHNICAL COOPERATION AGENCY TOKYO JAPAN
DRAWN
CHECKED
RECOMMENDED
CHIEF ENGINEER
DATE
SAMBOR PROJECT
NAVIGATION
INCLINED PASSAGE
INITIAL PLAN
FIG D-15
SHEET No

Winch:	Winding speed–30 m per min. 260 HP x 2 for medium-sized vessels, 180 HP x 1 for rafts
Pusher:	50 HP x 3

D-2-3-2 Dredging Work

In order to maintain an effective channel width of 45 m and a water depth of 2 m at a discharge of 1,350 cu.ms, dredging is planned to be executed in the downstream direction from the dam over a distance of 3 km. The volume of rock to be excavated and dredged is estimated to be 95,000 cu.m.

Dredging is also planned to be executed at a point 25 km downstream of Stung Treng as well as in the section between 7 km and 14 km downstream of Stung Treng,whereby an effective channel width of 60 m and river bed elevation of 34.5 m may be maintained. The volume of earth to be dredged is estimated to be 570,000 cu.m.

D-3 Agricultural Development Program

D-3-1 Description of Development Area

D-3-1-1 Land Resources

(1) Topography: The development area lies in the intermediate zone where the Mekong, after passing through the mountain district, enters the flat area, and is composed of hills and the flood plain formed by the Mekong mainstream and tributaries. The area can topographically be divided into the following eight districts.

Hilly-land of Tertiary Formation: Elevation of this district is the highest of the eight districts, and it is covered mostly by thin forests growing on thin surface layer and by jungles in certain parts. (See Fig. D-14)

Valley bottom plain inside hilly lands: These are the plains in the palm-shaped valleys formed by the Mekong tributaries, and cultivated as paddy fields in the wet season.

Gentle slope in mountain foot: This is the transitional zone from the hilly district to the low-lying land including marshes, and is formed of decomposed soils of the mountain slope.

Ridge in natural levee: This is the high section of the natural levee formed by the Mekong. It is a gently curved levee running parallel with river, and also serves as an important road.

Back slope in natural levee: This sloping district behind the natural banks of the river was formed by silt deposition of the Mekong. Most of this land is inundated during the rainy season. However, the land is very fertile and is utilized as upland farm.

Sedimentation area by the small river in marshy land: This area is composed of natural levee and delta formed by small tributaries, and is frequently inundated.

Low area in back: Having an elevation ranging from 14 m to 20 m, this district is the lowest of the eight districts. It is completely inundated in the wet season and the land is not being utilized.

Lakes, pond or shallow concave area in back marshland: This area consists of the former river bed, winding stream beds and ponds which are inundated in the wet season. Most of this area has stagnant water throughout the year.

(2) Geology and Soil: The development area belongs geologically to the Indosinian Formation which is composed mainly of sandstone and shale of the Tertiary Period. Most of the soil in the area is fine alluvial. Soils of medium and coarse grain are found extensively on the natural levee and other places where the sediment carried down by the Mekong River is deposited. The grain size becomes smaller towards the low-lying

hinterland. The soil profile generally presents a undeveloped or weak development.

The soil can be classified into series by soil texture and drainage. Red-yellow podzolic soil is distributed in the hilly district, with its color becoming redder at higher elevations and yellower at lower elevations and in those zones that it comes into contact with diluvial soil. The low humic gley soil extends, by the effect of paddy culti-vation, to the valley bottom plain inside hilly lands. In some parts of Bos Leav and Kanhchor, the transitional soil to Regur which developed from basalt is found distributed. The soil series above is illustrated in Fig.D-15 and Table D-24. Fig.D-16 gives profiles of each soil series.

The infiltration of the surface soil layer and soils underlying it varies by soil textures and tilling conditions. In upland fields, it is generally less than 120 mm/day in the clayey soil and less than 500 to 1,000 mm/day in the loamy or sandy soil. In paddy fields, percolation averages 4.8 mm/day in loamy soil during the wet season, and 1.8 mm/dayin soil during the dry season. The maximum water-holding capacity is 50% to 60% in most soils. The residual water volume after gravity drainage, i.e., the field capacity was a little less than 30% with a wilting point of 6% to 7% in most cases. Therefore, it can reasonably be concluded that the available moisture is 20% to 25%. In the wet season, practically all soils have water contents exceeding the field capacity and reach a nearly saturated state, but towards the end of the dry season, most soils lose water until the water content drops to several percent in the surface soil.

Table D-24 Classification of Soils into Great Soil Groups and Soil Series

Great Soil Groups	Soil Series	Parent Material	Soil Texture	Drainage Class	Profile Development	Area (ha)	Capability Classification	
							Upland	Paddy
Alluvial soils	1 Chong Kaoh	Alluvium	S	Good	None to weak	400	III	
	2 Pôngrô	Alluvium	SiL	Good	None to weak	2,500	II	
	3 Bos Léav	Alluvium	SiCL	Good	Weak	5,300	II	
	4 Môreum	Alluvium	HC	Very poor	Weak	1,000		II
Lithosols	5 Pou	Basaltic/Tertiary		Good	None	300	IV	
Vertisols	6 Prek Chamlak	Basaltic	HC	Moderately good	Weak	900	II	II
	7 Sre Prang	Basaltic/Tertiary	HC	Moderately good	Weak	1,100	IV	
Low Humic Gley soils	8 Stung Preah	Alluvium	SL	Good	Strong	300		III
	9 Kampi	Alluvium/Tertiary	CL	Moderately good	Medium	2,500	III IV	
	10 Roha	Alluvium	LiC	Good	Medium	4,600		III
	11 Sambok	Alluvium	HC	Moderately good	Medium	24,000	III	II
	12 Russei Char	Alluvium	HC	Poor	Medium	6,500		II
Red-Yellow Podzolic soils	13 Krâkôr	Old alluvium	LS	Good	Medium	6,300	III IV	
	14 Kêng	Old alluvium	LS	Good	Medium	1,500	III	
	15 Tuôl	Old alluvium/ Tertiary	LS/CL	Moderately good	Medium to strong	8,800	III	

(3) Land Classification: The land was classified and the productivity of upland fields and paddy fields was graded according to the method adopted at the Japanese Agriculture, Forestry and Fisheries Research Council, which was held in 1962. The results of the classification and grading are given in Table D-25. (See Fig. D-15)
(4) Present Status of Land Use: In Kratie Province, an area of 28,800 ha or 2.6% of the total area of 1,115,000 ha is utilized as farm land. (See Table D-26) The remainder is mostly forests. Houses and farms are found on the natural levee of the Mekong. In the back slope of the natural levee, there is a strip of upland field 1 km to 3 km wide and in the lower ground area paddy fields (these paddy fields are for dry season cultivation using flood water of the wet season). In the valley bottom plain inside the hilly-lands are paddy fields for wet season cultivation. (See Dwgs. No. 2 to No. 9 in Vol. IV and Fig. D-17)

Table D-25 Land Classification

	Soil Series	Area (ha)	Capability Classification	
			Upland	Paddy
1	Chong Kaoh	400	III	
2	Pôngrô	2,500	II	
3	Bos Léav	5,300	II	
4	Môreum	1,000		II
5	Pou	300	IV	
6	Prek Chamlak	900	II	II
7	Sre Prang	1,100	IV	
8	Stung Preah	300		III
9	Kampi	2,500	III IV	
10	Roha	4,600		III
11	Sambok	24,000	III	II
12	Russei Char	6,500		II
13	Krâkôr	6,300	III IV	
14	Kêng	1,500	III	
15	Tuôl	8,800	III	
16	Lakes and Ponds	3,000		
	Total	69,000		

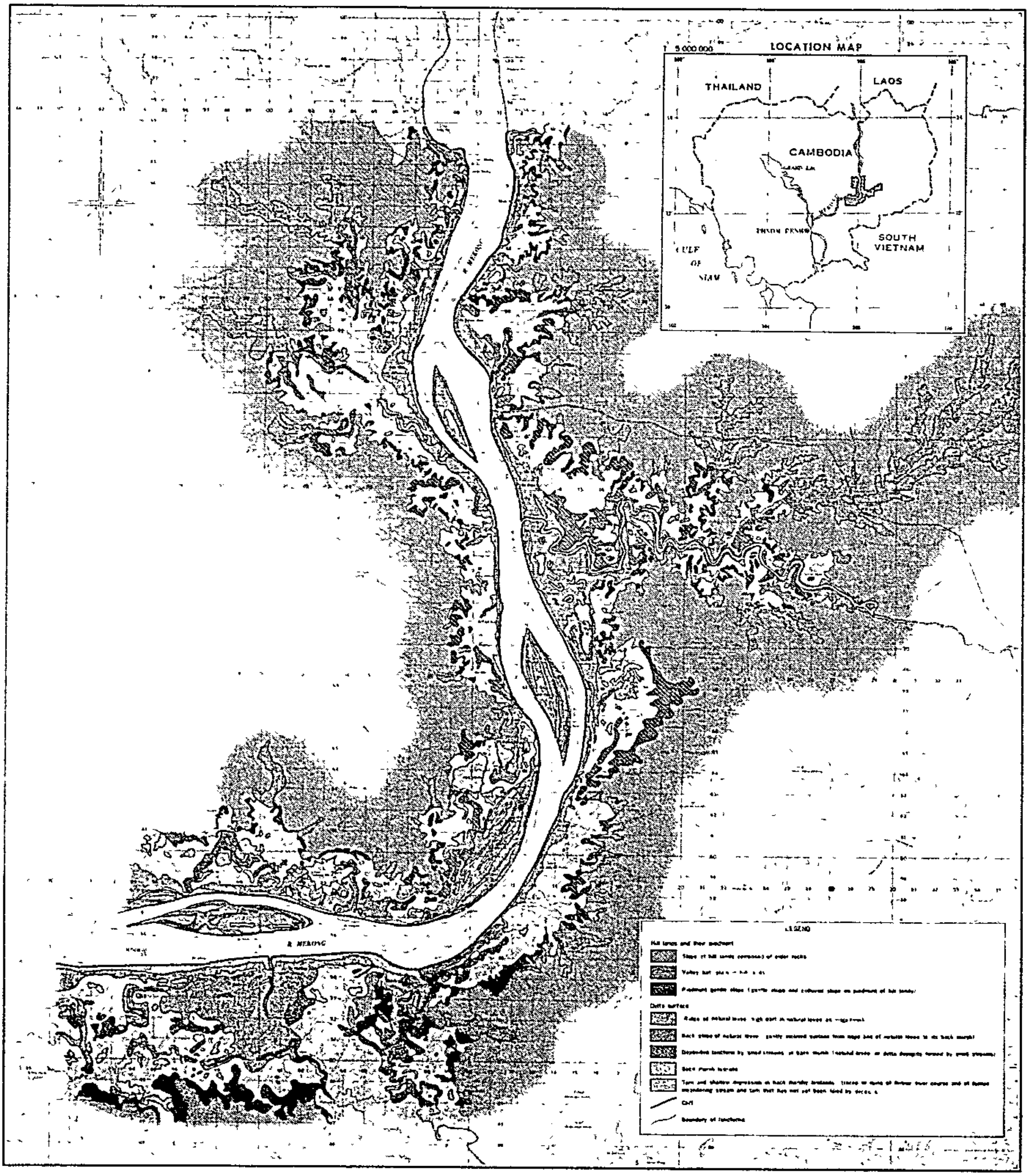
Note: Class I: Land which is considered to be good arable land having no restrictive or obstructive factors, and completely free from the fear of deterioration of soil condition.

Class II: Land having a certain degree of restrictive or obstructive factors, or subject to the fear of limited deterioration of soil condition.

Class III: Land having restrictive or obstructive factors to a fairly large extent, or subject to the fear of appreciable deterioration of soil condition.

Class IV: Land having extremely large restrictive or obstructive factors, or extremely liable to deterioration of soil condition, and not considered suitable for cultivation.

Fig D-14 Land Classification Map



1 : 100 000

Fig D-15 Soil Map

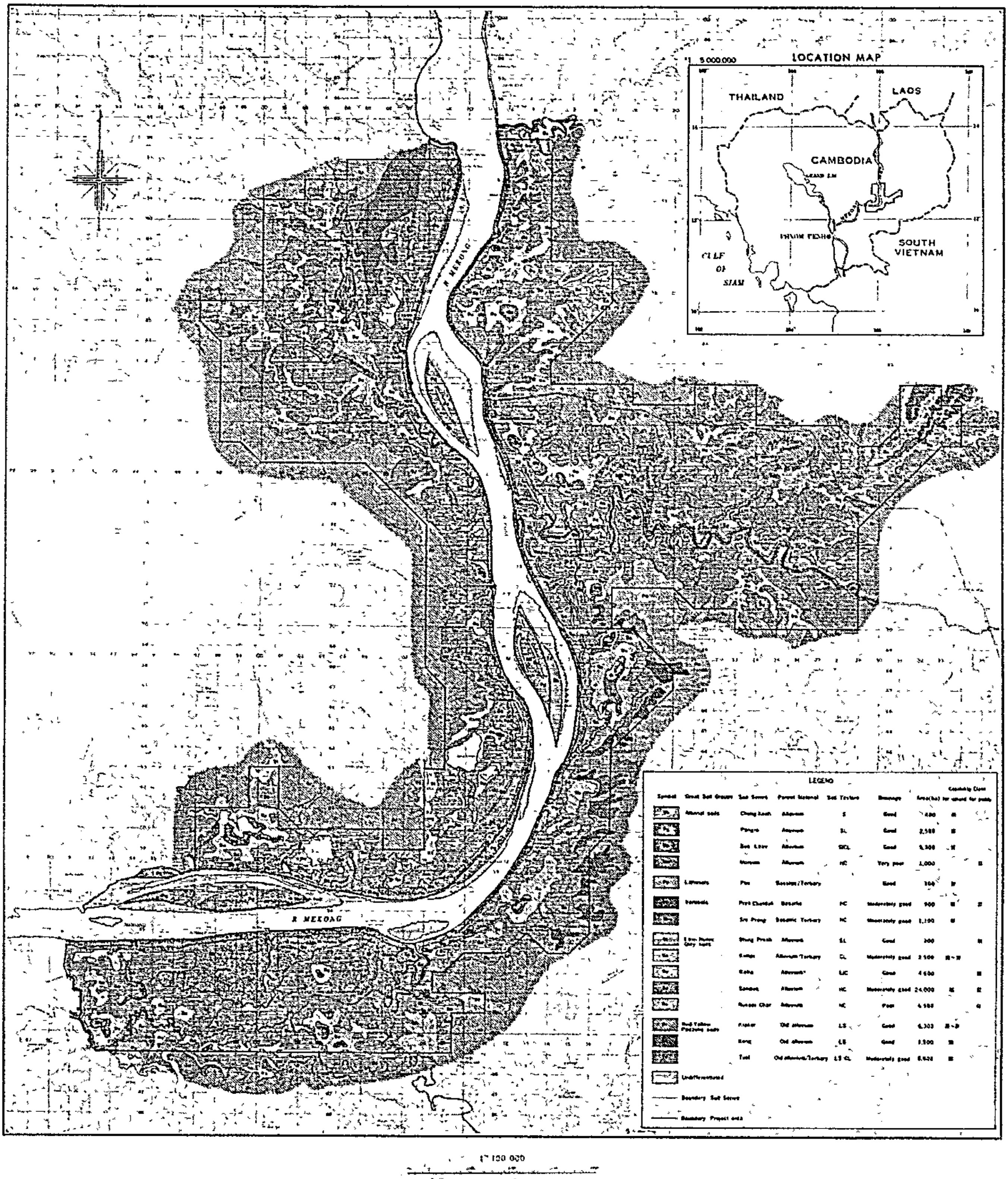


Fig. D-16 Exemplar Columnar Section of Various Soil Series in the Sambor Area

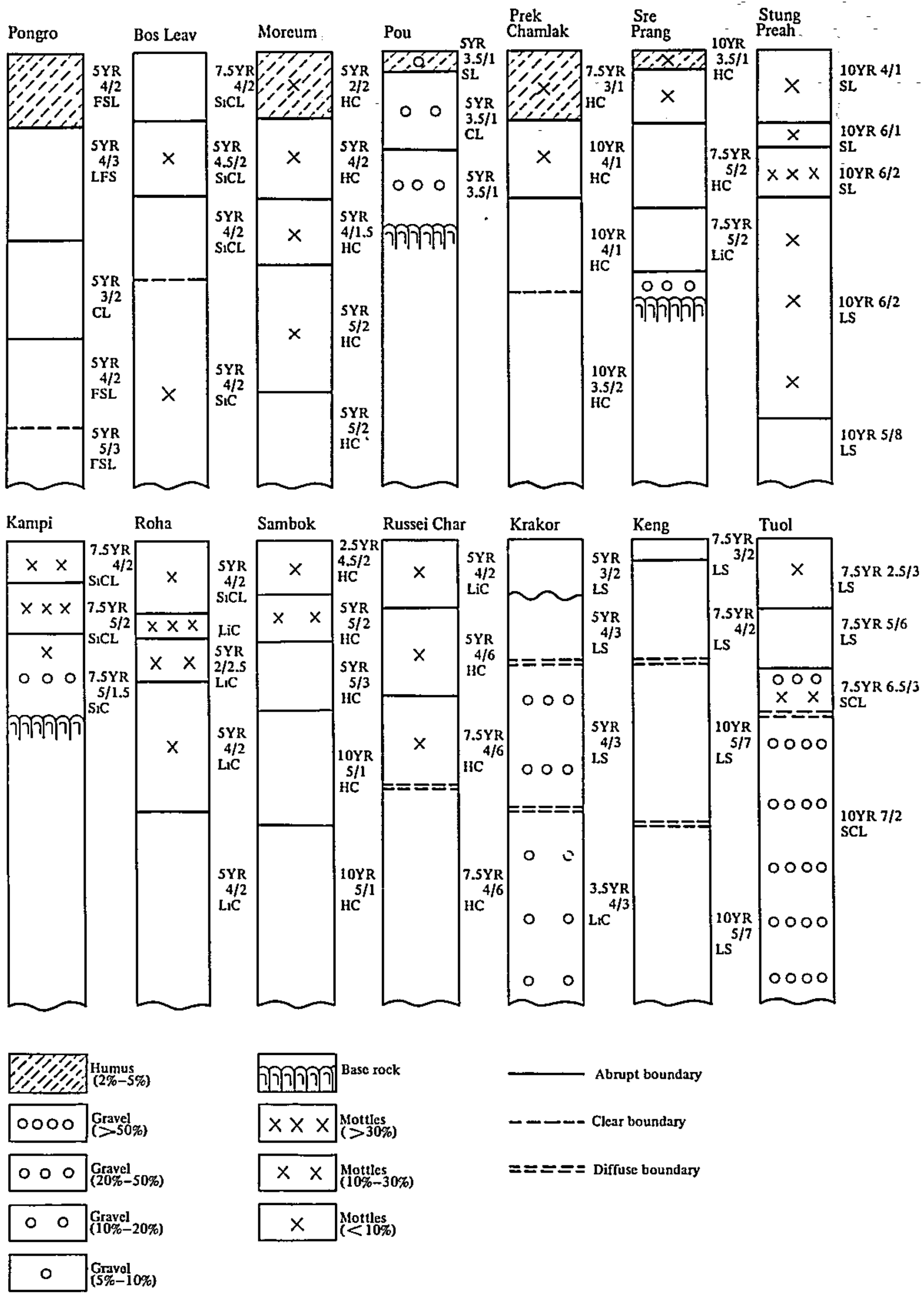


Table D-26 Outline of Land Use

(Unit: ha)

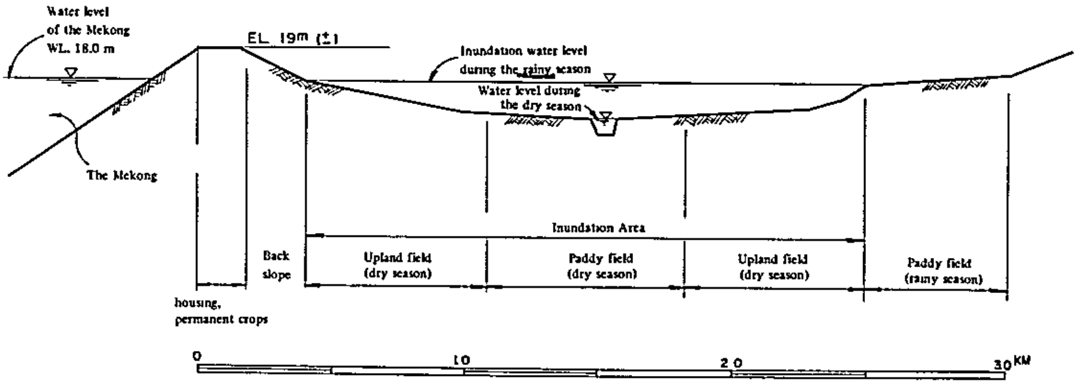
	Total area	Potential arable land	Cultivated land			Forest
			Total	Paddy field	Others	
Cambodia	18,103,500 (100%)	6,698,300 (37.0%)	2,050,000 (11.4%)	1,750,000	300,800	9,051,700 (51.6%)
Kratie	1,115,187 (100%)	40,000 1/ (3.6%)	28,806 (2.6%)	21,216	7,590	1,046,381 (93.8%)

Note: 1) Figures for Cambodia are based on *Bulletin de la statistique et des études agricole*, No. 3, 1963.

2) Figures for Kratie are based on *La Superficie de Rizers, Chamcar & Forêts dans la Province de Kratie* which was made available by the Government of Kratie Province.

3) 1/ indicates the area available for paddy production obtained from *Superficies des rizers cultivées (saison des pluies).*

Fig. D-17 Illustration of Standard Land Utilization



The existing land classification and the corresponding soil classification and productivity rating are tabulated below.

Table D-27 Existing Land Classification and Soil Classification

Item	Area (1,000 ha)	Soil texture	Soil Series and Productivity	Inundation
Paddy field	5.1	C, SiC, SL	Russei Char (II), Sambok (II), Stung Proah (III), Roha (III)	Whole of (II) and part of (III)
Upland fields	7.7	SiL, SiCL, C	Pongro (II), Bos Léav (II), Sambok (III)	More than 50%
Marshy area	28.8	C – S	Russei Char (II), Sambok (II), Moreum (II), Chong Kaoh (III), Pongro (II), Bos Léav (II)	Entirely inundated
Clear forests	22.6	LS, CL, C	Krakor (III–IV), Tuol (IV), Kampi (III–IV), Prok Chamlak (II), Sre Prang (IV), Pou (IV)	Seldom inundated
Jungles	4.8	LS	Keng (III), Krakor (III–IV)	No inundation
Total	69.0			

Table D-27 reveals that the existing farm lands are developed, without exception, by making use of areas whose productivity is rated either class II or III. Most of the paddy fields are wet season fields such as Roha Series (III) which resort to rain water. From the viewpoint of productivity, dry season paddy fields such as Sambok Series (II) have more favorable conditions. In practice, however, the production of rice does not necessarily conform to the rated productivity since it is largely affected by the species of rice cultivated as well as by the irrigation facilities.

Clear forests and jungles, which are rated at class III or IV productivity, are not utilized. The marshy land which is entirely inundated every wet season, is mostly classified under class II, and can be broadly divided into areas characterized by SiL-SiCL (Pongro and Bos Léav) which is suitable for upland field cultivation and areas characterized by clay. (Russei Char, Sambok, Moreum) which is good for paddy fields.

(5) Feasibility of Land Use: The land classification revealed that the area rated at class II comprises of 8,700 ha of upland field and 32,400 ha of paddy field (of which 900 ha can be cultivated as upland field). All other areas are rated at class III or IV. For cultivation, the class II land is handicapped by some natural restrictive factors, but the effects of these factors can be substantially reduced if measures are taken for soil improvement by dressing and by fertilization and drainage improvement and other pertinent means. It is therefore planned that the agricultural development plan based on the establishment of irrigation and drainage systems would have to be limited to the above-mentioned class II land which covers an areas of 40,200 ha.

For the effective use of land in the future, the following should be taken into account.

(a) In the existing farm land which is blessed with excellent conditions, irrigation facilities should be improved with efforts also directed to securing necessary water sources. Existing upland fields and paddy fields should in principle, remain as they are. It is believed that fertilization can be neglected for the time being for the areas which are inundated in the wet season, particularly if the *colmatage* method is employed.
It must be noted that the introduction of year-round cultivation will require full-scale fertilization if the land fertility is to be elevated for increased productivity.

(b) The greater part of the proposed development area is uncultivated land, and the lands with soil conditions suited to development are the marshy area. The farming period in those areas is essentially limited by the inundation during the wet season. However, the development of marshy lands compared to that of clear forests and jungle, is much easier and will yield much greater benefits that would amply make up for the restriction on the farming period.

(c) If the soil condition in the uncultivated land remains as it is, most of the project area could be reclaimed for paddy fields and utilized for dry season paddy production since the control of inundation would be practicable only in limited parts of the area. However, if the *colmatage* method is introduced to recover silt from the Mekong, reclamation of upland fields would be feasible in many parts.

(d) Development of clear forests and jungles would involve the establishment of irrigation system and fertilization.

(e) If inundated area is desired to be utilized in the wet season, it would require the installation of drainage pumps and construction of polders. Other areas could be transformed into dry field if proper drainage ditches are constructed.

D-3-1-2 Water Resources

(1) Rainfall: Records of precipitation observed at Kratie and Stung Treng reveal that the annual average rainfall in the two cities is about 1,200 mm and 1,600 mm respectively and concentrates in the period from May to November (See Fig. D-2).

Most rainfalls are squalls, and this makes the rainfall variable by district and period. The rainfall fluctuation obtained from the precipitation record of Phnom Penh is given in Fig. D-18. The records of precipitation observed in the irrigation development area in 1965 show the occurrence of drought days that continued for more than seven days on two to three occasions during May to November.

(2) Temperature and Humidity: The temperature at Kratie, averaging 27°C throughout the year, rises to the peak in April (average of past record is 29.7°C) and drops to the minimum in December (average of past record is 24.7°C), the difference being 4°C to 6°C on the average. (See Fig. D-2) It occasionally happens that the temperature is high or low throughout the year. The highest and lowest temperatures recorded in Phnom Penh is 40.5°C (April 1926) and 13.3°C (January 1955) respectively.

The relative humidity is rather high year-round, ranging from 60% to 90% and reaching the peak value in or around September and dropping to the lowest in or around March.

(3) Evaporation: Evaporation does not vary by district and averages about 5.6 mm/day. The maximum value of 7.4 mm/day appears around April immediately before the advent of the wet season, while the lowest of 3.9 mm/day is observed around August (See Fig. D-19).

(4) River Runoff: Description of the discharge of the Mekong has already been given in Chapter D-1 (Power Development Program). The discharges of tributaries, which have close bearing upon the irrigation program, have been observed by the Japanese Survey Team on two occasions from April to November 1965 and May to October 1966.

From the observation data prepared by the Japanese Survey Team, it is estimated that the total discharge of tributaries is 589 million cu.m per year as shown in Table D-28.

Table D-28 Discharge of Tributaries

Tributary	Observation Site	Catchment Area (sq.km)	Discharge (million cu.m/year)
Prek Sao	Saop	230	371
Prek Paprak	Paprak	110	177
Prek Khnach	Khnach Touch	35	41
Total		375	589

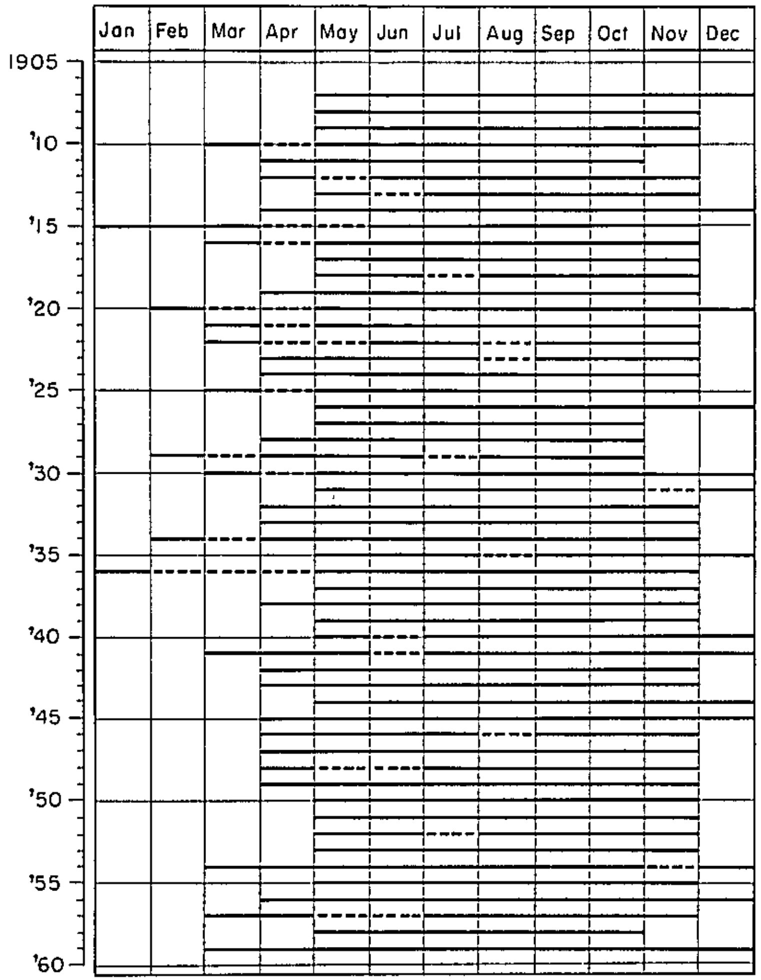
Lakes and ponds scattered in the irrigation development area collect water in the wet season by flooding of the Mekong and the inflow from their own catchment areas. Water thus collected and stored can be utilized for irrigation in the dry season. As described in Table D-29, eight lakes and ponds provide a total of 21 million cu.m of water which can be used for irrigation of farmland.

Table D-29 Lakes and Ponds Available as Water Sources

District	Lake or Pond	Available Water		
		Area (ha)	Depth (m)	Volume (1,000 cu.m)
Bos Leav	Pou	50	1.5	750
Chhlong	Kompong Kor	110	3	3,300
"	Ta Thon	35	3	1,050
"	Pre Kor	200 sq.m	11 km	2,270
Saop	Khnay Romea	160	2	3,200
Prek Prasap	Chhrea	200	2	4,000
Ta Mau	Trapeang Thom	150	3	4,500
"	Mokoy	100	2	2,000
Total	8 Lakes and Ponds			21,070

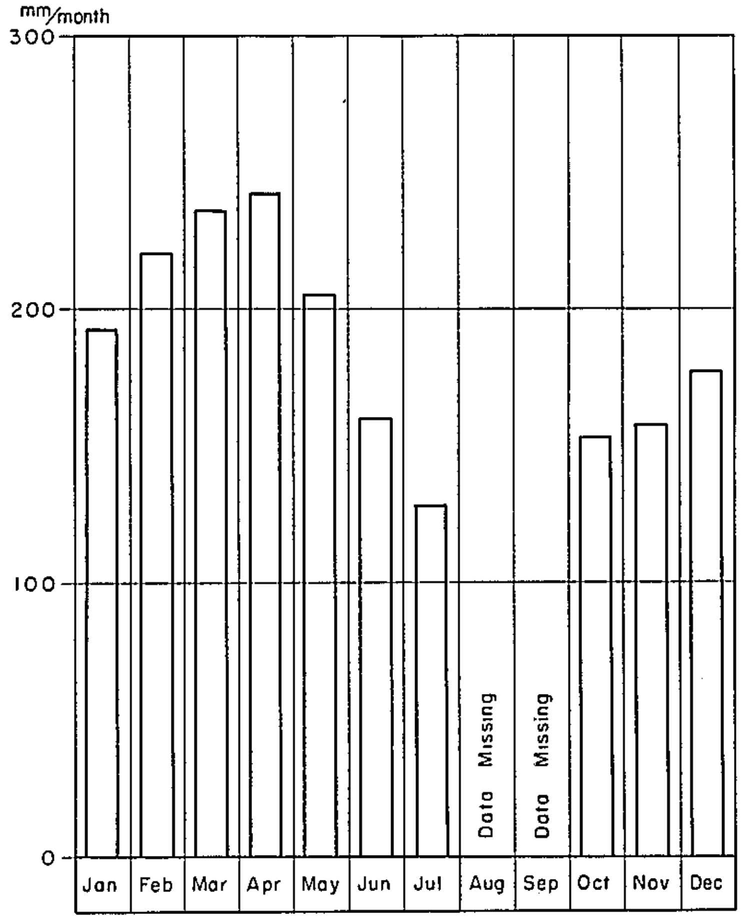
Note: The available volume is the water volume obtainable if the outflow is controlled by means of dikes and gates.

Fig. D-18 Rainy Period (Monthly Precipitation Exceeds 5% of Annual Precipitation)



NOTE Raintall at Phnom Penh

Fig. D-19 Monthly Evaporation at Kratié



NOTE . Avevage, Oct 1962 ~ Jul 1964

(5) Flooding: When the water level of the Mekong rises in the wet season, the mainstream water flows into the tributaries blocking the runoff of the tributaries and causes flooding of the plains on both banks of the Mekong. This flood water does not recede for a considerably long time. As shown in Fig. D-20, the area inundated by the flood water covers an area of 19,000 ha with a depth of 2 m to 3 m that does not recede for a period of 60 to 100 days.

Although utilization of the inundated area is not practicable during the wet season, the silt deposited by the flood water make the farmland in the sloping hinterland beyond the natural levees fertile and highly Productive in the dry season.

In limited districts including Kanhchor, Chhlong, Saop and Prek Prasap, the *colmatage* method has long been practised by drawing the turbid water of the Mekong.

(6) Water Temperature and Quality: The water temperature observed at Stung Treng in 1960 and 1961 by Harza Engineering Co. shows little variation throughout the year and averages 25°C to 30°C. The variation, if any, is generally in proportion to the change in atmospheric temperature.

The water quality was found to be suited for irrigation by the investigations conducted by Mr. J. Kobayashi of Okayama University in Japan, are outlined in Table D-30. The turbid water in the wet season contains much suspended sediments which provide the inundated area with nutritious substances. The suspended sediment further add to the fertility of land by the creation of nitrogen and phosphoric acid resulting from the breeding of duckweeds and the activities of bacteria. The fertility values of water revealed by the test are shown in Table D-31.

Table D-30 Test Results of Water Quality

Unit ppm

River	Time of Sampling	Ca	Mg	Na	K	HCO_3	SO_4	Cl	SiO_2	Fe	PO_4	NO_3 N	NH_4 N	Albuminoid N	$KMnO_4$	T.D.S	T.S.S	Turbidity	PH	Hardness
	1956 Jul.	17 9	2.8	3.6	1 3	66.0	3 7	2.5	12 9	0 00	0.00	0 05	0.02	0 17	7 1	81	-	137 6	6 7	56 0
	Aug	18 9	2 4	2 7	1 1	71.5	2 4	0 7	13.4	0.00	0.00	0.03	0 05	0.33	20.0	80	241 2	107.8	6.6	57 2
	Oct	23.6	3.5	5.0	1 2	92 1	7.6	2 9	12.4	0.01	0.01	0.02	0.02	0 01	3.5	105	154.2	95 1	6.8	73 3
	Nov	26 6	4 2	6 1	1 1	102 9	10 4	4.5	13 6	0.00	0.00	0.01	0.03	0 01	4 9	116	119 5	136.5	6.9	83.8
Mekong	Dec.	29 0	5 7	7.6	1 2	111 2	12.5	3.4	14.6	0.00	0.02	0.01	0.03	0 01	4 9	129	63 6	61.8	7 2	96 0
(Mukdahan)	1957 - Jan.	30.2	6.0	8 6	1 2	114.8	15.0	7 8	17 2	0.00	0 00	0.00	0.02	0.03	6.4	137	46.3	12.6	7 0	100.3
	Feb	31 2	6.3	10.0	1 3	117.0	16.0	9 1	15 1	0.00	0.00	0.00	0.04	0.03	1 1	147	29 8	2 3	7 1	104 1
	Mar	31 9	6.6	10.6	1 3	119 2	19 9	9 9	15 3	0.01	0.00	0.00	0.05	0.06	1.5	152	16 8	13.0	7 1	106 9
	Apr	32 4	6 3	10 3	1 8	119 2	17.5	10.0	14.8	0 00	0.00	0.00	0.08	0.07	1 4	155	21 9	21 3	6 9	106 9
	May	33 7	6.6	12.0	1 9	116 7	21 8	13.4	13 6	0.00	0.00	0.33	0.03	0.30	1 9	164	20 7	5 8	7 0	111 4
	Jun	19 9	3.6	6.5	1 5	73.2	7 4	8 4	9 2	0.00	0.00	0.01	0.06	0.04	3.5	101	285 0	34.5	6.8	64.5
Average		26.8	4 9	7.5	1 4	100 3	12.2	6.6	13.8	0.00	0.00	0.04	0.04	0 10	5 1	124 3	99 9	57 1	6 9	87 3

Source Chemical investigation on River Waters of South-Eastern Asiatic Countries (Report I)
The quality of waters of Thailand by J Kobayashi, Okayama University Japan.

(7) Subsurface Water: In those parts of the project area which lie along the Mekong mainstream and tributaries, many wells are found for drinking water. It is evident that rain water and the Mekong are the sources of the subsurface water in these districts. Investigations revealed that the subsurface water level in the vicinity of Kratie during the period from December to January is 1.5 m to 4.0 m below the surface ground. The subsurface water level starts to rise around May, and reaches the peak during July to September, drops to the lowest during March to April when some of the wells become completely dry.

The quality of the subsurface water is not known, but the water is almost completely free from turbidity. Subsurface water is used only for drinking. Its utilization as source of irrigation water cannot be economically justified compared with surface water of the Mekong mainstream and tributaries.

Fig D-20 PRESENT INUNDATION MAP

PRESENT INUNDATION AREA IN SAMBOR PROJECT

(UNIT : ha)

NAME OF DISTRICT	PROJECT AREA	INUNDATION AREA
KRATIE	6,381	* 5,029
PREK TE (R)	1,348	489
PREK TE (L)	995	780
BOS LEAV	2,696	911
KAMCHOR	2,479	2,188
CHHLONG	3,114	** 2,221
SAOP	7,176	3,990
PREK PRASAP	4,135	2,241
TA MAU	2,029	1,101
KAOH TRUNG	247	0
KAOH CHRENG	638	0
KAOH TASUY	806	0
	34,000	18,987

* OUT OF 5,029 ha (KRATIE DISTRICT), 2,720 ha WILL BE CONVERTED INTO NON-INUNDATED AREA.

** OUT OF 2,221 ha (CHHLONG DISTRICT), 1,000 ha WILL BE CONVERTED INTO NON-INUNDATED AREA.

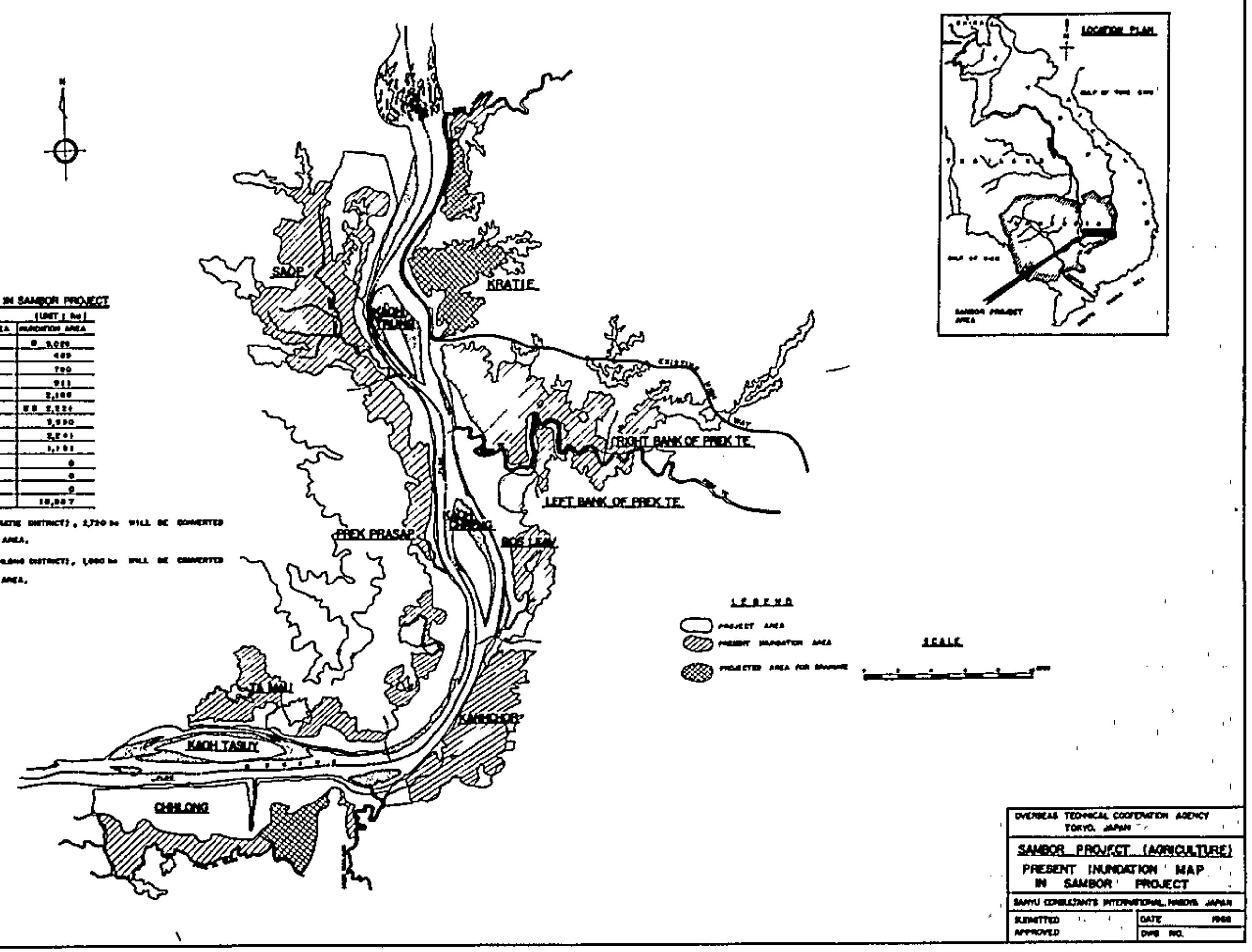


Table D-31 Fertility Values

(Unit: mg/lit)

	PH	K_2O	SiO_2	Alkalinity	Sampling period
Average of 13 places	6.4	1.3	17	35	Jul. to Oct.
Average of 203 tests in Japan	6.9	1.8	18	35	-
Mekong Mainstream (Kompong Cham)	7.3	1.2	24	62	Nov.
Mekong Mainstream (Samrong Thom)	7.0	1.2	14	46	"
Barai Occidental	6.0	0.8	10	10	"

Source: Centre Technique Agricole de l'Amitie Khmero-Japonaise reporting on the fertility effects obtained by continuous 100 day irrigation with 13 mm water per day.

D-3-1-3 Agricultural Economy

(1) Scale of Management: The arable land of 28,806 ha in Kratie Province is mostly found in the area which is inundated by the Mekong mainstream and tributaries. Paddy fields comprise 21,216 ha of the entire arable land (See Chapter D-3-1-2).

The number of farm households in Kratie Provice is 14,900 which constitutes 76% of all households in the province. Each farm household has an average cultivated land of a little less than 2.0 ha, and is composed of 5.8 members on an average. Most of them are owner farmers, and tenant farmers are very few.

(2) Production: Main agricultural products of Kratie Province are rice, maize, mung bean, peanut, sesame and tobacco. Output and cropping pattern of these products are shown in Table D-32 and Fig. D-21. The annual production of rice which is the staple food of the Cambodian people is about 24,000 tons (of which about 20,000 tons can be allocated for food), and this is less than the demand of approximately 30,000 ton by about 130,000 inhabitants of the province (per capita annual consumption is 230 kg). The proposed agricultural development program in the province is justified by this absolute shortage of supply.

With respect to the output per unit of area, estimate has been made, as shown in Table D-33, based on data of Secteur Agricole de Kratie.

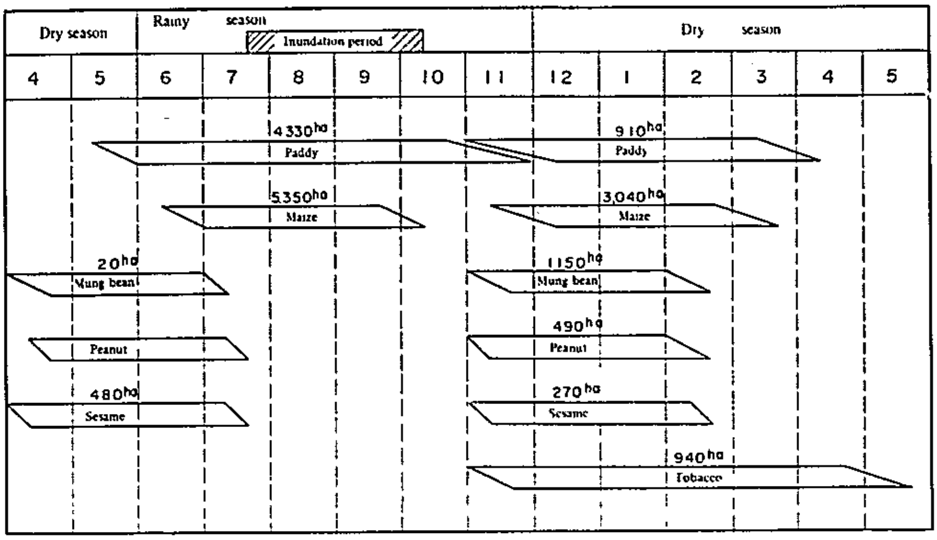
Table D-32 Output of Agricultural Products in Kratie Province

(Unit: tons)

	Wet Season	Dry Season	Total
Rice	22,347	1,227	23,574
Maize	9,218	3,726	12,944
Mung bean	-	1,307	1,307
Peanut	-	146	146
Sesame	213	183	396
Tobacco	-	1,072	1,072

Source: Liste des Superficies de la Production Prevues des Cultures Saison Hieres et Saison Seche dans Campagne 1963 - 65.

Fig. D-21 Present Cultivation Period for Main Crops



(3) Market and Price of Commodities: Each Srok (corresponding to country) has a market where transactions of agricultural products, clothes and daily necessities are carried out. Transactions are conducted between merchants in most cases, though farmers occasionally deal in the business. Collection of rice and maize, main export items of Cambodia, is increasingly undertaken by OROC (Office Royal de Cooperation) which has handled two thirds of the 270,000 tons of exported rice during the fiscal year 1966 and 1967.

Cooperative unions, which are subordinate organizations of OROC, are in direct contact with farmers, and are engaged in such activities as making loans, supplying farmers with various commodities, and promoting the organization of cooperative unions. For the promotion of exports of products, the Government established SONEXIM (Société National d'Exportation et d'Importation) in 1963. The 1967 prices at which agricultural products were purchased (farmer's price) by cooperative unions and merchants are given in Table D-33.

(4) Revenues: For the calculation of the gross and net revenues, all agricultural products were evaluated at their selling price, though not all products are not sold by the farmers. The gross and net revenues from the per ha output of each crop are estimated to be $70 to $400 and $30 to $80 respectively as shown in Table D-33.

In arriving at the above estimate, the output of major agricultural products per unit area was obtained from the data of Secteur Agricole de Kratie, and the selling price from the value mentioned in item (3) above (farmer's price). The production cost as of 1967 was estimated based on *Bulletin de la Statistique et des Etudes Agricoles.* No. 4, 1964 as well as from the investigations conducted by the Agricultural Administration Office of Kratie Province.

The estimated annual net revenue of a standard farmer having 2 ha of arable land is about $90.

In the entire development area, the gross and net revenues are $1,742,000 and $592,000, respectively, as shown in Table D-36 (See Chapter D-3-3-2).

(5) Livestock: The average number of domestic animals owned by each farmer in Kratie Province is 1.9 heads of cattle, 1.6 heads of water buffalos, 0.8 head of pigs and 7.3 of poultry. 1/ Cattle and water buffalos are kept for tilling and transporting purposes. These domestic animals are left free, and no feed crops are grown.

1/ Service Veterinaire et du Epizzoties de Kratie, 1964.

Table D-33 Output, Price and Revenue

Kind of Crop		Output (ton/ha)	Unit Price ($/ton)	Gross Revenue ($/ha)	Production Cost ($/ha)	Net Revenue ($/ha)
Paddy rice	Wet season	1.1	71.6	78.8	49.6	29.2
	Dry season	1.0	71.6	71.6	48.8	22.8
Maize	Wet season	1.3	60.8	79.0	51.1	27.9
	Dry season	1.1	60.8	66.9	50.4	16.5
Mung bean	Wet season	0.7	189.1	132.4	66.0	66.4
	Dry season	0.7	189.1	132.4	66.1	66.3
Peanut	Wet season	0.7	200.1	140.1	60.9	79.2
	Dry season	0.7	200.1	140.1	61.1	79.0
Sesame		0.6	228.5	137.1	67.6	69.5
Tobacco		0.7	582.9	408.0	325.9	82.1

Source: Secteur Agricole de Kratie. Figures for peanut were estimated from *Bulletin de la Statistique et des Etudes Agricoles*, 1964 - 65. Values were converted to $ at the exchange rate of US$1 = 35 Riels.

D-3-2 Scheme of Development

Description has already been given in Chapter C in respect of the delineation of the proposed agricultural development area of 34,000 ha. A portion of this area, or 21,531 ha, is uncultivated and is planned to be developed into paddy fields and upland fields depending on the results of land classification. The area intended for paddy field and upland field, as shown in General Plan and Table D-34, is 19,820 ha and 14,180 ha respectively where irrigation improvement will be effected by using water from the Sambor Reservoir, Mekong tributaries, lakes and ponds, as well as by pumping up water of the Mekong Mainstream. Annual irrigation water requirement is estimated to be 468 million cu.m. An area of 19,000 ha in the development area is inundated by flood water in the wet season. Drainage pumps will be installed in Kratie and Chhlong Districts (3,770 ha) where the drainage work is considered simpler than in the other part of the area.

For the full-scale introduction of the *colmatage* method, exclusive canals will be constructed in the five districts of Kratie, Bos Leav, Kanchor, Prek Prasap and Ta Mau where the method has long been in practice.

It is hoped that the implementation of these plans, which is expected to bring about increased food production and stabilized farm economy in the development area, will provide the basis for the future agricultural development in areas extending along the Mekong.

Table D-34 Breakdown of Project Area

(Unit: ha)

Planned land-category \ Present land-category	Paddy field	Upland field	Uncultivated land	Total
Paddy field	5,017	-	14,803	19,820
Upland field	-	7,452	6,728	14,180
Total	5,017	7,452	21,531	34,000

D-3-3 Agricultural Production after Completion of the Development Program

D-3-3-1 Farming Program

When the development program is completed, the arable land in the development area will increase from the present 13,130 1/ ha to 34,000 ha. Since about 2,000 farming households are expected to move into the area from the land to be submerged under the Sambor Reservoir, the total number of farming household is estimated to be 8,500, and each farmer will have an average of about 4 ha land.

The cropping pattern, shown in Fig. D-22 and Table D-35, have been prepared with due account taken of the changes in natural environment after completion of the program, demand for agricultural products, availability of labor force as well as the most rational farm management.

Fig. D-22 Planned Cultivation Period for Main Crops

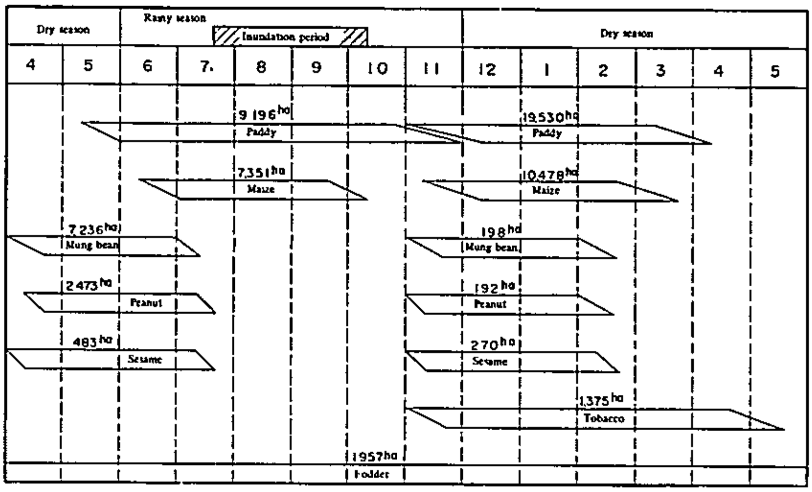


Table D-35 Planting Area

(Unit: ha)

Kind of Crop		Area
Paddy rice	Wet season	9,196
	Dry season	19,530
Maize	Wet season	7,315
	Dry season	10,478
Mung bean	Wet season	7,236
	Dry season	198
Peanut	Wet season	2,473
	Dry season	192
Sesame	Wet season	483
	Dry season	270
Tobacco	Dry season	1,375
Fodder		1,957
Total		60,739

1/ 5,280 ha (paddy field) + 7,850 ha (upland field) = 13,130 ha
The difference 661 ha between upland field 7,452 ha and paddy field 5,017 ha are to be used as facilities such as canals, roads, etc.

D-3-3-2 Agricultural Production

When production is stabilized after completion of the program, the output of major crops will be as follows.

Paddy rice:	86,169 tons
Maize:	71,488 tons
Mung bean:	9,714 tons
Peanut:	3,504 tons
Sesame:	699 tons
Tobacco:	2,179 tons

The gross production and the net revenue are estimated, as shown in Table D-36, to be $14,564,000 and $6,166,000 respectively. These values were calculated on the following premises.

1) The output per unit area would be the value given in Table D-37 which is based on the results of experiments conducted at the experimental farm in Battambang Province and of field investigations.

2) The selling price of products is the farmer's price in 1967.

3) The production cost and output as of 1967, are estimated to be the values given in Table D-38. In determining these values, data of the experimental farm of Battambang Province and the results of field investigations were used.

Achievement of the planned output, which would not be feasible immediately after completion of the program, is considered to require about 10 years.

The development program envisages the establishment of experimental and demonstration farms to disseminate new techniques and knowledge to farmers, and also gives consideration to the expansion of various facilities.

D-3-3-3 Increased Production

The estimated increase of output, gross revenue and net revenue when the stabilized agricultural production is attained after completion of the program, as compared to the existing condition, are given below. (See Table D-36)

1) Output:

Paddy rice:	80,496 tons
Maize:	61,189 tons
Mung bean:	8,895 tons
Peanut:	3,161 tons
Sesame:	249 tons
Tobacco:	1,521 tons

2) Gross revenue: $12,822,000

3) Net revenue: $5,574,000

Table D-36 Increased Revenue

Crop	Existing					Planned					Increased		
	Area (ha)	Total Output (ton)	Gross Revenue ($)	Total Production Cost ($)	Net Revenue ($)	Area (ha)	Total Output (ton)	Gross Revenue ($)	Total Production Cost ($)	Net Revenue ($)	Output (ton)	Gross Revenue ($)	Net Revenue ($)
Paddy Rice	5,240	5,673	406,360	259,176	147,184	28 726	86,169	6 169,351	4,179,861	1,989,490	80 496	5,762,991	1,842,306
Mung Bean	1,170	819	154,908	77,335	77,573	7,434	9,714	1,840,091	869,540	970,551	8,895	1,685,183	892,978
Maize	8,390	10,299	626,026	426 601	199,425	17,829	71,488	4,413,607	2,364,941	2,048,666	61,189	3,787,581	1,849,241
Sesame	750	450	102,825	50,700	52,125	753	699	159 850	89,906	69,944	249	57,025	17,819
Peanut	490	343	68,649	29,939	38,710	2,665	3,504	711,305	292,298	419,007	3,161	642,656	380,297
Tobacco	940	658	383,520	306,346	77,174	1,375	2,179	1,270,089	601,700	668,389	1,521	886,569	591,215
Total	16,980	18,242	1,742,288	1,150,097	592,191	58,782	173,753	14,564,293	8,398,246	6,166,047	155,511	12,822,005	5,573 856

Table D-37 Planned Output per Unit Area

Crop	Output (ton/ha)		
	Class I land	Class II land	Class III land
Paddy rice	3.2	3.0	2.9
Maize	4.2	4.0	3.8
Mung bean	1.4	1.3	1.2
Peanut	1.4	1.3	1.2
Sesame	1.1	1.0	0.9
Tobacco	1.6	1.5	1.4

Table D-38 Planned Production Cost per ha

(Unit: $)

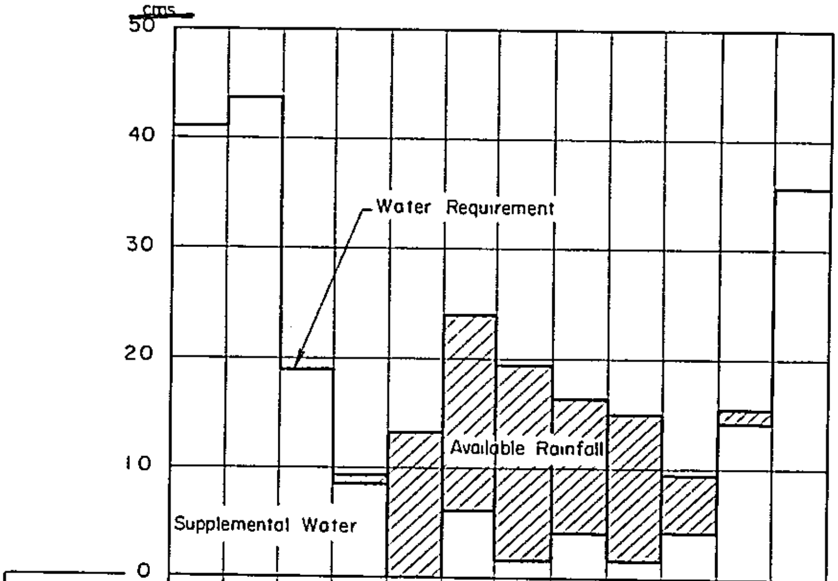
Crop		Production Cost
Paddy rice	Wet season	145.1
	Dry season	145.7
Maize	Wet season	131.0
	Dry season	133.8
Mung bean	Wet season	116.9
	Dry season	119.4
Peanut	Wet season	109.5
	Dry season	112.0
Sesame	Wet season	118.5
	Dry season	121.0
Tobacco		437.6

D-3-4 Irrigation and Drainage

D-3-4-1 Land Development

The land to be reclaimed for cultivation comprises of 14,803 ha of paddy field and 6,728 ha of upland field. Land preparations will be carried out so that flood irrigation would be made possible for paddy fields and furrow irrigation for upland fields. Terminal equipment and drainage canals will cover the entire area of 34,000 ha. A road, 4 m wide, will be constructed on one side of the main and lateral canals.

Fig. D-23 Monthly Water Requirement



Month	Jan	Feb	Mar.	Apr	May	Jun	Jul	Aug.	Sep	Oct	Nov	Dec
Water Requirement	41 1	43 8	19 0	9 3	13 4	23 9	19 4	16 4	15 0	9 3	15 4	35 8
Available Rainfall	0	0	0	0 8	13 4	17 7	17 9	12 3	13 5	5.2	1 1	0
Supplemental Water	41.1	43 8	19 0	8 5	0	6 2	1.5	4 1	1 5	4 1	14 3	35 8

D-3-4-2 Irrigation

(1) Water Requirement: The annual water requirement has been calculated to be 468 million cu.m. The maximum and minimum requirements are 43.9 cu.ms (February) and zero (May), respectively as shown in the monthly variation of water requirement (See Fig. D-23).

These values have been calculated based on the following premises.

1) The cropping pattern would be as mentioned in Chapter D-1-3-1.

2) Evapotranspiration would be the value obtained by the Blaney-Criddle Method, with the empirical coefficient set as follows: paddy rice: 1.0, maize and crops for feed: 0.75, beans, tobacco and sesame: 0.65, and vegetables: 0.55.

3) Percolation of paddy field would be 4.8 mm/day in sandy soil, 2.8 mm/day in loamy soil and 0.8 mm/day in clayey soil.

4) Irrigation efficiency of upland fields would be 50% in sandy soil, 70% in loamy soil and 80% in clayey soil.

5) Conveyance losses including operational loss would be 25% in paddy field and 20% in upland field.

6) Domestic water for general purposes would be 4,000 liters per farm family.

(2) Water Source: For irrigation purpose, 238 million cu.m per annum of water would be drawn from the Sambor Reservoir having an effective storage capacity of 2,050 million cu.m. Water will be drawn from two places on the right bank and one place on the left bank at EL 38.0 m. For the effective utilization of water, dikes and gates will be built at major lakes and ponds in the development area to prevent the outflow of water. Total volume of water available annually from the eight lakes and ponds in the area is expected to be 21 million cu.m. A total of three dams, two upstream of the Prek Saop and one upstream of the Prek Te, will be constructed to secure an annual water supply of 38 million cu.m. An outline of the three reservoirs is given in Table D-39 below.

Table D-39 Outline of Tributary Reservoirs

Reservoir	Paprak	Chuspok (Saop)	Khrach Touch
River	Prek Saop	Prek Saop	Prek Te
Catchment area (sq.km)	110	230	35
Annual discharge (10^6 cu.m)	177	371	41
HWL (m)	29.0	28.0	33.0
Effective storage capacity (10^6 cu.m)	20	10	5

Reservoir water will be conducted through canals by gravity flow, but pumping facilities will be required to utilize the water of the Mekong and lakes (See Table D-40). Pumps will be installed at 23 places to secure an annual water volume of 156 million cu.m. Power required to operate the pumps is estimated to be about 2,200 kW.

The total length of canals is 557.4 km, consisting of 106.6 km of mains and 450.8 km of laterals that will tap the water sources and supply water to farm lands. Canals will be constructed without timbering work. Available water by source is given in Table D-40.

Table D-40 Available Water by Source

Water Source	Volume (10^6 cu.m)	Remarks
Sambor Reservoir	238	
Mekong tributaries	53	Water to be obtained by construction of reservoirs and pumping up
Lakes and ponds	21	Water to be obtained by pumping up
Mekong mainstream	156	"
Total	468	

(3) Planned Irrigation System: The irrigation system is given in Fig. D-24.

D-3-4-3 Drainage

The proposed drainage area has a catchment area of 8,900 ha, of which 3,770 ha is inundated by flood water and 2,845 ha is intended for drainage improvement. Breakdown by district is given in Table D-41.

Fig. D-24 Irrigation and Drainage Systems

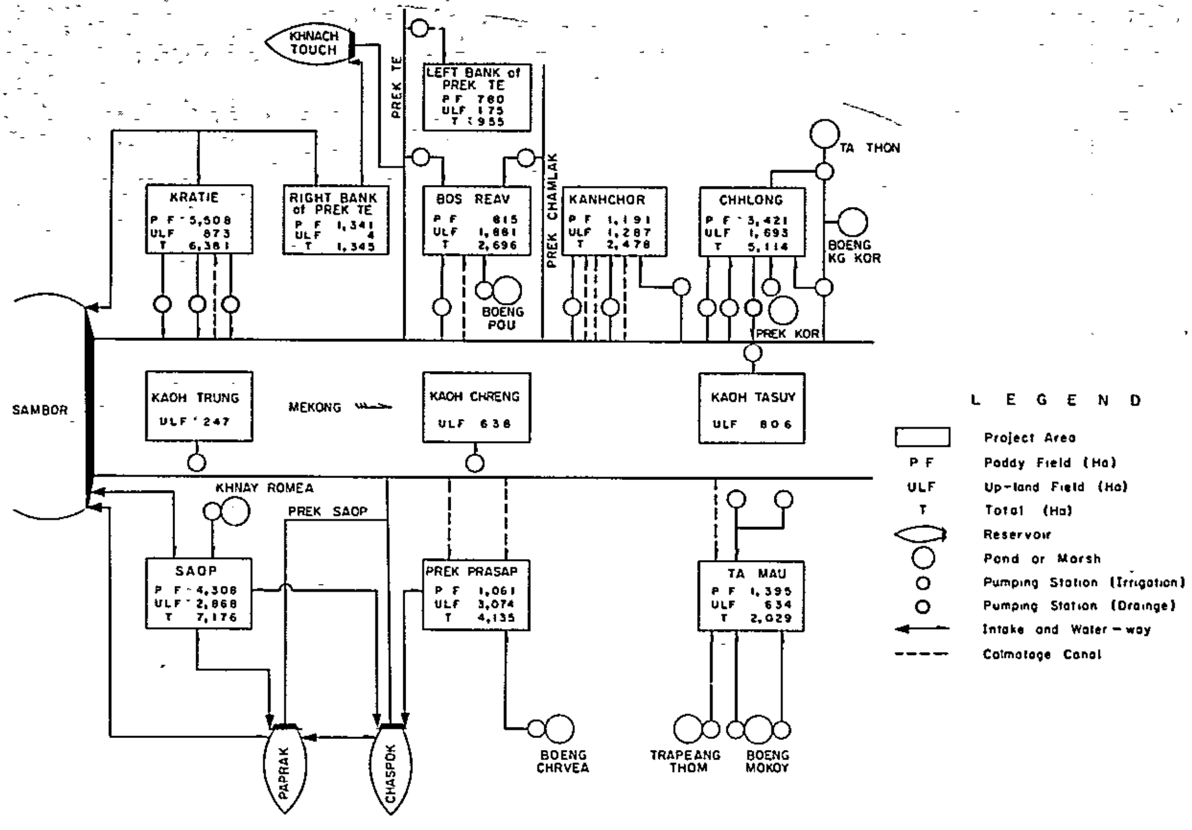


Table D-41 Breakdown of Proposed Drainage Area

(Unit: ha)

District	Catchment Area	Inundated Area	Drainage Area (Paddy Field)
Kratie	7,100	2,720	1,960
Chhlong	1,800	1,050	885
Total	8,900	3,770	2,845

The drainage discharge from the area given below was estimated as follows.

Kratie district:

Prek Sambok:	2.57 cu.ms
Prek Krakor:	8.90 cu.ms
Prek Pring:	2.17 cu.ms

Chhlong: 3.70 cu.ms

In making the above estimate, the allowable flooding depth has been set at 0.4 m on the basis of the maximum 30 days rainfall of 497 mm recorded at Kratie in 1965, with account taken of drainage restrictions through notches installed in paddy fields and through tributaries. Drainage pumps to be installed in each district will require 1,937 kW of power. Description of pumping facilities is given in Table D-42.

Table D-42 Description of Pumping Facilities

District	Drainage Discharge (cu.ms)	Head (m)	Power (kW)
Sambok	2.57	7.10	274
Krakor	8.90	7.75	1,035
Pring	2.17	7.12	232
Chhlong	3.70	7.14	396
Total			1,937

Canals leading to each pump will have a total length of 30.5 km.

D-3-4-4 *Colmatage* Canal

Eight *colmatage* canals having a total length of 8,600 m will be constructed. (See Fig. D-24) In designing these canals, considerations were given to the following.

1) Water of the Mekong should be taken in for a total of about 100 days each year.

2) The design of the canal should be such to permit unobstructed flow by the fluctuation of the water level of the Mekong (Daily maximum: 1.8 m).

3) No silt should be deposited in the canals. Accordingly, the velocity should not be less than 2.0 m/sec and the canals should be lined.

D-3-5 Major Structures

D-3-5-1 Dams

Name	Type	Crest Length (m)	Height (m)	Volume (1,000 cu.m)
Sambor		(See Chapter D-1-1)		
Paprak	Fill	2,950	8	222
Chaspok	Fill	2,520	12	537
Khnach Touch	Fill	830	4	24

D-3-5-2 Pumps

Purpose	No. of Installation Sites	Type	Head (m)	Power (kW)
Irrigation	23	Centrifugal	4 to 30	6,859
Drainage	4	Swash plate	7 to 8	1,937
Total	27			8,796

D-3-5-3 Canals

Purpose	Structure	Length (km)	Remarks
Irrigation:		557.4	
Main canal	Unlined	106.6	
Branch canal	"	450.8	
Drainage:		30.5	
Main canal	"	18.1	
Branch canal	"	12.4	
Colmatage	Concrete lined	8.6	8 canals

D-3-5-4 Gates for Lakes and Ponds

Quantity: 10

D-3-5-5 Land Development

Type	Area (ha)
Paddy field	14,803
Upland field	6,728
Total	21,531

CHAPTER E. CONSTRUCTION

CHAPTER E. CONSTRUCTION

E-1 Basic Construction Schedule

From the required construction period and supply-and-demand balance, it was assumed that power from the Sambor Project would be on the line in 1978, and the basic construction schedules for navigation and agriculture have been formulated to coincide with the power program. The basic construction schedule of each aspect of the project is given in Figs. E-1 and E-2, and description of the schedule of each project component is given in the following subsections.

Fig. E-1 Construction Schedule for Power and Navigation

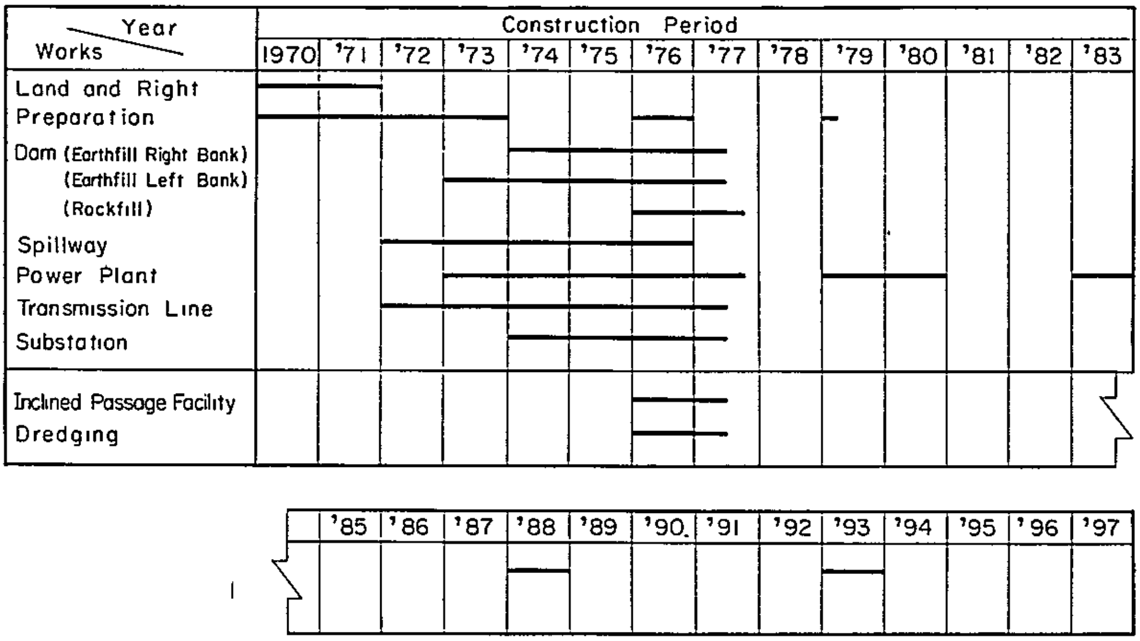
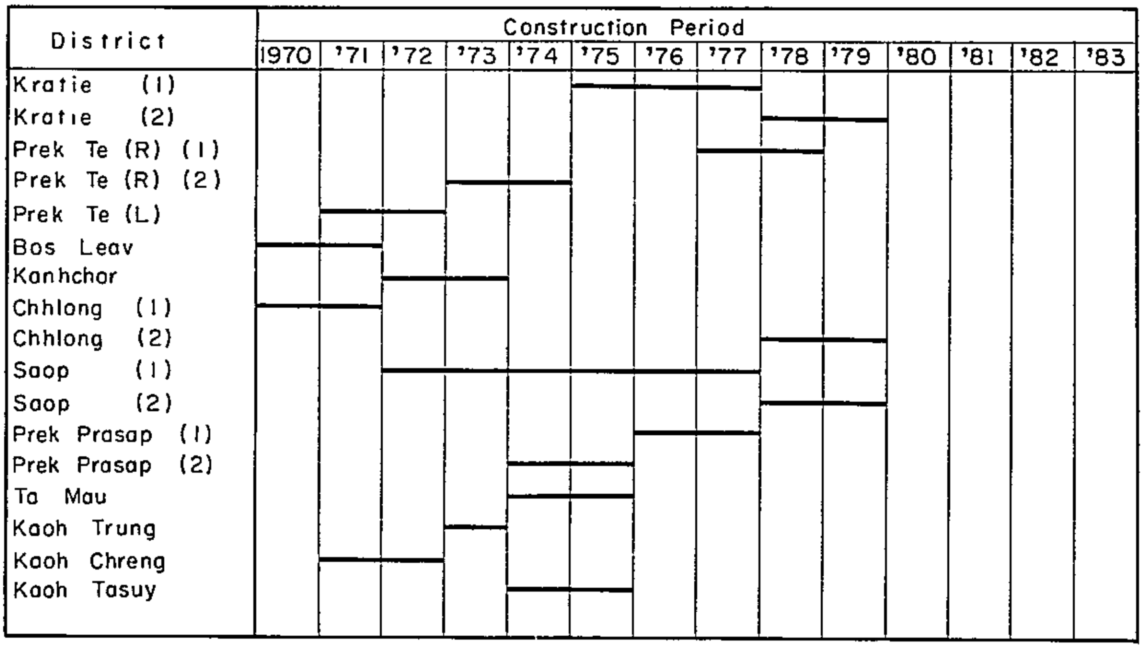


Fig. E-2 Construction Schedule for Irrigation and Drainage Project



E-1-1 Power

(1) In view of the scale of the construction work, nature of each structure, capacity of contractors, as well as the time required for the delivery of machines and equipment, start of construction of the principal works has been scheduled as follows: spillway, powerhouse and transmission line, from 1973, left bank earth-fill dam from 1974 and right bank earth-fill dam from 1975.

Construction of the rock-fill dam in the river bed is planned to be started in the dry season of 1976. By this time, earth-fill dams on both wings, spillway and powerhouse would essentially completed, and diversion and care of the river during construction is to be handled through the intake for the future generating units and the spillway which will used as temporary diversion channels. Embankment of rock in the first dry season is to be executed up to EL 12 m to permit the diversion of water through the temporary diversion channels. After the dam is built up to this evelation full-scale embankment work will start from both ends of the dam. As the construction work proceeds, the river flow will be forced through a narrow, channel causing the upstream water level to rise. At this stage almost all of the discharge would be flowing through the temporary diversion channel. Final closure of the river bed is scheduled to be executed in the dry season of 1977.

(2) Five units of turbines and generators are scheduled to be installed by 1977, and one each in 1980 and 1983.

(3) Execution of the above construction schedule should be preceded by preparatory works including access roads, construction camp for construction, relocation of roads and other temporary facilities.

E-1-2 Navigation

Navigation improvement includes the construction of inclined passage facility and dredging work.

Construction of one line for rafts and dredging work are to start one and a half years prior to the scheduled date of completion of the dam, in order that the inclined paszage facility will be ready for service simultaneously with the completion of the dam. For this purpose, detail design work should start one and a half years before the scheduled date of commencement of construction, and during this one and a half years, the detail design, the bid documents and preparatory works should be completed.

Of the two lines for medium-sized vessels, construction of one line is planned to be commenced in 1988 and the other in 1993. Construction period required for each line is one year.

E-1-3 Irrigation and Drainage Facilities

Construction period of irrigation and drainage facilities is scheduled to be 10 years from 1970 to 1979.

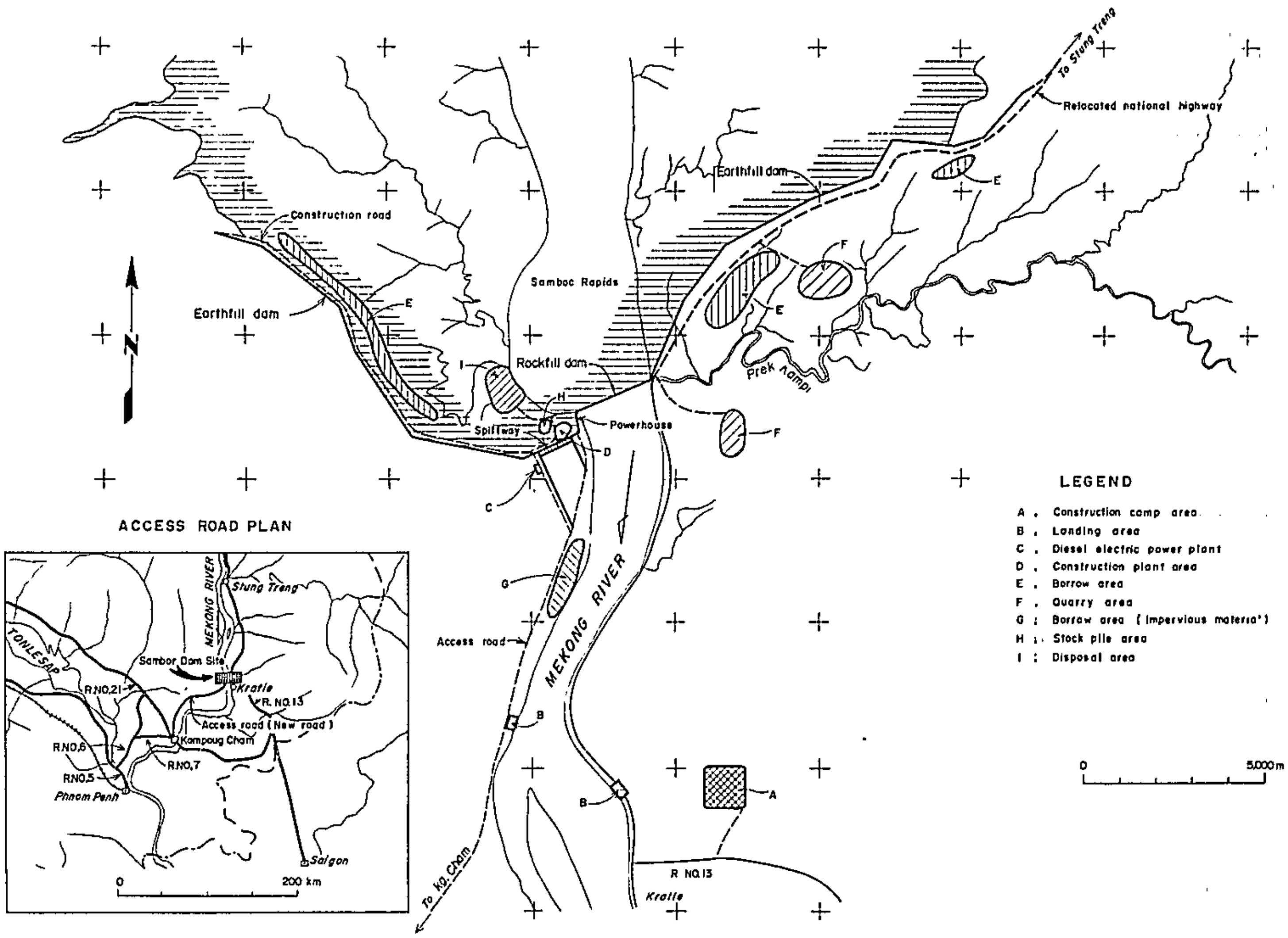
For the formulation of the development program, the development area has been divided into 12 districts by type of farm management and water utilization. The area has also been divided into 17 work districts by type and commencement time of various construction work to be executed. Construction work is to be initiated in Bos Leav and Chhlong Districts where experimental farms would be established. In those districts which will rely exclusively on the Sambor Reservoir for supply of water, construction is planned to be started upon completion of the dam. These districts are the two districts of Kratie, one district of Prek Te and two districts of Chhlong. Construction in other districts has been planned to be executed in such a way that the annual volume of work would become approximately equal. The construction period for each district is about two years.

E-2 Construction Method

E-2-1 Preparatory Work

The layout of the construction camp, landing facilities on the Mekong, power for construction (diesel), construction plants, access roads and relocation of roads is shown in Fig. E-3.

Fig. E-3 Project Layout



E-2-2 Dam

The structure in the river bed section will be a rock-fill dam with an inclined impervious core, 2,350 m long at the crest. Embankment of the dam is planned to be executed in water after the powerhouse and other structures are essentially completed. Since coffering will not be employed in the construction of the dam, large boulders and other suitable materials must be used to prevent the materials from being washed away by the velocity of flow, the work must be completed within as short a period as possible in the dry season. Highly advanced techniques are required for the in-water embankment work particularly of the impervious zone. It is therefore necessary that detailed material tests be conducted and careful work schedule be established at time of the detail design work.

Location of borrow areas is shown in Fig. E-3. It may be possible to use excavated materials from the powerhouse site for embankment in the dam.

E-2-3 Powerhouse

The power installation of the Sambor Project, if developed as an Isolated Project and assumed to adopt Type I power consumption scheme, would consist of seven units of turbines and generators. In the first stage, that is, in 1977 when the dam is scheduled to be completed, five units will be installed. However, the foundations for the two units in the second stage plus foundations for the future five units, which can be additionally installed upon completion of the proposed upstream projects, will be constructed in the first stage, too. The intakes and bays for the two units and the future units will be utilized as temporary diversion channels during construction of the dam.

E-2-4 Inclined Passage Facility

The foundation of the inclined passage facility is scheduled to be executed simultaneously with the construction of the rock-fill dam and will form a component part of the dam.

E-2-5 Dredging

The river bed for a distance of 3 km from the downstream end of the inclined passage will be dredged to elevation of 3.5 m. The estimated volume to be dredged in this section of the river is expected to be rather small, and dredging will be performed by rock cutter and grab bucket dredger (volume: rock 95,000 cu.m).

The existing shoals between 7 km and 14 km, and those at a point about 25 km downstream of Stung Treng, will be dredged to elevation of 34.4 m. Since the deposit on the river bed in these sections are mostly sandy, a pump-dredger or a grab bucket dredger will be used (volume: sand 570,000 cu.m).

E-2-6 Land Development and Canals

In the land development work, bulldozers will be used for clearing, stumping and land leveling. Final preparations such as removal of gravels, and first plowing are to be performed manually, (50 men per ha). The total length of the irrigation canals is long, and in order to curtail the construction period, the work will be divided into several sections.

CHAPTER F. ESTIMATE OF CONSTRUCTION COST

CHAPTER F. ESTIMATE OF CONSTRUCTION COST

F-1 Basis of Cost Estimation

Construction costs for all aspects of the project have been estimated based on the commodity prices as of January 1967, with consideration given to the natural conditions of the project area, regional socio-economic environments as well as the present level of construction technique. In the power aspect, Type I power consumption scheme is assumed to be adopted.

The principal bases on which the costs of the project were estimated are described in the following paragraphs.

F-1-1 Scope of Estimate

(1) In the power aspect, the estimated costs include structures such as dam, powerhouse, spillway, as well as of electrical and mechanical equipment, transmission lines, substations, communication equipment for the administration and operation of these installations, and temporary facilities such as access roads and construction camps. Contingencies and engineering fee were also included in the estimated cost.

The cost of the dam has been included in the power aspect.

(2) In the navigation aspect, the construction costs have been estimated for the inclined passage, channel dredging, ancillary and temporary facilities, and includes contingencies and engineering fee.

(3) Cost for the agricultural aspect covers land reclamation, irrigation canals and intakes, drainage canals, pumping stations, reservoirs and ponds, *colmatage* canal, and aoso includes experimental farms, contingencies and engineering fee.

(4) In the estimated costs of the three project components, the following costs have not been included

(a) Interest during construction (It is taken into consideration in the economic evaluation and the financial program. See also Chapter K, K-4)

(b) Duties and taxes

F-1-2 Basis of Estimation

(1) In estimating the amount of indemnity for relocation of farm houses in the reservoir area, evaluation of houses and public buildings have been made on the basis of data provided by the Governor of Kratie Province.

(2) The civil works has been assumed to be executed on contract basis, and the cost estimate has been made on the basis of data obtained through experiences in similar works in Japan, with account taken of local conditions including unit costs adopted by the Cambodian Ministry of Public Works.

(3) The contingencies for power and navigation are 15% for civil works and 5% for other works. For irrigation and drainage, a 10% contingencies has been included.

(4) The engineering fee, which is the costs of detailed design work and supervision of construction work, is estimated as follows:

Power:	about 4.5% of the estimated total cost
Navigation·	about 4.8% of the estimated total cost
Agriculture:	about 9% of the estimated total cost

F-1-3 Costs in Local and Foreign Currencies

Construction costs have been divided into two portions, namely, local currency and foreign currency Estimate in local currency covers wages of local laborers, living expenses in Cambodia of dispatched foreign supervisors and technical advisors, costs of construction materials available in Cambodia including timber, aggregates, power, and inland transportation charges

All costs and charges other than those covered above are included in the foreign currency requirement

Construction materials to be imported from abroad are assumed to be procured from Japan.

F-2 Funds Required

F-2-1 Total Funds Required

The total funds, required for the Sambor Project as estimated on the above-mentioned basis and shown in Table F-4, amounts to $358,030,000 comprising of $256,588,000 (71.7%) in foreign currency and $101,442,000 (28.3%) in local currency. The cost for each feature of the project is $318,100,000 (88 8%) for power, $5,030,000 (1.4%) for navigation and $34,900,000 (9.8%) for agriculture. Thus, the major portion of the funds is required for the power aspect.

The breakdown of the funds required by items of work for each aspect of the project is shown in Table F-1 through F-3. It will be noted that the funds for the construction of the powerhouse constitutes about 50% of the power aspect, for the inclined passage facility about 45% of the navigation aspect, and for the main irrigation canals and land reclamation about 57% of the agriculture aspect.

F-2-2 Annual Funds Required

Annual funds required, shown in Table F-4, have been calculated on the basis of the construction schedule described in Chapter E If the construction period is divided into two stages, the first stage is the construction of the dam, powerhouse and one line of inclined passage which are scheduled to be completed in 1977, and the second stage is the installation of two generating units and construction of two inclined passages. The funds required for the first stage is $322,532,000 and the second stage is $35,498,000. Of the funds required in the first stage, the foreign currency is $231,307,000 and the local currency is the equivalent of $91,225,000. Consequently, in the first stage, an amount equivalent to about $10,000,000 will be required in local currency.

Table F-1 Construction Cost of Power Program

(Unit: $1,000)

Description	Total	Foreign Currency	Local Currency
Dam and Reservoir			
Land and water rights	3,240		
Compensation for relocation of farm houses	2,140		
Earth-fill dam on left bank	12,400		
Rock-fill dam in river bed	14,400		
Earth-fill dam on right bank	10,900		
Spillway	53,000		
Spillway retaining wall	4,020		
Subtotal	99,700	66,220	33,480
Powerhouse			
Civil work	94,800		
Electrical equipment	62,700		
Subtotal	157,500	118,180	39,320
Transmission Line and Substations			
Sambor-Phnom Penh	10,700		
Phnom Penh-Sihanouk Ville	8,900		
Sambor-Saigon	6,300		
Substations	19,400		
Subtotal	45,300	39,100	6,200
Other Facilities			
Communication facilities	1,400		
Maintenance equipment for transmission	500		
Subtotal	1,900	1,400	500
Engineering Fee	13,700	11,700	2,000
Total	318,100	236,600	81,500

Table F-2 Construction Cost of Navigation Program

(Unit: $1,000)

Description	Total	Foreign Currency	Local Currency
Inclined Passage Facility			
Embankment	1,445	740	705
Sleepers	115.2	61.2	54
Rails	117	90	27
Winches	99.6	67.5	23.1
Cradles	154	120	34
Pusher	16 4	13	3.4
Machine room	181	92	89
Others	164.8	92.3	72.5
Subtotal	2,293	1,285	1,008
Dredging			
Downstream of Stung Treng	537	342	195
Downstream of Sambor Dam	1,120	710	410
Subtotal	1,657	1,052	605
Other Works	50	10	40
Contingency	573	331	242
Access Road and Field Office	228.5	133 5	95
Engineering Fee	228.5	133.5	95
Total	5,030	2,945	2,085

Table F-3 Construction Cost of Agricultural Program

(Unit: $1,000)

Description	Total	Foreign Currency	Local Currency
Land reclamation	10,640	6,400	4,240
Irrigation canals	9,030	3,100	5,930
Drainage canals	548	190	358
Pumping station	5,000	1,930	3,070
Reservoirs & ponds	2,795	1,670	1,125
Colmatage construction	1,010	380	630
Contingency	2,896	1,303	1,593
Experimental farms	85	43	42
Engineering fee	2,896	2,027	869
Total	34,900	17,043	17,857

Table F-4 Summary of Annual Construction Cost

(Unit $1,000)

Description	Currency	Total	First Stage 0	1 1970	2 1971	3 1972	4 1973	5 1974	6 1975	7 1976	8 1977	Subtotal	Second Stage 9 1978	10 1979	11 1980	12 1981	13 1982	14 1983	After 1983
A Power																			
Dam & Reservoir	F	66,220		8,480	7,060	3,310	7,570	10,850	12,570	8,190	8,190	66,220							
	D	33,480		3,400	3,010	2,300	4,920	6,340	6,290	3,630	3,590	33,480							
Subtotal		99,700		11,880	10,070	5,610	12,490	17,190	18,860	11,820	11,780	99,700							
Powerhouse	F	118,180		8,950	7,330	3,060	9,950	10,600	19,450	25,710	17,670	102,720		4,860	5,440			5,160	
	D	39,320		3,650	3,150	2,250	4,740	6,070	6,430	4,620	4,000	34,910		2,730	880			800	
Subtotal		157,500		12,600	10,480	5,310	14,690	16,670	25,880	30,330	21,670	137,630		7,590	6,320			5,960	
Transmission Lines & Substations	F	39,100		2,140	1,060	2,140	1,060	4,530	4,890	12,220	10,000	34,840		1,480	2,780				
	D	6,200		840	420	840	420	780	1,360	1,350	750	5,500		230	470				
Subtotal		45,300		2,980	1,480	2,980	1,480	5,310	6,250	13,570	10,750	40,340		1,710	3,250				
Other Facilities	F	1,400						120	180	800	300	1,400							
	D	500						100	80	210	110	500							
Subtotal		1,900						220	260	1,010	410	1,900							
Engineering Fee	F	11,700	3,890	620	530	360	730	1,010	1,330	1,450	1,140	7,170		240	250			150	
	D	2,000	670	110	90	60	130	170	210	250	200	1,220		40	40			30	
Subtotal		13,700	4,560	730	620	420	860	1,180	1,540	1,700	1,340	8,390		280	290			180	
	F	236,600	3,890	18,050	14,920	8,870	19,310	27,110	38,420	48,370	37,300	216,240		6,580	8,470			5,310	
Total	D	81,500	670	7,160	6,250	5,450	10,210	13,460	14,370	10,060	8,650	76,280		3,000	1,390			830	
		318,100	4,560	25,210	21,170	14,320	29,520	40,570	52,790	58,430	45,950	292,520		9,580	9,860			6,140	
B Navigation	F	2,945							16	991	1,190	2,197							748
	D	2,085							14	684	855	1,553							532
Total		5,030							30	1,675	2,045	3,750							1,280
	F	239,545	3,890	18,050	14,920	8,870	19,310	27,110	38,436	49,361	38,490	218,437		6,580	8,470			5,310	748
A + B	D	83,585	670	7,160	6,250	5,450	10,210	13,460	14,384	10,744	9,505	77,833		3,000	1,390			830	532
Total		323,130	4,560	25,210	21,170	14,320	29,520	40,570	52,820	60,105	47,995	296,270		9,580	9,860			6,140	1,280
C. Agriculture	F	17,043	578	1,190	1,553	1,404	1,239	1,586	1,966	1,553	1,801	12,870	2,247	1,926					
	D	17,857	580	1,240	1,619	1,464	1,291	1,653	2,049	1,619	1,877	13,392	2,342	2,123					
Total		34,900	1,158	2,430	3,172	2,868	2,530	3,239	4,015	3,172	3,678	26,262	4,589	4,049					
	F	256,588	4,468	19,240	16,473	10,274	20,549	28,696	40,402	50,914	40,291	231,307	2,247	8,506	8,470			5,310	748
A + B + C	D	101,442	1,250	8,400	7,869	6,914	11,501	15,113	16,433	12,363	11,382	91,225	2,342	5,123	1,390			830	532
Grand Total		358,030	5,718	27,640	24,342	17,188	32,050	43,809	56,835	63,277	51,730	322,532	4,589	13,629	9,860			6,140	1,280

Remarks F Foreign currency requirements D. Domestic currency requirements

CHAPTER G. ECONOMIC EVALUATION

CHAPTER G. ECONOMIC EVALUATION

G-1 Method of Analysis

Two methods are generally employed to evaluate the economics and determine the priority of a project, namely, (1) actualization calculation system and (2) rate of return method. The former is applicable when the interest rate charged in the financial market is predictable to some extent, while the latter is a method by which the difficulty of fixing the discount rate can be avoided and the project feasibility is judged by first obtaining the marginal rate of return on the invested capital, or the discount rate at which the benefit and cost become equal, and by comparing it with that of alternative projects or studying it in relation to the loan conditions of the financial market. The economic evaluation of the Sambor Project is made by the latter method instead of benefit-cost ratio at the request of the Mekong Committee.

The internal rate of return is obtained by the following equation.

$$K = \sum_{t=1}^{n} \frac{Rt}{(1+i)^t}$$

Where

K	:	Initial investment (including interest during construction of the same rate i as the rate of return)
i	:	Rate of return
Rt	:	Cash flow (income minus expenditure) in the t th year
n	:	Capital recovery period

Economic evaluation for each aspect of the project will be described in the following sections.

G-2 Internal Rate of Return for Power

G-2-1 Benefit

(1) Power Sales: As described in Chapter D, the demand estimate is made of three cases, i.e., Type I, II and III.

The annual energy output of the Sambor Project, when developed to the maximum output of 875 MW, will be 7,000 million kWh in a mean hydro year (the average of 35 years), and the energy sales in the above-mentioned three cases will be as follows.

(a) Type I: If the powerhouse is commissioned in 1978, 141 million kWh will be consumed by general demand, 2,016 million kWh by the aluminum refining industry, and 1,747 million kWh by other power-oriented industries, totaling 3,904 million kWh. The general demand will continue to grow until it reaches 5,731 million kWh in and after 1986.

(b) Type II: In this case, no aluminum refining industry is included, and power will be allocated to other power-oriented industries and general demand. Power sales will reach to 1,034 million kWh in 1978, and with the gradual growth of general demand the energy sales will reach to 4,728 million kWh after 1990.

(c) Type III: In this case, power will be allocated only to general demand. Sales will reach only to 141 million kWh in 1978, but will increase to 4,415 million kWh in and after 1991 with the gradual growth of demand.

At the final period of each type of consumption pattern, the surplus energy, after deducting an overall loss of 4% between the powerhouse and load centers, will be 1,028 million kWh for Type I, 2,073 million kWh for Type II, and 2,400 million kWh for Type III. The ratio of surplus energy to total available output will be 15%, 30% and 34%, respectively.

Type I is recommended as most suitable power consumption program from the standpoint of effective utilization of power and for the early development of the project.

(2) Unit Value of Benefit: The unit value of benefit has been determined separately for general demand and power-oriented industries.

(a) Unit Value of Benefit for General Demand: The power charge is around 60 to 80 mills/kWh in Phnom Penh District where electricity is supplied at the lowest rate in Cambodia, and around 60 mills/kWh in Saigon-Cholon District, the cheapest in Vietnam. These high rates are one of the obstacles hindering the industrial and economic development in the two countries. In determining the unit value of benefit, therefore, the prevailing power charge was not taken into account, but the cost of power assumed to be generated by an alternative project located adjacent to the load center has been taken as the unit value. On the assumption that this alternative power source would be a thermal plant having two 125 MW oil burning units operating at an average thermal efficiency of 36.5% and a load factor of 60%, and that the interest rate would be 6%, the cost of power from this alternative source has been calculated to be around 9 mills/kWh, delivered at the load center. This value has been adopted as the unit value of benefit for general demand.

(b) Unit Value of Benefit for Power-Oriented Industries: The power charge for power-oriented industries should be fixed at a rate which would permit the industries to develop competitively on the international market. Comparative studies of power rates charged to the aluminum refining industry in various countries of the world led to the conclusion that the attractive rate for this industry would be within the range of 2 to 3 mills/kWh. The average of 2.5 mills/kWh has therefore been taken as the unit value of benefit for the aluminum refining industry.

With respect to other power-oriented industries, the unit value of benefit should be set at a level somewhat lower than that of the aluminum refining industry because they consume secondary energy. Therefore, the unit value for power-oriented industries, other than aluminum refining, has been set at 2 mills/kWh.

(3) Benefits: Based on the above-mentioned energy sales and the unit values of benefits, the annual benefits in a mean hydro year after full load operation of 875 MW are estimated as follows.

(a) Benefits for Type I:

	Benefit ($1,000/year)
General demand	17,712
Aluminum refining industry	5,040
Other power-oriented industries	3,494
Total	26,246

(b) Benefits for Type II:

	Benefit ($1,000/year)
General demand Power-oriented industries other than aluminum refining	36,301

(c) Benefits for Type III:

	Benefit ($1,000/year)
General demand	39,735

G-2-2 Cost

(1) Operation and Maintenance Cost: The operation and maintenance cost have been calculated on the basis of actual costs of projects of similar scale. Upon completion of the 875 MW installation, the operation

and maintenance cost will be as follows.

	Assumption
Salaries and wages	80 persons
Maintenance and repair of civil structures and transmission lines	0.75% of total construction cost of these facilities
Electrical and mechanical equipment	0.6% of the total cost of the equipment
Other costs	10% of the total expenses above

(2) Replacement Cost: The serviceable life of civil structures and transmission lines has been set at 50 years, and that of turbines, generators and substation equipment at 35 years. The replacement cost during the serviceable life is as follows.

	Replacement Year	Cost ($1,000)		
		Type I	Type II	Type III
Turbine, generator and substation equipment	2012	67,400	47,600	39,300
ditto	2015	11,200	8,300	8,300
Turbine and generator	2017		6,100	6,100
ditto	2018	6,100		
Turbine, generator and substation equipment	2019		10,500	10,500
Turbine and generator	2021		6,100	6,100
ditto	2023		6,100	6,100
ditto	2024			
Total		84,700	84,700	76,400

G-2-3 Internal Rate of Return

The annual benefits, and operation and maintenance costs based on the above-mentioned conditions are shown in Table G-1.

Based on the above data, the internal rate of return for power over a 50 years period has been calculated as follows by means of an electronic computer.

Type I:	4.4%
Type II:	5.3%
Type III:	5.3%

G-3 Internal Rate of Return for Navigation

G-3-1 Benefit

(1) Volume of Traffic: At present, in the project area 10,000 tons of daily necessities are transported by truck, 8,000 tons of timber by water, and 30,000 persons are carried by bus each year. With the improvement of navigation, the volume of cargo and passenger traffic by water will show a sizeable growth. It is estimated that the volume of cargo and passenger traffic will increase by 11.5% annually.

From the 20th year after the project is put into operation, or in and after 1997, the volume of water traffic will expand to 120,000 tons per year of cargo (64,000 tons of general cargo and 56,000 tons of lumber) and to 200,000 passengers per year.

(2) Benefit: The benefits of navigation can be considered to be of the following three categories.
(a) Inclined passage tolls to be collected by the operating organization
(b) Income of transportation agencies operating organization
(c) Reduction of transportation cost to consignors and passengers, namely, the difference between the present and future freight and passenger fares.

These benefits are explained by item below.

(a) Inclined Passage Toll: An attempt to amorize the investment and to pay the operation costs of the inclined passage facility solely by the tolls would not reduce the cost of water transport as compared with overland transportation, and the significance of the project would be lost. Therefore, the toll rate has been set at about 1/30 of the difference between the prevailing cost of overland transportation and the assumed cost of water transportation. In determining the toll charge, the fares charged by state-operated ferryboats have been used as reference.

As a result, the toll rate, as the unit value of benefit, has been determined at $0.25 per ton for general cargo, $0.03 per person for passengers, and free for lumber. In 20 years after the project is put into operation, the annual toll income will amount to $22,000 as shown below.

	Volume (t)	Unit ($/t)	Income ($)
Charcoal	5,000	0.25	1,250
Daily necessities	54,000	0.25	13,500
Lumber	56,000	0	0
Other cargo	5,000	0.25	1,250
Passengers	200,000 (persons)	0.03	6,000
Total			22,000

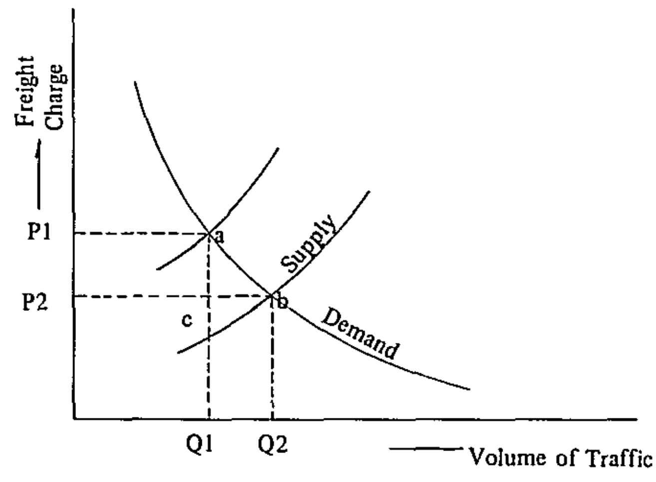
(b) Income of Transportation Agencies: The income of transportation agencies has been estimated based on the above-mentioned volume of traffic as well as on the assumed unit revenues and unit costs after completion of the navigation structure which were estimated from the present transport costs. The annual income of transportation agencies in 20 years after the project is put into operation will reach to $159,000 as broken down below.

	Volume (t)	Freight ($/t)	Costs ($/t)	Net Income ($)
Charcoal	5,000	9.0	7.8	6,000
Daily necessities	54,000	6.5	5.7	43,200
Rafts	56,000	4.1	3.5	33,600
Raft tugboat	56,000	1.2	1.0	11,200
Other cargo	5,000	6.5	5.7	4,000
Passengers	20,000(persons)	1.4	1.1	60,000
Total				158,000

(c) Benefits to Consignors: The benefit to be enjoyed by the consignors is equal to the product of the difference between the present and future freight charges and the future volume of traffic that will increase with the demand and supply curve. Assuming that the service distance after completion of the navigation structure will remain almost the same as at present, the difference between the present and future freight charges between the planned service distance would be as tabulated below.

	Present Charge (\$/t)	Charge after Completion of Program (\$/t)	Difference (\$)
General cargo	15.7	8.45	7.25
Timber	4.1	5.3	– 1.2
Charcoal	20.3	9.25	11.05
Passenger	2.85	1.43	1.42

The increase of volume of traffic in relation to the reduction of freight charges is illustrated by the following demand and supply curve.



In the above figure, the benefit to be enjoyed by the consignors is the area surrounded by $P_1 - P_2 - b - a$. Assuming that the curve (a - b) is nearly linear, the benefit or surplus "S" to the consignors can be obtained by the following equation.

$$S = Q_1 (P_1 - P_2) + 1/2 (Q_2 - Q_1) (P_1 - P_2)$$

Where;
$P_1 - P_2$ represents the afore-mentioned difference in freight charges, and $Q_2 - Q_1$ represents the increment of volume of cargo and passengers by navigation improvement.

By the application of the above equation using the volume of traffic given in Chapter G-3-1 (1), the benefit to consignors is calculated to reach to \$545,100 in 20 years after the project is put into operation as broken down below.

	Benefit ($)
Daily necessities	195,800
Timber	161,600
Charcoal	27,600
Others	18,100
Passenger	142,000
Total	545,100

(d) Total Benefit: The annual benefits of navigation in the 20 years after the project is pun into operation, as given in items (a), (b) and (c) above are tabulated in the following table.

	Annual Benefit($)
Inclined passage tolls	22,000
Income of transportation agents	158,000
Benefit to consignors	545,100
Total	725,100

G-3-2 Cost

(1) Operation and Maintenance Cost: The operation and maintenance costs in the 20 years after the project is put into operation have been estimated as follows;

		Annual cost ($)
Labor	3 shifts, 35 laborers x $2,500/year	87,500
Power	5 mills/kWh x 720,000 kWh	3,600
Materials	7.5 mills/t x 120,000 tons	900
Administration	8 officers x $6,000/year	48,000
Miscellaneous	5% of the total expenses above	7,000
Maintenance & Repair	Construction cost ($5,030,000) x 0.1%	5,000
Total		152,000

(2) Replacement Cost: The serviceable life has been determined to be 40 years for cradles, pushers, rails and winches, and 30 years for lighting installations. On this basis, the replacement costs will be as follows.

	Replacement Year	Cost ($)
Cradles, pushers, rails and winches	2017	123,000
"	2028	131,600
Lighting apparatus and others	2007	104,800
"	2018	30,000
Total		389,400

G-3-3 Internal Rate of Return

Annual benefits and operation and maintenance costs based on the aforementioned estimates are shown in Table G-2. The internal rate of return for navigation over a 50 years period gave a rate of 5.2%.

G-4 Internal Rate of Return of Agriculture

G-4-1 Benefit

(1) Planting Area, Yields and Net Revenues: The project area embodies a total of 12,469 ha of cultivated land comprising of 5,017 ha of paddy fields and 7,452 ha of farm land. It is assumed that after completion of the project, paddy fields will expand to 19,820 ha (about 4 times) and farm land to 14,180 ha (about 1.9 times), totaling 34,000 ha. The planting area at present is 16,980 ha, which is utilized at a rate of 136% only. With the completion of the project, however, it is anticipated that the planting area will increase to 60,739 ha by the supply of adequate irrigation water, which will raise the rate of land utilization to 179%. By the expansion of the planting area which will be accompanied by the introduction of irrigated agricultural technique, the production of rice and maize will increase by 15 and 7 times respectively, and that of other crops will also increase to a substantial extent.

As a result, the gross annual revenue will rise from the present S1,742,000 to S14,564,000, and the net annual revenue, which is the gross revenue minus the costs of labor, seeds, fertilizer, agricultural chemicals, depreciation of machines and equipment, duties and taxes, etc., will also increase from the present S592,000 (S47.50/ha) to S6,166.00 (S181.40/ha), which is an increase of S5,574,000 (S163.90/ha) as shown in Table G-3.

(2) Benefit: The benefits of agriculture are the difference between the present net revenue without project and the estimated future value with project. It has been assumed that the construction work will be executed separately in each work district and completed at different times, and that the production will gradually increase and attain the target volume in a 10 years period. Table G-3, prepared on the above assumption, shows the transition in the growth of arable land and benefits. The net revenue per unit farm area will be S163.9/ha upon completion of the project.

G-4-2 Cost

(1) Maintenance and Administration Costs: The maintenance and administration costs upon completion of the project are estimated to be as follows.

		Cost (S/year)
Salaries & wages Maintenance of canals	Net construction cost x 3 %	870,700
Power	5 mills/kWh x 17,340 kWh	86,700
Total		957,400

(2) Replacement Cost: Replacement will be required only for the pumping facilities whose life time is set at 25 years. Cost in each replacement year is given below.

G-4-3 Internal Rate of Return

Annual benefits and the maintenance and administration costs based on the above-mentioned estimates are shown in Table G-3. The internal rate of return calculated on the basis of these data is 7.9% (as present worth at 1978).

	Replacement Year	Expenses (\$)
Pumping facilities	1997	697,000
"	1998	361,000
"	1999	931,000
"	2001	897,000
"	2001	778,000
"	2003	242,000
"	2005	1,094,000

G-5 Overall Evaluation

Study of the internal rate of return of each aspect of the project reveals that power which occupies almost 90% of the total project cost, will yield 4.4% for Type I pattern of consumption, and about 5.3% for Types II and III pattern of consumption. In Types II and III, the surplus energy is more than twice the volume estimated for Type I, and a longer time will be required before full load operation is achieved. For the effective utilization of power which will become available and for the early economic development of the two countries, Type I pattern of consumption is recommended though its internal rate of return is somewhat lower than Types II and III.

The overall evaluation is therefore made of Type I for power as well as for navigation and agriculture.

(1) An internal rate of return of 4.4% might not seem to be attractive if the project were to be undertaken by a private enterprise. However, in arriving at this rate of return, the tangible benefit of saving fuel consumption of existing thermal plants by supplying surplus energy of the Sambor Project was not considered. If this benefit is taken into account, it will serve to improve the rate of return. Furthermore, this rate of return has been evaluated on the basis of an isolated project, and, therefore, if the regulation of discharge upon construction of the upstream Pa Mong and Nam Ngum Projects are considered, the benefit to the Sambor Project, as more fully described in the annex to this report (Vol. II), is estimated to increase the rate of return of power to about 6% or 7%.

(2) The internal rate of return for navigation is a little low. As the cost of the navigation structures is less than 2% of the total project cost, the cost can be considered a portion of the cost of the dam, and, therefore, the internal rate of return is assumed to be included in that of the power aspect.

The benefits of navigation should rather be evaluated in the light of its secondary effects, such as the promotion of regional industrial development and as the first step to the future extension of navigable waters into Laotian territory.

(3) The internal rate of return of agriculture is 7.9% which can be considered to be on an international level.

(4) The factor which controls the economic feasibility of the Sambor Project is power. An internal rate of return of 4.4% is not so high. Generally speaking, in developing countries, the full benefits of a large-scale project cannot be anticipated from the beginning of operation because there will not be an immediate market to consume all of the power output, and consequently the internal rate of return is generally low. However, there are many cases in which projects with rate of return of this level have been implemented.

It is not proper to judge the economic feasibility of large-scale projects by the rate of return only, particularly in developing countries. With a 4.4% rate of return, as described in the following chapter, the investment in the Sambor Project can be recovered at repayment conditions which are considered acceptable internationally. From the foregoing points, it is judged that the Sambor Project is economically feasible.

In the above evaluation of the Sambor Project, no reference was made to its secondary benefits to the social, economic and industrial development of Cambodia and Vietnam. If these are taken into due consideration, they will greatly enhance the economic importance of the Sambor Project which could be implemented with priority over other mainstream projects.

Table G-1 Annual Benefits and Costs (Power)

	Year	Case I									Case II			Case III		
		Power Sales (10^6kWh)				Benefits ($1,000)										
		General Demand	Aluminum Refining	Other Power-oriented Industries	Total	General Demand	Aluminum Refining	Other Power-oriented Industries	Total	Costs (Operation & Maintenance)	Power Sales (10^6kWh)	Benefits ($1,000)	Costs ($1,000)	Power Sales (10^6kWh)	Benefits ($1,000)	Costs ($1,000)
1	1978	141	2,016	1,747	3,904	1,269	5,040	3,494	9,803	2,856	1,034	3,055	2,713	141	1,269	2,549
2	79	302			4,065	2,718			11,252	2,856	1,195	4,504	2,713	302	2,718	2,549
3	1980	495			4,258	4,455			12,989	2,856	1,388	6,241	2,713	495	4,455	2,604
4	81	716			4,479	6,444			14,978	3,017	1,609	8,230	2,767	716	6,440	2,604
5	82	979			4,742	8,811			17,345	3,017	1,872	10,597	2,767	979	8,811	2,643
6	83	1,257			5,020	11,313			19,847	3,017	2,150	13,099	2,820	1,257	11,313	2,643
7	84	1,539			5,302	13,851			22,385	3,059	2,432	15,637		1,539	13,851	2,643
8	85	1,847			5,604	16,569			25,103		2,734	18,355		1,841	16,569	2,726
9	86	1,968			5,731	17,712			26,246		3,093	21,586		2,200	19,800	2,726
10	87										3,472	24,997		2,579	23,211	2,856
11	88										3,890	28,759		2,997	26,973	2,910
12	89										4,324	32,665		3,431	30,879	2,910
13	1990										4,728	36,301		3,880	34,920	2,949
14	1991													4,415	39,735	
50	2027	1,968	2,016	1,747	5,731	17,712	5,040	3,494	26,246	3,059	4,728	36,301	2,820	4,415	39,735	2,949

Table G-2 Annual Benefits and Costs (Navigation)

	Year	Transport Volume		Benefits ($)				Cost ($) (Operation & Maintenance)
		Cargo (ton)	Passenger (person)	Tolls	Revenue of Transportation Agencies	Indirect Benefits to Consignors	Total	
1	1978	10,000	25,000	2,083	15,750	37,513	55,346	86,120
2	79	11,400	27,890	2,357	17,772	42,316	62,445	86,251
3	1980	12,990	31,120	2,666	20,053	47,734	70,453	86,391
4	81	14,800	34,720	3,015	22,626	53,844	79,485	86,556
5	82	16,870	38,730	3,411	25,537	60,753	89,701	86,747
6	83	19,230	43,210	3,860	28,828	68,563	101,251	86,958
7	84	21,920	48,210	4,369	32,547	77,387	114,303	87,196
8	85	24,980	53,780	4,944	36,743	87,338	129,025	87,490
9	86	28,470	60,010	5,596	41,491	98,597	145,684	87,911
10	87	32,450	66,950	6,936	46,856	111,317	165,109	88,157
11	88	36,980	74,690	7,172	52,916	125,677	185,765	88,580
12	89	42,150	83,320	8,120	59,770	141,916	209,806	121,893
13	1990	48,040	92,960	9,194	67,521	160,276	236,991	122,417
14	91	54,750	103,720	10,412	76,285	181,028	267,725	123,027
15	92	62,400	115,710	11,791	86,193	204,485	302,469	123,725
16	93	71,120	129,100	13,356	97,404	231,019	341,779	124,517
17	94	81,060	144,020	15,129	110,081	261,013	386,223	148,464
18	95	92,380	160,680	17,137	124,418	294,927	436,482	149,493
19	96	105,290	179,270	19,417	140,645	333,304	493,366	150,673
20	1997	120,000	200,000	22,000	159,000	376,700	557,700	152,000
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
50	2027	120,000	200,000	22,000	159,000	376,700	557,700	152,000

Table G-3 Annual Benefits and Costs (Agriculture)

(Unit: Million dollars)

	Year	Benefits ($1,000)													Benefits per ha ($1,000)	Costs (Maintenance & Administration) ($1,000)	Net Income: Annual Total ($1,000)	Net Income: Add Total ($1,000)
		Kratie	Prek Te (R)	Prek Te (L)	Bos Leav	Kanhehor	Chlong	Saop	Prek Prasap	Ta Mau	Kaoh Trung	Kaoh Chreng	Kaoh Tasuy	Total				
1	1973				50.5									50.5	18.7	157.1	-106.6	-106.6
2	74			12.8	101.0							14.1		127.9	29.8	237.8	-109.9	-216.5
3	75			25.6	151.5	49.0		106.4			5.3	28.2		366.0	38.8	319.4	46.6	-169.9
4	76			38.4	202.0	98.0		212.8			10.6	42.3		604.1	42.6	403.0	201.1	31.2
5	77			51.2	252.5	147.0		319.2		33.7	15.9	56.4	14.3	890.2	52.3	517.3	372.9	404.1
6	78	91.3		54.0	303.0	196.0		425.6		67.4	21.2	70.5	28.6	1,257.6	53.7	614.3	643.3	1,047.4
7	79	182.6		76.8	353.5	245.0		532.0	76.9	101.1	26.5	84.6	42.9	1,721.9	62.5	715.0	1,006.9	2,054.3
8	1980	273.9	16.6	89.6	404.0	294.0		638.4	153.8	134.8	31.8	98.7	57.2	2,192.8	75.9	833.4	1,359.4	3,413.7
9	81	365.2	33.2	102.4	454.5	343.0	86.4	744.8	230.9	168.5	37.8	112.8	71.5	2,750.8	80.9	957.4	1,793.4	5,207.1
10	82	456.5	49.8	105.2	505.2	392.0	192.8	851.7	309.6	202.2	42.4	126.9	85.8	3,319.6	97.6	:	2,362.2	7,569.3
11	83	547.8	66.4	127.7	:	441.0	259.2	957.6	384.5	235.9	47.7	140.7	100.1	3,813.8	112.2	:	2,856.4	10,425.7
12	84	639.1	83.6	:	:	489.6	345.6	1,064.1	461.4	269.6	52.8	:	114.4	4,293.8	126.3	:	3,336.4	13,762.1
13	85	730.4	99.6	:	:	:	432.0	:	531.3	303.3	:	:	128.7	4,605.4	135.5	:	3,648.0	17,410.1
14	86	821.7	116.2	:	:	:	518.4	:	615.2	337.5	:	:	143.0	4,932.1	145.1	:	3,974.7	21,384.8
15	87	913.4	132.8	:	:	:	604.8	:	692.1	:	:	:	:	5,203.7	153.1	:	4,246.3	25,631.1
16	88	:	149.4	:	:	:	691.2	:	769.3	:	:	:	:	5,383.9	158.4	:	4,426.5	30,057.6
17	89	:	166.2	:	:	:	777.6	:	:	:	:	:	:	5,487.1	161.4	:	4,529.7	34,587.3
18	1990	:	:	:	:	:	864.3	:	:	:	:	:	:	5,573.8	163.9	:	4,616.4	39,203.7
:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
50	2022	913.4	166.2	127.7	505.2	489.6	864.3	1,064.1	769.3	337.5	52.8	140.7	143.0	5,573.8	163.9	957.4	4,616.4	39,203.7

CHAPTER H. FINANCIAL PROGRAM

CHAPTER H. FINANCIAL PROGRAM

H-1 Premise

(1) In preparing the financial program for the Sambor Project, separate programs have been formulated for power, navigation, and for agriculture for the following reasons.

a) The benefit from the project will be realized from the first two sectors from 1978, and from the latter gradually in and after 1973 corresponding to the progress of development work in each work district.

b) In an agricultural development project, the benefit cannot always be appropriated to amortization of invested funds.

c) There are generally more possibilities of securing soft loans for agricultural development than for industrial development.

(2) The conditions of credit offered by international financing organizations are usually such that all the local currency requirements should be borne by the country in which the project is located. However, since the local currency requirements for the project is of a sizeable amount, studies were made of the following two cases.

Case I: Local currency requirements to be financed by the Royal Government of Cambodia and the foreign currency requirements to be financed by external loans.

Case II: Half of the local currency requirements to be financed by the Royal Government of Cambodia in such a way that the maximum annual requirement will be held within approximately 1% of the gross national product, and the remaining part including the foreign currency to be financed by external loans.

H-2 Funds Required

The total funds required for the Sambor Project, if excluding interest during construction, amounts to $358,030,000 comprising of $323,130,000 for power including navigation and $34,900,000 for agriculture. Of this amount, $256,588,000 is required in foreign currency and $101,442,000 in local currency. The annual fund requirement for power and navigation, and agriculture is shown in the following table.

(Unit: $1,000)

Year	Power and Navigation			Agriculture		
	Foreign currency	Local currency	Total	Foreign currency	Local currency	Total
	3,890	670	4,560	578	580	1,158
1970	18,050	7,160	25,210	1,190	1,240	2,430
1	14,920	6,250	21,170	1,553	1,619	3,172
2	8,870	5,450	14,320	1,404	1,464	2,868
3	19,310	10,210	29,520	1,239	1,291	2,530
4	27,110	13,460	40,570	1,568	1,653	3,239
5	38,436	14,384	52,820	1,966	2,049	4,015
6	49,361	10,744	60,105	1,553	1,619	3,172

(to be continued)

(continued) (Unit: $1,000)

Year	Power and Navigation			Agriculture		
	Foreign currency	Local currency	Total	Foreign currency	Local currency	Total
7	38,490	9,505	47,995	1,801	1,877	3,678
8				2,247	2,342	4,589
9	6,580	3,000	9,580	1,926	2,123	4,049
1980	8,470	1,390	9,860			
:						
:						
1983	5,310	830	6,140			
:						
:						
1988	374	266	640			
:						
:						
1993	374	266	640			
Total	239,545	83,585	323,130	17,043	17,857	34,900

H-3 Financing of Funds

H-3-1 Sources of Funds

Since power development projects generally require a long time to amortize the invested funds, it is desirable that they be financed by long-term funds at low interest rates. In case of agricultural development projects, a fairly long period of time is required to realize the anticipated increase of production, because the yield increases gradually with the dissemination of agricultural knowledge and technique. Hence, in this case also, long-term and low interest funds must be secured.

In this study the required foreign currency was considered to be financed from international financial machinery, such as the World Bank, the International Development Association and the Asian Development Bank, and also from financial institutions of developed countries. The total amount of the local currency or half of it was considered to be made available from the national treasury of the Royal Government of Cambodia, with the remainder, if any, to be financed by Fonds National de l'Equipement.

H-3-2 Interest and Term of Repayment

(1) Interest: First, in respect of foreign currency, the World Bank currently charges an interest rate of 6.5% and a commitment charge of 0.375% and the International Development Association charges no interest other than 0.75% loan-handling charge. The Asian Development Bank charges an interest rate of 6.875% for normal transactions and a commitment charge of 0.75%. It is said that establishment of the Agricultural Development Fund, the Mekong Development Fund, etc., as a means to provide long-term low interest special funds, is being considered in the near future. As for loans from foreign countries, one of the rate set by AID of the United States, for example, is 6%, and very recently loans bearing an interest rate of around 3.0% to 3.5% have been made

available to the Prek Thnot Project by various countries. There are few cases which are government to government loans in which the interest rate is 4.5% to 5.75%. For domestic currency, the interest rate set by Fonds National de l'Equipement of the Royal Government of Cambodia is 3.5%. In this study, the sources of loans to power and navigation was assumed as shown in the table which follows. As the result, in case I, the weighted average interest rate is 4.0% for the first stage and 6.2% for the second stage, and, in case II, it is 4% for the first stage and 5.9% for the second stage.

Description of work	Source of fund (Assumed)	Interest rate (%) (1st stage)	Interest rate (%) (2nd stage)
Dam & Reservoir	International Development Association	0.75	
Civil works for power station	Financial institutions in various countries	4.0	5.5
Power station equipment	"	5.75	6.5
Transmission line and other facilities, and navigation facilities	World Bank and others	6.5	
	Total of foreign currency	4.0	6.2
50% of local currency	Fonds National de l'Equipement of Cambodia	3.5	
	Weighted average	4.0	5.9

For agriculture, because of the normal practice of applying more soft loans than to industrial development, an interest rate of 3.5% per annum was adopted.

(2) Term of Repayment: For the term of repayment, the World Bank conditions are 15 to 25 years and the International Development Association sets a term of repayment at 50 years (after a 10-year grace period, 1% of the principal is to be repaid every year for 10 years and 3% of the principal is to be repaid every year during the remaining 30 years). Loans from various countries are about 18 years at the longest for equipment and materials and about 20 years at the maximum for civil works. For Fonds National de l'Equipement of the Royal Government of Cambodia, a period of 50 years which is the full serviceable life was adopted. As the result, in Case I, the term of repayment for power and navigation is calculated to be 25 years for the first stage and 18 years for the second stage, and in Case II, 28 years for the first stage and 18 years for the second stage. As for agricultural aspect the full serviceable life is assumed to be 20 years after the completion of Sambor Dam in both cases.

(3) Disbursement from the Treasury of the Royal Government of Cambodia. Local currency to be borne by the Royal Government of Cambodia was regarded as capital investment, and payment of divident or interest was not considered.

H-4 Debt Financing

H-4-1 Power and Navigation

(1) Revenue from Sales of Electricity: The energy generated will be sold at 9 mills/kWh for general demand, 2.5 mills/kWh for the aluminum refining industry and 2 mills/kWh for other power-oriented industries, which is to be delivered at the primary substations to be set up near Phnom Penh, Sihanouk Ville and Saigon. The annaul revenue from sales of electricity by type of demand is shown in Table G-1. The rate of 9 mills/kWh for general demand is extremely low compared to the current rate in force, and it may be possible to charge the customers a little higher rate than 9 mills/kWh when the project will be implemented.

(2) Inclined Passage Tolls: For navigation, it is considered that the revenue as the source of repayment will only be the toll charges of the inclined passage facility. The tolls as determined are $0.25/t for general cargo, $0.03 per passenger, and free for timbers. Toll revenue for each year are shown in Table G-2.

(3) Operation and Maintenance Cost: Operation and maintenance costs for power are estimated as follows.

Salaries and wages (56 persons):	$522,000/year
Civil structures and transmission lines:	0.75% of total construction cost of these facilities
Machines and equipment:	0.6% of the total cost of the equipment
Otherscosts:	10% of the total expenses above

Operation and maintenance costs for navigation are estimated as follows.

Labor (3 shifts, 35 persons):	$87,500/year
Power (5 mills x 720,000 kWh):	$3,600
Materials (0.75 cents x 120,000 t):	$900
Administration (8 persons x $600/year):	$48,000
Expendables:	Total above x 5%
Maintenance and repair:	Construction cost x 0.1%

(4) Depreciation Cost: For both power and navigation, the straight-line method, with a 10% residual value has been adopted. The serviceable life for the purpose of depreciation has been determined as follows:

(a) Power

Turbine, generator, and substation equipment:	35 years
Other facilities:	50 years

(b) Navigation

Cradle, pusher, rail, and winch:	40 years
Illumination facilities:	30 years
Other facilities:	50 years

(5) Financial Cost: The estimates of financial costs (interest charge) of the borrowings for Cases I and II based on the credit conditions assumed in Chapter H-3-2 (2) are shown in Tables H-1 (1) and H-1 (2).

(6) Net Revenue: The net revenues for Case I and Case II, after deducting operation and maintenance depreciation and financial costs from the operating revenues including power sales, inclined passage tolls,etc., are shown in Tables H-2 (1) and H-2 (1).

H-4-2 Agriculture

It is anticipated that the benefits of agriculture will gradually increase after completion of the development works in each work district and production will reach the target volume in 10 years after completion of the program. However, it is considered not appropriate to allocate all of these revenues to repayment of borrowings. In this study, therefore, debt financing of agriculture was assumed on the following conditions.

(a) The Royal Government of Cambodia will be solely responsible for the procurement of project funds and repayment of loans.

(b) The benefited farmers will bear the costs of maintenance, management and replacement of pumping facilities.

(c) Recovery of construction cost and depreciation from the benefited farmers will not be taken into consideration.

It will be desirable that those matters will be studied and determined by the Royal Government of Cambodia in the future.

H-5 Amortization Schedule

The funds to be appropriated for repayment of loans will be the depreciation reserves and the net revenues.

The repayment schedules for power, navigation, and agriculture based on the conditions mentioned in Chapter H-3-2 are shown in the following tables:

Case I:	Tables H-1 (1) and H-3
Case II:	Tables H-1 (2) and H-3

H-6 Finding

The cash balance for power and navigation calculated on the basis of the above data are shown in Table H-4 (1) for Case I and Table H-4 (2) for Case II.

(1) The financing situation of power and navigation in terms of cash balance will take a favorable turn from the eight year after start-up both for Case I and Case II. If the annual surplus in the cash balance is retained and accumulated, the reserve will exceed the capital investment made by the Royal Government of Cambodia within 27 years after start-up for Case I and within 29 years for Case II. After repayment of all borrowings and setting aside a sum equal to the investment by the Royal Government of Cambodia, the surplus in the cash balance will be accumulated as internal spinning reserve. This reserve which will accrue in 50 years after start-up is estimated to amount to $550 million for Case I and $490 million for Case II.

A part of this reserve will be appropriated for the improvement of facilities (approximately $110 million) which will reduce the internal reserve to $440 million for Case I and $380 million for Case II.

(2) For agriculture, the total amount to be repaid including interest will be $26.20 million for case I and $39.80 million for Case II, and the disbursement from the treasury of the Royal Government of Cambodia will be $17.86 million and $8.93 million respectively. Accordingly, the total capital cost will be $44.06 million for Case I and $48.73 million for Case II. On the other hand, the net revenue of all farmers in the project area after deducting maintenance and management costs will amount to $39.20 million in 18 years after the first benefit, as shown in Table G-3. Thereafter, a net revenue of about $4.62 million will be realized every year and the net revenue in 50 years after the first benefit will amount to about $186.93 million.

Therefore, if investments in agriculture are proposed to be recovered by the Royal Government of Cambodia from the net revenues of farmers, this is quite possible, and after the recovery of the investment in agriculture, there will still be a net revenue of $143.0 million for Case I and $138.0 million for Case II.

(3) The financial ability of the Royal Government of Cambodia (construction cost to be covered by local currency and funds to offset cash balance deficit), which is one of the most important element of this financial program, will in ten years after start of operation of the Sambor Project amount to a total of $104.9 million and $16.4 million in the maximum year for Case I, and a total of $60.1 million and $8.2 million in the maximum year for Case II. Comparing this financial burden with the GNP, the Royal Government of Cambodia sets the growth rate of GNP for the 1968-72 period under the current 2nd Five-Year Plan at 5% per annum and estimates the GNP to amount to 37.3 billion Riels ($1,070 million) in 1971 and 39.1 billion Riels ($1,120 million) in 1972. On the assumption that the GNP will increase at the same rate thereafter, the GNP in ten years from 1971 - 80 will be approximately $13,520 million. As a result, the ratio of the financial burden to the treasury for the Sambor Project against the GNP will be 0.7% to 0.8% for Case I and 0.4% for Case II.

(4) The term of repayment of borrowings established in this study was based on the current conditions set by international financial institutions and current practice of cooperation by various countries to developing countries. The amount of investment by the Royal Government of Cambodia would be less than 1% of the GNP, and therefore the financing of this amount would be considered possible. It may be concluded, therefore, that the feasibility of the Sambor Project seems to be justified also from the financial point of view if the required conditions can be satisfied.

Table H-1 (1) Amortization Schedule (Power and Navigation, Case I)

(Unit. Million dollars)

	Year	Funds Requirements							Repayment of Loan										
		Loan							1st Stage				2nd Stage				Total		
		Foreign Currency	Domestic Currency	Sub-total	Interest during Construction	Total	Government Grant	Total	Principal	Interest	Total	Outstanding Balance	Principal	Interest	Total	Outstanding Balance	Principal	Interest	Total
-9		3.89			0.06	3.95	0.67	4.62				3.95							
-8	1970	18.05			0.45	18.50	7.16	25.66				22.45							
-7	1	14.92			1.12	16.04	6.25	22.29				38.49							
-6	2	8.87			1.62	10.49	5.45	15.94				48.98							
-5	3	19.31			2.14	21.45	10.21	31.66				70.43							
-4	4	27.11			3.04	30.15	13.46	43.61				100.58							
-3	5	38.44			4.30	42.74	14.38	57.12				143.32							
-2	6	49.36			6.01	55.37	10.74	66.11				198.69							
-1	7	38.49			7.81	46.30	9.51	55.81				244.99							
1	1978									9.80	9.80	244.99						9.80	9.80
2	9	6.58			0.16	6.74	3.00	9.74		9.80	9.80	244.99						9.80	9.80
3	1980	8.47			0.62	9.09	1.39	10.48		9.80	9.80	244.99				15.83		9.80	9.80
4	1									9.80	9.80	244.99	0.50	0.98	1.48	15.33	0.50	10.78	11.28
5	2									9.80	9.80	244.99	0.53	0.95	1.48	14.80	0.53	10.75	11.28
6	3	5.31			0.13	5.44	0.83	6.27	8.23	9.80	18.03	236.76	0.57	0.91	1.48	19.67	8.80	10.71	19.51
7	4								8.56	9.47	18.03	228.20	0.78	1.21	1.99	18.89	9.34	10.68	20.02
8	5								8.91	9.12	18.03	219.29	0.82	1.17	1.99	18.07	9.73	10.29	20.02
9	6								9.26	8.77	18.03	210.03	0.87	1.12	1.99	17.20	10.13	9.89	20.02
10	7								9.63	8.40	18.03	200.40	0.93	1.06	1.99	16.27	10.56	9.46	20.02
11	8								10.02	8.01	18.03	190.38	0.99	1.00	1.99	15.28	11.01	9.01	20.02
12	9								10.42	7.61	18.03	179.96	1.05	0.94	1.99	14.23	11.47	8.55	20.02
13	1990								10.84	7.19	18.03	169.12	1.11	0.88	1.99	13.12	11.95	8.07	20.02
14	1								11.27	6.76	18.03	157.85	1.18	0.81	1.99	11.94	12.45	7.57	20.02
15	2								11.72	6.31	18.03	146.13	1.25	0.74	1.99	10.69	12.97	7.05	20.02
16	3								12.19	5.84	18.03	133.94	1.33	0.66	1.99	9.36	13.52	6.50	20.02
17	4								12.68	5.35	18.03	121.26	1.41	0.58	1.99	7.95	14.09	5.93	20.02
18	5								13.18	4.85	18.03	108.08	1.50	0.49	1.99	6.45	14.68	5.34	20.02
19	6								13.71	4.32	18.03	94.37	1.60	0.39	1.99	4.85	15.31	4.71	20.02
20	7								14.26	3.77	18.03	80.11	1.69	0.30	1.99	3.16	15.95	4.07	20.02
21	8								14.83	3.20	18.03	65.28	1.80	0.19	1.99	1.36	16.63	3.39	20.02
22	9								15.42	2.61	18.03	49.86	0.43	0.08	0.51	0.93	15.85	2.69	18.54
23	2000								16.04	1.99	18.03	33.82	0.46	0.05	0.51	0.47	16.50	2.04	18.54
24	1								16.68	1.35	18.03	17.14	0.47	0.04	0.51	0	17.15	1.39	18.54
25	2002								17.14	0.89	18.03	0					17.14	0.89	18.03
Total		238.80			27.46	266.26	83.05	349.31	244.99	164.61			21.27	14.55			266.26	179.16	

Table H-1 (2) Amortization Schedule (Power and Navigation, Case II)

(Unit: Million dollars)

	Year	Fund Requirements: Loan: Foreign Currency	Fund Requirements: Loan: Domestic Currency	Fund Requirements: Loan: Sub-total	Fund Requirements: Interest during Construction	Fund Requirements: Subtotal	Fund Requirements: Government Grant	Fund Requirements: Total	Repayment of Loan: 1st Stage: Principal	1st Stage: Interest	1st Stage: Total	1st Stage: Outstanding Balance	2nd Stage: Principal	2nd Stage: Interest	2nd Stage: Total	2nd Stage: Outstanding Balance	Total: Principal	Total: Interest	Total: Total
-9		3.89	0.33	4.22	0.07	4.29	0.34	4.63				4.29							
-8	1970	18.05	3.58	21.63	0.52	22.15	3.58	25.73				26.44							
-7	1	14.92	3.12	18.04	1.32	19.36	3.13	22.49				45.80							
-6	2	8.87	2.73	11.60	1.94	13.54	2.72	16.26				59.34							
-5	3	19.31	5.11	24.42	2.61	27.03	5.10	32.13				86.37							
-4	4	27.11	6.73	33.84	3.74	37.58	6.73	44.31				123.95							
-3	5	38.44	7.19	45.63	5.28	50.91	7.19	58.10				174.86							
-2	6	49.36	5.37	54.73	7.25	61.98	5.37	67.35				236.84							
-1	7	38.49	4.75	43.24	10.34	53.58	4.76	58.34				290.42							
1	1978									11.62	11.62	290.42						11.62	11.62
2	9	6.58	1.50	8.08	0.19	8.27	1.50	9.77		11.62	11.62	290.42						11.62	11.62
3	1980	8.47	0.70	9.17	0.70	9.87	0.70	10.57		11.62	11.62	290.42				18.14		11.62	11.62
4	1									11.62	11.62	290.42	0.59	1.07	1.66	17.55	0.59	12.69	13.28
5	2	5.31	0.42	5.73	0.13	5.86	0.42	6.28		11.62	11.62	290.42	0.63	1.03	1.66	22.78	0.63	12.65	13.28
6	3								7.93	11.62	19.55	282.49	0.86	1.34	2.20	21.92	8.79	12.96	21.75
7	4								8.27	11.28	19.55	274.22	0.91	1.29	2.20	21.01	9.18	12.57	21.75
8	5								8.60	10.95	19.55	265.62	0.97	1.23	2.20	20.04	9.57	12.18	21.75
9	6								8.95	10.60	19.55	256.67	1.02	1.18	2.20	19.02	9.97	11.78	21.75
10	7								9.33	10.22	19.55	247.34	1.08	1.12	2.20	17.94	10.41	11.34	21.75
11	8								9.66	9.89	19.55	237.68	1.15	1.05	2.20	16.79	10.81	10.94	21.75
12	9								10.05	9.50	19.55	227.63	1.21	0.99	2.20	15.58	11.26	10.49	21.75
13	1990								10.45	9.10	19.55	217.18	1.29	0.91	2.20	14.29	11.74	10.01	21.75
14	1								10.87	8.68	19.55	206.31	1.36	0.84	2.70	12.93	12.23	9.52	21.75
15	2								11.30	8.25	19.55	195.01	1.44	0.76	2.20	11.49	12.74	9.01	21.75
16	3								11.75	7.80	19.55	183.26	1.51	0.69	2.20	9.98	13.26	8.49	21.75
17	4								12.22	7.33	19.55	171.04	1.60	0.60	2.20	8.38	13.82	7.93	21.75
18	5								12.71	6.84	19.55	158.33	1.69	0.51	2.20	6.69	14.40	7.35	21.75
19	6								13.22	6.33	19.55	145.11	1.79	0.41	2.20	4.90	15.01	6.74	21.75
20	7								13.74	5.81	19.55	131.37	1.90	0.30	2.20	3.00	15.64	6.11	21.75
21	8								14.32	5.23	19.55	117.05	2.01	0.19	2.20	0.99	16.33	5.42	21.75
22	9								14.89	4.66	19.55	102.16	0.48	0.06	0.54	0.51	15.37	4.72	20.09
23	2000								15.49	4.06	19.55	86.67	0.51	0.03	0.54	0	16.00	4.09	20.09
24	1								16.10	3.45	19.55	70.57					16.10	3.45	19.55
25	2								16.74	2.81	19.55	53.83					16.74	2.81	19.55
26	3								17.41	2.14	19.55	36.42					17.41	2.14	19.55
27	4								17.61	1.94	19.55	18.81					17.61	1.94	19.55
28	2005								18.81	0.74	19.55	0					18.81	0.74	19.55
Total		238.80	41.53	280.33	34.09	314.42	41.54	355.96	290.42	217.33	507.75		24.00	15.60	39.60		314.42	232.93	547.35

Table H-2 (1) Statement of Income (Power and Navigation, Case I)

(Unit Million dollars)

	Year	Revenue			Operating Expenses							
		Power Sales	Tolls (Navigation Incline)	Total (A)	Operation & Maintenance			Depreciation	Total (B)	Balance (C) = (A) − (B)	Payment of Interest	Net Income (C) − (D)
					Power	Navigation	Subtotal					
1	1978	9.80	0.002	9.80	2.86	0 08	2 94	6 42	9.36	0 44	9.80	− 9.36
2	9	11 25	0 002	11.25	2 86	0 08	2 94	6.42	9.36	1.89	9.80	− 7.91
3	1980	12 99	0.003	12.99	2 86	0 08	2.94	6 42	9.36	3.63	9.80	− 6.17
4	1	14.98	0 003	14 98	3 02	0 08	3 10	6 94	10 04	4 94	10 78	− 5.84
5	2	17.35	0 003	17 35	3 02	0 08	3 10	6 94	10 04	7.31	10 75	− 3 44
6	3	19 85	0 004	19.85	3.02	0.08	3 10	6.94	10 04	9.81	10.71	− 0.90
7	4	22.39	0 004	22.39	3.06	0.09	3.15	7.10	10 25	12 14	10 68	1.46
8	5	25.10	0.005	25.11	3.06	0 09	3 15	7.10	10.25	14.86	10 29	4.57
9	6	26.25	0 006	26 25	3 06	0 09	3.15	7.10	10 25	16.00	9 89	6 11
10	7	26.25	0 007	26 25	3.06	0 09	3.15	7.10	10 25	16 00	9 46	6.54
11	8	26.25	0 007	26 25	3 06	0 09	3.15	7.10	10.25	16 00	9 01	6.99
12	9	26.25	0.008	26.25	3.06	0 12	3 18	7.10	10.28	15 97	8.55	7.42
13	1990	26.25	0 009	26.26	3.06	0.12	3.18	7 10	10.28	15.98	8.07	7.91
14	1	26.25	0 01	26.26	3.06	0 12	3.18	7.10	10 28	15.98	7.57	8.41
15	2	26.25	0.01	26.26	3.06	0 12	3 18	7.10	10 28	15 98	7.05	8 93
16	3	26.25	0 01	26.26	3.06	0 12	3.18	7.10	10.28	15.98	6.50	9.48
17	4	26.25	0.02	26 27	3 06	0 15	3 21	7.10	10 31	15.96	5.93	10.03
18	5	26.25	0 02	26.27	3 06	0 15	3.21	7.10	10 31	15.96	5.34	10 62
19	6	26.25	0.02	26 27	3 06	0 15	3 21	7.10	10 31	15 96	4.71	11.25
20	7	26.25	0.02	26 27	3.06	0.15	3 21	7.10	10 31	15.96	4.07	11.89
21	8	26 25	0 02	26 27	3 06	0 15	3 21	7.10	10.31	15 96	3.39	12.57
22	9	26.25	0.02	26.27	3 06	0.15	3.21	7 10	10 31	15.96	2.69	13 27
23	2000	26.25	0 02	26 27	3 06	0.15	3.21	7.10	10.31	15.96	2.04	13.92
24	1	26 25	0.02	26.27	3.06	0.15	3 21	7.10	10.31	15.96	1.39	14.57
25	2002	26 25	0.02	26.27	3.06	0.15	3.21	7.10	10.31	15.96	0 89	15 07

Table H-2 (2) Statement of Income (Power and Navigation, Case II)

(Unit : Million dollars)

·	Year	Revenue			Operation Expenses					Balance	Payment of	Net Income
		Power Sales	Tolls (Navigation Incline)	Total (A)	Operation & Maintenance			Depreciation	Total (B)	(C) = (A)-(B)	Interest	(C)-(D)
					Power	Navigation	Subtotal					
1	1978	9.80	0.002	9.80	2.86	0.08	2.94	6.54	9.48	0.32	11.62	- 11.30
2	9	11.25	0.002	11.25	2.86	0.08	2.94	6.54	9.48	1.77	11.62	- 9.85
3	1980	12.99	0.003	12.99	2.86	0.08	2.94	6.54	9.48	3.51	11.62	- 8.11
4	1	14.98	0.003	14.98	3.02	0.08	3.10	7.06	10.16	4.82	12.69	- 7.87
5	2	17.35	0.003	17.35	3.02	0.08	3.10	7.06	10.16	7.19	12.65	- 5.46
6	3	19.85	0.004	19.85	3.02	0.08	3.10	7.06	10.16	9.69	12.96	- 3.27
7	4	22.39	0.004	22.39	3.06	0.09	3.15	7.22	10.37	12.02	12.57	- 0.55
8	5	25.10	0.005	25.11	3.06	0.09	3.15	7.22	10.37	14.74	12.18	2.56
9	6	26.25	0.006	26.25	3.06	0.09	3.15	7.22	10.37	15.88	11.78	4.10
10	7	26.25	0.007	26.25	3.06	0.09	3.15	7.22	10.37	15.88	11.34	4.54
11	8	26.25	0.007	26.25	3.06	0.09	3.15	7.22	10.37	15.88	10.94	4.94
12	9	26.25	0.008	26.25	3.06	0.12	3.18	7.22	10.40	15.85	10.49	5.36
13	1990	26.25	0.009	26.26	3.06	0.12	3.18	7.22	10.40	15.86	10.01	5.85
14	1	26.25	0.01	26.26	3.06	0.12	3.18	7.22	10.40	15.86	9.52	6.34
15	2	26.25	0.01	26.26	3.06	0.12	3.18	7.22	10.40	15.86	9.01	6.85
16	3	26.25	0.01	26.26	3.06	0.12	3.18	7.22	10.40	15.86	8.49	7.37
17	4	26.25	0.02	26.27	3.06	0.15	3.21	7.22	10.43	15.84	7.93	7.91
18	5	26.25	0.02	26.27	3.06	0.15	3.21	7.22	10.43	15.84	7.35	8.49
19	6	26.25	0.02	26.27	3.06	0.15	3.21	7.22	10.43	15.84	6.74	9.10
20	7	26.25	0.02	26.27	3.06	0.15	3.21	7.22	10.43	15.84	6.11	9.73
21	8	26.25	0.02	26.27	3.06	0.15	3.21	7.22	10.43	15.84	5.42	10.42
22	9	26.25	0.02	26.27	3.06	0.15	3.21	7.22	10.43	15.84	4.72	11.12
23	2000	26.25	0.02	26.27	3.06	0.15	3.21	7.22	10.43	15.84	4.09	11.75
24	1	26.25	0.02	26.27	3.06	0.15	3.21	7.22	10.43	15.84	3.45	12.39
25	2	26.25	0.02	26.27	3.06	0.15	3.21	7.22	10.43	15.84	2.81	13.03
26	3	26.25	0.02	26.27	3.06	0.15	3.21	7.22	10.43	15.84	2.14	13.70
27	4	26.25	0.02	26.27	3.06	0.15	3.21	7.22	10.43	15.84	1.94	13.90
28	2005	26.25	0.02	26.27	3.06	0.15	3.21	7.22	10.43	15.84	0.74	15.10

Table H-3 Financial Schedule (Agriculture)

(Unit Million dollars)

	Year	Case I Fund Requirement Loan Foreign Currency	Case I Loan Interest during Construction	Case I Loan Subtotal	Case I Government Grant	Case I Total	Case I Repayment of Principal plus Interest	Case II Fund Requirement Loan Foreign Currency	Case II Loan Domestic Currency	Case II Loan Subtotal	Case II Interest during Construction	Case II Total	Case II Government Grant	Case II Total	Case II Repayment of Principal plus Interest
-9		0.58	0.007	0.59	0.58	1.17		0.58	0.29	0.87	0.01	0.88	0.29	1.17	
-8	1970	1.19	0.03	1.22	1.24	2.46		1.19	0.62	1.81	0.05	1.86	0.62	2.48	
-7	1	1.55	0.07	1.62	1.62	3.24		1.55	0.81	2.36	0.11	2.47	0.81	3.28	
-6	2	1.40	0.12	1.52	1.46	2.98		1.40	0.73	2.13	0.18	2.31	0.73	3.04	
-5	3	1.24	0.16	1.40	1.29	2.69		1.24	0.65	1.89	0.24	2.13	0.64	2.77	
-4	4	1.59	0.20	1.79	1.65	3.44		1.59	0.82	2.41	0.30	2.71	0.83	3.54	
-3	5	1.97	0.25	2.22	2.05	4.27		1.97	1.02	2.99	0.38	3.37	1.02	4.39	
-2	6	1.55	0.30	1.85	1.62	3.47		1.55	0.81	2.36	0.46	2.82	0.81	3.63	
-1	7	1.80	0.35	2.15	1.88	4.03		1.80	0.94	2.74	0.54	3.28	0.94	4.22	
1	1978	2.25	0.03	2.28	2.34	4.62	1.01	2.25	1.17	3.42	0.04	3.46	1.17	4.63	1.54
2	9	1.93	0.02	1.95	2.12	4.07	1.17	1.93	1.06	2.99	0.03	3.02	1.06	4.08	1.78
3	1980						1.31								1.78
4	1						1.31								1.99
5	2						1.31								1.99
6	3						1.31								1.99
7	4						1.31								1.99
8	5						1.31								1.99
9	6						1.31								1.99
10	7						1.31								1.99
11	8						1.31								1.99
12	9						1.31								1.99
13	1990						1.31								1.99
14	1						1.31								1.99
15	2						1.31								1.99
16	3						1.31								1.99
17	4						1.31								1.99
18	5						1.31								1.99
19	6						1.31								1.99
20	7						1.31								1.99
21	8						1.31								1.99
22	9						0.30								0.45
23	2000						0.14								0.21
	Total	17.04	1.54	18.58	17.86	36.44	26.20	17.04	8.93	25.97	2.34	28.31	8.93	37.24	39.80

Table H-4 (1) Statement of Cashflow (Power and Navigation, Case I)

(Unit. Million dollars)

	Year	Cash Retainable			Funds Receivable			Total Cash Inflow (A)	Requirement for Construction	Repayment of Principal	Total Cash Outflow (B)	Cash Balance (A)-(B)	
		Net Income	Depreciation	Subtotal	Loan	Government Grant	Subtotal					Annual	Added Total
-9					3.95	0.67	4.62		4.62				
-8	1970				18.50	7.16	25.66		25.66				
-7	1				16.04	6.25	22.29		22.29				
-6	2				10.49	5.45	15.94		15.94				
-5	3				21.45	10.21	31.66		31.66				
-4	4				30.15	13.46	43.61		43.61				
-3	5				42.74	14.38	57.12		57.12				
-2	6				55.37	10.74	66.11		66.11				
-1	7				46.30	9.51	55.81		55.81				
1	1978	-9.36	6.42	-2.94				-2.94				-2.94	-2.94
2	9	-7.91	6.42	-1.49	6.74	3.00	9.74	8.25	9.74		9.74	-1.49	-4.43
3	1980	-6.17	6.42	0.25	9.09	1.39	10.48	10.73	10.48		10.48	0.25	-4.18
4	1	-5.84	6.94	1.10				1.10		0.50	0.50	0.60	-3.58
5	2	-3.44	6.94	3.50				3.50		0.53	0.53	2.97	-0.61
6	3	-0.90	6.94	6.04	5.44	0.83	6.27	12.31	6.27	8.80	15.07	-2.76	-3.37
7	4	1.46	7.10	8.56				8.56		9.34	9.34	-0.78	-4.15
8	5	4.57	7.10	11.67				11.67		9.73	9.73	1.94	-2.21
9	6	6.11	7.10	13.21				13.21		10.13	10.13	3.08	0.87
10	7	6.54	7.10	13.64				13.64		10.56	10.56	3.08	3.95
11	8	6.99	7.10	14.09				14.09	0.64	11.01	11.65	2.44	6.39
12	9	7.42	7.10	14.52				14.52		11.47	11.47	3.05	9.44
13	1990	7.91	7.10	15.01				15.01		11.95	11.95	3.06	12.50
14	1	8.41	7.10	15.51				15.51		12.45	12.45	3.06	15.56
15	2	8.93	7.10	16.03				16.03		12.97	12.97	3.06	18.62
16	3	9.48	7.10	16.58				16.58	0.64	13.52	14.16	2.42	21.04
17	4	10.03	7.10	17.13				17.13		14.09	14.09	3.04	24.08
18	5	10.62	7.10	17.72				17.72		14.68	14.68	3.04	27.12
19	6	11.25	7.10	18.35				18.35		15.31	15.31	3.04	30.16
20	7	11.89	7.10	18.99				18.99		15.95	15.95	3.04	33.20
21	8	12.57	7.10	19.67				19.67		16.63	16.63	3.04	36.24
22	9	13.27	7.10	20.37				20.37		15.85	15.85	4.52	40.76
23	2000	13.92	7.10	21.02				21.02		16.50	16.50	4.52	45.28
24	1	14.57	7.10	21.67				21.67		17.15	17.15	4.52	49.80
25	2002	15.07	7.10	22.17				22.17		17.14	17.14	5.03	54.83
	Total			322.37				348.86			294.03		

Table H-4 (2) Statement of Cashflow (Power and Navigation, Case II)

(Unit. Million dollars)

	Year	Cash Retainable			Funds Receivable			Total Cash Inflow (A)	Requirement for Construction	Repayment of Principal	Total Cash Outflow (B)	Cash Balance (A)-(B)	
		Net Income	Depreciation	Subtotal	Loan	Government Grant	Subtotal					Annual	Added Total
-9					4.29	0.34	4.63		4.63				
-8	1970				22.15	3.58	25.73		25.73				
-7	1				19.36	3.13	22.49		22.49				
-6	2				13.54	2.72	16.26		16.26				
-5	3				27.03	5.10	32.13		32.13				
-4	4				37.58	6.73	44.31		44.31				
-3	5				50.91	7.19	58.10		58.10				
-2	6				61.98	5.37	67.35		67.35				
-1	7				53.58	4.76	58.34		58.34				
1	1978	-11.30	6.54	-4.76				-4.76				-4.76	-4.76
2	9	-9.85	6.54	-3.31	8.27	1.50	9.77	6.46	9.77		9.77	-3.31	-8.07
3	1980	-8.11	6.54	-1.57	9.87	0.70	10.57	9.00	10.57		10.57	-1.57	-9.64
4	1	-7.87	7.06	-0.81				-0.81		0.59	0.59	-1.40	-11.04
5	2	-5.46	7.06	1.60	5.86	0.42	6.28	7.88	6.28	0.63	0.91	0.97	-10.07
6	3	-3.27	7.06	3.29				3.29		8.79	8.79	-5.50	-15.57
7	4	-0.55	7.22	6.67				6.67		9.18	9.18	-2.51	-18.08
8	5	2.56	7.22	9.78				9.71		9.57	9.57	0.21	-17.87
9	6	4.10	7.22	11.32				11.32		9.97	9.97	1.35	-16.52
10	7	4.54	7.22	11.76				11.76		10.41	10.41	1.35	-15.17
11	8	4.94	7.22	12.16				12.16	0.64	10.81	11.45	0.71	-14.46
12	9	5.36	7.22	12.58				12.58		11.26	11.26	1.32	-13.14
13	1990	5.85	7.22	13.07				13.07		11.74	11.74	1.33	-11.81
14	1	6.34	7.22	13.56				13.56		12.23	12.23	1.33	-10.48
15	2	6.85	7.22	14.07				14.07		12.74	12.74	1.33	-9.15
16	3	7.37	7.22	14.59				14.59	0.64	13.26	13.90	0.69	-8.46
17	4	7.91	7.22	15.13				15.13		13.82	13.82	1.31	-7.15
18	5	8.49	7.22	15.71				15.71		14.40	14.40	1.31	-5.84
19	6	9.10	7.22	16.32				16.32		15.01	15.01	1.31	-4.53
20	7	9.73	7.22	16.95				16.95		15.64	15.64	1.31	-3.22
21	8	10.42	7.22	17.64				17.64		16.33	16.33	1.31	-1.91
22	9	11.12	7.22	18.34				18.34		15.37	15.37	2.97	1.06
23	2000	11.75	7.22	18.97				18.97		16.00	16.00	2.97	4.03
24	1	12.39	7.22	19.61				19.61		16.10	16.10	3.51	7.54
25	2	13.03	7.22	20.25				20.25		16.74	16.74	3.51	11.05
26	3	13.70	7.22	20.92				20.92		17.41	17.41	3.51	14.56
27	4	13.90	7.22	21.12				21.12		17.61	17.61	3.51	18.07
28	5	15.10	7.22	22.32				22.32		18.81	18.81	3.51	21.58
	Total			337.28				363.90			342.32