SAMBOR PROJECT REPORT

Lower Mekong River Basin

Volume V

Navigation

OVERSEAS TECHNICAL COOPERATION AGENCY

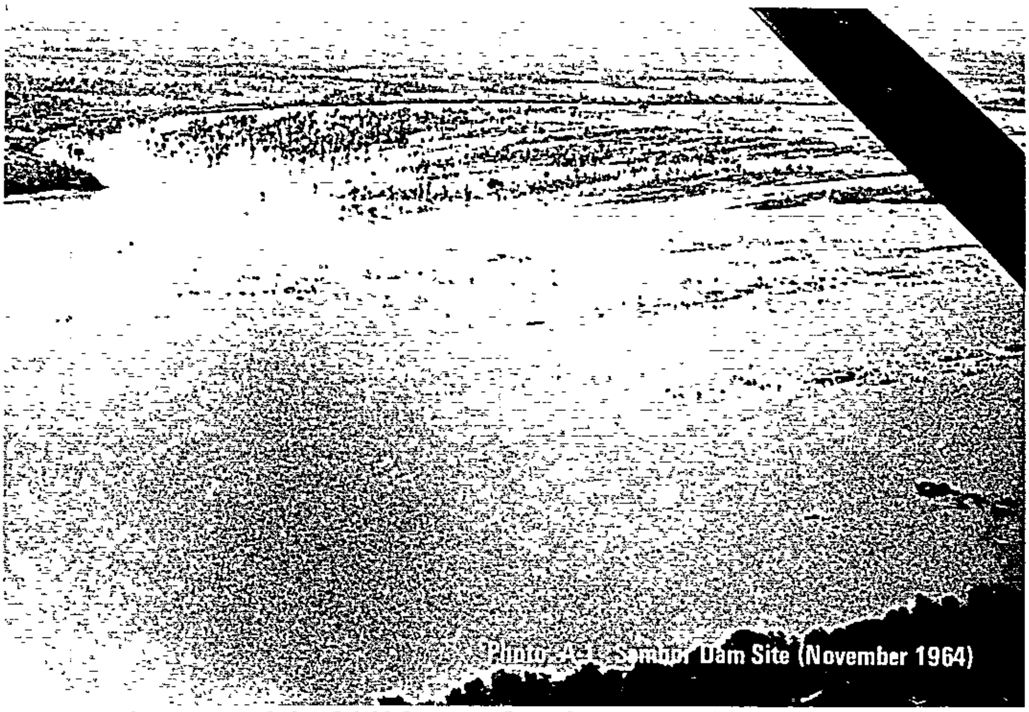
GOVERNMENT OF JAPAN

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



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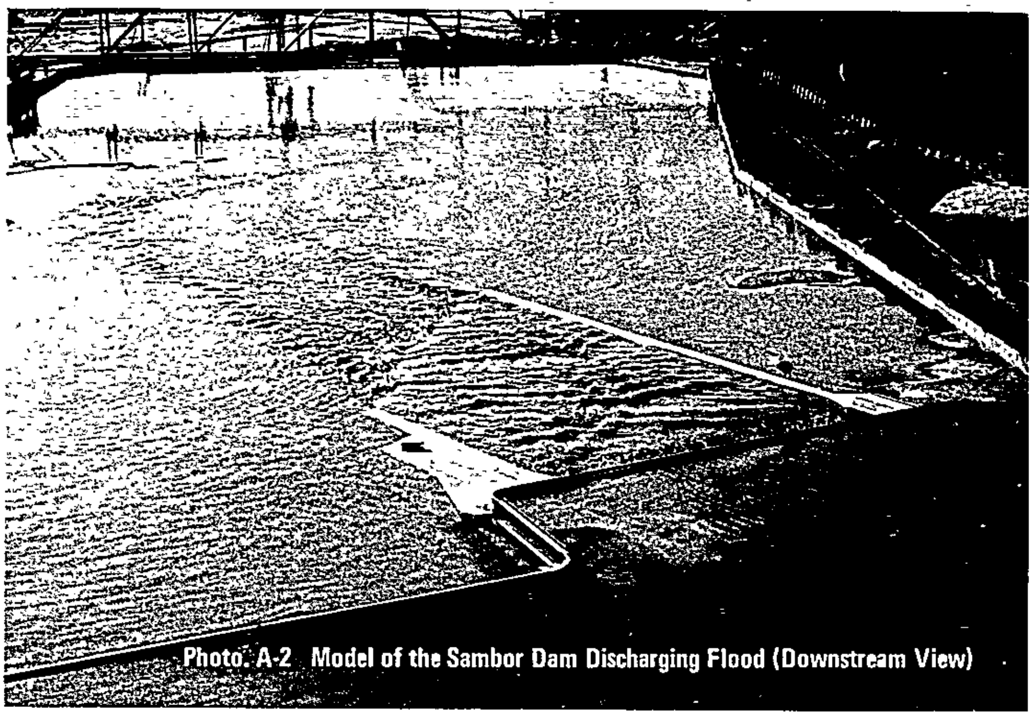

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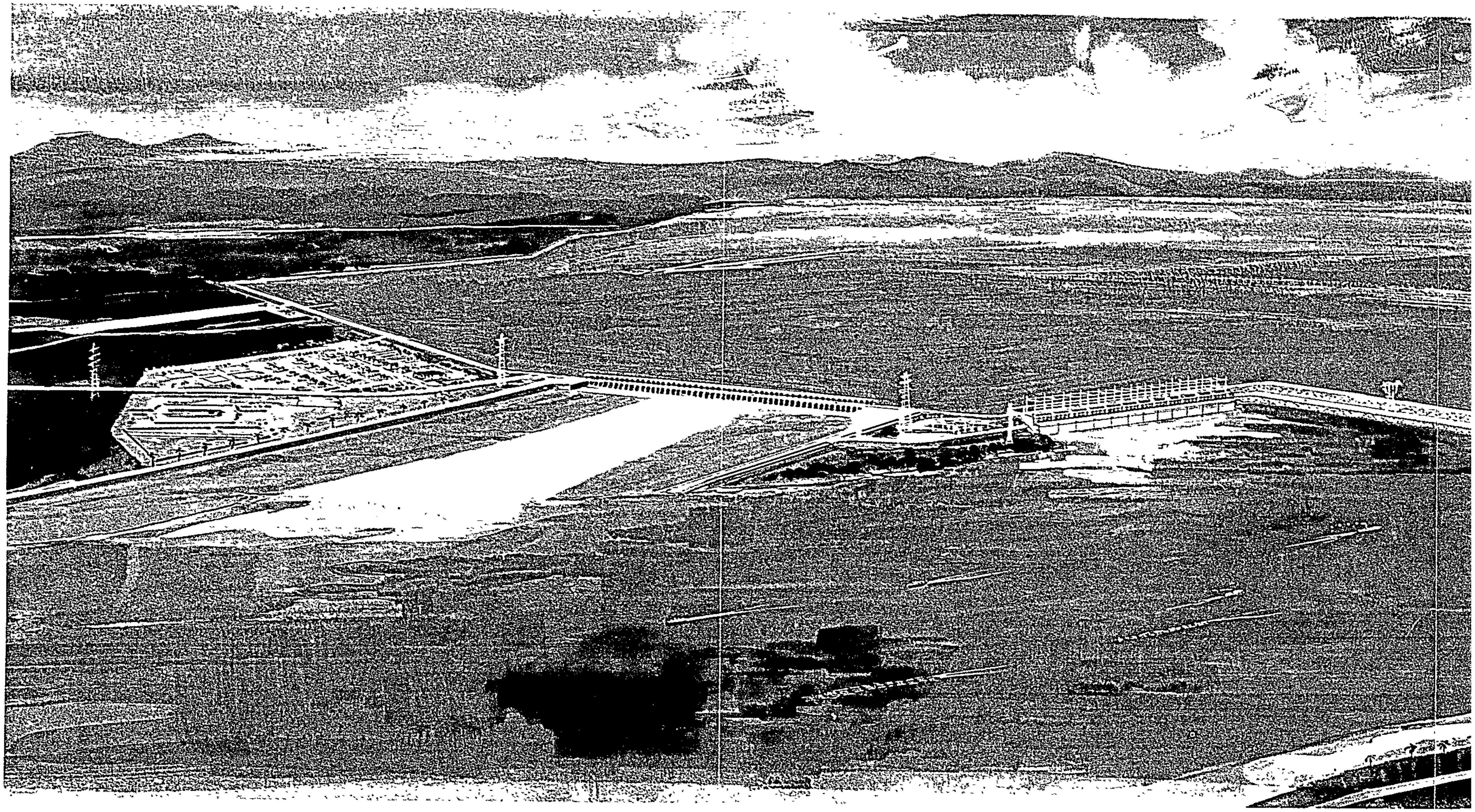

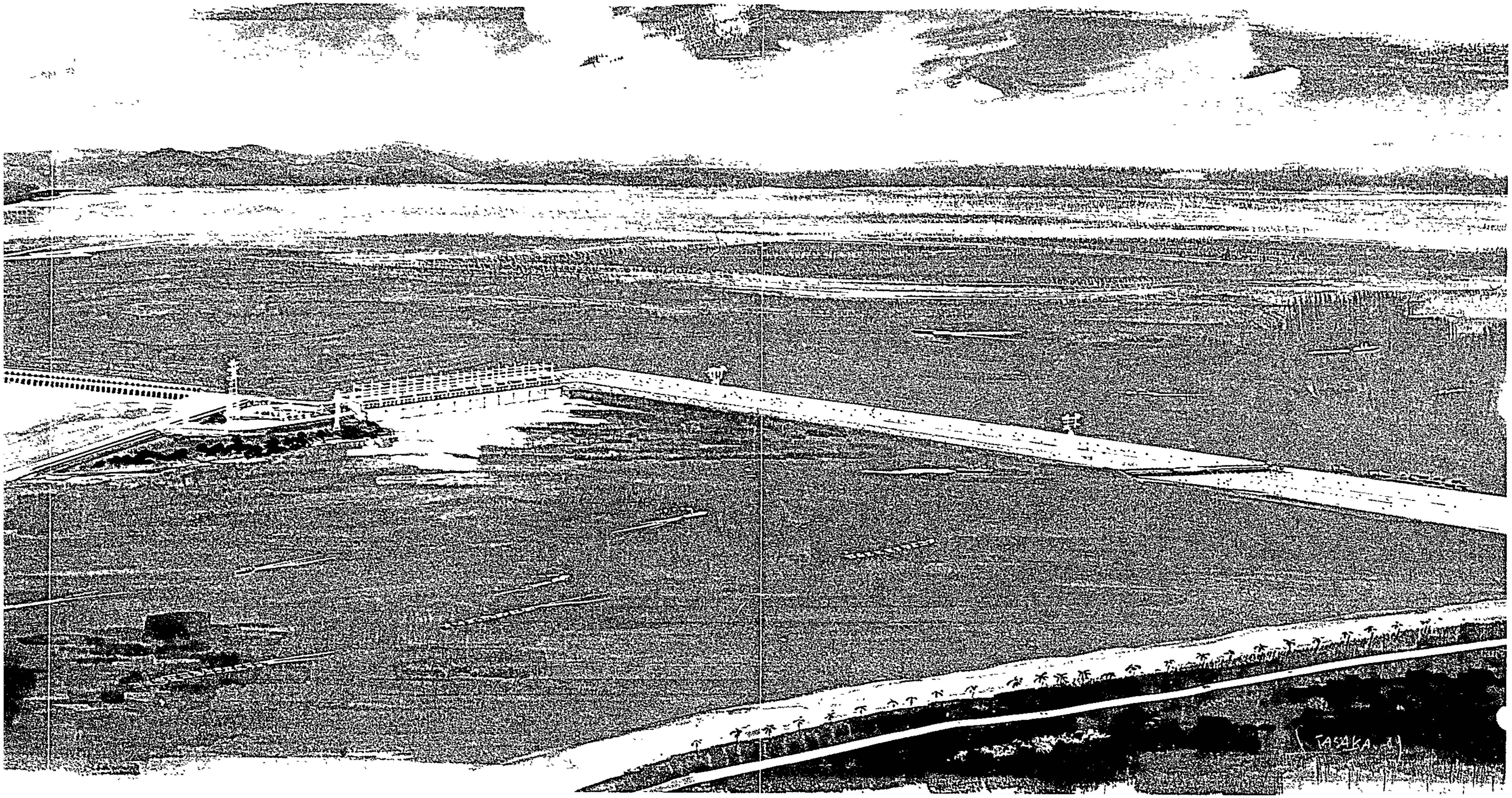

Aerial View of the Projected Sambor Dam

SAMBOR PROJECT REPORT

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Navigation

Supplementary Material to Volume I

OVERSEAS TECHNICAL COOPERATION AGENCY

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FOREWORD

The Government of Japan has sent since January 1959 several investigation teams to Cambodia with the intention of contributing to the development project of the water resources in the Lower Mekong River Basin. After a reconnaissance and preliminary investigations, detailed studies were started in January 1963 on hydroelectric power generation, navigation, irrigation and fishery.

The field investigations and studies concerning the navigation on the Mekong were carried out in three phases on the following schedule in the period from January 1963 to February 1965.

1) From January 13 to February 10, 1963: (a) Survey of the river regime of the Mekong Mainstream (water level, water depth, current velocity and so forth);

2) From August 24 to September 11, 1963: (b) Survey of the existing waterway traffic on the Mekong (kinds and routes of traffic, freightage, vessels used and so forth); and

3) From December 20, 1964 to February 9, 1965: (c) Survey of the existing navigation facilities and cargo handling; (d) Survey of the existing land traffic (kinds and routes of traffic and freightage); (e) Economic survey (population and production activities); and (f) Soil investigation (visual observation, core borings and hand-auger borings).

The data obtained and given in this report are mostly of 1962 to 1966. Accordingly, it seems that these data have now become somewhat outdated, but they may still be of use as the substantial bases of consideration.

In the following are described the investigation and planning made on the navigation facilities that shall be installed around the dam on the Mekong at Sambor in Cambodia about 565 km upstream from the river mouth.

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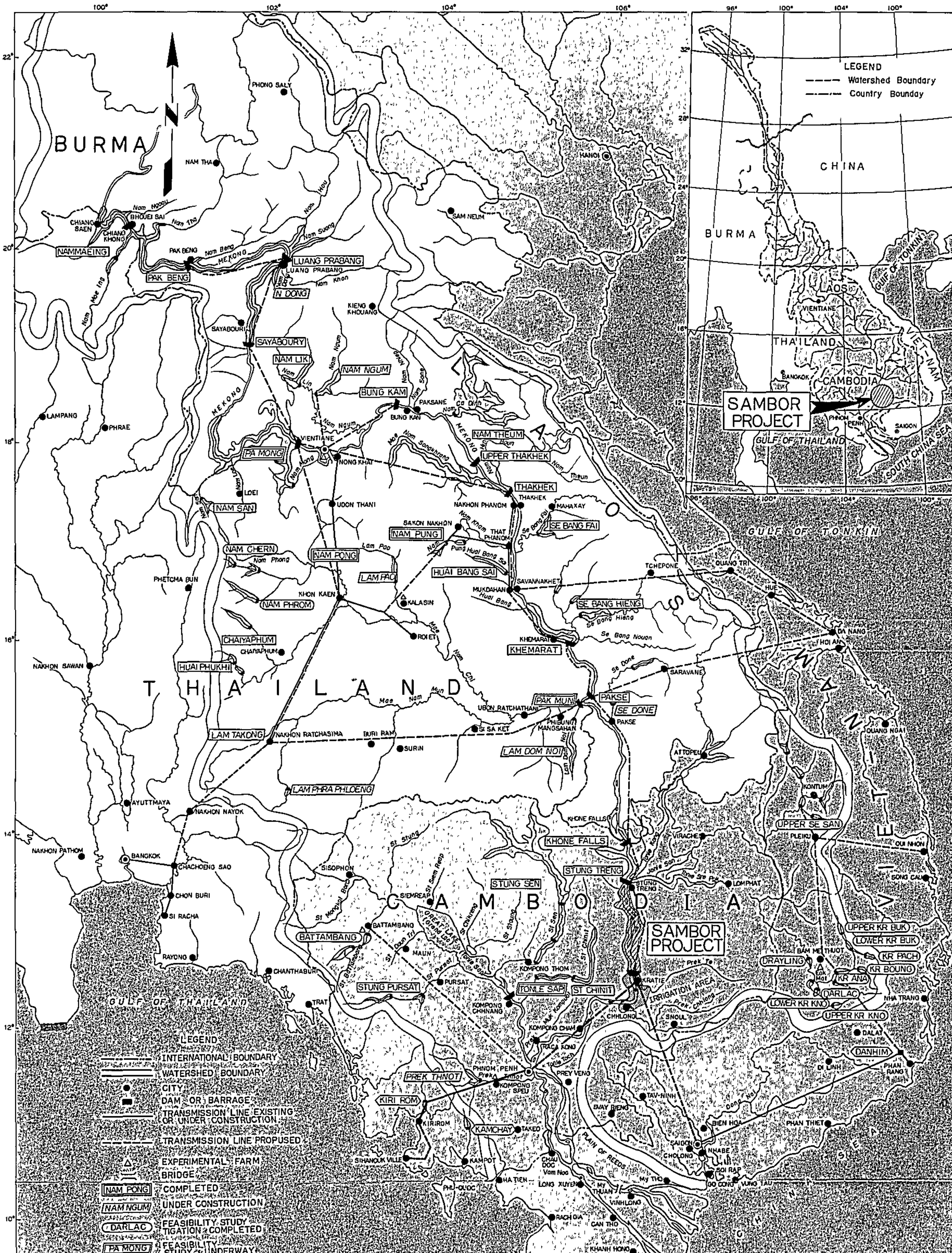
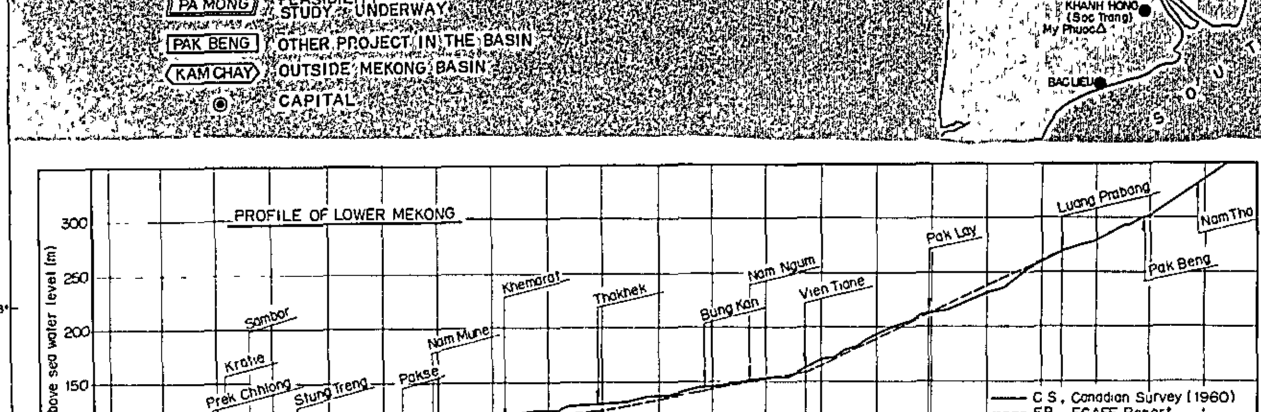
UNITS AND CONVERSIONS

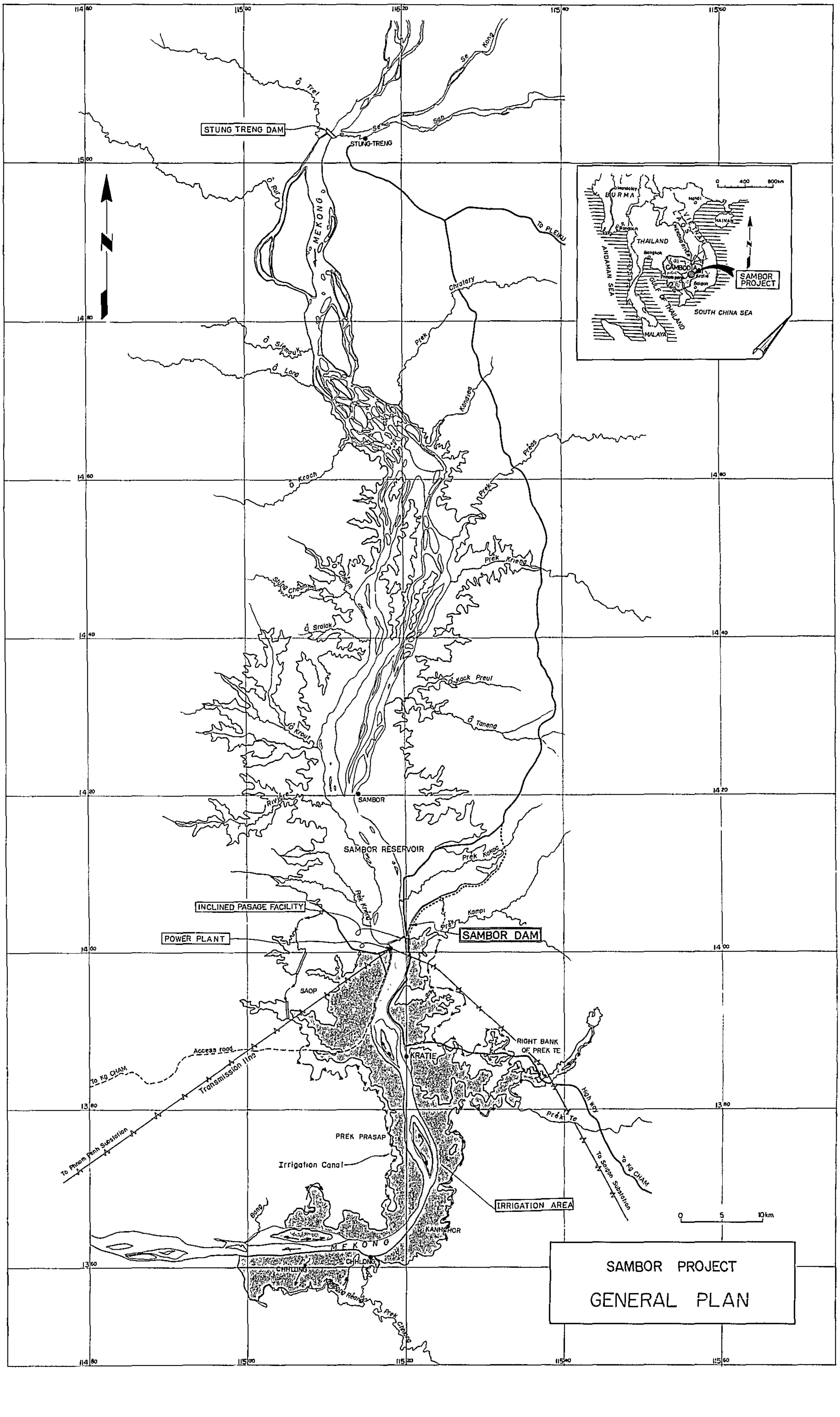
cm	centimeter
cm^2	square centimeter
cu	cubic
D.W.T.	Dead Weight Tonnage
EL	Elevation (Height above Mean Sea Level)
Fig.	figure
gr.	gram
ha	hectare
HP	Horse Power
hr	hour
H.W.L.	High Water Level
kg	kilogram
km	kilometer
km^2	square kilometer
L.W.L.	Low Water Level
m	meter
m^2	square meter
m^3	cubic meter
m^3/s	cubic meters per second
Max.	maximum
m/sec	meters per second
Min.	minimum
M.S.L.	Mean Sea Level
sec	second
sq.	square
t	metric ton
$	U.S. Dollar
%	percent
°C	Centigrade scale





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
Se Kong
San
Ô Trel
Ô Rur
To PLEIKU
Chralary
Prek
Ô Slempuk
Ô Lona
Kandieg
Ô Kroch
Preas
Prek Krieng
Ô Cham
Stung Cheam
Ô Sralok
Ô Kack Preul
Ô Tanena
Ô Kraul
SAMBOR
SAMBOR RESERVOIR
Prek Kokoc
Prek Krieng
Kampi
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
Prek Te
To Saigon Substation
PREK PRASAP
Irrigation Canal
IRRIGATION AREA
KANHCHOR
CHHLONG
Bong
Prek Chhlong
0 5 10km
BURMA
THAILAND
ANDAMAN SEA
GULF OF THAILAND
SOUTH CHINA SEA
MALAYA
CAMBODIA
HAINAN
SAMBOR PROJECT
0 400 800km

The Mekong in Cambodia

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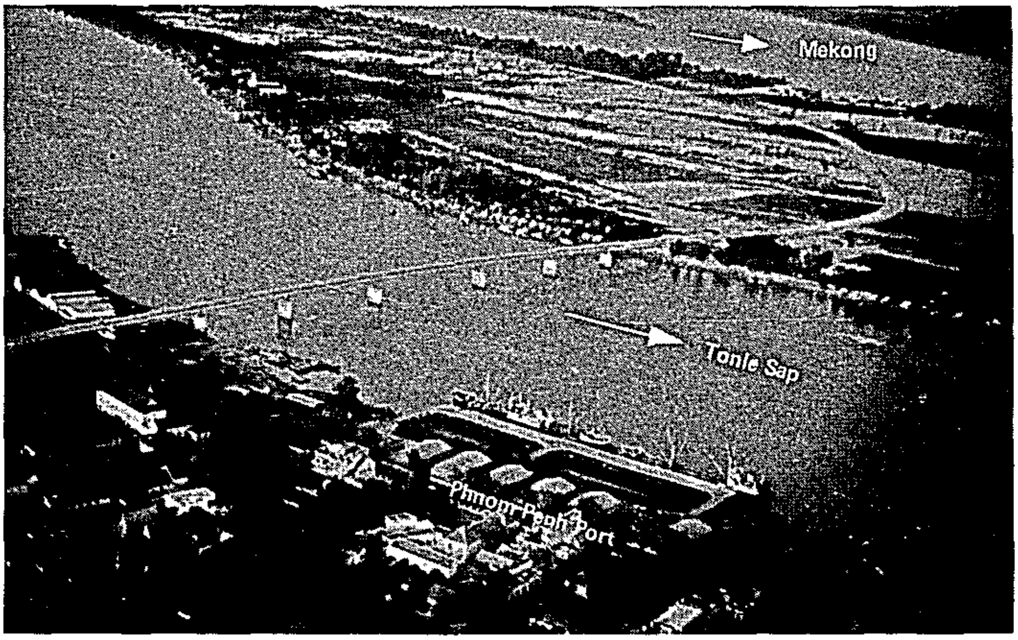

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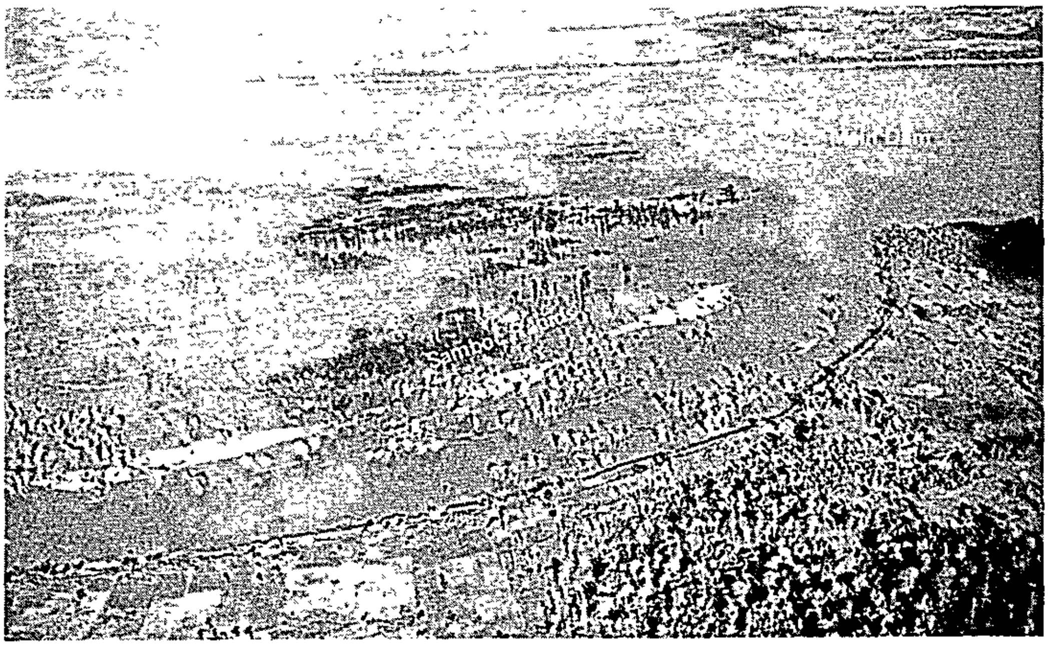
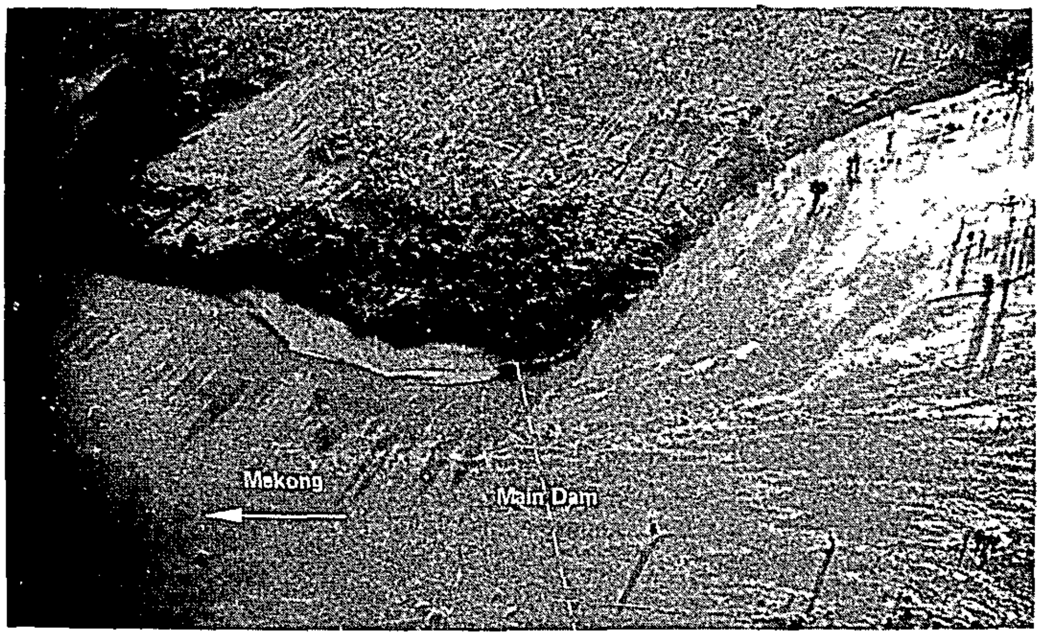


Photo. B-6 Sambor Dam Site (December 1964)



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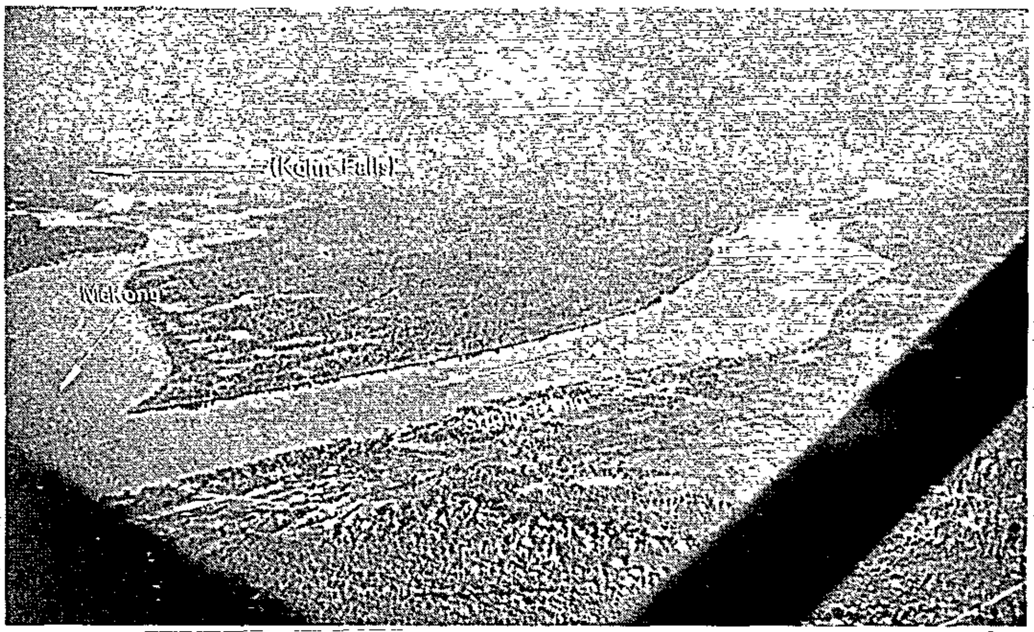

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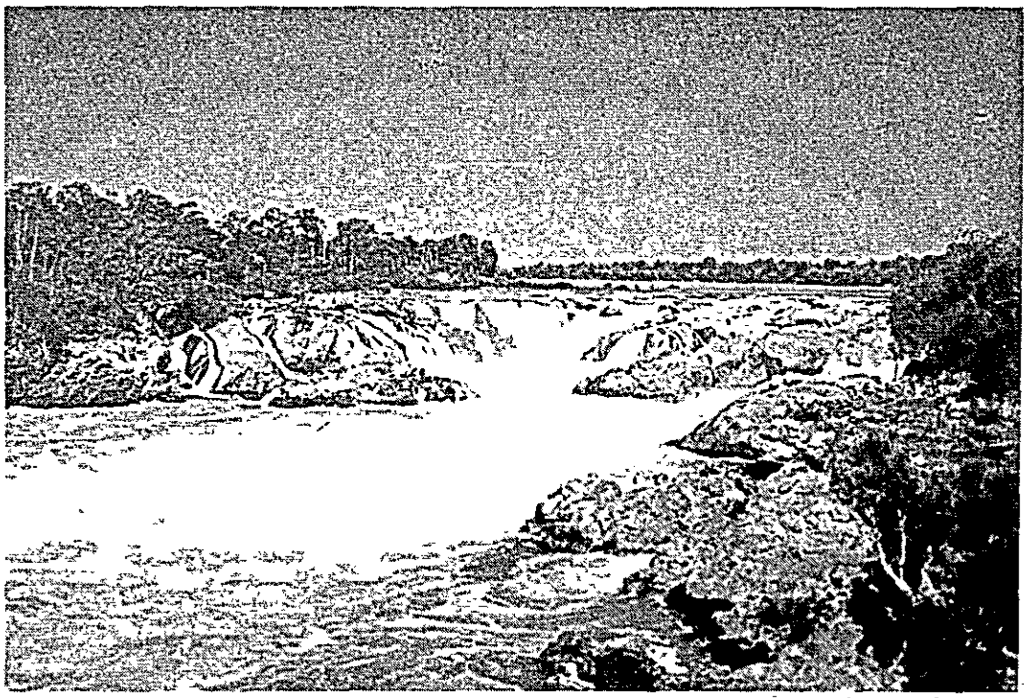
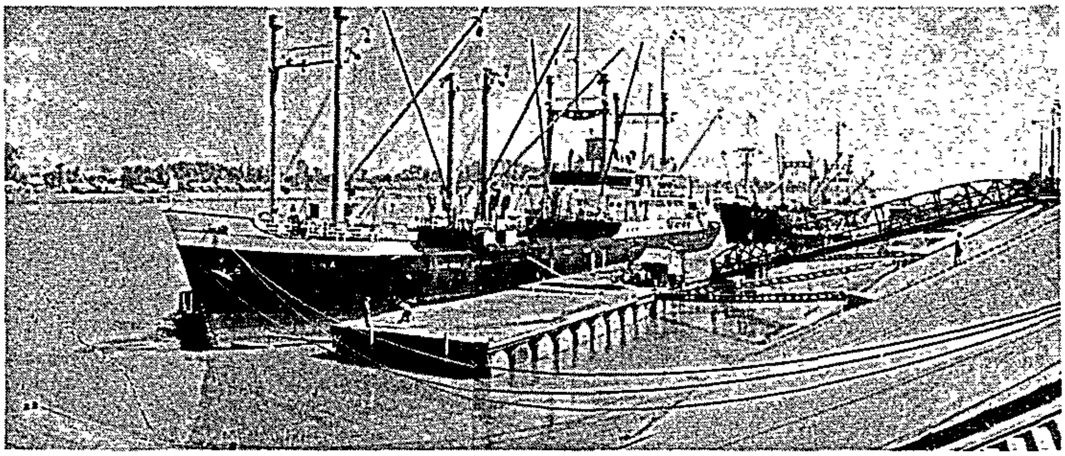


Photo. B-12 Part of the Kohn Falls (December 1964)

Navigation



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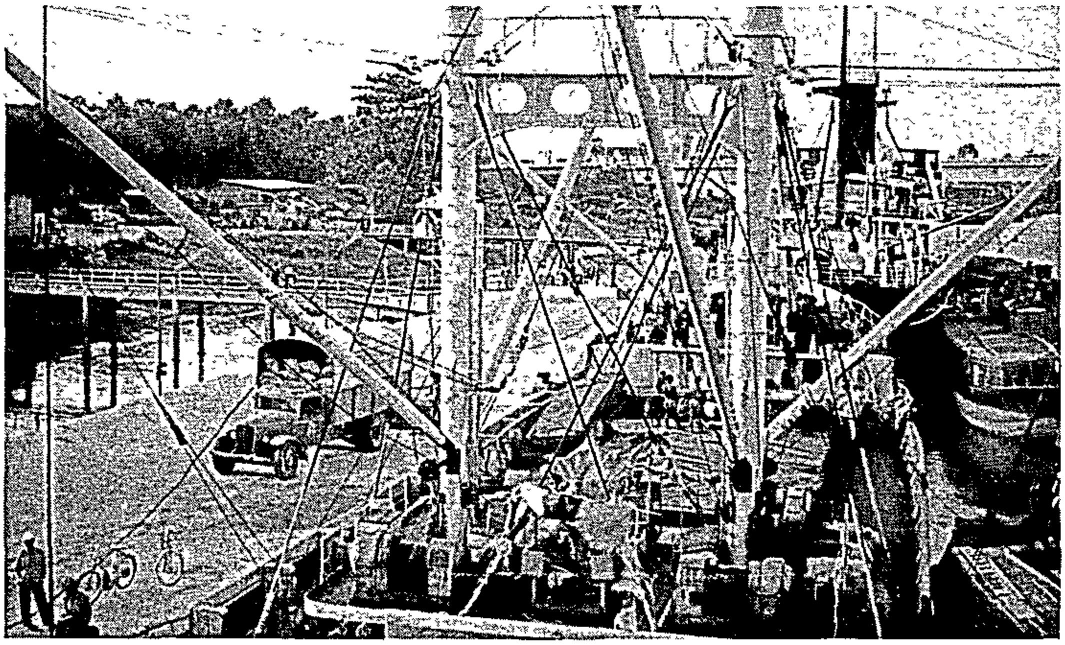

Photo. F-2 Cargo Ship at Phnom Penh Port

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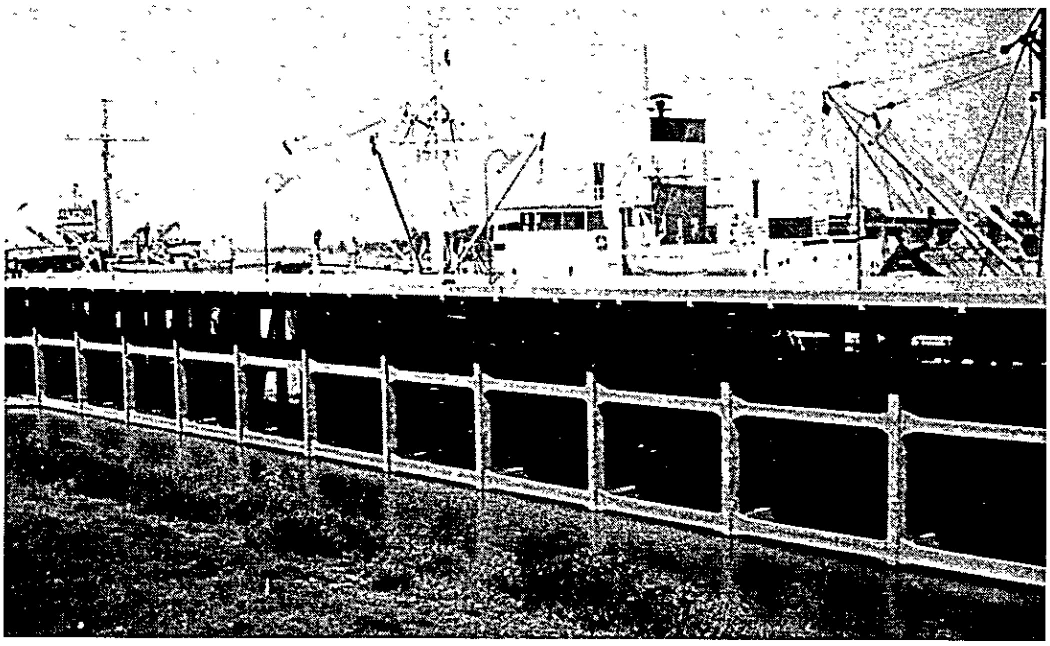
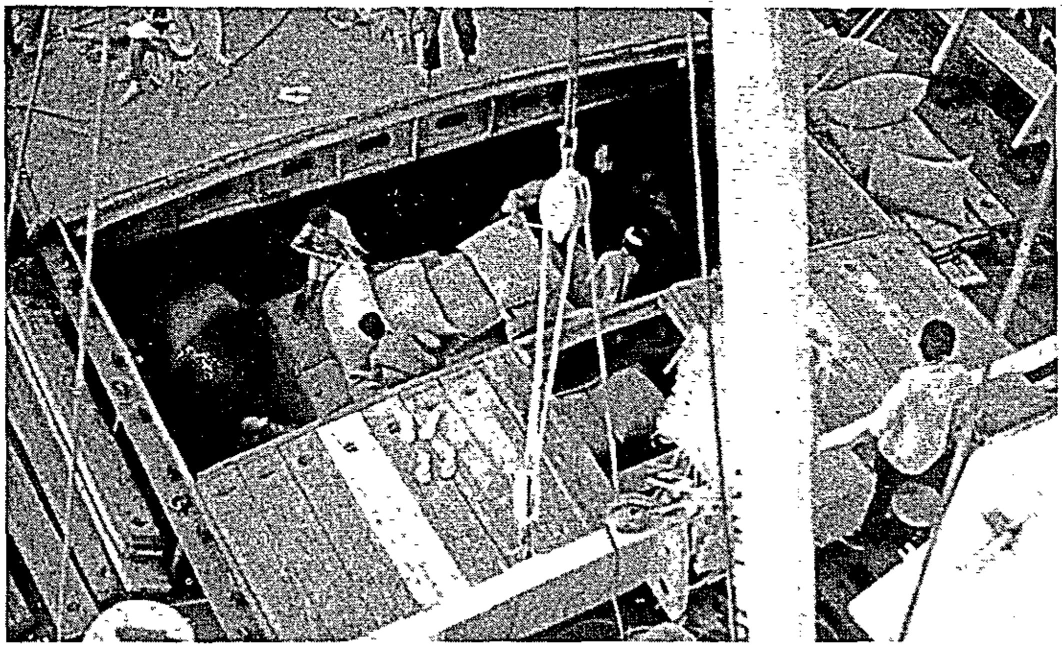


Photo. F-4 Berth of Phnom Penh Port



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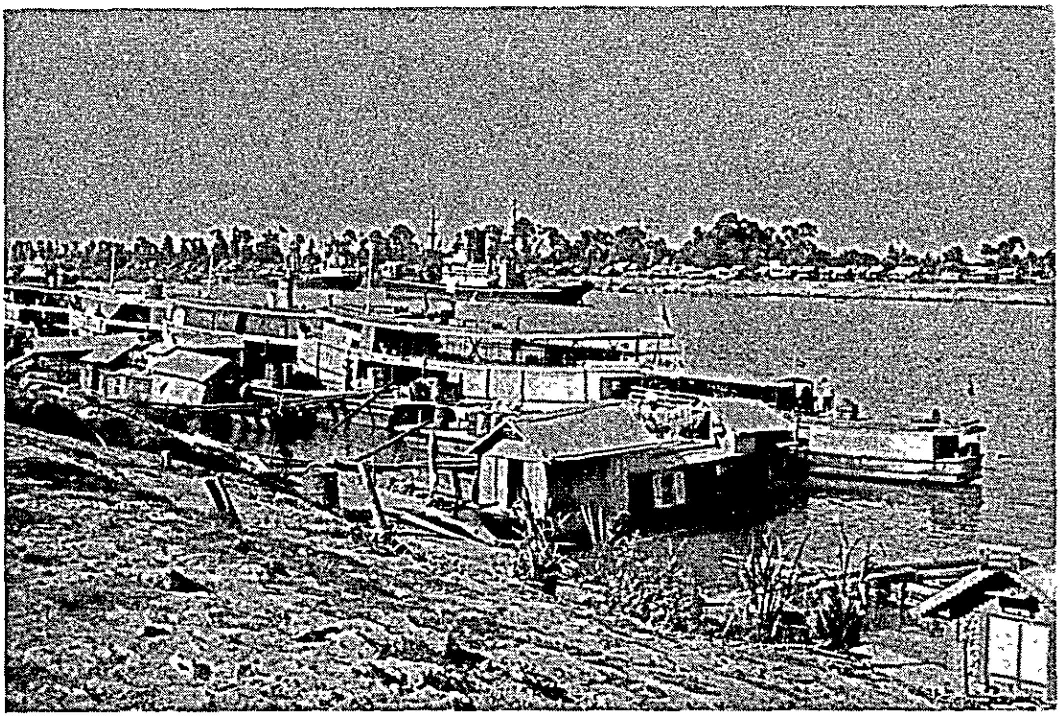


Photo. F-6 Inter-water Liners at Phnom Penh Port (Dry Season)

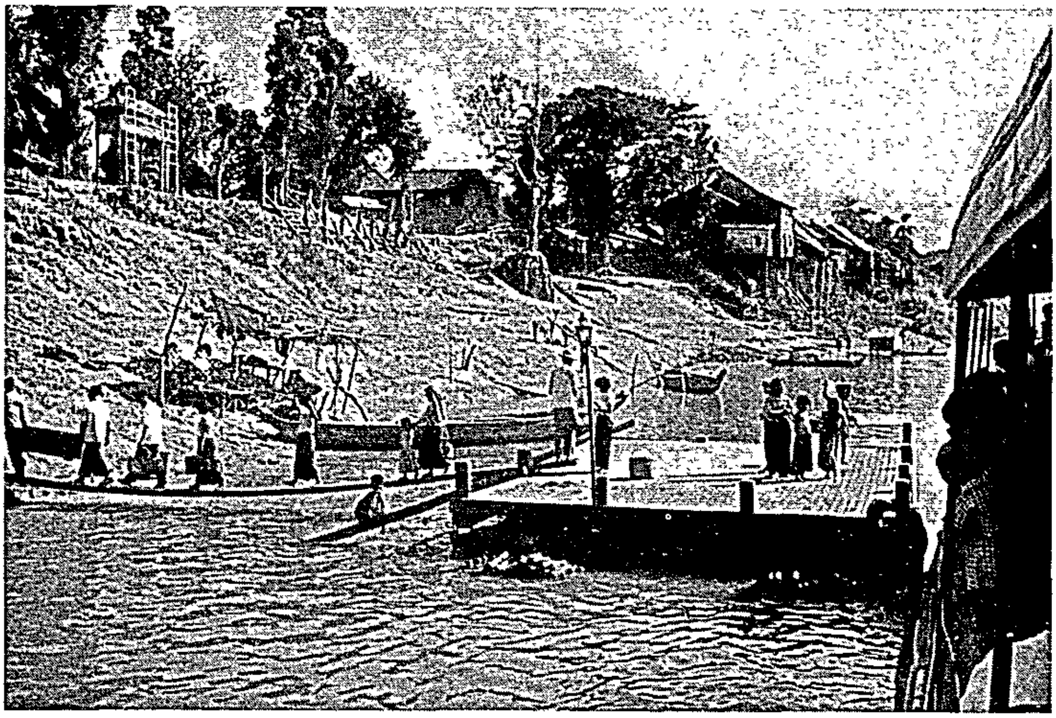


Photo. F-7　One of River Ports between Phnom Penh and Kratie

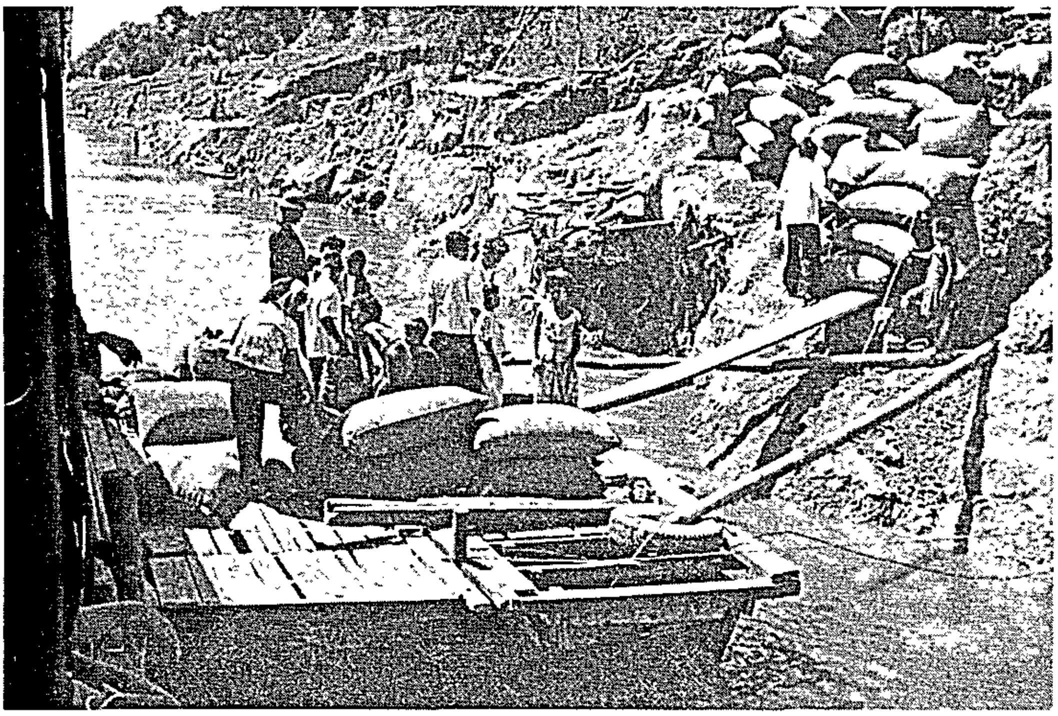


Photo. F-8　One of River Ports between Phnom Penh and Kratie

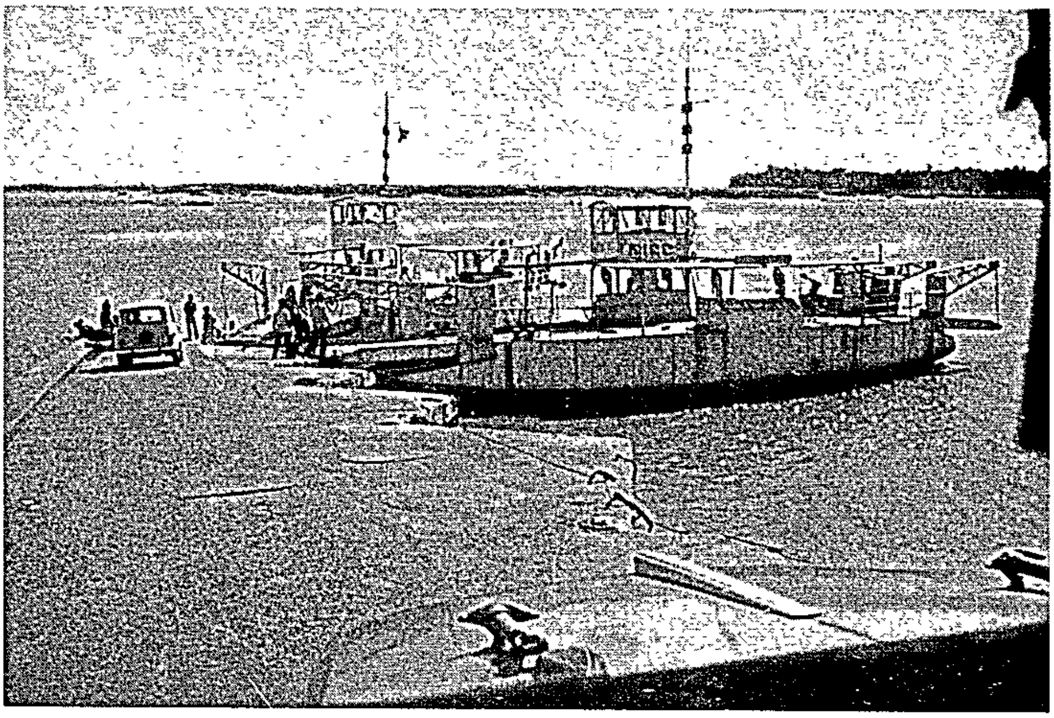


Photo. F-9 Ferry-boat at Kompong Cham Port (Dry Season)

Photo. F-10 Inter-water Liners at Kompong Cham Port (Dry Season)

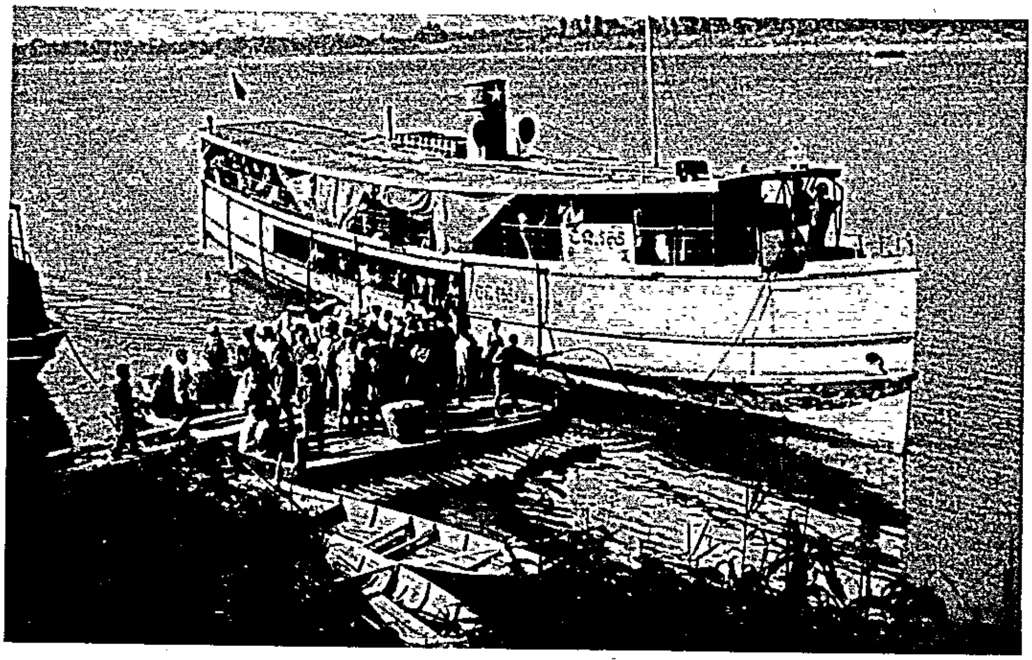


Photo. F-11 Inter-water Liner at Kratie Port (Dry Season)

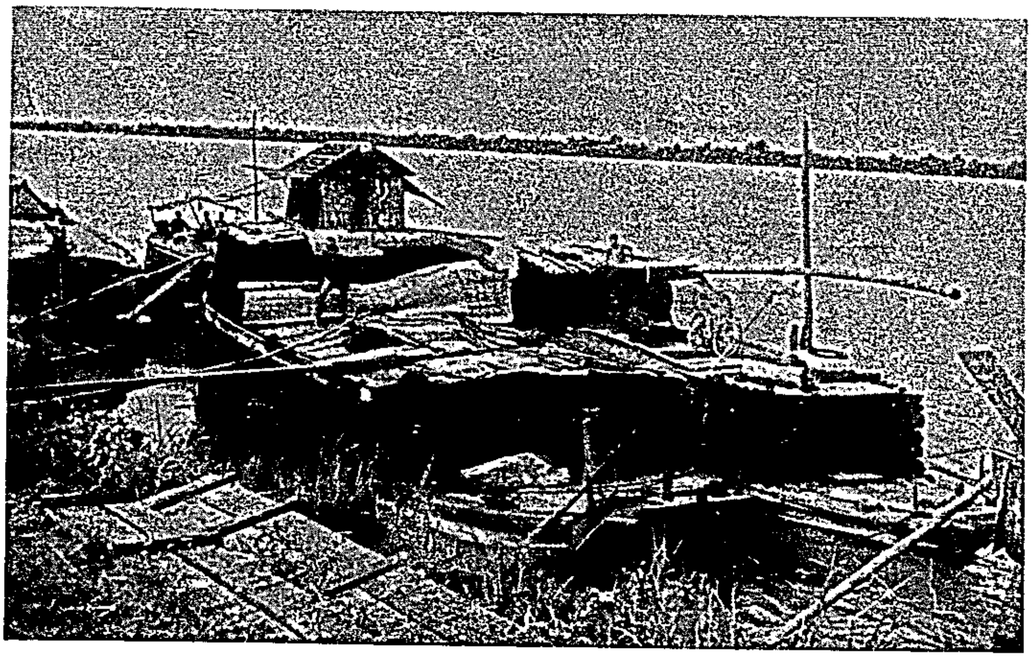


Photo. F-12 Charcoal Ships (100 ton) at Kratie

Photo. F-13 Timbers at Riverside (Kratie)

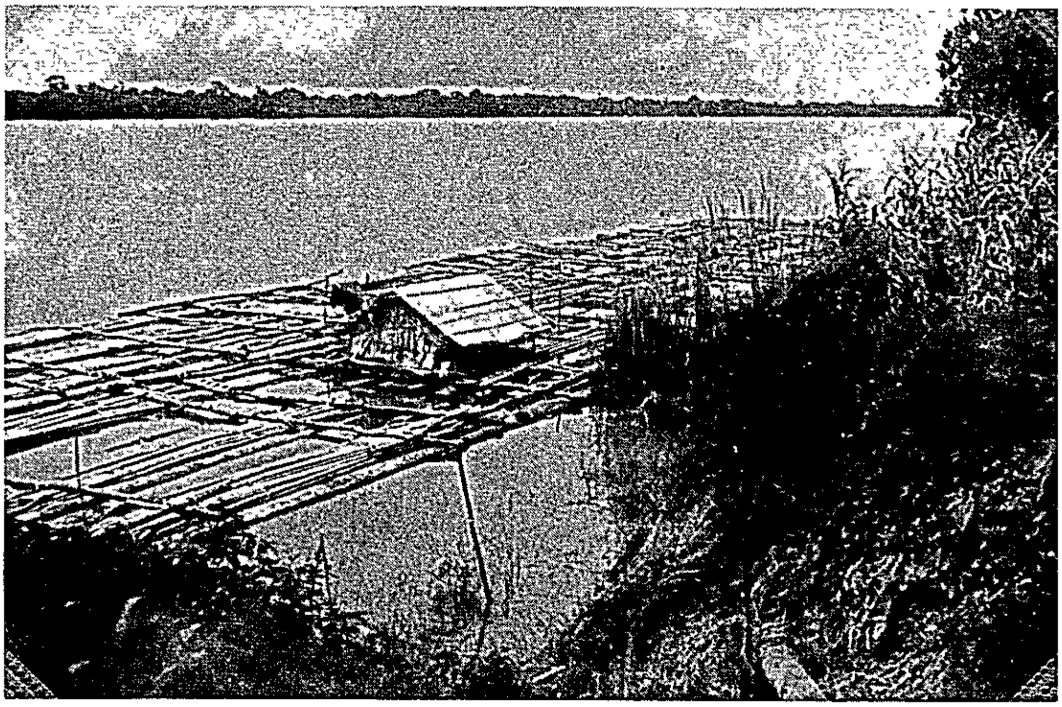


Photo. F-14 Raft of Timber (Kratie)

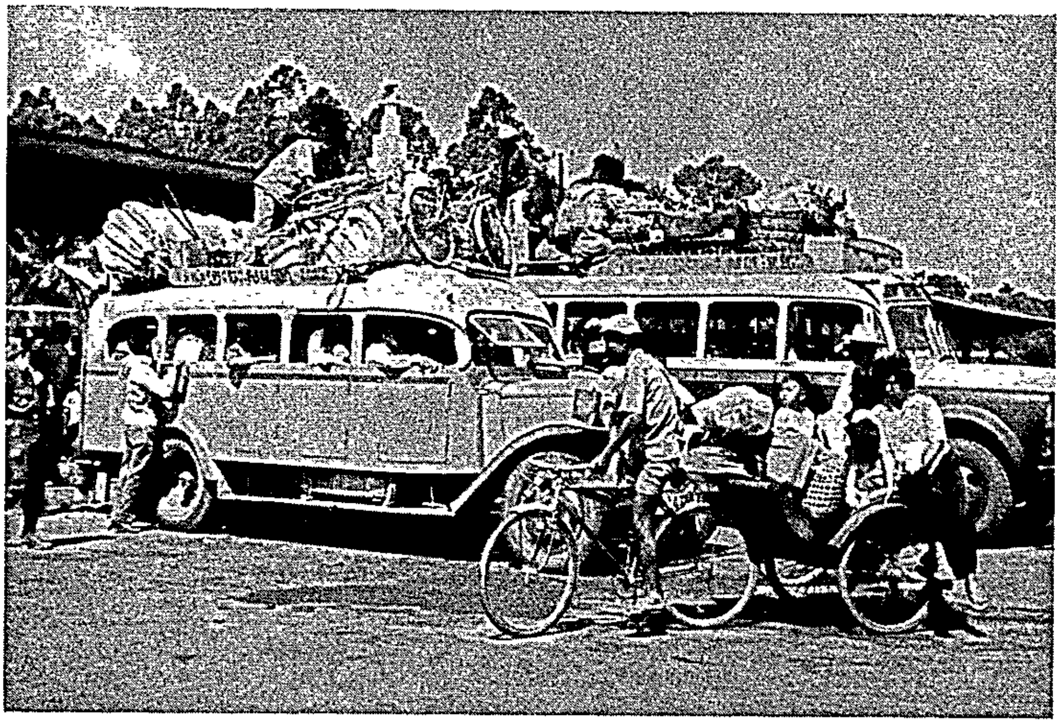


Photo. F-15 Buses at Terminal (Kratie)

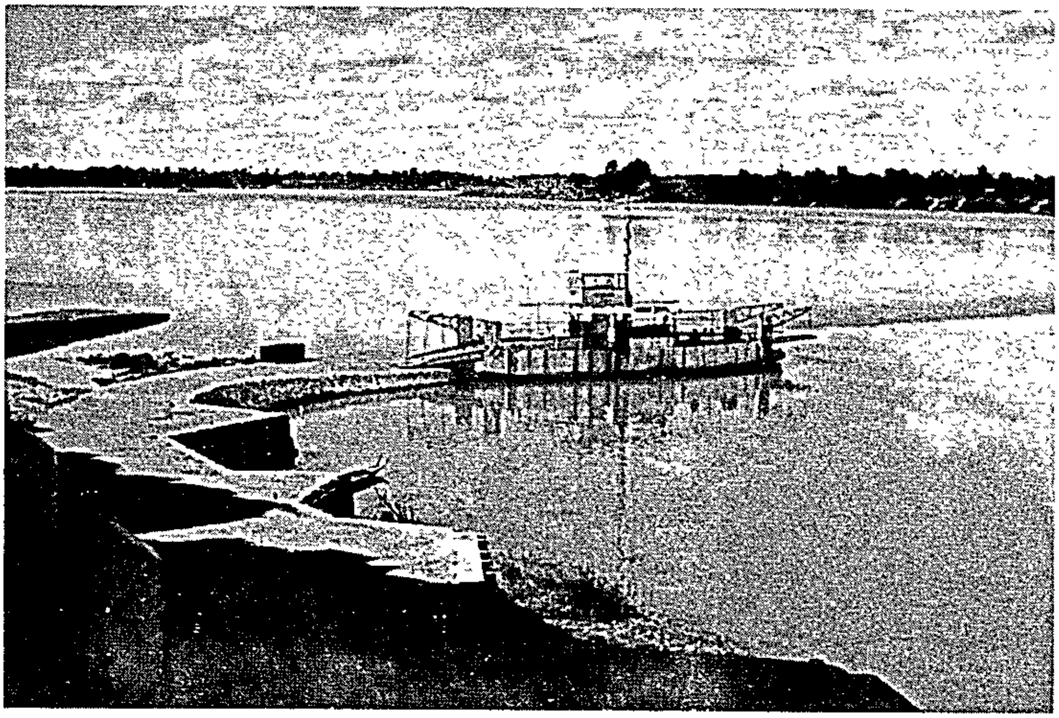


Photo. F-16 Ferry-boat at Stung Treng (Dry Season)

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 by changing 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 Scope of Investigation

This report deals with the investigation and planning made on the navigation facilities around the Sambor dam projected on the Mekong some 15 km upstream from Kratie in Cambodia.

It goes without saying that to ensure the navigation that will be interrupted by the dam, it is necessary to install ship locks, inclines or other facilities. Studies have been made on what shall be provided at Sambor.

The effect on the Mekong's navigation of the Sambor Project will extend directly to Stung Treng and will also be felt in the eastern part of Cambodia. Accordingly, the studies on the existing traffic, river regime, soil conditions and so forth have been done mainly with respect to those within the boundaries of Cambodia.

The influence of the Sambor Project, however, is not confined within the boundaries of Cambodia. It is one major objective of the development of water resources in the Lower Mekong River Basin to make the river navigable from its mouth to Luang Prabang in Laos. And the Sambor dam is the one located most downstream of those envisaged in the development plan. Therefore, dredging of shoals to improve navigation course has been planned not only within the reach from Sambor to Stung Treng but also in the downstream reach from Sambor to the estuary in Vietnam. And also in studying the future plan of the Sambor Project, future traffic on the Mekong from its mouth through Cambodia and Thailand to Laos has been considered (Fig. V-1).

A-2 Outline of the Progress of Investigation

The basic concept of the water resources development in the Lower Mekong River Basin was first set forth in an ECAFE report, *Development of Water Resources in the Lower Mekong Basin* [1]. The River following are the gists on the Mekong's navigation stated in this report.

1. On the mainstream of the Mekong, there exists river traffic from the estuary up to the Vientiane Area in Laos. But certain reaches of the river are at present not navigable or navigable only with danger and difficulty, and that in a limited period of the year.

From Vientiane downstream to Savannakhet, the river flows through a vast flatland and the channel retains a depth of one meter even in the low-water season so that the river traffic is operated through the year.

In the 96-km section from Keng Kabao, a little downstream from Savannakhet, to Keng Yapeut, the river runs through a cliffy gorge with protruding bedrock, forming rapids such as the Khemarat rapids. The current is swift reaching as high as 5 m per second. Hence, navigation in this section is prohibitive except in a limited period of the year.

From its confluence with the Mune River past Pakse to Khone Falls, the channel is dotted with rock outcrops but the river is still navigable.

Khone Falls is a series of rapids extending over a distance of about 10 km and entirely prohibits navigation. From Khone to Stung Treng, the river is generally navigable.

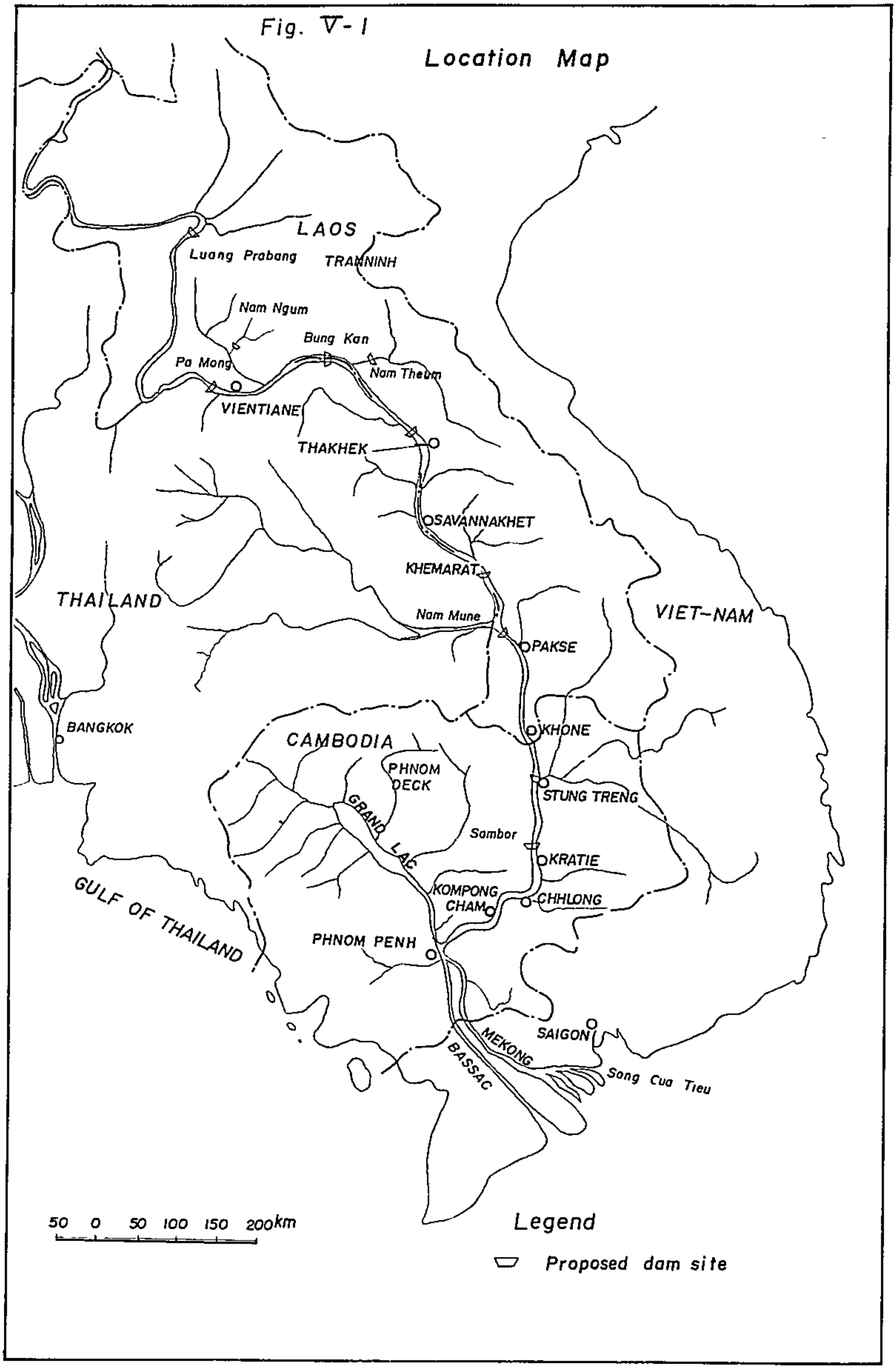
In the 133 km reach from Stung Treng to Kratiê, the river becomes wide but rock outcrops protrude above the low-water level at many places and there are the Prepalang and Samboc Rapids. Therefore, the navigation in this section is impossible in the low-water season.

The river downstream from Kratie flows in a gentle and deep flow allowing traffic of small boats at all times. But there are some places in its way to Phnom Penh where it becomes shallow and swift, for example, at Chhlong.

2. If, to cope with the above-cited difficulties in navigation, ship locks and/or other facilities will be provided around the dams projected at Khemarat, Khone Falls and Sambor and if the channel will be cleared of dangerous rock and shoals, the Mekong will become navigable from its mouth to Vientiane with no substantial difficulties.

1/ : Flood Control Series, No. 12, ST/ECAFE/SER.F/12, October 1957.

Fig. V-1 Location Map



3. As a basis in planning locks and other facilities, it is recommended that a flotilla of four 180-ton barges and a tug shall be considered in the section between Phnom Penh and Kratie, and two 100-ton barges and a tug between Kratié and Vientiane.

4. At present, most of the population in the Lower Mekong River Basin is engaged in agriculture and production is largely from agriculture. But about 40% of the land area is covered by forests that represent a major asset in the economy of Cambodia, Laos and Thailand. Besides agricultural and forest products, mineral resources are of great importance. Although the information is yet incomplete, the Mekong Basin abounds in various resources as shown in Fig. V-2. However, the forest and mineral resources have not yet been exploited on any significant scale because of transport difficulties.

5. If cheap power and inexpensive transportation will become available, there will spring up industries that will make use of these natural resources as essential raw materials. Both these materials and their products will depend on the Mekong for their transport.

6. The choice of the most economical route to handle the future traffic in the Mekong Basin depends on comparative transport costs by railway, highway and waterway. For the export and import of goods from or to Khemarat and downstream, the Mekong will offer the most economical route. But, for bulk cargo between a seaport and Vientiane, rail transport from or to Bangkok would be preferred. Transport to or from the area between Khemarat and Vientiane constitutes a marginal case. In this area and upstream from Vientiane, the importance of waterway lies mainly in carrying local traffic.

The Government of Japan has sent in the period from January 1959 to October 1960 survey teams to reconnoiter major tributaries of the Mekong. The reconnaissance was done in three phase mainly by means of aerial photography supplemented by field observations at key points. In the report of the reconnaissance 1/, a profile of the Mekong after the completion of the projected dams is presented (Fig. V-3) and it is stated concerning navigation that if the dams, especially at Khemarat, Khone Falls and Sambor, will be completed, the backwaters of the dams would cover most part of the river channel in these sections submerging dangerous rapids and shoals and thus substantially improve the navigability of these sections, as already noted in the above-cited ECAFE report.

The Committee for Coordination of Investigations of the Lower Mekong River Basin (the Mekong Committee) is functioning actively in various fields. The following are some fo the recent activities and the projects completed by the Committee 2/, that shall be taken into account in planning navigation facilities at Sambor.

1. River channel sounding from the Cambodian-Vietnamese border up to Sambor and the measurement of the water depth and the velocity and direction of flow around Phnom Penh were carried out. And a hydrographic survey has recently been done from the estuary to the Cambodian-Vietnamese border.

2. Navigation aids have been set up in the course from the estuary to Phnom Penh and around Vientiane.

3. The channel around the port of Phnom Penh is now being improved with two dredges donated by the Government of the Netherlands.

4. Bank erosion is a serious problem, which the countries along the mainstream of the Mekong have to cope with. At the request of the Mekong Committee, an Indian Team has made a study and presented a report.

5. A British Team was invited to study how and what improvement shall be done on cargo handling facilities at river ports in Cambodia, Laos and Thailand and presented a proposal of standard types of cargo handling facilities.

6. Envisaging to make the Mekong navigable throughout its lower basin, the Committee has proposed to make a comprehensive traffic survey in order to establish a general plan of traffic system in and around the whole area of the Lower Mekong River Basin. Some plans of traffic system for the present and for the future are now under study. And, a canal that will connect the upper reaches of the Pa Mong dam with the Gulf of Thailand, bypass canals at Khemarat and Khone Falls and a canal between Bassac and Kampot have been proposed.

1/ : *Comprehensive Reconnaissance Report of the Major Tributaries of the Mekong River*, by the Japanese Reconnaissance Team, September 1961.

2/ : *1968 Annual Report* of the Committee for Coordination of Investigations of the Lower Mekong Basin, 1966.

Fig. V-2 Distribution of Mineral Deposits in Lower Basin of the Mekong

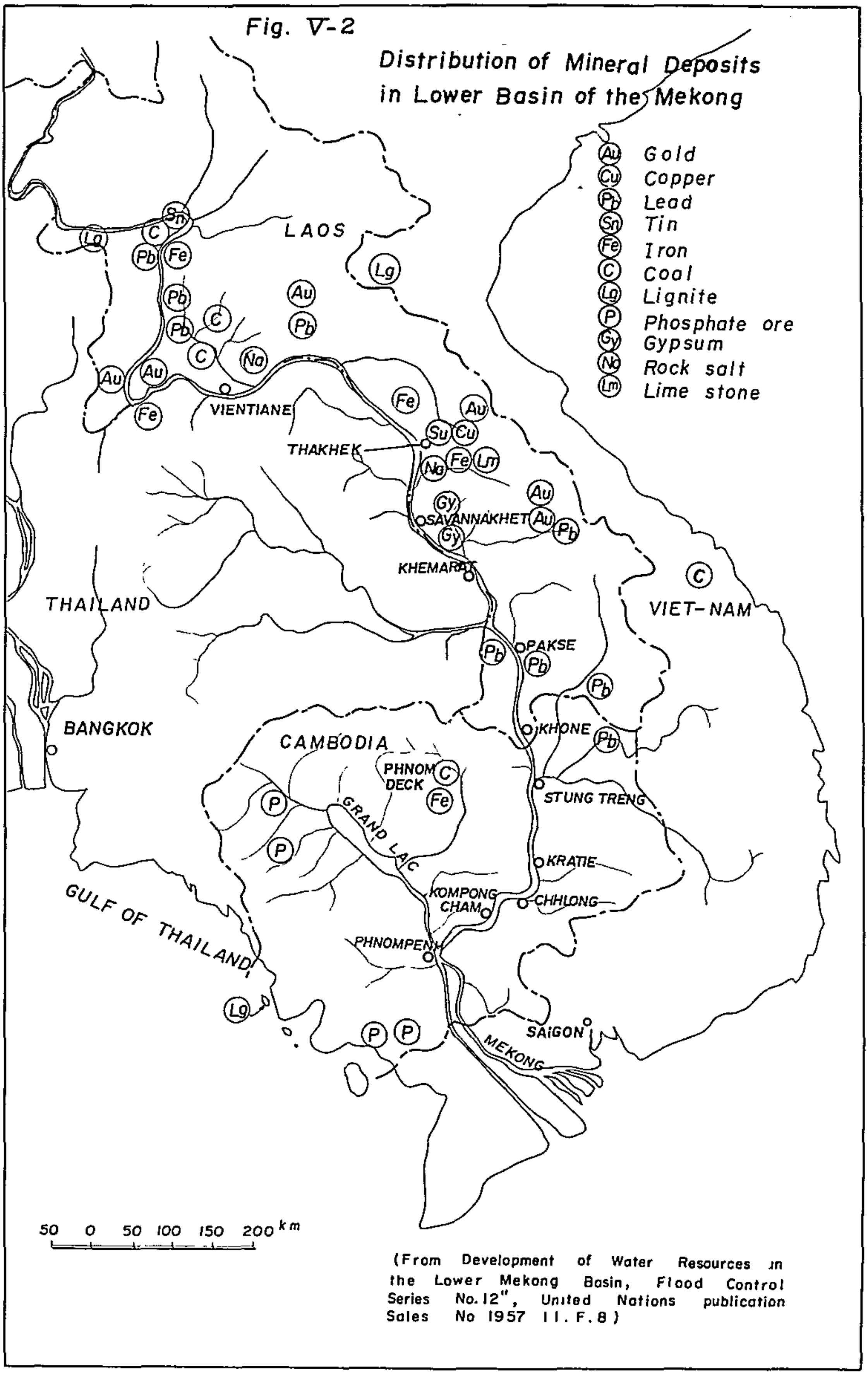
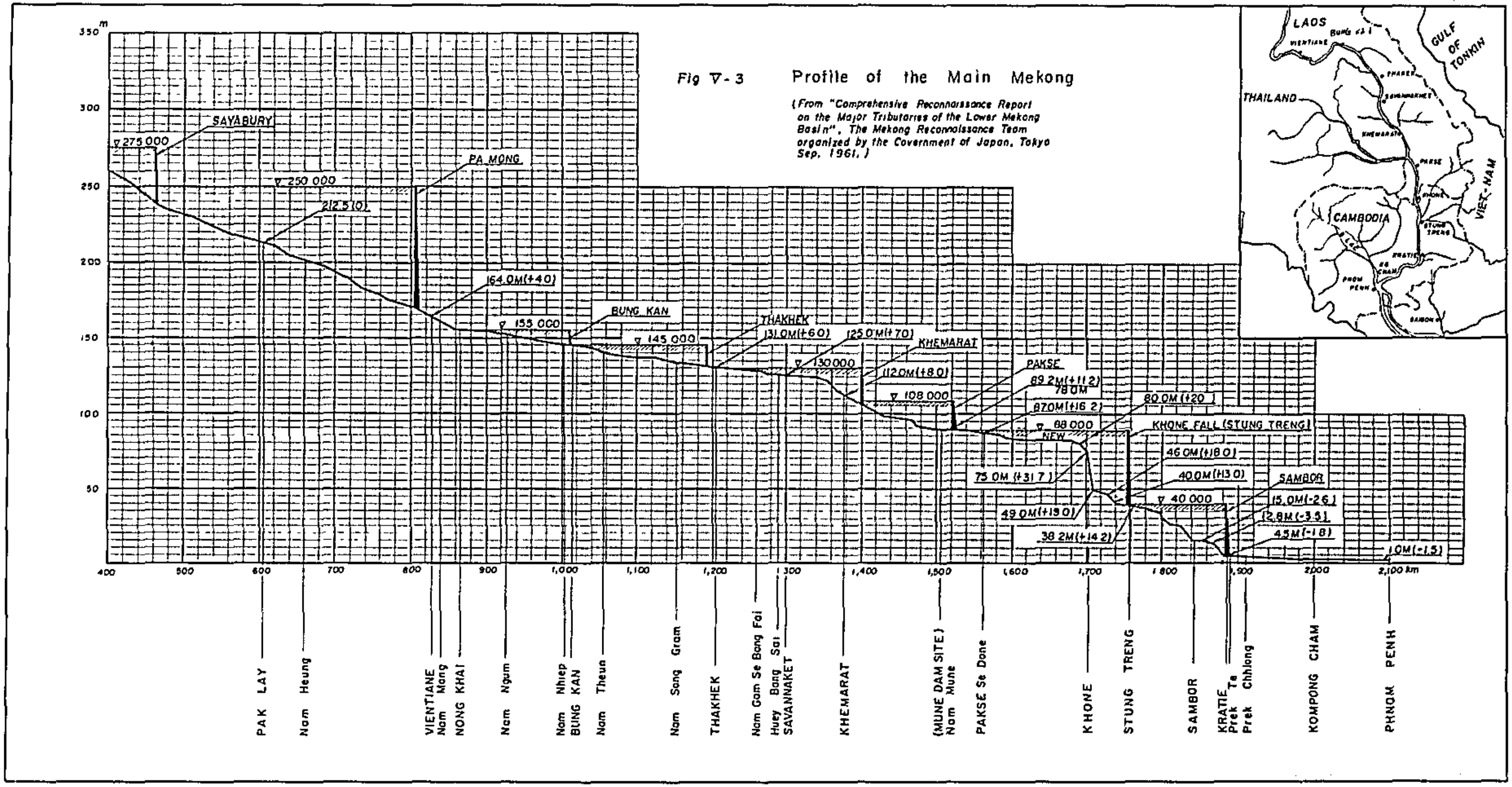


Fig. V-3 Profile of the Main Mekong



A-3 Desirability of Navigation Improvement

The water level of the Mekong varies greatly according to the season, the dry or wet. But on account of its abundant flow and especially owing to the placid current in its lower reaches, the Mekong is being briskly utilized for passenger traffic and for transport of agricultural and forest products and commodities. These are now being carried by waterway routes in a far greater volume than by land routes because the waterway transport is more economical and convenient, especially in carrying a large volume than the land transport in the area where traffic system on land is not fully developed.

Downstream from Vientiane, the Mekong for the most part is navigable to small crafts. But, as already noted certain sections such as the Khemarat Rapids, Khone Falls and the Samboc Rapids are not navigable or are navigable only with difficulty. If these sections will be made navigable, the Mekong will be opened to through navigation from its estuary to Vientiane.

The vast plain extending downstream from Kompong Cham yields a variety of and a quantity of agricultural products. The land upstream from Kompong Cham is covered for the most part with dense forests. Though not fully surveyed, mineral resources reported at different places in Cambodia, Laos and Thailand include iron, lead, copper, tin, zinc, gold, graphite, gypsum, salt and so forth.

Although some of these forest and mineral resources have been exploited to some extent, they remain for the most part unexploited on account of difficulties of traffic and transport.

The obstructions to the Mekong's navigation lie mainly between Kratie and Vientiane, a stretch of about 1,000 km with an elevation difference of about 160m. The Mekong Committee as of February 1967 is envisaging six multipurpose dams in this section. If these dams would be completed, the non-navigable or dangerous spots will be submerged, and if adequate facilities would be provided to connect the lower and upper reaches of the dams, through navigation will be effected.

Then, if cheap power will become at the same time available by the construction of the dams, exploitation of the above cited resources will be promoted bringing forth development of various industries and international intercourse to the substantial benefit of the countries concerned.

Of the projected dams, the Sambor dam is located most downstream, about 120 km downstream from Stung Treng. The Stung Treng Area is an underdeveloped region in Cambodia. If Stung Treng will become accessible by waterway, agriculture, forestry and related industries will be encouraged with a substantial contribution not only to the progress of the Stung Treng District but also to the national economy of Cambodia.

A-4 Items Studied

The following are the main items studied in this report.

1. Methods of transferring ships or rafts between the lower and upper reaches of the dam – ship locks, inclined passage facility or mechanical transhipment.

2. Dredging of shoals in the downstream reach from Sambor to the estuary for providing a navigation course with a planned width and water depth required for the all-the-year passage of envisaged vessels. And,

3. Dredging shoals and rock outcrops scattered in the section from 5 km to 40 km downstream from Stung Treng.

The following are also closely related to the navigation around the Sambor dam. They are, however, excluded from the present study.

1. Installation of navigation facilities and improvement of navigability upstream from Stung Treng.

2. Improvement of port facilities at Phnom Penh, Kompong Cham, Kratié, Stung Treng and at other ports along the river.

The need of the above two items will increase with the progress of industries and economy in these areas. Therefore, they shall be studied in parallel with the study of the Sambor Project.

3. Improvement of the navigation course off the estuary – to improve the navigation course in the sea

4. Countermeasure against bank erosion and maintenance of the channel depth in the mainstream – bank erosion is going on at many places along the mainstream of the Mekong and it shall be anticipated that shoals will be formed again in the dredged channel. A long-term study and investigation are desired on this problem.

5. Installation of navigation aids – beacons and other navigation aids are of course needed to ensure safe navigation. But this item lies beyond the scope of the present study.

CHAPTER B. CONCLUSION AND RECOMMENDATIONS

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B-1 Conclusion

The Mekong may be considered a good inland waterway from its mouth to Kratie in Cambodia and offers promising possibilities for the development of waterway traffic to the interior farther upstream. Difficulties in navigation start from the Samboc Rapids located 565 km from the river mouth and there scatter on the upper reach many stretches where navigation at present is not possible or is possible only with danger and difficulty.

However, if in the future the dams proposed at Sambor, Khone Falls, Khemarat and other sites on the mainstream would be completed, and if the lower and upper reaches of these dams would be connected for navigation, the river will be opened for through navigation from its mouth as far as to Vientiane in Laos. The Sambor dam is located most downstream. Accordingly, the project of providing the Sambor dam with the navigation facilities shall be planned on a consistent basis compatible not only with the possible future traffic at Sambor but also with the upstream dams that will be built in the future.

The project of the navigation facilities at the Sambor dam, as dealt with in this report, is divided into the initial plan and the future plan,[1/] because to construct beforehand a structure that would first become needed in the far future, to invest a large sum of money in it, and to lay the structure as well as the money idle for so long a period are in no way wise.

Initial Plan: The initial plan shall be put into execution at the same time with the construction of the dam and envisages the traffic that will be induced in the area where industries and economic activities will develop as the direct effect of the dam. The target year, for which the possible future traffic shall be envisaged, is set at the year when the population along the Mekong would double the present one, some 20 or 25 years after the present.

The future traffic in the target year has been estimated at about 120,000 tons of goods and 200,000 passengers. And as carriers of these goods and passengers, 120-ton passenger cruisers, 150-ton barges, tugboats, fishing boats, timber rafts and other small crafts as well as speedcrafts that might come into use in the future are considered.

To handle these vessels, an inclined passage facility comprising three lines of slipways will be built over the dam near the left river bank and shallow places around the downstream end of the inclined passage facility will be dredged.

The whole project of the initial plan shall be implemented in three stages. In the first stage, only a raft slipway will be built with necessary dredging. Two lines of vessel slipways will be installed one each in the 14th and in the 19th year after the start of the project so as to conform to the progress of the future traffic. The first stage will take about three years and the second and third stage each one year.

The total construction cost of the initial plan project is estimated at $5,220,000, of which about three-fourth, or $3,912,000, is accounted for by the first stage and the rest by the second and third stage.

The direct benefit of the project comprises the saving in the cost and time of traffic, economy in vessel operation and increase in carrying capacity, which can be assessed from the toll income on the part of the facility owner, the net profit in transport services and the benefits that shippers and passengers will receive.

Although the internal rate of return at which the present values of the invested costs and of the annual benefit will balance would not amount to much in the case of the initial plan, the implementation of the plan will nevertheless greatly improve the traffic condition in the area from Kratié to Stung Treng and will encourage the industrial and economical development and the improvement of the standard of living in the area so far remaining underdeveloped.

The initial plan is also of great significance in that it foreruns the future plan, which, if implemented, will contribute to the exploitation of forest and other resources in the upstream regions, especially in Laos.

1/ : *Sambor Project Report Lower Mekong Basin* Vol. 2, Jul. 1969. OCTA, JAPAN

B-2 Recommendations

It is recommended in general that the project of navigation facilities at Sambor shall be planned and implemented as one of the important projects in the comprehensive development plan of the Lower Mekong River Basin. To push forward the initial plan, in particular, it is recommended:

1. That the industrial development program of the Stung Treng District be established; and

2. That topographic surveys, soundings and soil investigations be undertaken on the shallows a little downstream from Stung Treng.

In order to further the future plan, it is desired that the following shall be undertaken when the initial plan will be put into execution.

1. Establishment of the through navigation plan on the Mekong's Mainstream;

2. Investigation of undeveloped resources;

3. Topographic, geological and hydrographical surveys of the regions upstream from Sambor; and

4. Since it will be many years after the completion of the initial plan that the future plan would be implemented, the plan shall be restudied by conducting a series of detailed investigations on various items such as the traffic trend and the industrial and economic development of the area concerned.

CHAPTER C. GENERAL ECONOMIC CONDITIONS IN CAMBODIA

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C-1 Population of Cambodia

The population of Cambodia has increased from 3,748,000 in 1948 to 6,250,000 in 1966 as shown in Table V-1.

The annual growth rate was 4.3% between 1948 and 1950, and 1.9% between 1950 and 1958, averaging 3.1% for the 14 years from 1948 to 1962, and 2.2% for the four years from 1962 to 1966. If such a rate is to continue in the future, the population of Cambodia will double in 20 to 25 years.

Table V-1 Population of Cambodia *[1/]

Year	Population
1948	3,748,000
1950	4,074,000
1958	4,740,000
1962	5,728,771
1966	6,249,748

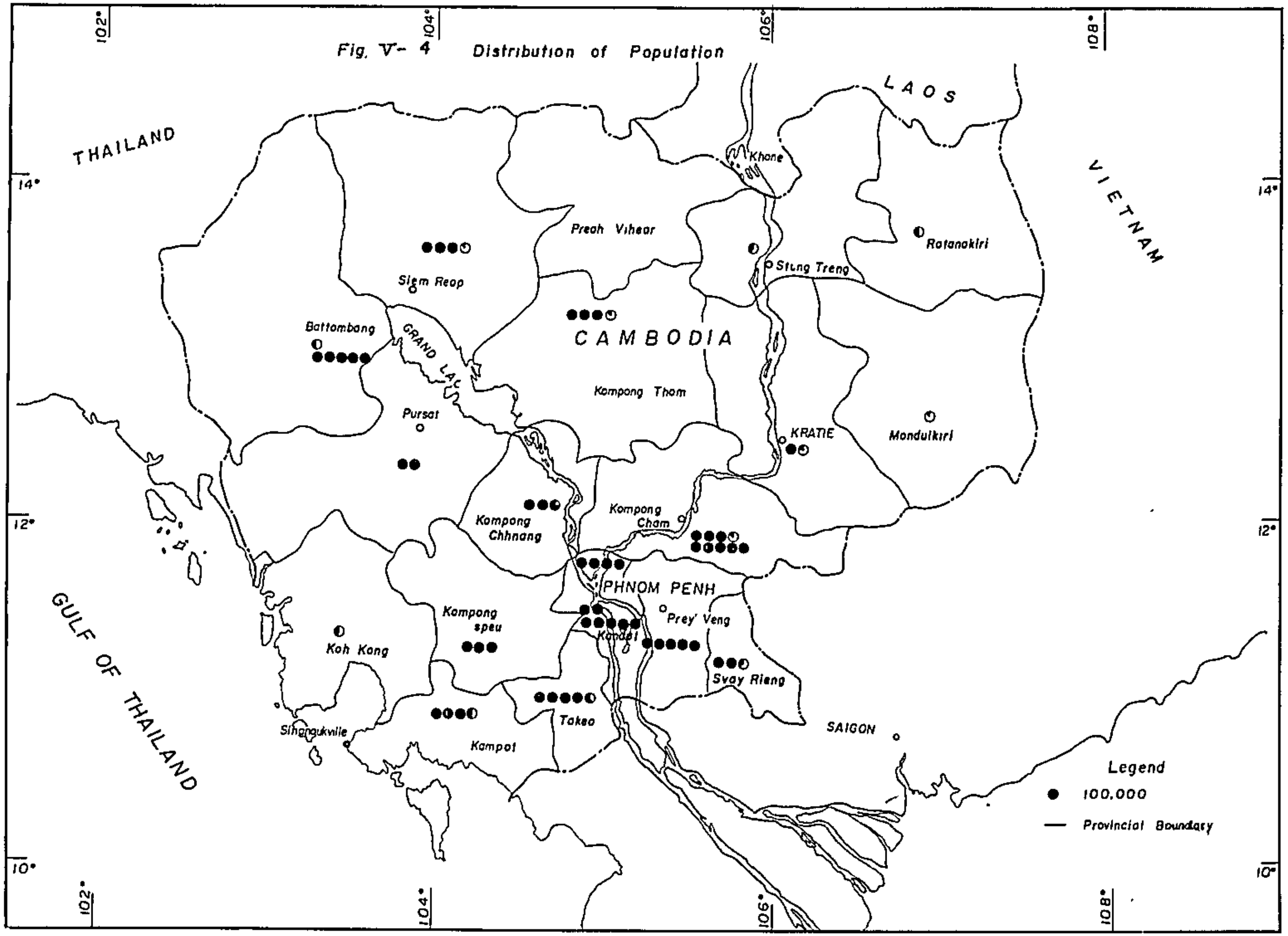
The region upstream from Kratie, is at present very thinly populated. As can be seen from Table V-2 and Fig. V-4, the provinces of Kratie, Stung Treng and Ratanakiri have a population of mere 2.2%, 0.6% and 0.9% of the national total, respectively. Although the three provinces share about one-fifth of the nation's total land area, their combined population amounts to only 3.7% of the national total. Especially, the population density of Stung Treng is as low as 3.1 persons per sq.km.

Table V-2 Population of Cambodia (1962)*

Administrative Division	Population	Area in sq. km.	Population Density, per sq. km
Cambodia in total	5,740,115	181,035.0	31.7
Phnom Penh	403,500	46.0	8,771.7
Kep	7,545	45.5	166.6
Bokor	523	1.1	475.5
Sihanouk Ville	6,578	68.2	96.5
Battambang	522,440	19,184.2	28.8
Kampot	540,239	5,962.4	57.1
Kandal	708,773	3,812.1	185.9
Koh Kong	38,694	11,160.6	3.5
Kompong Cham	819,223	9,798.7	83.6
Kompong Chhnang	272,911	5,520.8	49.4
Kompong Speu	308,013	7,016.8	43.9
Kompong Thom	321,015	27,601.6	11.6
Kratie	126,231	11,094.1	11.4
Mondolkiri	14,650	14,287.6	1.0
Prey Veng	488,462	4,883.2	100.0
Pursat	182,394	12,692.1	14.4
Ratanakiri	49,340	10,782.3	4.6
Siem Reap	312,329	16,456.8	19.0
Stung Treng	34,508	11,092.0	3.1
Svay Rieng	228,078	2,966.4	97.1
Takeo	464,669	3,562.7	130.4
Great Lake	–	3,000.0	–

1/ : Hereinafter, tables and figures marked with an asterisk(*) are those excerpted from or based on *Annuaire Statistique du Cambodge 1966*, Ministre du Plan, Royaume du Cambodge.

Fig. V-4 Distribution of Population



C-2 Production Activity in General

Cambodia is blessed with a vast plain and with the water of the Great Lake and of the Mekong with its tributaries. And since industries have not yet been developed, the majority of the population is engaged in agriculture. Hence, Cambodia's production is mostly from agriculture and agricultural products are her principal item of export. Beside agriculture, stockraising, forestry and fishery are contributing to Cambodia's economy.

Mining industry is still undeveloped. As regards manufacturing industry, textiles, paper, cement, plywoods, etc., are now produced in factories built with foreign aids.

At present, agricultural and other products are carried to consumer districts and for export either by land or by waterways depending on the circumstances. In the regions along the Mekong and its tributaries, waterways constitute the main traffic routes and the improvement of the navigability of the river will without doubt contribute to the development of these areas.

C-3 Agriculture

As already noted, agricutural products are the principal item of the Cambodian export, both in volume and in value, and are greatly contributing to her economy.

In Cambodian agriculture, rice is the most important crop followed by rubber. Other farm produce to be mentioned are maize, soybeans, French beans, groundnuts, tobacco, cotton, sesame, gomuti palm and kapok. The production and export in 1965 of these items are listed in Table V-3.

Table V-3 Annual Production and Export of Cambodian Agricultural Products (1965) *

Product	Production in tons	Export in tons	Product	Production in tons	Export in tons
Rice**	2,500,000	546,600	Caster beans	1,100	–
Rubber	53,000	68,700	Tobacco	10,500	100
Maize	139,000	81,600	Pepper	1,500	1,800
French beans	18,300	1,100	Kapok	7,000	3,600
Soybeans	8,000	8,500	Sweet potato	21,200	–
Cotton	5,400	–	Gomuti palm	50,000	8,500
Groundnuts	19,200	300	Sesame	10,000	8,900

Note: **: Unhulled.

a) Rice: The annual rice production in Cambodia in recent years is listed in Table V-4. The highest is 2,760,000 tons of 1964 and the lowest 775,000 tons of 1954, what indicates the high susceptibility of rice yield to the weather. On the whole, however, it is increasing year after year. About 1,000,000 tons to 1,500,000 tons go for domestic consumption, and 200,000 tons to 560,000 tons for export. The export of rice accounts for 35% to 70% in value of the total Cambodian export.

The area devoted to rice in Cambodia totals about 2,400,000 ha or about 13% of the total land area. The province that yields rice most is Battambang Province followed by the provinces of Prey Veng, Kompong Cham, Takeo and others as shown in Table V-5 and in Fig. V-5.

Table V-4 Production and Export of Rice *

Year	Acreage in 1,000 ha	Production in tons	Export, in tons
1957	1,227	1,382,000	231,000
1958	1,522	1,153,000	254,000
1959	1,612	1,419,000	242,000
1960	1,423	1,544,000	391,000
1961	1,561	1,250,000	285,000
1962	1,740	1,689,000	182,000
1963	–	2,622,000	447,300
1964	2,376	2,760,000	563,500
1965	2,344	2,500,000	546,600
1966	2,414	2,376,000	190,100

Note. Unhulled

These rice-producing provinces are situated along the Mekong, around the Great Lake or in the southwestern plains.

Fig. V-5 Production of Paddy Rice

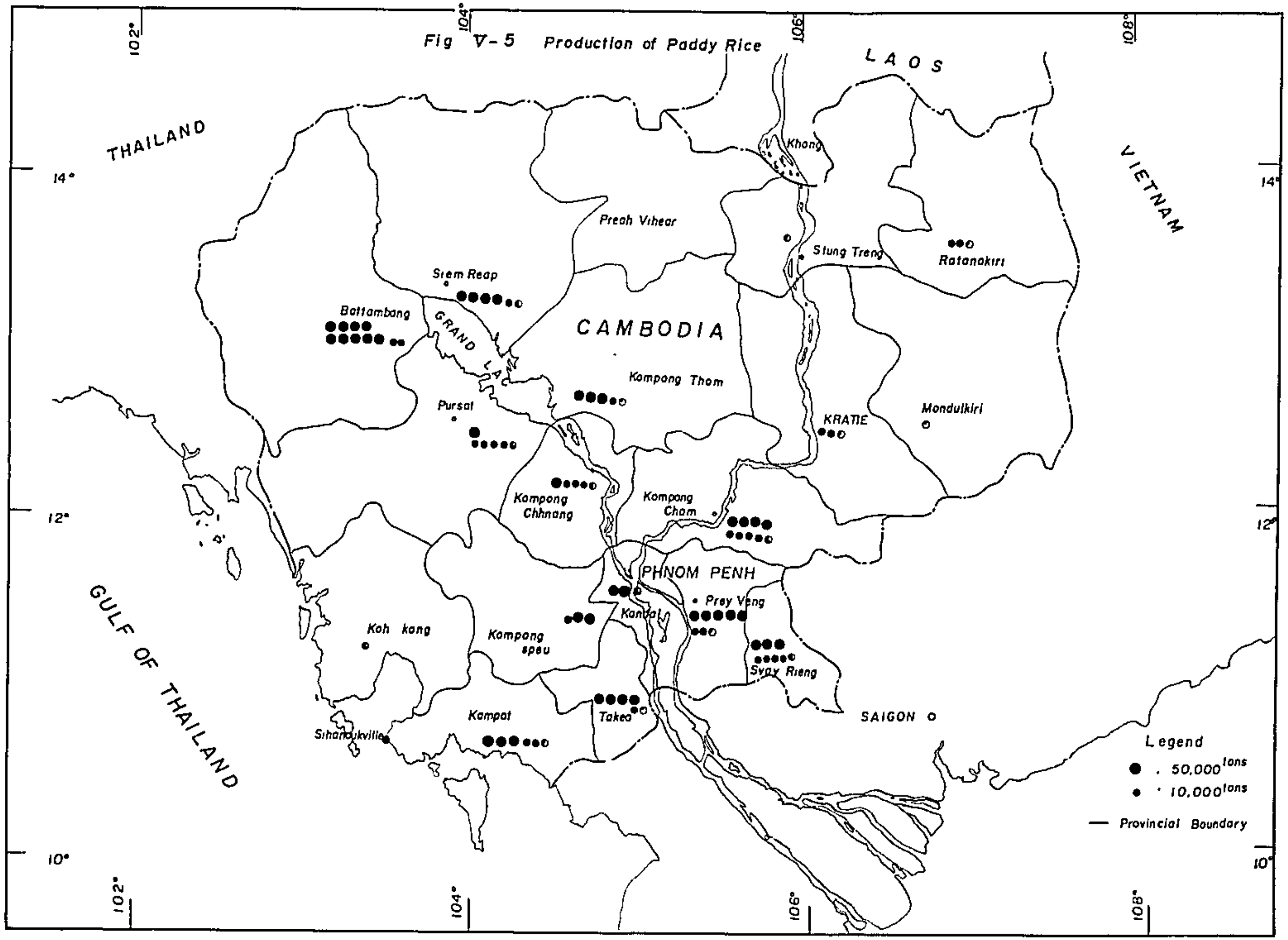


Table V-5 Production of Unhulled Rice (1965) *

Province	Production in tons	Province	Production in tons
Battambang	469,000	Kandal	107,000
Prey Veng	273,000	Pursat	97,000
Kompong Cham	247,000	Kompong Chhnang	85,000
Siem Riep	216,000	Kratie	23,000
Takeo	212,000	Rattanakiri	23,000
Svay Rieng	196,000	Koh Kong	7,000
Kampot	174,000	Stung Treng	5,000
Kompong Thom	162,000	Mondulkiri	2,000
Kompong Speu	108,000	Total	2,500,000

Rice is in general harvested in the period from November to February of next year depending on its variety. Threshing is usually done by farmers themselves, and polishing by farmers or by polishing mills located nearby. Harvested rice is usually shipped during the middle or at the end of the dry season.

b) Rubber: Natural rubber production in Southeast Asia concentrates in Malaya and Indonesia. Cambodia turns out a mere 2% of the total world production.[1] But, Cambodian rubber production in recent years has seen a steady increase as shown in Table V-6, and it can be said that Cambodia can still find much room for developing her rubber production. Cambodia's rubber export ranks next to that of rice in value and is contributing a great deal to Cambodia's trade balance and to the national budget as a major source of revenue.

Table V-6 Production of Rubber *

Year	Acreage in ha	Production in tons	Export in tons
1962	41,680	41,181	36,000
1963	43,913	40,696	42,200
1964	45,990	45,769	41,400
1965	47,726	48,790	68,700
1966	49,558	51,065	51,100

The lateritic land that extends along the lower reach of the Mekong is suited for rubber plantation because of its soil and much rainfall. Kompong Cham Province has the largest acreage of rubber growing followed by Kratié Province. Rubber is also grown in highlands between Kompong Cham and Kompong Thom. Rubber production per hectare is very high in some areas ranging from 1,000 kg to 2,200 kg per year.[2]

Collected rubber is carried to processing plants located in the vicinity of rubber plantations.

c) Maize: Maize, or corn, is grown all over Cambodia and much is yielded in Kompong Cham, Kandal and Prey Veng Provinces along the Mekong. These provinces are regarded the production center of Cambodian exportable maize.

There are two varieties of maize, the dry-season maize and the wet-season maize. The former is planted in November and harvested in next March to April and the latter is planted in April and harvested in August. Harvested maize is usually carried by water. The annual yield and export of Cambodian maize are given in Table V-7.

Table V-7 Annual Production and Export of Maize *

Year	Production in tons	Export in tons
1962	151,800	134,000
1963	183,200	114,900
1964	203,900	148,500
1965	139,000	81,600
1966	135,800	133,400

1/: *Handbook of International Statistics 1964,* Statistics Bureau, Prime Minister's Office of Japan.

2/. *Economic and Social Development in Cambodia and Laos,* Asian Economy Research Institute, Tokyo 1962.

d) Soybeans: Soybeans are grown mostly in regions along the Mekong. They are sown in July to September and harvested in December to next January. Harvested soybeans are carried chiefly by water to meet the domestic needs as well as to be exported (Table V-8).

Table V-8 Annual Production and Export of Soybeans *

Year	Production in tons	Export in tons
1962	9,500	–
1963	11,200	6,700
1964	11,300	4,000
1965	8,000	8,500
1966	5,100	700

e) Kapok: Kapok trees that can be found naturally growing all over the country are usually planted in the regions along the Mekong, particularly in Kompong Cham and Kratie Provinces.

The fruits of kapok trees, from which kapok fiber is obtained, are harvested in March to May and shipped out from the end of the dry season through the wet season. The annual yield in Cambodia is listed in Table V-9.

f) Cotton: Cotton is a traditional crop in Cambodia, but its crop has substantially declined as shown in Table V-10. The Royal Government of Cambodia, therefore, has placed in its Five-year Plan a high priority on cotton cultivation. This has brought forth a quick result such that the crop has been developed again to a degree sufficient to meet the needs of the country's spinning mills.

Table V-9 Annual Production and Export of Kapok *

Year	Production in tons	Export in tons
1962	8,500	7,600
1963	9,500	9,200
1964	10,200	3,200
1965	7,000	3,600
1966	7,000	11,700

Kompong Cham and Prey Veng are the main cotton yielding provinces. But Ratanakiri Province and some other regions seem suited for cotton.

Table V-10 Annual Production of Cotton*

Year	Production in tons
1962	27,500
1963	2,700
1964	3,500
1965	5,400
1966	5,100

Cotton plants need moisture during their growing period and dryness in maturing. Accordingly, they are sown around June and harvested in the dry season.1/

g) Other Agricultural Products: Besides the above-mentioned, Cambodia yields tobacco, gomuti palm, coconuts, groundnuts, pepper, ramie, tea, various vegetables and fruits. These are grown mainly in riparian areas and transported by waterway routes. The annual yields of some of these are listed in Table V-11.

Table V-11 Annual Production, in tons, of Various Agricultural Products*

Year	Groundnuts	Castor Nuts	Tobacco	Pepper	Gomuti Palm	Sweet Potato
1962	6,200	3,200	6,000	1,300	33,000	26,500
1963	6,700	3,200	6,500	1,400	36,000	29,400
1964	7,000	3,000	6,900	1,500	40,000	30,300
1965	19,200	1,100	10,500	1,500	50,000	21,200
1966	24,100	1,100	10,500	1,500	50,000	13,100

C-4 Stockraising

Stocks are raised in Cambodia since olden times to be used in farming as a draft or as a source of foodstuff. Their number is increasing in recent years as shown in Table V-12.

1/: *Economic and Social Development in Cambodia and Laos*, Asian Economy Research Institute. Tokyo, Japan 1962.

Live hogs, cows, water buffaloes as well as cowhides and feathers are exported as shown in Table V-13.

On the other hand, breeder bulls and boars are imported; and processed stuffs such as condensed milk, powdered milk, butter, cheese, leather and other items consumed in Cambodia are almost all imports.

Table V-12 Number of Stocks Bred in Cambodia*

Year	Yellow Cows	Water Buffaloes	Hogs
1962	1,322,000	476,000	689,000
1963	1,403,000	512,000	846,000
1964	1,533,000	577,000	932,000
1965	1,657,000	637,000	991,000
1966	1,737,000	654,000	1,057,000

C-5 Forestry

An area of 13,230,00 ha, or about 73% of the total land area of Cambodia, is under forest cover, dense, sparse, or flooded forest. About a third of the total forest area is set aside as forest reserves. Forest lands so far exploited in Cambodia, shown in Table V-14, extend along the Mekong and the upper reaches of the Great Lake tributaries as well as in the mountainous, western regions.

Cambodia's yield of timber ranges from 200,000 m³ to 400,000 m³ a year and shows a gradual increase. Of the 344,500 m³ of timber cut in 1966 (Table V-15), those rated superior grade and the first grade accounted for less than 2,000 m³ and 45,300 m³, respectively. Most of the timber was of the second grade, amounting to 257,000 m³.

Besides timber, 10,000 tons to 25,000 tons of charcoal, 230,000 steres to 350,000 steres of firewood and 40,000 m³ to 100,000 m³ of bamboo are produced annually as listed in the table.

These bring in about 200 million Riels annually. The annual export of Cambodian forest products listed in Table V-16 amounts to 70,000 tons to 150,000 tons with a cash value of about 60 million Riels.

Table V-13 Export of Livestock and Hides*

Year	Livestock, in heads			Hides in pieces
	Yellow Cows	Water Buffaloes	Hogs	
1962	18,280	18,785	104,708	1,235,875
1963	22,525	21,150	7,204	416,920
1964	–	6,121	–	87,006
1965	–	8,291	–	23,600
1966	1,120	10,908	–	79,166

Table V-14 Annual Timber Production, in Cubic Meters*

Province	1965	1966
Kandal, Svay Rieng, Prey Veng, Kompong Speu, and Takeo	4,100	32,800
Kompong Cham	32,200	20,600
Chhlong	37,900	48,700
Kratie	45,600	41,800
Stung Treng	21,400	23,700
Kompong Thom	32,300	38,600
Siem Riep	9,800	15,000
Kompong Chhnang	1,500	1,600
Pursat	9,600	23,800
Battambang	15,300	20,000
Kampot	13,700	11,900
Sihanouk Ville	76,800	69,100
Total	300,200	347,600

Table V-15 Annual Yield of Forest Products*

Year	Timber a/	Charcoal b/	Firewood c/	Bamboo a/
1960	414,700	24,000	258,500	40,800
1962	198,500	11,700	262,600	62,600
1963	360,700	13,900	265,500	102,500
1964	247,000	11,600	232,400	76,700
1965	299,700	15,900	280,500	65,300
1966	344,500	24,400	343,400	53,900

a/: in cubic meters; b/: in tons; c/: in steres

Table V-16 Export of Forest Products*

Year	Timber a/	Charcoal b/	Wood Oil c/	Bamboo a/
1958	7,000	–	11,600	1,600
1959	79,000	1,790	3,100	–
1960	114,000	50	3,500	700
1961	138,000	–	3,400	14,100
1962	102,000	–	6,600	–

a/: in cubic meters; b/: in tons; c/: in gallons

C-6 Mining Industry

Besides known iron ore and coal deposits, gold, copper, molybdenum, lead and zinc deposits are so far reported in Cambodia. A small amount of precious stones such as saphire and zircon can also be found. But, large-scale exploitation of these deposits is not yet attempted and there is little worth mentioning on Cambodian mining industry.

The iron ore deposit at Phnom Deck, north of Kompong Thom, with an estimated reserve of five million tons is worth attention, and a plan is now under way to install a blast furnace at Kompong Thom.

In Kompot Province, there is a limestone deposit, from which cement is now being manufactured.

C-7 Fishery

Fishery in Cambodia is operated in the Great Lake and the Tonle Sap, in the Mekong and in the sea off the coast. The Great Lake offers the best catch. Kas Kong Cheko and Ream are the two centers of the coastal fishery. But, little use is made of modern fishing techniques.

Landed fish are processed to make dried fish or fish meal. Fish oil is also extracted. Fish meal and residues are used for fertilizers.

Fish are exported either salted, dried or raw mainly to Singapore, Hongkong, Indonesia, Burma and Vietnam. The yield of Cambodian fishery products in recent years is listed in Table V-17.

Table V-17 Cambodian Fishery Yield*

Year	Raw Fish Catch in tons	Dried Fish in tons	Export of Fishery Products	
			in tons	in 1,000 Riels
1964	31,406	5,824	900	6,000
1965	56,415	6,500	500	4,000
1966	63,967	8,952	1,600	6,000

C-8 Manufacturing Industry

As, before her independence, nothing had been done on any scale to develop manufacturing industries in her territory, Cambodia until recently had only small-scale factories for processing agricultural and forest products. In recent years, however, many factories have been built with foreign aids for manufacturing textile, cement, plywood, paper and so forth.

Although there might arise many difficulties in the way, the increased and stabilized production of agricultural, forest and livestock products will necessitate, and will pave the way for, further development of these processing industries

The number of major factories in Cambodia as of 1966 is listed in Table V-18. As can be seen from the table, plants for agricultural products predominate. Their number is increasing year after year.

Table V-18 Number of Major Factories in Cambodia (1966)*

Rice Threshing and Polishing	1,466
Lumbering	464
Charcoal	197
Bricks and Tiles	166
Soda Water	122
Printing	104
Textiles	87
Machinery	74
Salt and Soy Sauce	61
Power Plant	59
Metal	58
Plastics	46
Sugar	34
Soap	28
Flour	16
Leather	10
Tobacco	3
Matches	1

CHAPTER D. EXISTING TRANSPORT IN CAMBODIA

CHAPTER D. EXISTING TRANSPORT IN CAMBODIA

D-1 General Pattern of Transport

The goods moving in Cambodia comprise products from agriculture, forestry, fishery and stock-farming, processed foods and other commodities as well as materials of construction, the greater part being accounted for by agricultural products.

Excepting those for self-consumption and consumed in their production areas, products from agriculture, forestry, fishery and stock-farming are carried via collection and distribution centers to consumer districts such as Phnom Penh or regional center towns. Goods for export are shipped out mostly from the port of Phnom Penh or of Sihanouk Ville, and a small part from the port of Kompong Cham. Processed foods, commodities and materials of construction generally move in reverse and are mostly consumed in cities and towns.

Goods are transported in different patterns depending upon the kind and volume of goods as well as upon the region. Trucks, buses, three-wheel autos and railways, and ox-carts for short haul, are used in land transport; and cruisers, barges, ferries and rafts on waterway routes. For passenger traffic are used buses, automobiles, three-wheel autos, trucks and railways in land travel, and cruisers and ferries in waterway travel.

The Royal Government of Cambodia operates the railway and ferries at four sites. Other ferries as well as the transport by trucks, buses and cruisers are operated as private enterprises, mostly on small scale.

In general, waterway transport costs less and is rather safe as compared with land transport. Some kinds of goods, however, depend chiefly on land transport. For bulk cargo such as rice, maize, wheat and barley, and for weight cargo such as iron and steel, cement and timber, waterway transport is preferred if it is available, especially in long haul. This preference holds also to charcoal and earthenware articles that are liable to break or to be damaged during their transport.

Usually, the just mentioned items are carried on the Mekong by barges concentratedly, and in some cases by cruisers. But in many cases of short haul, truck transport is rather preferred as it can connect a production site directly with distribution centers, warehouses or markets, and even with consumers. Truck transport is preferred also for carrying raw fish and fresh vegetables that need quick transport and for various commodities, in case they are small-sized and high-priced or small in quantity. Imported general goods are also for the most part carried by land.

D-2 Regional Patterns of Transport

Cambodia may be divided roughly into three regions: the southwestern region, the Great Lake and its neighborhood, and the region along the Mekong.

As there is hardly any navigable waterway, transport in the southwestern region is handled mostly on land with trucks, buses and three-wheel autos.

The Great Lake is fed by many tributaries and is connected with the Mekong by the Tonle Sap, providing good waterways. Although much traffic exists on these waters, it is not so brisk as on the Mekong's Mainstream. And, though there are no reliable traffic statistics, it seems that in this region land transport on the whole exceeds waterway transport.

Around the Great Lake, long-distance navigation is rather rare even in the wet season. But on its tributaries, passenger traffic and goods are handled very briskly by small-sized barges and cruisers.

On the Tonle Sap, on account of its deep and affluent water, there is brisk traffic downstream from Kompong Chhnang. Regular cruiser services are operated in six directions from Kompong Chhnang.

As for land traffic around the Great Lake, a trunk highway runs through the northeastern region and is utilized for long-distance traffic. In the southeastern region, a highway and a railway line run nearly parallel, playing a vital role for the domestic industry.

Fig. V-6 Map of Cambodia

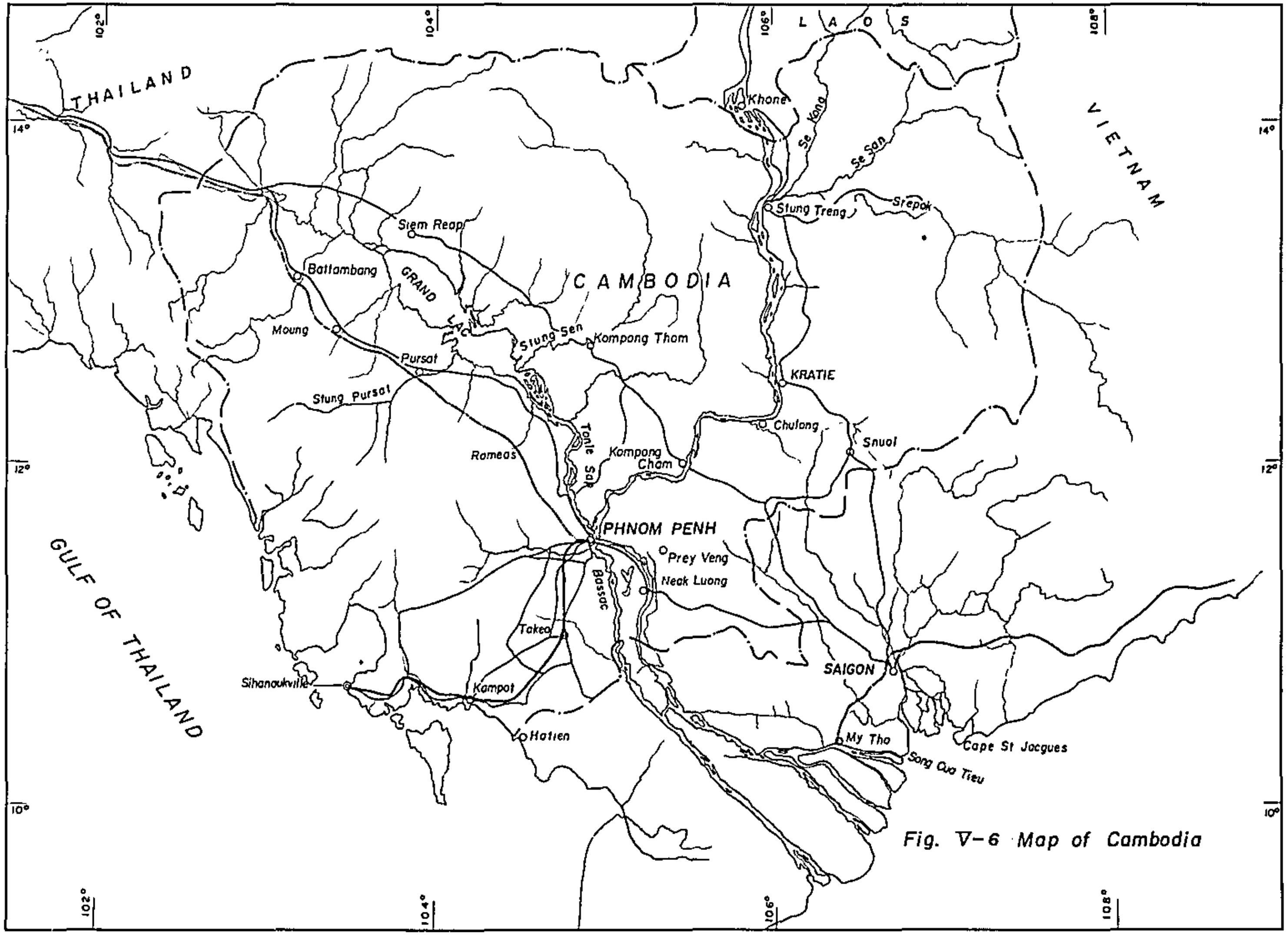


Fig. V-6 Map of Cambodia

In the region along the Mekong, unlike in the other two regions, the river constitutes the main traffic route. Most of the passenger and goods traffic are carried on the river.

There is a trunk road along the Mekong. It is located far off the river bank in order not to be inundated by the flood water of the river, and makes a meandering route that measures rather longer than the river. Besides, few adequate access roads are provided to reach the river bank.

Although there is relatively much land traffic in the area downstream from Kompong Cham, land traffic becomes less from Kompong Cham toward Kratie, and lesser still in the further north from Kratie.

D-3 Vehicles and Vessels in Cambodia

The number of vehicles registered in Cambodia is listed in Table V-19, and that of vessels in Table V-20.

Table V-19 Number of Registered Vehicles (1966)*

Motorcar	19,330
Truck[a]	8,945
Bus	1,332
Autocycle and Scooter	12,165
Motorbike	60,761
Tractor	1,072

a/: Including small-sized.

Table V-20 Number of Registered Vessels (1964)*

Kind of Vessel	Number	Total Tonnage
Junk[a]	2,292	113,256
Steel Barge	30	5,223
Self-propelled Barge	10	1,401
Launch	138	6,329
Motorboats and Others	666	5,535

a/: 16 tons or more

Table V-21 Size of Typical Cruisers, in Meters

Ship Number	Tonnage	Length	Width	Draft	Freeboard
HF 2748 PP	300	39.45	7.91	3.70	1.00
HF 3024 PP	250	38.66	7.91	3.05	1.15
HF 1266 PP	122	32.50	6.60	2.75	0.95
HF 3208 PP	111.5	31.91	6.26	2.75	0.85
HF 1524 PP	52.2	28.26	5.12	1.70	0.75
HF 3572 PP	10.3	15.45	3.23	0.90	0.40

Sizes of some typical cruisers, or plying passenger boats, are shown in Table V-21 based on the data of the Royal Government of Cambodia Office of Navigation Control. Most of cruisers are of the size between 50 tons and 150 tons. Small-sized cruisers of 50 tons or less are used chiefly in short-distance traffic. The cruiser service on the Mekong Mainstream is operated in a far greater number and with larger craft than on the Tonlé Sap.

D-4 Land Traffic

1) Bus Traffic: Bus network in Camboida is well developed, linking major cities and also carrying local traffic between regional centers and their neighborhoods.

The most important routes of the Cambodia bus network are what radiate from Phnom Penh. Very frequent service is operated on these routes.

Bus fares, schedules and other data as surveyed at the Phnom Penh bus terminal are listed in Table V-22

The data on bus traffic gathered at bus terminals in Kompong Cham and Kratie are listed in Tables V-23 and V-24. When these are compared with the data given in Table V-22, it can be seen that the bus traffic originating from these local cities is less active than those originating from Phnom Penh.

Table V-22 Data on Major Bus Routes from Phnom Penh

Route	Number of Daily Services	Passenger Fare in Riels	Freight per Bag[a/] of Rice in Riels
To Kompong Cham	25 (50)[b/]	50	30
To Siem Reap	9 (60)	120	–
To Sihanouk Ville	8 (50)	80	70
To Battambang	10 (50)	90	70
To Kratie	3 (50)	120	80
To Kampot	16 (50)	50	40
To Prey Veng	– (–)	40	–
To Svay Rieng	– (–)	50	–

Note: a/: One bag contains 100 kg of rice.
b/: Parenthesized figures denote the nominal passenger capacity of the bus.

Table V-23
Number of Bus Services on Major Bus Routes from Kompong Cham

To Phnom Penh	25
To Kratié	3
To Siem Reap	1
Short-distance Service	14

Table V-24
Data on Major Bus Routes from Kratie

Route	Number of Daily Services	Passenger Fare in Riels	Freight per Bag of Rice, in Riels
To Phnom Penh	3 (50)[a/]	120	80
To Stung Treng	2 (40)	60	30
To Ratanakiri	1 (–)	200	–

Note: a/: Parenthesized figures denote the nominal passenger capacity of the bus.

Areas lying midway along the bus routes from Kompong Cham or Kratie are in general very thinly populated. And, it can be said that the degree of utilization of bus traffic is in proportion to the population and the economic activity of the region concerned.

If calculated from the above data, the passenger fare and the freight of rice per kilometer become 0.35 to 0.40 Riels per passenger and 0.25 to 0.35 Riels per bag of rice in short distance; and 0.30 to 0.38 Riels per passenger and 0.23 to 0.30 Riels per bag of rice, for long haul

2) Truck Traffic: As for truck traffic, a survey has been conducted with main regard to rice transport. Most of harvested rice in Cambodia has formerly been carried unhulled to local cities to be threshed and polished and from there shipped mostly to Phnom Penh by truck or by waterway. But nowadays, on account of a substantital increase of local mills, rice is threshed and polished at or around production sites and then carried directly to Phnom Penh.

The greater part of rice harvested around the Great Lake is transported to Phnom Penh by trucks, but some is carried by barges down the Stung Sen or the Stung Pursat during the high-water period.

Downstream from Kompong Cham, however, navigation is well developed on the Tonlé Sap and most rice as well as goods are carried by waterway.

Truck freight of rice as surveyed at rice polishing mills located in various regions are listed in Table V-25, and freights of other goods in Table V-26.

As can be seen from the table, the rice freight per bag per kilometer ranges from 0.10 Riels to 0.22 Riels in short haul and from 0.08 Riels to 0.13 Riels in long haul. And it was also found that if rice is carried by bus in small quantity, it will cost 1.5 to 2.5 times the truck freight.

Table V-22 Data on Major Bus Routes from Phnom Penh

Route	Number of Daily Services	Passenger Fare in Riels	Freight per Bag[a/] of Rice in Riels
To Kompong Cham	25 (50)[b/]	50	30
To Siem Reap	9 (60)	120	–
To Sihanouk Ville	8 (50)	80	70
To Battambang	10 (50)	90	70
To Kratie	3 (50)	120	80
To Kampot	16 (50)	50	40
To Prey Veng	– (–)	40	–
To Svay Rieng	– (–)	50	–

Note: a/: One bag contains 100 kg of rice.
b/: Parenthesized figures denote the nominal passenger capacity of the bus.

Table V-23
Number of Bus Services on Major Bus Routes from Kompong Cham

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To Siem Reap	1
Short-distance Service	14

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Table V-25 Truck Freight of Rice

(Unit: Riels)

Transport Section ection	Distance in km	Freight per Bag	Freight per Bag-km
Kratie to Stung Treng	160	35	0.22
Kompong Cham to Phnom Penh	124	12-15	0.10-0.13
Battambang to Phnom Penh	191	24-25	0.08-0.85
Siem Reap to Phnom Penh	314	40	0.13
Kompong Chen to Phnom Penh	178	23	0.13
27 km north of Prey Veng to Phnom Penh	119	18	0.15
27 km north of Prey Veng to Prey Veng	27	6	0.22

Table V-26 Truck Freight of Some Goods

(Unit: Riels)

Transport Section	Distance in km	Kind of Goods	Freight per ton	Freight per ton-km
Kratie to Stung Treng	160	Cement	300	1.9
Kompong Chhnang to Phnom Penh	91	Cement	140	1.6
Kompong Chhnang to Phnom Penh	91	Reinforcing Steel	300	3.3
Phnom Penh to Siem Reap	314	General Goods	500	1.6

3) Railway: There are two railway routes in Cambodia: one running from Phnom Penh to the Thai border and the other from Phnom Penh to Takeo, the latter being now planned to be extended to Sihanouk Ville.

Passenger fares from Phnom Penh are listed in Table V-27. Bus passenger fares fall in general between the second- and third-class fares on railways.

Table V-27. Railway Passenger Fares from Phnom Penh

Destination	Distance in km	Fares in Riels			Sleeper Charge in Riels
		First Class	Second Class	Third Class	
To Romeas	57	61	41	19	33
To Pursat	166	131	86	44	69
To Moung	224	174	118	59	93
To Battambang	274	215	143	72	116

According to the Royal Government of Cambodia statistics,[1/] 1,634,000 passengers were carried by rail in 1966 with an average trip of about 66 km. The railway handled 81.3 million ton-km of freight in 1959, 50 million ton-km in 1962 and 96 million ton-km in 1965. The average haulage is about 220 km.

Rail transport of rice from Battambang, a rice production center, to Phnom Penh costs 205.6 Riels per ton. If, however, a cost of 40 Riels to 80 Riels per ton for carrying rice to a station and charges of 50 Riels to 70 Riels for the transport from the Phnom Penh Station to warehouses and for handling are added, the total transport cost of rice by rail often becomes higher than the transport cost by truck. Accordingly, while rice mills located in the vicinity of a railway station prefer rail transport, those situated far away from the railway prefer truck transport.

1/ : *Annuaire Statistique du Cambodge 1966*, Ministre du Plan, Royaume du Cambodge.

D-5 Waterway Traffic on the Mekong

D-5-1 General Remarks

On account of its abundant and placid flow, the Mekong constitutes the most important traffic route in Cambodia (Fig. V-7). On the downstream reach from Phnom Penh, 3,000-ton class ocean-going vessels are carrying export and import goods, and on the upstream reach from Phnom Penh to Kratie, cruisers, barges, fishing boats and timber rafts are moving.

Although sinuous in some parts of its course, the Mekong has rather few bends so that the distance along the waterway route on the river does not differ much from the straight distance and seldom exceeds that along existing land route. For instance, the waterway route between Phnom Penh and Kratie is far shorter and hence is utilized more briskly than the land route.

D-5-2 Traffic at Phnom Penh Port

According to the data as of August 1963 gathered at the Charge du Port de Phnom Penh, some 500 to 600 ocean-going vessels per year are making port at Phnom Penh.

In 1961, ocean-going vessels numbered 525 with a total net tonnage of 483,468, 50% increase from 1956. In 1962, the number has risen to 625.

D-5-3 Ferries

At present, no bridge crosses the Mekong Mainstream; there are only two highway bridges over its tributaries: the Monivong bridge over the Bassac and the Sangkum Reaster bridge across the Tonle Sap. At other places, namely at Neak Luong, Prek Kdam, Kompong Cham and Stung Treng ferries are operated to carry both vehicles and passengers. The existing traffic of vehicles and passengers at these ferries is listed in Table V-28 1/ and the ferry fares as surveyed are given in Table V-29.

Table V-28 Ferry Traffic (1961)

Location	Vehicles	Passengers
Neak Luong	72,606	482,300
Prek Kdam	139,785	882,300
Kompong Cham	48,796	unknown
Stung Treng	5,679	2,500

Table V-29 Ferry Fares in Riels

	Kompong Cham	Prek Kdam	Stung Treng
Passenger	1	3	1
Bus and Truck	100	100	100
Small-sized Motorcar	40	40	40
Autocycle	30	15	15
Motorbike	10	3	1
Bicycle	1	3	1

D-5-4 Cruiser Traffic

The number of cruiser services being operated from Phnom Penh and from Kratie as investigated at site in August 1963 is listed in Table V-30.

Although it varies with the type of the ship and the season and according to whether the ship moves with or against the stream, the time of cruiser travel is on an average as shown in Table V-31.

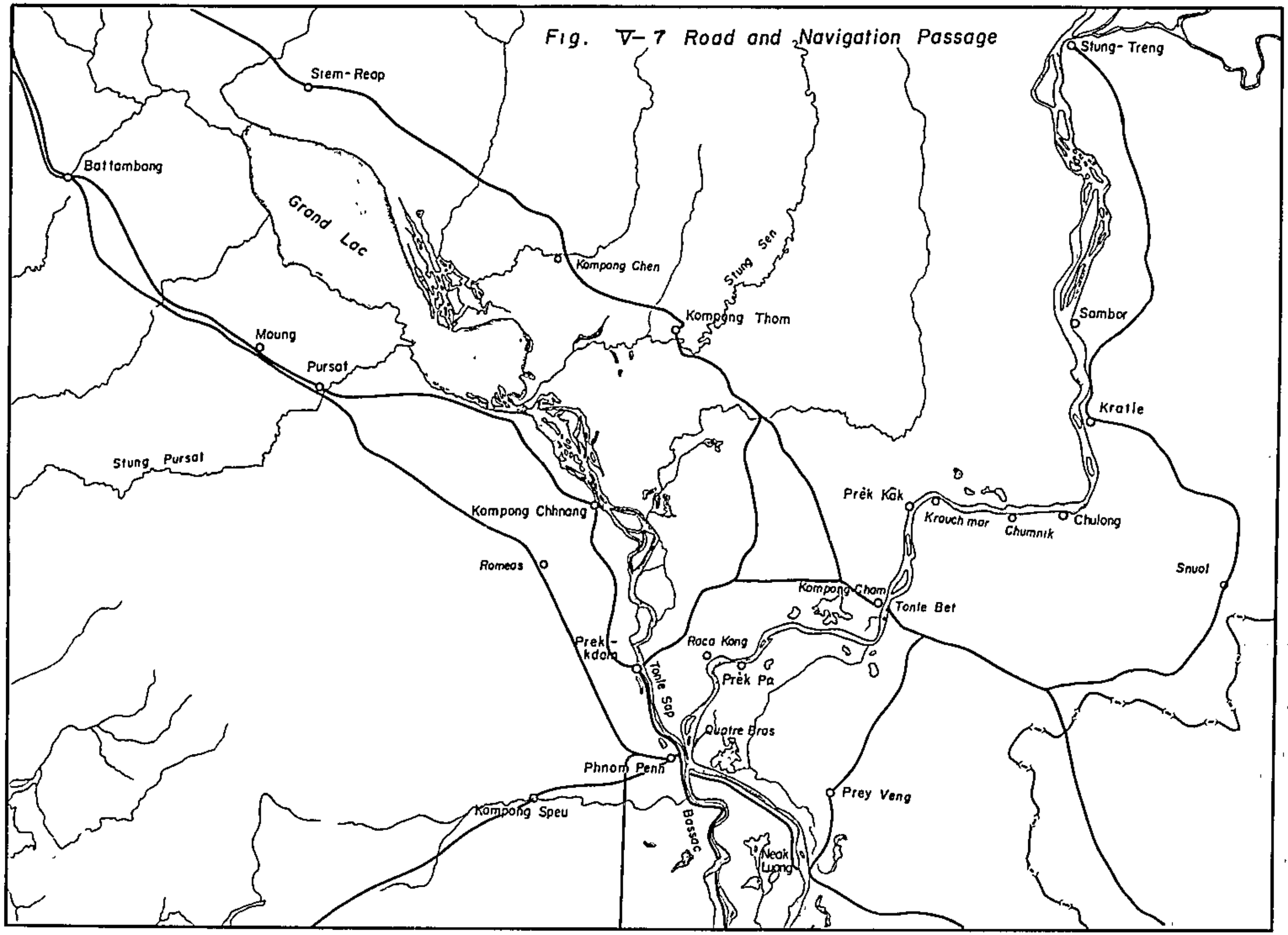
Cruisers now in service are of from 10 tons to 150 tons in size, with capacities shown in Table V-32.

As observed at Phnom Penh Port, cruisers are usually occupied from 50% to 70% of their capacity. But on weekends and on holidays the traffic reaches one and half times or two times that on weekdays.

A traffic census of cruiser passengers was taken by the survey team from January to February 1965 at the

1/ : *Bulletin Mensuel de Statistique*, 1962, Ministre du Plan, Royaume de Cambodge.

Fig. V-7 Road and Navigation Passage



ports of Phnom Penh, Kompong Cham and Kratie. The numbers of passengers who landed at these ports were counted and are shown in Table V-33.

Table V-30 Number of Daily Cruiser Services

Phnom Pehn to Kratie	3
Phnom Penh to Kompong Cham	4
Phnom Penh to Kompong Chhnang	1
Phnom Penh to Vietnamese Boider	1
Phnom Penh to Roca Kong	3
From Kratie to Phnom Penh	3
From Kratie to Kompong Cham	4
From Kratie to Opposite Bank	15 to 20

Table V-31 Travel Time, in Hours, on Cruisers

Travel Section	Down stream	Up-stream
Phnom Penh to Kompong Cham	6-9	9-10
Phnom Penh to Kratie	12-14	14-16
Phnom Penh to Prek Po	3	4
Phnom Penh to Krouchmar	8-10	15
Kompong Cham to Kratie	7-9	11
Kompong Cham to Krouchmar	4	5
Kompong Cham to Chumnik	5	6
Kompong Cham to Prek Kak	3	4
Kompong Cham to Prek Stek	2.5	3
Neak Luong to Vietnamese Border	14	15

Note: By night, a little less time is required.

Table V-32 Passenger Capacity of Cruisers

Size	Passengers
120 tons	200
100 "	170
80 "	150
30 "	80
12 "	55

Table V-33 Number of Disembarking Passengers

Passengers (per ship) Max.	Mean	who Landed at	Coming from	on Cruisers Moving between
127	87	Kratie	Phnom Penh	Phnom Penh and Kratie
97	55	Kratie	Kompong Cham	Kompong Cham and Kratie
47	30	Kompong Cham	Phnom Penh	Phnom Penh and Kompong Cham
20	15	Kompong Cham	Phnom Penh	Phnom Penh and Kratie
52	25	Kompong Cham	Kratie	Kratie and Phnom Penh
46	28	Kompong Cham	Kratie	Kratie and Kompong Cham
52	45	Phnom Penh	Kratie	Kratie and Phnom Penh
57	42	Phnom Penh	Kompong Cham	Kratie and Phnom Penh

Cruisers call at many other ports: The number of ports of call differs much according to traffic sections as well as to cruiser operators. In the services operated between Phnom Penh and Kratie, they number from 10 to 15, in the services between Phnom Penh and Kompong Cham from 9 to 25, and in the services from Kompong Cham to Kratie from 10 to as much as 30.

Cruiser Traffic vs. Bus Traffic: As compared in Table V-34, passenger fares on cruisers are about 40% of bus fares. In trips of short distance, however, bus travel is much preferred in spite of its higher fare because of its speediness.

The travel distance on land between Phnom Phnh and Kompong Cham differs little from that on the river route. Therefore, those who travel

Table V-34 Passenger Fares on Cruisers and on Buses in Riels

Travel Section	Cruiser	Bus
Phnom Penh to Kompong Cham	20	50
Phnom Penh to Kratie	45	120
Kompong Cham to Kratie	30	–

on this section generally use buses as thereby they can make their trip in a far shorter time. But in intermediate sections between Phnom Penh and Kompong Cham, the cruiser travel seems much preferred to the bus travel.

Between Phnom Penh and Kratie, on the contrary, the land route measures 340 km as compared with the 215 km of the river route. Moreover, the land route crosses two ferry sites where much time is needed to pass. Hence, there is no much difference in travel time whether the trip is made by bus or on a cruiser. In addition, a long bus travel is apt to make one feel tired. Accordingly, the passenger traffic on cruisers in this section exceeds that on land route. Cruisers also carry more passengers than buses on sections lying in between Kratié and Phnom Penh.

Cargo Transport on Cruisers: Besides passengers, various cargoes such as rice, maize, fruits, vegetables, kapok, drinking water, processed foods, cement, machine parts and other commodities are carried by cruisers.

An example of cruiser freights is shown in Table V-35. Cruiser freights vary much according to the quantity of cargo to be carried and to other circumstances. But cruiser transport in general costs far less than bus transport, about half as compared with truck transport.

Table V-35 Example of Cruiser Freights in Riels

Transport Section	Rice	Cement
Phnom Penh to Kratie	7-15	4-5
Phnom Penh to Kompong Cham	5-7	2-3
Phnom Penh to Tonle Bet	4	–
Phnom Penh to Kompong Chhnang	7	–
Kompong Cham to Kratie	6-10	3

Note. Freights per bag of rice or cement

D-5-5 Barge Transport

On the Mekong and its tributaries are moving many barges carrying various kinds of cargo that consists mainly of farm produce such as rice, maize, kapok, vegetables and fruits as well as charcoal and earthenware pots and jars. Of these, rice ranks first in quantity.

Barges are of various tonnage, ranging from 50 tons to 500 tons Large quantities of volume cargo such as rice are carried by large-sized barges, provided that the course is navigable to them. For instance, 350 tons to 500 tons barges are often used for shipping rice from Kompong Cham[1/]

Table V-36. Barge Freights

Transport Section	Cargo	Freight
Kompong Cham to Phnom Penh	Rice	8-10 Riels per Bag
Kompong Cham to Phnom Penh	Maize	12 Riels per Bag
Kompong Thom to Phnom Penh	Rice	11 Riels per Bag
Prey Veng to Phnom Penh	Rice	6-7 Riels per Bag
Phnom Penh to Kratie	Coaltar	25 Riels per Bag

Table V-36 shows the barge freights surveyed at site. In general, barge freights are about 40% to 70% of truck freights. Accordingly, agricultural products such as rice and maize produced in the vicinity of the river are mostly carried by water. But those produced in areas far off from the river are often carried by truck directly to their destinations.

For instance, when tranported by truck from a rice mill located 27 km north of Prey Veng to Phnom Penh, a bag of rice will cost 18 Riels. In practice, however, the rice is trucked up to Prey Veng at a cost of 6 Riels, transhipped to a barge there at paying a loading charge of 1 Riel (in the wet season) and then carried by water to Phnom Penh at a cost of 6 Riels to 7 Riels. This way of transport costs 13 Riels to 14 Riels in total as compared with the 18 Riels of truck transport.

1/: When the water level is high in the Great Lake, barges of about 100 tons are used to carry rice from Kompong Thom to Phnom Penh.

and then carried by water to Phnom Penh at a cost of 6 Riels to 7 Riels. This way of transport costs 13 Riels to 14 Riels in total as compared with the 18 Riels of truck transport.

Table V-37 Loading and Unloading Charges in Riels per Bag[a/]

Port	Cargo	Handling	Charge
Kratie	Rice	Loading, Unloading	5
Kratie	Cement	Unloading	2
Kompong Cham	Rice	Loading	2-5
Kompong Cham	Cement	Unloading	2
Phnom Penh	Rice	Unloading	5
Phnom Penh	Cement	Unloading	2
Prey Veng	Rice	Loading	1-5[b/]
Kompong Chhnang	Rice	Loading	1
Kompong Chhnang	Salt[c/]	Loading	1

a/ : Charges vary according to the quantity and becomes higher as the water level becomes lower.

b/ : 1 Riel per bag, in the high-water season.

c/ : One bag contains 45 kg of salt.

In this case of transport, the shipment up to Prey Veng may be made by water in the wet season on a small tributary of the Mekong. But, in the dry season, the shipment is made mostly by truck because not only the traffic on the tributary becomes difficult on account of its low water level but also the loading charge rises.

Another example is the refreshing drinks arriving at Stung Treng. They are carried by water from Phnom Penh to Kratie, where they are landed and then carried to Stung Treng by land.

Loading and unloading charges were surveyed at several ports and are listed in Table V-37.

D-5-6 Transport of Charcoal

According to the statistics[1/] and the data obtained in February 1965 at the Service des Eaux, Forêt, Chaussée et Pêches at Kratie, Cambodia's charcoal production amounts to 10,000 tons to 30,000 tons a year, the greater part being produced in Kratie Province as shown in Table V-38.

About 50% to 80% of the Cambodian total production are carried to Phnom Penh, where some 10,000 tons are consumed annually. Export of charcoal has once recorded an all-time-high of 25,000 tons, but now not so much is exported.

Table V-38 Annual Charcoal Production in Cambodia and in Kratie Province (Unit: tons)

District	1960	1961	1962
Cambodia, as a Whole	24,000	11,400	13,000
Kratie Province	9,980	8,040	8,400
Chhlong	1,870	1,320	3,562
Snuol	240	360	360
Kratie:	7,780	6,360	4,478
West of the Mekong	3,450	3,747	2,230
East of the Mekong	4,330	2,613	2,248

1/ : *Annuaire Statistique du Cambodge 1962*, Ministre du Plan, Royaume de Cambodge

On both sides of the Mekong near Kratie, there are some twenty charcoal factories, mostly located close to the river bank.

Raw wood is carried by trailer trucks or oxcarts from sites some 15 km to 40 km distant from Kratie, mostly in the dry season because roads becomes muddy in the rainy season. Raw wood costs 90 Riels to 120 Riels per cubic meter at site and its transport by truck to Kratie costs 20 Riels to 80 Riels per cubic meter. One cubic meter of raw wood yields 180 kg to 190 kg of charcoal. A manufactory produces 300 tons to 900 tons a year.

Manufactured charcoal is carried to the river bank and loaded on to barges that range from 40 tons to 100 tons in tonnage. Small-sized barges carry about 600 crates[1/] per barge and large-sized ones about 1,300 crates.

Loaded barges are towed by tugs downstream from Kratié to Phnom Penh. Barge transport from Kratié to Phnom Penh takes 5 to 7 days in the wet season and about 20 days in the dry season; it costs 10 Riels to 17 Riels per crate in the dry season and less in the wet season. The price of charcoal is 70 Riels to 120 Riels per crate in Phnom Penh and 60 Riels to 80 Riels in Kratie.

Some charcoal factories have recently been built in Stung Treng. But, on account of navigation difficulties on the Mekong around Stung Treng, these factories' combined annual output amounts to mere 20 tons, so small as only to meet the demand in Stung Treng, where the price is about 120 Riels per crate.

D-5-7 Timber Rafting

Annual production of timber in Cambodia and in Kratie and Stung Treng Provinces are shown in Table V-39.

Table V-39. Annual Timber Production in Cambodia and in Kratie and Stung Treng Provinces

(Unit: m^3)

Production Site	1960	1961	1962
Cambodia, as a Whole	414,700	247,300	198,500
Kratie Province	54,178	28,899	25,459
Chhlong	14,832	6,222	3,821
Snuol	23,050	5,827	8,753
Kratie:			
West of the Mekong	10,626	12,544	6,598
East of the Mekong	5,670	4,306	6,287
Stung Treng Province	13,681	6,936	2,877

As can be seen from the table, Kratie and Stung Treng Provinces account for about 15% of the total national production and are the main timber production areas comparable to the Kompong Cham and Kompong Thom Districts.

Felling and logging are made in forests in the interior. Logs are stacked close to roads, carried on trailers more than 100 km to shipping sites on the river bank, composed into rafts together with bamboo floats, and then sent down the river to Phnom Penh. The rafts are composed at Se Kong, Stung Treng, Kratié, Tonlé Bet and other sites.

Logs measure 60 cm to 140 cm in diameter and are cut to lengths of 7 m to 12 m so as to facilitate trailer transport and rafting. One log has a volume of 3 m^3 to 10 m^3.

Timbers from the Kratie District is of hardwood species called Chhoeu Teal, Choc Chong, Beng, Spong, Phdiek, etc., the specific gravity of which exceeds unity.

Accordingly, logs do not float by themselves and bamboos are composed into rafts so as to make them float. A raft measures from 8 m to 10 m wide and from 10 m to 15 m long. Several of such rafts are joined together to form a train of 50 m to 90 m.

1/ . One crate contains 60 kg of charcoal.

Rafts are let float down the river with the stream as far as possible. But during the dry season or in reaches where the current is very slow, they must be helped by tugs. Accordingly, rafting is more done in the wet season than in the dry season, while logging is mostly done in the dry season.

In the reach upstream from Kratie, in particular, rafting is limited in the wet season as there appear many obstacles on account of the low water level in the dry season.

It takes from 10 to 15 days for a raft to reach Phnom Penh from Kratie, if it floats down with the stream in the wet season, and four or five days in the dry season with the help of a tug.

The price of logs as sold by the Royal Government of Cambodia is said to range from 200 Riels to 400 Riels per cubic meter. Transport by land up to the river bank costs 400 Riels to 600 Riels per cubic meter, and water transport to Phnom Penh 40 Riels to 100 Riels per cubic meter.

D-6 Existing Port Facilities

1) General Remarks: The Port of Phnom Penh is provided with a reinforced concrete pier and four pontoons, both for use of ocean-going vessels, and twenty-four pontoons of simple construction for use of vessels of inland navigation.

Lying at the center of the Cambodian Plain and situated at the confluence where the Tonle Sap and the Bassac join the Mekong, Phnom Penh assumes the position of the pivot of the Cambodian traffic network. But its port facilities are at present in no way well equipped not only on scale but also in efficiency. The Royal Government of Cambodia has planned to construct a new port of Phnom Penh equipped with up-to-date facilities at Chruoy Chang War and its construction is expected to begin soon.

2) Facilities for Ocean-going Vessels at Phnom Penh: The reinforced concrete pier at Phnom Penh Port measures 12 m by 185 m and provides two berths. Although cargoes can be handled there at all times, a drop of efficiency is not avoidable in the dry season because the river surface will fall to a level more than 10 m lower than the pier platform.

Of the four pontoons, all 20 m wide, two are 40 m, one is 60 m and another one is 80 m long. Each is made of several iron floats coupled together. The pontoons are connected to the shore by long gangways to cope with the difference of elevations between the pontoon and the shore.

Cargo handling between a mooring ship and the pontoon is operated mostly by the ship's own derrick, and between the pontoon and the shore almost exclusively by manpower. In the dry season, therefore, cargo handling becomes to require much labor, time and cost. Moreover, the pontoons are now all worn-out and are under load restriction. Cargoes that can be handled on the pontoons are limited to animals and light cargoes such as general goods.

In addition to these inadequacies, the existing facilities are not sufficient in their overall capacity to handle the increased volume of cargo smoothly. Therefore, many ships are now compelled to wait off the shore or to make offshore cargo handling. 625 ships have made port at Phnom Penh in 1962.

3) Facilities for Inland Water Traffic: The twenty-four pontoons at Phnom Penh for inland waterway traffic lie a little downstream from those for ocean-going vessels. Of these, twenty are now in use. Most of them are wooden pontoons or iron-float pontoons of shallow draft and measure 6 m by 10 m. Each of them is connected to the shore by a wooden gangplank. In the high-water season, they are drawn toward the shore as near as the draft of mooring vessels allows.

There are, at Kompong Cham, four pontoons of the same construction as those at Phnom Penh. Of these, the large-sized one measures 8 m by 15 m.

At Kratie, there are four pontoons for cruiser traffic, which float by the buoyancy of bamboos. The large-sized one measures 7 m by 10 m. In the dry season, much labor is needed for cargo handling because of the drop of the water level.

CHAPTER E. SALIENT FEATURES OF THE PROJECT AREA

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E-1 Climate

Cambodia, lying between 10° 15' Lat. and 14° 35' N Lat., belongs to a tropical monsoon zone. The period from May to October is called the wet or rainy season when the southwest monsoon carying moist warm air prevails, and the period from November to next April the dry season when the northeast monsoon prevails.

In Cambodia, there is little change in temperature throughout the year. The annual mean temperature in Phnom Penh is 27° C. The temperature recorded in 1958 and in 1959 at several selected sites are listed in Table V-40.1/

Table V-40 Highest and Lowest Temperature and Annual Rainfall at Selected Stations

Station	Temperature in Centigrade Degrees				Annual Rainfall, in Millimeters	
	1958		1959			
	Highest	Lowest	Highest	Lowest	1958	1959
Battambang	41.0	14.5	36.0	20.5	1,130.7	1,199.6
Kampot	36.5	19.0	34.6	22.0	2,053.7	2,007.3
Kompong Cham	38.5	18.8	34.1	21.5	1,534.6	1,302.2
Kompong Som	34.4	21.9	32.3	23.0	3,457.8	4,110.9
Phnom Penh	39.1	18.4	35.2	21.8	1,058.9	1,116.7
Siem Reap	38.9	15.4	35.3	20.7	1,374.3	1,475.8
Svay Rieng	38.5	17.8	35.1	21.4	1,700.3	1,628.0
Stung Treng	41.4	13.0	35.1	20.3	1,849.7	1,665.0

The precipitation differs largely from region to region; in the western coast region and in the northeastern mountainous region, there is much rainfall, while in the plain region the annual rainfall is about 1,100 mm to 1,500 mm as shown in Table V-40.

E-2 River Regime of the Mekong

E-2-1 Distance and Elevation

In Table V-41 are shown the distances from the river mouth to the six selected sites along the Mekong and the elevations of these sites. The table shown that the river has a comparatively steep slope between Savannakhet and Kratie.

Table V-41 Distance and Elevation

Selected Site	Distance From Estuary in km 2/	Elevation Above Mean Sea Level in meters 3/
Vientiane	1,606	175
Savannakhet	1,148	140
Pakse	891	100
Stung Treng	680	50
Kratie	547	22
Phnom Penh	332	11

E-2-2 Water Level

The water level of the Mekong begins to rise from May and reaches its peak in August or September. During the high-water period, part of water surges back into the Great Lake through the Tonle Sap, inundating the area around the lake. Water levels of the river at various sites are listed in Table V-42. (Fig. V-8, Fig. V-9)

1/: *Bulletin Mensuel del Statistique*, 1962, Ministre du Plan, Royaume de Cambodge.

2/: *Development of Water Resources in the Lower Mekong Basin*, Flood Control Series, No 12, ST/ECAFE/SER. F 12, October 1957.

3/: *Comprehensive Reconnaissance Report on the Major Tributaries of the Lower Mekong Basin*, The Mekong Reconnaissance Team of the Government of Japan, September 1961.

Fig. V-8 Change of Water Level of the MEKONG

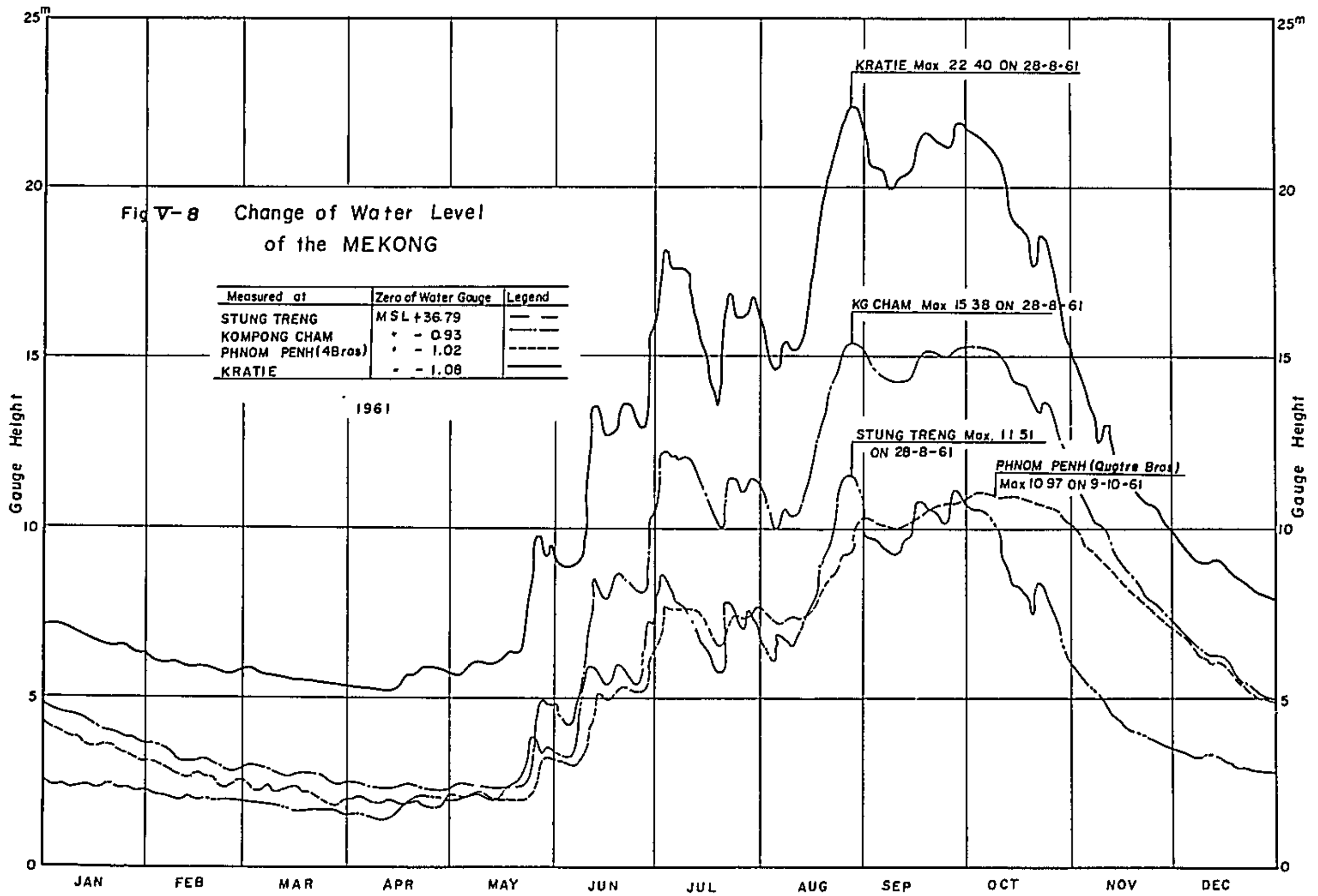


Fig. V-9 Change of Water Level of the MEKONG

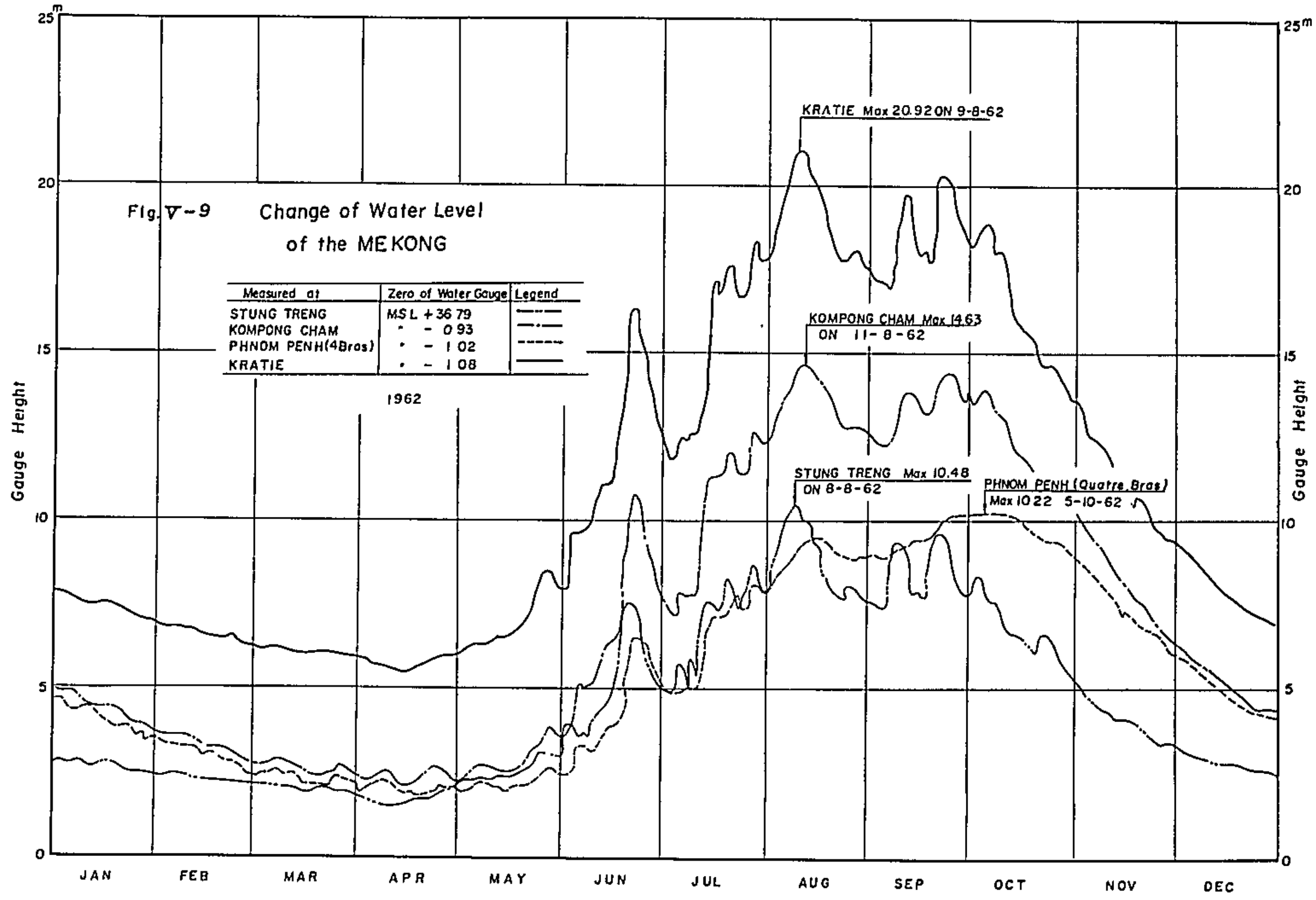


Table V-42 Water Levels at Various Sites in Meters above Mean Sea Level at Hatien

Site	Distance From Estuary in km	1961		1962	
		Highest	Lowest	Highest	Lowest
Stug Treng	680	48.30	38.20	47.27	38.36
Kratie	547	21.32	4.02	19.84	4.22
Kompong Cham	435	14.45	1.32	13.70	1.07
Phnom Penh	332	9.95	0.68	9.20	0.73

E-2-3 Current Velocity

According to the Royal Government of Cambodia's measurement conducted in 1960 and 1961, the mean current velocities in the high-water season at Stung Treng, Kratie, and Kompong Cham are 1.6, 1.7 and 1.6 m/sec, respectively. It is presumed, however, that the current velocity in the center of stream will amount to 3 to 4 m/sec.

When a survey was made in August 1961 at Phnom Penh, the discharge was measured as about 50,000 cu.ms and the current velocity as 2.3 m/sec on the average and 3.34 m/sec in the center of stream (Fig. V-10)

Data are hardly available on the current velocity in the low-water season. But it may presumed at from 0.2 to 0.5 m/sec.

It is during the high-water season that the current velocity becomes a matter of concern with regard to navigation. In this season, it will sometimes become almost impossible for small craft to go up the river against it its swift current.

E-3 River Regime and Navigability of Individual Sections

In the following is described the existing regime of the Mekong with respect to navigation, dividing its course from the estuary to Stung Treng into several sections.

E-3-1 Around the River Mouth

The Mekong braches into five streams when it runs through the so-called Mekong Delta and enters the sea. It deposits her fine clayey silt and sand on the beds of the river as well as of the sea, making the sea shallow stretching to a great distance from the shore. In the chart of this region, the five-meter contour line runs about 15 km off the shore showing that the slope of the sea bottom is extremely small.

At present, the Song Cua Tieu, the northernmost branch, is used for navigation of ocean-going vessels. But off its mouth, ships have to sail about 10 km where the sea is only 2.5 m to 3.5 m deep. Therefore, when sailing this section, vessels of 3,000-ton class are compelled to sail only in the high tide. Oncoming ships wait the high tide usually under the lee of Cape St. Jaques, southeast of Saigon, and outgoing ships wait the tide on the Mekong in the vicinity of the Cambodian-Vietnamese border.

The tidal range at My Tho on the north bank of the Song Cua Tieu is 3.5 m in the spring tide and 2.9 m in the neap tide. At present, therefore, the draft of vessels is limited to 4.1 m in April and to 5.2 m in September.1/

E-3-2 Within the Republic of Vietnam

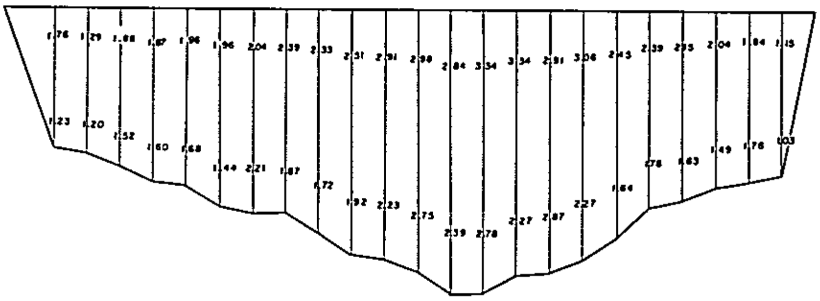
According to the chart, the Song Cua Tieu is 500 m to 600 m wide and provides a fairway of 5 m to 7 m deep. There are, however, some shallow places where the water is 2 m to 3 m deep.

On the Song My Tho upstream of the Song Cua Tieu, there are many meanders and branches and the river becomes wide and irregular in depth with many shoals.

Fig. V-10 Distribution of Current Velocity

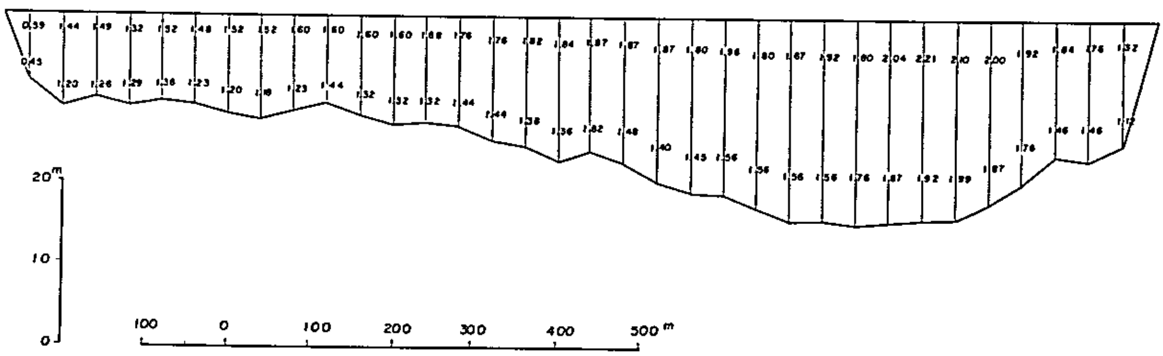
Phnom Penh

Location	USINE DES EAUX		
Width	885 m	Date	28-8-61
Mean Velocity	2 31 m/sec	Area	23 068 m^2
Discharge	50 817	Gage Height	10 09 m



Kratie

Width	13 60 m		
Mean Velocity	1 67 m/sec	Date	28-9-60
Discharge	36 260 m^3/sec	Area	21 644 m^2
Mean Depth	15 91 m	Gage Height	18 32 m



In stretches where the river meanders in an S-shaped course, the channel becomes very deep along the outer side of the bends, showing a depth of 10 m at some sites. But in straight stretches and around the site where the channel branches, there are many shallows where the water depth is 5 m or less.

E-3-3 From the Cambodian-Vietnamese Border to Phnom Penh

The Royal Government of Cambodia has made the sounding of the Mekong from the Vietnamese border to Kratie at 500 m intervals. According to the hydrographic map made based on the sounding, there are many sand bars in the river course downstream from Phnom Penh. The river becomes very wide around these bars and measures about 1,700 m or more across. Especially around Koh Peam Reang Island and around Kas Tachor, the width measures about 2,700 m and 3,300 m, respectively.

In other stretches, the river width ranges in general from about 1,000 m to 1,800 m. But there are many narrow stretches. For instance, at 42 km and 74 km downstream from Phnom Penh, the river narrows to 600 m and 500 m, respectively.

At 3 km, 45 km, 69 km and 77 km downstream from Phnom Penh, there exist shallows with a depth of 6 m or less. On the other hand, a depth of more than 25 m can be found at places 42 km, 53 km, 67 km, 74 km, 78 km and 95 km downstream from Phnom Penh.

1/ *Report of the Investigation on the New Port Construction Project at Phnom Penh, Kingdom of Cambodia 1965,* OTCA, Tokyo, Japan

E-3-4 Around Phnom Penh

The Port of Phnom Penh is located near the confluence of the Tonle Sap and the Mekong, where also the Bassac branches out from the mainstream. At this site, the mainstream makes a turn from the north to the southeast, causing a very complicated flow.

Upstream from the confluence, the Mekong is about 1,000 m wide and the Tonle Sap about 500 m wide; they form a channel of about 2,000 m at the confluence. Downstream from the confluence, the main river is about 1,700 m wide and the Bassac about 600 m wide.

The flow slackened in the vicinity of the confluence causes much deposition of sediments making the water around the Port of Phnom Penh as shallow as 1.5 m to 2m. This constitutes a bottleneck in the waterway traffic to and from Phnom Penh and is costing the Royal Government of Cambodia annual dredging.

E-3-5 From Phnom Penh to Kompong Cham

From Phnom Penh upstream to Kompong Cham, the channel is maintained at a depth and width safe enough for the traffic of cruisers and barges. Although there are provided no navigation aids, the channel seems to allow passage of 2,000-ton-class vessels at all times. But caution must be taken of the fact that the river regime at some sites is liable to change.

At distances of about 8 km, 10 km, 65 km and 93 km upstream from Phnom Penh, there are islands, and at about 31 km and 36 km from Phnom Penh there lie sand bars.

In the greater part of this section, the river is 800 m to 1,500 m wide. The center of stream usually lies deviated from the river center and the depth measures more than 10 m for over 85% of the stretch from Phnom Penh to Kompong Cham. Especially at distances of 10 km, 22 km to 29 km, 32 km and 44 km upstream from Phnom Penh, there can be found deep channels measuring more than 25 m deep.

The river makes an S-shaped bend over a stretch of about 12 km from a point about 22 km upstream from Phnom Penh. Here, the river narrows to 600 m increasing its depth and current velocity.

There are some shallow places. They can be found at sites where the center of stream makes a shift from one side to the other side of the river.

Bank erosion and silt deposition seem to be going on as in shown by some new traces of crumbling on the bank and by tumbled trees. Such traces can be observed on the left bank at distances of 14 km and 95 km from Phnom Penh and on the right bank at 37 km, 50 km and 83 km from Phnom Penh. It is the bank erosion that caused the fall in 1964 of the Monivong bridge near Quatre Bras

E-3-6 From Kompong Cham to Kratie

The Mekong in this section flows generally shallow as compared with in the reach downstream from Kompong Cham and presents many obstacles to navigation. The river flows in irregular streams with many sand bars, shoals and meanders. So, many navigation aids are provided.

At distances of 110 km, 122 km, 127 km, 152 km, 160 km, 175 km and 200 km upstream from Phnom Penh, there exist sand bars and islands which cause the meander of the center of stream. Channels deeper than 20 m can be found at 103 km, 106 km, 118 km, 136 km, 139 km to 142 km, 147 km and 194 km upstream from Phnom Penh, and shallows with a depth of 3 m or less at 112 km, 115 km, 136 km, 144 km, 157 km, 168 km, 184 km and 206 km upstream from Phnom Penh.

The river banks are eroded at many places, instances of which are: the north shore of a sand bar at 112 km, the right banks at 116 km, 125 km and 157 km, the left bank at 147 km and the west shore of a sand bar at 201 km upstream from Phnom Penh. The stream flows in deep channels along the eroded banks at these sites and vessels are often seen sailing as near as some 50 m from the shore.

E-3-7 From Kratie to Sambor

An island called Kas Trong lies facing the city of Kratie and divides the river into two channels as shown in Fig. V-11. The water around the island is very shallow and the island enlarges its area above the water in the low-water season.

However, a channel of 2 m to 5 m deep runs at a distance of 100 m to 150 m from either bank of the river and allows all-the-year passage of small craft.

At a distance of about 5 km upstream from the landing place at Kratie, the river narrows to some 1,300 m. The swift current here scours the river bed and makes the channel as deep as 4 m to 11 m. Upstream from this site, the river becomes wide about 2,000 m.

In the vicinity of and upstream from Phnom Samboc, the center of stream deviates towards the left bank and many bassets of bedrock crop out from the river bed. Especially in the vicinity of the projected dam site at Sambor, there appear during the low-water period many outcrops of rock above the water surface, and the river flows with a swift current in narrow and deep channels meandering through the protruding rock outcrops. Therefore, navigation on this section during the low-water season is almost prohibitive and can be done only by small craft. Navigation aids are set up atop the rock outcrops to guide these craft.

E-3-8 From Sambor to Stung Treng

No detailed survey has yet been made on the reach between Sambor and Stung Treng. But the following can be mentioned on the river regime in this section.

There exist in this section some stretches where the channel remains deeper than 10 m even in the low-water season. These sites, however, are dotted with many a dangerous spot.

There are many rapids, including the Samboc Rapids In the low-water season, many islands as well as sand bars and rock crops which lie submerged during the high-water period show their shapes above the water surface dividing the river into many narrow and sinuous channels Navigation on this section during the low-water period, therefore, becomes almost impossible.

According to Mr. Dooleage's survey of the United Nations, sites markedly dangerous to navigation are as follows. A narrow channel in the vicinity of Kas Pring extending about 15 km upstream from a site 60 km from Kratie; around the Sambor Rapids; and an about 15 km long channel around many islets in the vicinity of Kas Senha and of Kas Preas situated between 100 km to 150 km from Kratie.

Although many dangerous spots will disappear into the water in the high-water season, many submerged rock crops and sunken trees as well as the rapid current make navigation difficult even in the high-water season In this period, only timber rafts or casual lighters are seen moving on rare occasions.

Near Stung Treng, the Se San and the Se Kong join the Mekong. In the dry season, these rivers become so shallow as their beds come into appearance at some sites, thus making navigation impossible. But during the high-water season, they become navigable.

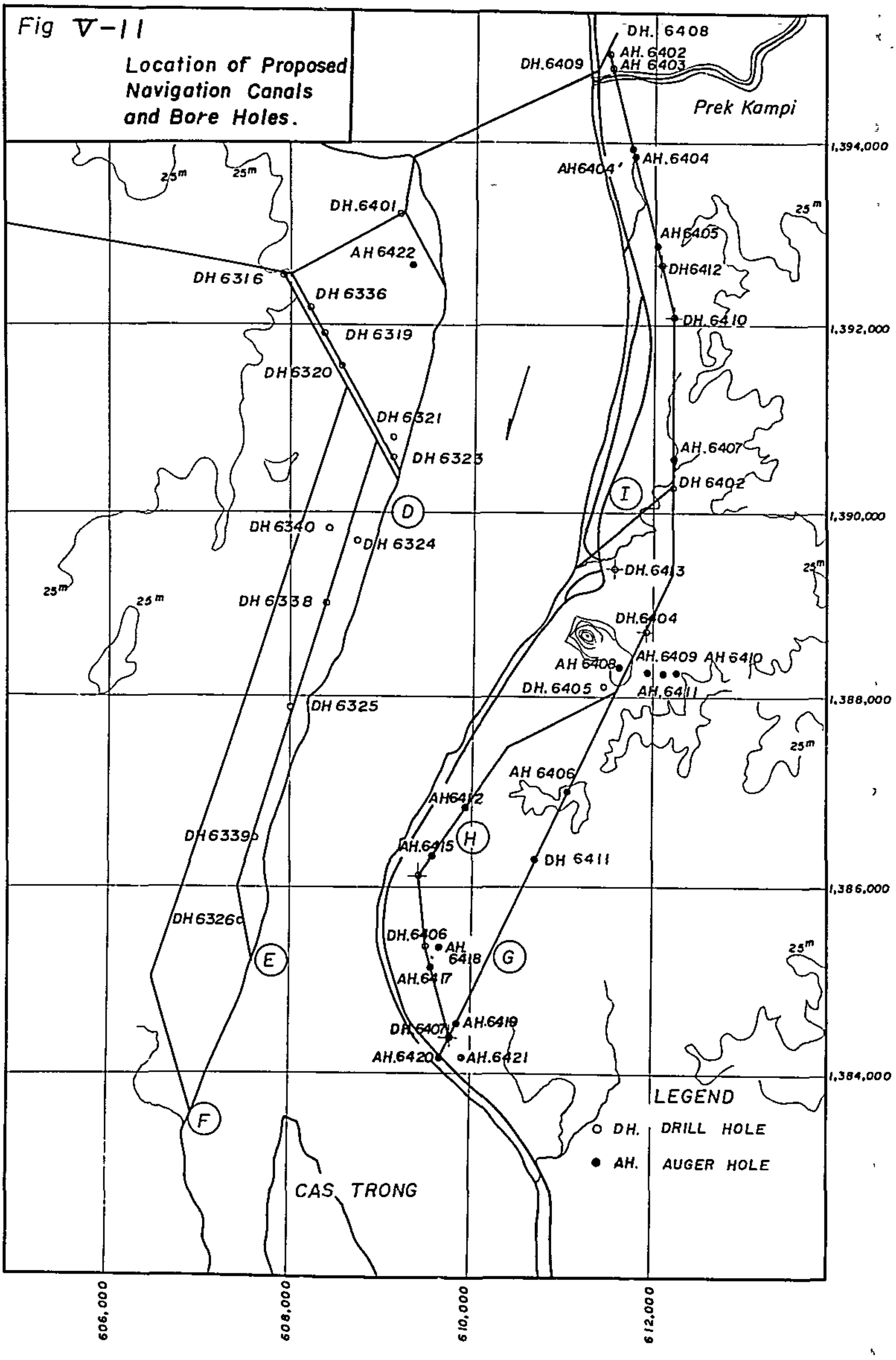
E-4 Topography of the Area around the Dam Site

1) On the Right Bank: A road runs from the projected dam site downstream on the right-bank embankment at elevations of EL 22.00 to EL 23.00 1/ (Fig. V-11). This road is unsurfaced and is not well maintained. In a section of this road stretching about 20 km from the dam site, two brooks that drain the low hinter-lands and run into the Mekong cross the road. These brooks at present are not spanned by bridges for vehicle traffic.

Several roads branch off from the above riverside road almost at a right angle toward Prek Kak and are used for carrying timber, charcoal and other goods to the river bank.

1/ EL: Elevation hereinafter are in meters above mean sea level

Fig. V-11 Location of Proposed Navigation Canals and Bore Holes



Dwellings and charcoal plants scatter along the riverside road. They become sparse toward north, and number less as compared with those on the left bank.

Behind the row of these houses extends a succession of farms with a width ranging from 500 m to 1,500 m on the land of EL 18.00 to EL 22.00. The area under cultivation is larger than that on the left bank. The produce is shipped to Kratie and to Phnom Penh.

A tract of swampy lowlands of EL 13.00 to EL 19.00 stretches to the west of the farmlands skirted on the west by an old river course that lies at EL 23.00 to EL 24.00 and is at present thickly wooded. The lowlands are subject to inundation in the high-water season.

2) On the Left Bank: A road runs from the dam site downstream on the left-bank embankment of EL. 22.00 to EL. 24.00. Coming from Stung Treng, this road is an important road and is paved.

Between the dam site and the city of Kratie, the Prek Kampi and four other rivers run into the Mekong. All these rivers are spanned by bridges. The Prek Kampi has a drainage area of about 915 sq. km. The drainage areas of the other four are all very small.

A large number of houses stand close together along the riverside road. There are also some charcoal plants and timber mills. But in a stretch of one kilometer from the dam site southward and in areas 1 km north and some 5 km south of Phnom Samboc, houses are relatively sparse.

A row of paddy-fields 200 m to 400 m wide extends behind these houses at EL 19.50 to EL 21.00. The land lying to the east of the paddy-fields is swampy lowlands of EL 16.00 to EL 19.00 covered by grass or thickets and is inundated in the high-water season.

Phnom Samboc is a hill situated about midway between the dam site and the city of Kratie. The eastern part of Phnom Samboc is at EL 25.00 to EL 30.00 and stretches to another hill of EL 40.00.

At two sites about 3.5 km downstream from Phnom Samboc, there can be seen rock outcrops in the left-bank revetment.

E-5 Geological Features around the Dam Site

According to the geological survey of the area around the projected dam site conducted by a Japanese Survey Team, there is difference in geological features between the right and left bank of the Mekong and between the area in the vicinity of the dam and the area far downstream from the dam site.

1) On the Right Bank around the Dam Site 1/: Judged from the result of borings made at DH-6316, DH-6336, DH-6319 and DH-6320 2/ located along the west bank of the projected spillway, the ground in this area is covered with a 2- to 10-meter-thick layer of clay or silty clay, and from an elevation of EL 13.00 to EL 22.00 underneath, there extends bedrock of sandstone or shale. It is one characteristic of this area that bedrock can be found so near the ground surface.

At DH-6321, DH-6323, DH-6324 and DH-6340, located a little downstream from the above cited, the stratum is essentially similar, but the bedrock lies a little deeper, at EL 7.00 to EL 14.00.

2) On the Right Bank Downstream from the Dam Site 1/: The ground in the vicinity of DH-6325, DH-6326 and DH-6336 is composed of thick layer of sand or sandy silt underlain by sandstone that extends from an elevation of EL 13.00 to EL −5.00 underneath. At DH-6338 are found both features of the areas in the vicinity of and far downstream from the dam site. Located opposite to Phnom Samboc, this site may be the boundary of the two areas in respect of geological features.

3) On the Left Bank around the Dam Site: Around DH-6408 and DH-6409, where the planned canal route of the future plan, Route G shown in Figs. V-11 and V-12, crosses the dam site line, the top layer is of very compact laterite clay underlain by silty sand or silty clay. Sandstone bedrock lies underneath this layer at EL 10.00 to EL 11.00.

1/ : *The Second Progress Report on Investigations of the Sambor Project*, Overseas Technical Cooperation Agency, Japan, September 1964.

2/ : "DH" stands for "drill hole" of borings. DH-6336 and so forth denote the location of boring holes as shown in Figs V-11.

The bedrock appears at EL 8.50 to EL 9.00 in the vicinity of the mouth of the Prek Kampi, at EL 4.50 to EL 5.00 at sites on the river bank about one kilometer downstream from the Prek Kampi, and at EL 15.00 to EL 17.00 at inland sites some 400 m to 500 m distant from the above sites.

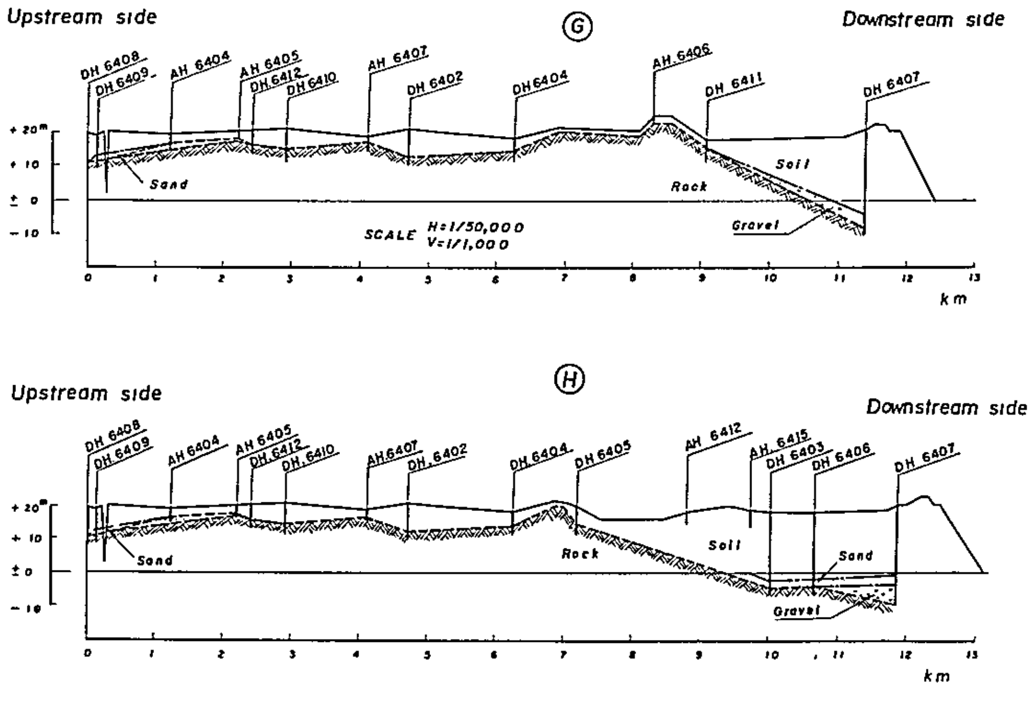
At DH-6410 and DH-6412 on Route G, the surface soil is of the nature similar to the above described and shale bedrock is found at EL 15.00 to EL 16.00. Bedrock lies at EL 12.00 to EL 15.00 in the vicinity of DH-6402 and DH-6404; at EL 5.50 at DH-6413 on Route I shown in Fig. V-11; and at EL 2.50 at DH-6344.

Swampy lands subject to inundation in the high-water period are thinly covered with humus clay. Laterite in this area is very compact and dry, showing a small value of moisture content.

4) On the Left Bank Downstream from the Dam Site: On the eastern side of Phnom Samboc that extends to hills to the east, the ground surface lies a little high, and bedrock is found at a depth of one to three meters from the ground surface. There is a hill of EL 26.00 some two kilometers south of Phnom Samboc, where bedrock lies also not far from the ground surface.

At DH-6403 and DH-6406 on an alternative canal route, Route H in Figs. V-11 and V-12, the surface soil, similarly to that around the dam site, consists of humus clay, laterite clay, silty clay or clayey silt, underlain by silty sand at DH-6403, and by sand at DH-6406. Sandstone bedrock is reached at EL –4.00 at DH-6403 and DH-6406, and at EL –8.6 at DH-6407.

Fig. V-12 Profiles of Proposed Navigation Canals



E-6 Soil Properties

In the following are outlined the main properties of soils as tested on samples obtained by thin-wall samplers when borings were done in 1964 and based on the result of at-site penetration tests. (see Table V-44)

1) Water Content: Water content of soils ranges from 16% to 35%, but in most cases it lies between 22% and 23%. Soils having a water content of more than 30% are very rare.

Laterite lying near the ground surface is very dry and compact with a water content of 16% to 27%. For instance, when a boring was done with a hand auger into the waterside ground in a swampy land, it was found that though the surface soil to a depth of 50 cm contains relatively much water, the underlying layer was in dry condition. This means that the layer is impermeable and is not affected by the surface water.

The water content of silty clay layers lying 8 m to 12 m from the ground surface ranges from 26% to 32% and that of clayey silt lying 18 m from the ground is 35%. But the water content in these layers is in general relatively small.

2) Real Specific Gravity: The real, or absolute, specific gravity of soil particles tested ranges from 2.49 to 2.68, and most soil particles have a specific gravity of 2.60 or thereabout.

3) Dry Density: Dry density was found to range from 1.42 to 1.78 gr/cm^3, being 1.63 gr/m^3 for most soils. The one showed a large value of 1.75 gr/m^3 or 1.78 gr/m^3 was the laterite lying 5 m to 7 m from the ground at DH-6407.

4) Void Ratio: Void ratio ranges from 0.48 to 0.88. It is 0.55 to 0.69 for most soils.

5) Degree of Saturation: Most samples showed degree of saturation of 90% or more, being close to 100% for a majority, what indicates a high consistency of the soils.

6) Plasticity: Liquid limit, plastic limit and plasticity index of soils tested range from 31% to 52%, from 15% to 23%, and from 14% to 32%, respectively.

7) Grading: Most samples were of the following gradation: 100% in weight of the total of soil particles pass a 2,000 - μ sieve, 97% to 99% pass a 420-μ sieve, and 78% to 97% pass a 74-μ sieve. These soils may be classified as clay.

8) Uniaxial Compressive Strength: The uniaxial compressive strength ranges from 0.7 to 3.6 kg/cm^2. For laterite lying in upper layers, it varies in a wide range, averaging 1.86 kg/cm^2. For silty caly layers, it ranges from 0.7 kg/cm^2 to 2.2 kg/cm^2, averaging 1.3 kg/cm^2. Clayey silt in lower layers has a low strength that averages 0.75 kg/cm^2. When remoulded, silty soil decreases its strength, showing a sensivity ratio of 1.3 to 10.0

9) Penetration Test: As, contrary to expectation, there are few sandy sites fit for penetration test, it was done at a few sites. The tests were carried oiut following the standard method of soil-penetration tests as provided by the Japanese Industrial Standards, in which it is specified that a 63.5 kg weight let fall 75 cm freely and the number of blows per 30 cm of penetration is recorded as "N-value."

At several sites where laterite lies in the surface layer, fairly large N-values, ranging from 39 to 47, were recorded.

For silty clay layer 12 m to 18 m from the ground surface, N-value ranges from 17 to 23. The comparative figures for silty sand layer range from 14 to 67, and for sand and gravel from 35 to 43.

Table V-43 Properties of Soil Samples from Augered Holes

Location AH[1/]	Water Content in %	Real Specific Gravity	Grain Size Percentage in Weight				Classification
			Gravel	Part that pass			
				2,000μ	420μ	74μ	
6402 (2.5)	17.6	2.613	2.0	98.0	94.4	81.8	Silty loam
6402 (5.0)	30.4	2.570	29.1	70.9	62.7	52.7	Silty loam with gravel
6403 (2.5)	18.8	2.607	4.8	95.2	91.6	78.5	Silty loam
6403 (5.0)	21.0	2.558	4.0	96.0	94.8	66.5	Clayey loam
6404 (2.2)	29.8	2.612	0	100.0	93.5	53.2	Sandy loam
6405 (2.5)	18.7	2.579	8.3	91.7	56.4	51.6	Ditto
6407 (2.0)	14.9	2.559	0.4	99.6	92.3	53.3	Ditto
6408 (0.7)	6.9	2.578	22.2	77.8	71.8	55.0	Ditto
6409 (2.5)	26.3	2.608	0.8	99.2	94.2	71.9	Clayey loam
6409 (4.0)	27.0	2.584	24.9	75.1	54.3	38.6	Sandy loam with gravel
6410 (0.8)	9.3	2.579	29.1	70.9	49.4	33.8	Ditto
6411 (0.7)	7.8	2.561	4.0	96.0	84.8	40.9	Sandy loam
6412 (2.5)	17.7	2.545	34.2	65.8	52.9	47.4	Silty loam with gravel
6415 (2.5)	23.3	2.616	0	100.0	99.6	95.2	Clay
6415 (5.0)	38.2	2.627	0	100.0	99.5	90.8	Ditto
6417 (2.5)	22.9	2.639	0	100.0	99.6	95.6	Ditto
6417 (5.0)	21.1	2.621	0	100.0	100.0	96.0	Ditto
6418 (2.5)	18.6	2.640	0	100.0	100.0	98.8	Ditto
6419 (2.5)	23.2	2.645	0	100.0	99.2	93.5	Ditto
6419 (5.0)	20.9	2.622	0	100.0	98.0	92.0	Ditto
6420 (1.5)	32.8	2.602	0	100.0	99.2	91.7	Ditto
6421 (2.5)	37.6	2.625	0	100.0	97.2	88.0	Ditto
6421 (5.0)	29.1	2.562	0	100.0	98.7	91.4	Ditto
6422 (1.0)	18.7	2.618	66.4	33.6	19.0	4.0	Sand gravel
6422 (2.5)	11.9	2.669	18.7	81.3	64.0	16.3	Ditto
6423 (2.5)	15.2	2.658	0	100.0	99.6	64.6	Sandy loam
6423 (5.0)	24.6	2.658	0.4	99.6	98.8	69.4	Ditto

Note: 1/: "AH" stands for "augered hole." For locations of holes, see Figs. V-11 and V-12. Parenthesized figures denote the depths from the ground surface in meters.

Table V-44. Properties of Soil Samples from Drilled Holes (1)

Location		Water Content in %	Real Specific Gravity	Dry Density in gr/cm³	Void Ratio	Degree of Saturation in %	Liquid Limit in %	Plastic Limit in %	Plasticity Index
DH6402	T1	23.4	2.638	1.63	0.62	99.6	52.6	23.3	29.0
DH6403	T1	24.2	2.621	1.55	0.69	91.9	45.5	20.2	25.3
"	T2	24.3	2.603	1.63	0.60	100.0	45.8	·21.0	24.8
"	T3	31.8	2.629	1.46	0.84	99.5	37.1	17.5	19.6
DH6404	T1	22.9	2.640	1.61	0.64	94.5	29.7	32.7	17.0
DH6405	T1	25.8	2.567	1.43	0.80	82.8	42.0	24.0	18.0
"	T2	21.1	2.577				37.4	17.7	19.7
"	T3	16.9							
DH6406	T1	23.6	2.570	1.60	0.61	88.9	45.8	20.6	25.2
"	T3	19.5	2.580	1.66	0.55	91.5	51.5	19.8	31.7
"	T4	21.5	2.490	1.62	0.54	100.0	39.7	16.8	22.9
"	T5	25.8	2.516	1.57	0.60	100.0	40.1	17.8	22.3
"	T6	32.5	2.616	1.52	0.72	100.0	34.4	20.3	14.1
"	T7	35.7	2.589	1.42	0.82	100.0	35.0	20.2	14.8
DH6407	T1	26.3	2.577	1.50	0.72	94.1	47.2	23.3	23.9
"	T2	27.6	2.684	1.56	0.72	100 0	37.4	15.7	21.7
"	T3	26.4	2.625	1.68	0.56	100.0	38.3	15.9	22.4
"	T5	24.3	2.644	1.66	0.59	100.0	37.6	15.5	22.1
"	T6	18.2	2.628	1.75	0.50	95.7	36.3	15.3	21.0
"	T7	20.1	2.626	1.78	0.48	100.0	35 0	16.0	19.0
"	T8	20.6	2.624	1.63	0.61	88.6	33.6	15.0	18.6
"	T9	35.2	2.607	1.39	0.88	100.0	33.7	15.1	18.6
"	T10	27.7	2.595	1.56	0.66	100.0	31.5	17.5	14.0
DH6408	T1	22.0	2.641	1.61	0.64	90.8	39.2	18.3	20.9
"	T2	20.3	2.641	1.67	0.58	92.4	37.3	16.9	20.4
"	T3	20.0	2.607	1.68	0.55	94.8	37.7	10.7	17.0
DH6409	T1	20.2	2.615	1.69	0.55	96.0	46.2	19.9	26.3
"	T2	22.5	2.610	1.64	0.59	99.5	51.1	18.6	32.5
DH6413	T1	25.8	2.608	1.60	0.63	100.0	45.4	22.7	22.7

Note: For location see Figs. V-11 and V-12.

(To be continued.)

Table V-44. Properties of Soil Samples from Drilled Holes (3)

Location		Grain Size Percentage in Weight				Uniaxial Compression Test			Cohesion kg/cm²	Angle of Internal Friction	Classification
		Gravel	Part that pass			Strength kg/cm²		Sensitivity Ratio			
			2,000μ	420μ	72μ	(A)	(B)				
DH6402	T1	0	100.0	99.6	97.4	3.11					(1)
DH6403	T1	0	100.0	99.6	95.5	1.08			0.42	26.0	(1)
"	T2	1.2	98.6	97.2	92.6	2.51	1.39	1.81	0.90	20.5	(1)
"	T3	4.5	95.5	93.8	89.8	0.79	0.21	3.76	0.28	21.5	(2)
DH6404	T1	0.8	99.2	89.0	46.9	0.64	0.43	1.33	0.32	7.6	(3)
DH6405	T1	0.8	99.2	89.6	66.7	1.13	0.86	1.31	0.50	35.0	(4)
"	T2	8.6	91.4	66.7	16.1						(5)
"	T3	66.9	33.1	22.3	5.9						(6)
DH6406	T1	0	100.0	99.6	94.7	1.94					(1)
"	T3	0	100.0	99.2	94.8	3.67					(1)
"	T4	0	100.0	97.6	83.3	1.64			1.72	21.0	(1)
"	T5	0	100.0	98.8	94.5	1.54	0.68	2.26	0.42	19.5	(1)
"	T6	0	100.0	98.7	90.3	0.69	0.11	6.27	0.29	6.5	(7)
"	T7	0	100.0	99.0	78.2	0.81	0.08	10.13	0.42	19.0	(7)
DH6407	T1	0	100.0	97.4	86.6	0.65	0.80	0.81	0.58	37.0	(1)
"	T2	2.5	97.5	95.9	94.7	1.65	0.86	1.92	0.38	4.32	(1)
"	T3	0	100.0	97.9	92.1	1.95	1.78	1.10			(1)
"	T5	0.4	99.6	98.0	89.8	1.13	0.79				(1)
"	T6	0.4	99.6	98.4	87.3	2.96			0.29	6.5	(1)
"	T7	0.4	99.6	98.0	84.4	2.11	0.64	3.30	0.24	34.5	(1)
"	T8	0	100.0	97.6	78.0	1.41	0.38	3.71			(4)
"	T9	0.5	99.5	98.1	91.7	0.71	0.13	5.46	0.31	31.0	(1)
"	T10	0.8	99.2	98.4	84.0	0.81	0.14	5.79			(1)
DH6408	T1	0.4	99.6	97.2	87.1	1.73	1.10	1.57			(1)
"	T2	0	100.0	98.8	92.4	2.19	1.67	1.31	0.62	39.5	(1)
"	T3	1.2	98.8	95.2	76.8	2.50					(1)
DH6409	T1	0.8	99.2	92.4	83.2	2.79			0.38	30.0	(1)
"	T2	0	100.0	97.6	91.5	1.67	0.90	1.96			(1)
DH6413	T1	0	100.0	97.5	89.1	0.86	0.84	1.02			(1)

Note: Uniaxial compressive strengths in Column (A) are those for undistrubed samples, and those in (B) for remoulded samples.

Classifications: (1) clay; (2) silty clay, (3) sandy silty clay, (5) sand; (6) sand and gravel, and (7) silty loam.

CHAPTER F. PRINCIPLE OF NAVIGATION IMPROVEMENT

CHAPTER F. PRINCIPLE OF NAVIGATION IMPROVEMENT

F-1 Target Year

In planning the navigation facilities to be installed around the projected Sambor dam, as is usually the case in plans of traffic improvement, the plan must be made not based on the existing traffic but based on the possible traffic that shall be envisaged for a certain period in the future, because any traffic system must conform in capacity and in pattern to the traffic it has to handle from the present through to the future.

The year in the future, for which the possible traffic shall be envisaged is called the target year. In the present plan, the target year is set at the year when the population along the Mekong would become double the present one. As described in paragraph C-1, Cambodia's population is estimated to double in 20 to 25 years. It is most likely that the trend is the same in the areas along the Mekong. Thus, the target year of the present plan is set at 20 to 25 years from the present.

F-2 Initial Plan and Future Plan

The Sambor dam is the one located most downstream among the dams on the Mekong proposed by the Mekong Committee. The traffic on the Mekong after the completion of these dams, if they would be accomodated for through navigation between their lower and upper reaches, will substantially differ in volume and in pattern from what can be expected when the Sambor dam alone will be completed. Accordingly, when and on what scale the project at Sambor shall be envisaged becomes an important item to be studied carefully.

At present, the river stretch between Kratie and Stung Treng is only used for carrying a small quantity of timber and other goods and that only in a favorable condition of the river.

The Sambor dam will raise the level of its backwater to an elevation that will lie between EL 31.00 and EL 40.00. If it will be provided with facilities that connect its upper and lower reaches for navigation, the backwater will enable vessels to reach as far as Stung Treng and this will encourage forestry and economic activity in the Stung Treng Area, contributing a great deal to the local economy. The above effect, however, will remain confined only to Stung Treng and Ratanakiri Provinces unless the upstream dams will be completed.

When in the future all the upstream dams, provided with navigation facilities, would be completed and the through navigation on the Mekong from its estuary to Vientiane would be realized, much of the resources that lie mostly within the boundaries of Laos and would remain undeveloped until then, will be exploited and their products will become to be carried on the waterway. Therefore, the navigation-facility project at Sambor must not be planned by solely envisaging the traffic at the dam site. Instead, it must be planned as a component of the through-navigation plan conforming to a consistent line compatible with all the upstream dams, and, of course, to meet the needs of Cambodia.

Consequently and from the following considerations, the navigation-facility project at Sambor as described in this report has been planned dividing it into two plans – the initial plan that shall be put into execution at the same time with the construction of the dam, and the future plan that envisages the need in the future and shall be implemented when the upstream dams would be completed.

As will be explained later, the target volume of goodstraffic in the initial plan is 120,000 tons a year and that in the future plan is 4,400,000 tons a year. These are imcomparable figures. Therefore, the future plan will call for facilities of different type and of incomparably large scale as compared with the initial plan. Furthermore, even if it would ever become necessary to put the future plan into execution, it will certainly be after many years from the initial plan. And, it must be expected that the traffic and other conditions would become in this long period different from what are envisaged at the present time point.

To construct beforehand a structure that would first become needed in the far future, to invest a large sum of money in it, and to lay the structure as well as the money idle for so long a period are in no way wise. Therefore, the project of navigation facilities at Sambor has been planned dividing it into the initial and the future plan. By so doing, at least the possible needs after the completion of the Sambor dam will be met at a feasible cost.

F-3 Ways of Intercommunication between the Upper and Lower Reaches

In general, the following three methods are conceivable for connecting the upper and lower reaches for navigation:

1) The vessel navigation itself is broken off at the dam site, and cargoes are transferred upstream or downstream by mechanical means and passengers are required to change vessels;

2) Vessels are transferred by means of inclined passage facility;

3) To provide locks.

The first method costs the least in its installation but is handicapped by troublesome and time-consuming transhipping operations, involving eventual damages to or loss of cargoes during their transhipment, and passengers are compelled to take trouble of changing vessels. The second does not cost much but has a limit in its handling capacity; and the third can handle large-sized vessels but costs much in its construction.

The goods traffic at the Sambor dam is estimated in the initial plan to consist mainly of timber rafts and a relatively small quantity of charcoal, agricultural products, materials of construction and various commodities which will be carried by medium-sized barges or cruisers. Therefore, the inclined passage method seems suited for the initial plan. In the future plan, however, large quantities of industrial materials and products, agricultural products, finished goods fuels and other goods are envisaged to be carried by large-sized vessels such as ocean-going freighters, for which locks will have to be constructed.

Consequently, the initial plan has been studied with regard to the inclined passage method and the future plan with regard to locks.

CHAPTER G. INTIAL PLAN

CHAPTER G. INITIAL PLAN

G-1 Estimation of Future Traffic

G-1-1 General Remarks

When the Sambor dam will be completed, the section of the Mekong from the dam to Stung Treng will be opened for traffic all the year round. And, in the high-water period, the some 50 km section from Stung Treng upstream to Khone Falls as well as the Se Kong, the Se San and the Srepok, the tributaries of the Mekong, will also become navigable to some extent.

Consequently, the future waterway traffic at Sambor can be considered as composed of the following two parts: the increased volume of various products due to the industrial development in the areas along the Mekong and its tributaries from Kratie upstream to Khone Falls; and part of the existing traffic between Kratie and the Stung Treng District, which will be induced to waterway traffic.

The former will comprise various products from forestry, agriculture and mineral resources, the greater part being accounted for by forest products followed by agricultural products.

G-1-2 Forest Products

1) Timber: The most important item of the forest products is timber. The production and transport of timber in Cambodia and in the Kratie and Stung Treng Areas are already stated in Paragraph C-5 and Subparagraph D-5-7 and listed in Table V-14 to V-16 and V-39.

As can be seen in Table V-39, Cambodia's annual production of timber as of from 1960 to 1962 averaged about 287,000 m^3. If it is now assumed that timber production will increase in proportion to the Cambodia's gross national production, the annual growth rate of which from 1967 through to 1988 is estimated to average 4.4%, [1/] the timber production in the target year, some 20 to 25 years from the present, will increase to about 2.6 times, or 750,000 m^3 per year.

Table V-39 shows that while about 1/25 to 1/15 of the national total of timber comes from the areas around Kratie, the Stung Treng Province is at present yielding only half as much notwithstanding its rich forests. This is mainly because the present conditions in this section of the Mekong are not suitable for the water transport. Accordingly, if the waterway will be opened for timber rafting from Stung Treng downstream after the comparable with that in the Kratie Area. Hence, if it is assumed that the timber production in the Stung Treng Province in the target year will amount to 1/15 of the national total, it will amount to 750,000/15 or 50,000 m^3 per year.

This volume of timber will almost all be carried by waterway. Then, if the timber is assumed to weigh 1.12 tons/m^3, the possible timber traffic in the target year at Sambor becomes 56,000 tons.

2) Charcoal: The charcoal production in Cambodia and in Kratie Provinces are described in Paragraph C-5 and Subparagraph D-5-6 and listed in Tables V-15, V-16 and V-38.

As shown in Table V-38, the annual charcoal production around Kratie as of from 1960 to 1962 averages 6,200 tons. If it is now assumed that the production will increase in proportion to the population, the annual production around Kratie in the target year, in which the population is assumed to double, will become 12,400 tons.

At present, very little charcoal is produced in the Stung Treng Area. But, if in the future the forests will be exploited and waterway traffic will become available, much charcoal will be produced in this area to the amount that can be assumed about 40% of what will be produced around Kratie or 0.4 x 12,400 = 5,000 tons a year.

Thus, the possible traffic of charcoal in the target year can be estimated at 5,000 tons a year.

1/: *A Framework for Planned Economic Development of Lower Mekong Basin Countries,* by V.V. Bhatt and Khan, a Mekong Committee Report, 1966.

G-1-3 Agricultural and Other Products

Of the agricultural products in areas upstream from Sambor, the item worth of mentioning is rubber. Cambodian rubber production as of from 1962 to 1966 averages about 45,500 tons a year as shown in Table IV-6 in Paragraph C-3, c). If it is assumed that the rubber production will increase in proportion to the gross national production, it will amount to 2.6 x 45,500 or 118,300 tons in the target year. Now, if it is presumed that about 2.5% of the national total will be produced in areas upstream from Sambor, the annual rubber production in these areas will become 0.025 x 118,300 or approximately 3,000 tons in the target year. This amount of rubber will exclusively be carried downstream.

Items other than rubber which shall be reckoned in the estimate of the future traffic are bamboo, fruits and dried fish as well as zircon in Ratanakiri Province. Although these are at present very small in quantity, it may be expected that they will increase to some extent, to about 2,000 tons a year, in the future when they will become carried by waterway.

Thus, adding this 2,000 tons to the 3,000 tons of rubber, 5,000 tons a year has been estimated as the possible traffic of "miscellaneous items" in the future.

G-1-4 Commodities

The future traffic volume of commodities, or necessaries of life, will be estimated in relation to the population. The population of Cambodia, as a whole and divided in provinces, is listed in Table V-1 and V-2. The populations in the areas that concern the traffic at Sambor are listed in Table V-45.

Table V-45 Populations of Regions Upstream from Kompong Cham (1962)

Region	Population	Density per sq.km	Percentage to National Total
Cambodia	5,740,000	31.7	100
Kompong Cham Province	819,200	83.6	14.2
Kratie Province	126,200	11.4	2.2
Stung Treng Province	34,500	3.1	0.6
Ratanakiri Province	49,340	4.6	0.9
Kompong Cham	27,977		
Kratie	11,908		
Stung Treng	3,369		

As can be seen from the table, the combined population of the provinces of Kratie, Stung Treng and Ratanakiri amounts to only 3.7% of the national total.

The rate of population growth is in no way the same for all districts. In general, it is high in industrialized provinces and cities but remains low in rural and undeveloped regions. Much increase in population in areas north of Kratie cannot be expected if the economic and social conditions in these areas will remain unchanged. But, if these conditions would be improved after the completion of the Sambor dam and the opening of waterway traffic, the population in these areas will increase by about half when the national total will double.

Thus, it can be assumed that the populations in these provinces will increase to 1.5 times of the present one and in cities will double in the future, the possible populations become as shown in Table V-46.

Table V-46 Possible Future Populations in Areas Upstream from Kratie

Region	Population
Kratie Province	190,000
Stung Treng Province	52,000
Ratanakiri Province	75,000
Kratie	23,000
Stung Treng	7,000

After the completion of the Sambor dam, the port of Kratie will become a way port and will give the place as a terminal port to Stung Treng having as its hinterlands the provinces of Stung Treng and Ratanakiri. Accordingly, the combined future population of these two provinces, 127,000, is taken into account for estimating the future volume of commodity traffic to be handled at Stung Treng.

The future consumption of commodities will be estimated based on the present consumption per capita. When judged from the volume of imports and the domestic production of this item, the total national consumption can be estimated at 1,400,000 to 2,000,000 tons a year, or 0.24 to 0.35 tons a year per capita.

In general, the consumption of commodities in a country increases with the gross national production of the country. As stated in Subparagraph G-1-2, Cambodia's gross national production will increase to about 2.6 times in some 20 years from 1967. Then, the national average of commodity consumption in the future becomes 0.6 to 0.9 tons a year per capita.

It is most likely that the standard of living in areas upstream from Kratie would be raised by the completion of the Sambor dam to a level of some two-thirds of the national average. Then, as the gross national production, the standard of living and the per capita commodity consumption will grow in parallel, the future consumption commodities in the Stung Treng district will become 0.4 to 0.6 tons a year per capita, or about 50,000 to 76,000 tons a year.

Finally, if it is assumed that 85% of the above volume of commodities shall be carried by waterway upstream to Stung Treng, 43,000 to 65,000 tons a year will have to pass Sambor. Thus, taking the average, the possible volume of commodities to be considered in the initial plan has been set at 54,000 tons a year.

G-1-5 Passenger Traffic

Bus travel between Kratie and Stung Treng now costs 60 Riels. It will perhaps cost 25 Riels to 30 Riels by cruisers if they would become available on the waterway to be opened by the completion of the dam. Even then, however, a sizable number of passengers will still prefer bus ride for its short travel time (the cruiser will require about twice the time as compared with the bus). At present, about 80% of passengers who arrive at Kratie are making their trip by waterway and 20% by bus. This ratio will most likely remain unchanged in the future.

Passengers who at present leave ships at Kratie totals about 150,000 persons a year. The number of passengers who will travel by waterway in the future after navigation is extended up to Stung Treng will likely to amount to 60% to 80% of the above 150,000 or 90,000 to 120,000.

Thus, the future passenger traffic for the initial plan is set, taking an average, at 100,000 passengers a year in both upstream and downstream directions

G-1-6 Design Traffic Volume for Initial Plan

From the above estimations, the possible future traffic in the target year, based on which the facilities for the initial plan shall be planned, becomes as listed in Table V-47.

Table V-47 Design Traffic Volume for Initial Plan

Downstream Traffic		Upstream Traffic	
Item	Annual Traffic	Item	Annual Traffic
Timber	56,000 tons	Commodities	54,000 tons
Charcoal	5,000 tons	Passengers	100,000
Miscellaneous	5,000 tons		
(Total)	66,000 tons		
Passengers	100,000		

G-2 Kind and Type of Vessels

G-2-1 General Remarks

Insofar as the dams proposed upstream from Sambor will not be completed, vessels that will in the future come to pass the Sambor dam will not differ much in their type and number from what are now in service on the reach downstream from Kratie. They would comprise passenger cruisers, fishing craft, tugs and timber rafts.

Although the facilities at the Sambor dam shall of course be planned to serve these vessels, it must be anticipated that in the future there might come into service some new kinds of vessel such as speedcrafts or hovercraft.

G-2-2 Passenger Cruisers

As estimated in Subparagraph G-1-5, passengers expected to pass the dam site number 100,000 a year each way, corresponding to about 70% of those who now land from or board cruisers at the port of Kratie. Accordingly, passenger cruisers that will pass the dam site will be the same in their type and size as those now in service on the reach downstream from Kratie.

Most of the cruisers now arriving at Kratie are of 80 tons to 120 tons. The principal dimensions of these cruisers are given in Table V-21. This table being referred to, the size of the cruiser, on which the design of structures for the initial plan will be based has been assumed as given in Table V-48.

Table V-48 Assumed Size of Cruiser

Tonnage	120 tons
Length	32.50 m
Breadth	6.60 m
Draft	2.75 m

Even though the facilities will be planned based on these dimensions, there might occur during the low-water period that large-sized cruisers cannot sail because of the insufficient channel depth.

G-2-3 Speedcrafts

At present, no speedcraft is in service on the Mekong. Although cruisers have an advantage of serving a travel of less cost and physically less fatiguing as compared with bus travel, they generally require more time. Accordingly, it seems likely that in the future speedcrafts that can sail much faster than cruisers would be brought into service for competing with buses in speed, though they may cost more than cruisers. For the same reason, hovercraft that have become into practical use in many parts of the world may also make their appearance on the Mekong.

The dimensions of speedcrafts vary with their capacity. To give an instance, the principal dimensions of a 30-passenger boat is shown in Table V-49.

Table V-49 Principal Dimensions of Speedcraft

Capacity	30 Passengers
Length	16.3 m
Breadth	3.6 m
Overall Breadth, including Planes	5.8 m
Draft	2.0 m
Displacement	12 tons
Speed	65 to 75 km per hour

As for hovercraft, roundshaped ones of 7 m to 12 m in diameter, or square-shaped ones of 8 m by 15 m are conceivable, if ever they should be used.

G-2-4 Barges

Barges that now come to Kratie are of the size ranging from 40 tons to 100 tons and are mostly loaded with charcoal.

As the volume of charcoal and other goods that would pass the Sambor dam may be thought almost the same as that now handled at Kratie, barges of nearly the same size as those used at present will suffice.

Accordingly, allowing some margin barges of 100 tons to 150 tons are considered in the initial plan.

G-2-5 Timber Rafts and Other Vessels

The way of timber rafting from the Stung Treng Area will not differ much from that now in practice in the Kratie District. That is, a train of rafts consisting of five to seven rafts, each measuring 8 m to 12 m in width, 10 m to 15 m long and 1.5 m to 2 m in thickness, is let flow down with the stream or is towed by a tug.

Thus, the dimensions of a raft train to be considered in the initial plan are assumed 8 m to 12 m in width, 100 m in length including a tug, and 2 m in thickness.

Besides the above-mentioned vessels, fishing boats, motorboats, sampans and other small-sized crafts shall be considered to pass the dam site.

G-3 Relationship between Water Level and Navigation

When dams would be constructed on the Mekong, a large amount of water will be detained in the river channel and will be used for power generation and irrigation. The discharge and water level of the river will then become different from those at present, and at the same time the range of their fluctuation will be narrowed. These circumstances shall be taken into account in designing facilities for the initial plan as well as for the future plan.

In the power-generation project at Sambor, the dam crest is set at an elevation of EL 44.00 and the river will be headed up to EL 40.00 with a draw-down of 2 m. This means that the water level of the backwater will normally lie at EL 38.00 to EL 40.00 and at a time of an extraordinary flood it may rise to EL 42.00.

The minimum discharge that shall be used for power generation after the completion of the dam is set at 1,350 m^3/sec. This minimum discharge is by 100 m^3/sec greater than the 1,250 m^3/sec, the lowest discharge at Kratie measured in the past. This means that the lowest water level in the downstream reach of the dam will be raised a little from what is at present to an extent that corresponds to the increased minimum discharge.

When estimated based on the projected minimum discharge of 1,350 m^3/sec the lowest water level in the future will be at EL 5.50 at the toe of the dam and at EL 3.80 at Kratie. [1] Navigation facilities, dredging and other items in the initial plan have been studied and planned based on the above lowest water levels.

As already stated in Subparagraph E-3-7, a stretch extending some 5 km downstream from the dam at present becomes, for a certain period of the year, unnavigable or difficult to navigate even for small craft or timber rafts. Namely, in the high-water period the current becomes too rapid for vessels to sail against the stream and in the low-water season the channel becomes in many places so shallow that it cannot be sailed by vessels larger than 5 tons or so.

After the construction of the dam, the regime of the downstream reach will be improved to some extent on account of the increased and controlled discharge. However, much cannot be expected because the rise of the water level due to the increase in the discharge will amount to only 0.2 m to 0.3 m. And so, the navigability in the low-water season of the stretch will not change much.

1/ : *The First Progress Report of Investigations of the Sambor Project*, October 1963; and *The Second Progress Report of Investigations of the Sambor Project*, September 1964, OTCA, Tokyo, Japan.

Accordingly, some considerations should be given to the vessels that will come to pass the dam site such as, for instance, to use vessels of the size that will fit the water level or discharge, i.e., to use vessels of small draft in the low-water season and high-power vessels in the high-water season.

The upper and the lower limit of the discharge that would allow navigation on the downstream reach of the dam have been estimated as shown in Table V-50. The navigable periods for the respective kinds of vessels have been calculated based on these limits and given also in Table V-50.

Table V-50 Navigable Range of Discharge and Navigable Period
(On the Downstream Reach of the Dam)

Kind of Vessel	Discharge in Lower Limit	m^3/sec Upper Limit	Navigable Period In Months per Year
For Cruiser (120-t)	4,000	50,000	10.5 to 11.5
For Small Craft	1,350	25,000	8 to 9
For Timber Raft	1,350	40,000	9 to 10

From the above consideration, it has been concluded that in the stage of the initial plan the maximum draft of vessels shall be limited to 1.5 m during the low-water period and that the downstream end of the inclined passage facility shall not be located at an elevation higher than EL 3.50 in order to provide a water depth of at least 2 m from the lowest water level of EL 5.50.

As for the upper reach of the dam, the existing navigation obstacles such as the Samboc Rapids would be submerged entirely in the backwater and an all-the-year-round and safe waterway would be extended. However, a little downstream from Stung Treng, as mentioned in Subparagraph E-3-8, there exist some shallow places that shall be dredged to the planned depth.

G-4 Main Items of Initial Plan

Main items of the initial plan for providing a waterway route around the Sambor dam are the inclined passage facility that comprises two slipways for use of medium-sized vessels and another for timber rafts and dredging of shallows around the slipway toes and in the vicinity of Stung Treng.

G-5 The Inclined Passage Facility

G-5-1 Slipways for Use of Medium-sized Vessels

The slipways have been planned for handling medium-sized vessels of 30 tons to 150 tons, which include cruisers, barges, fishing boats, tugs and other crafts. These slipways will be provided with cradles, winches and other equipment.

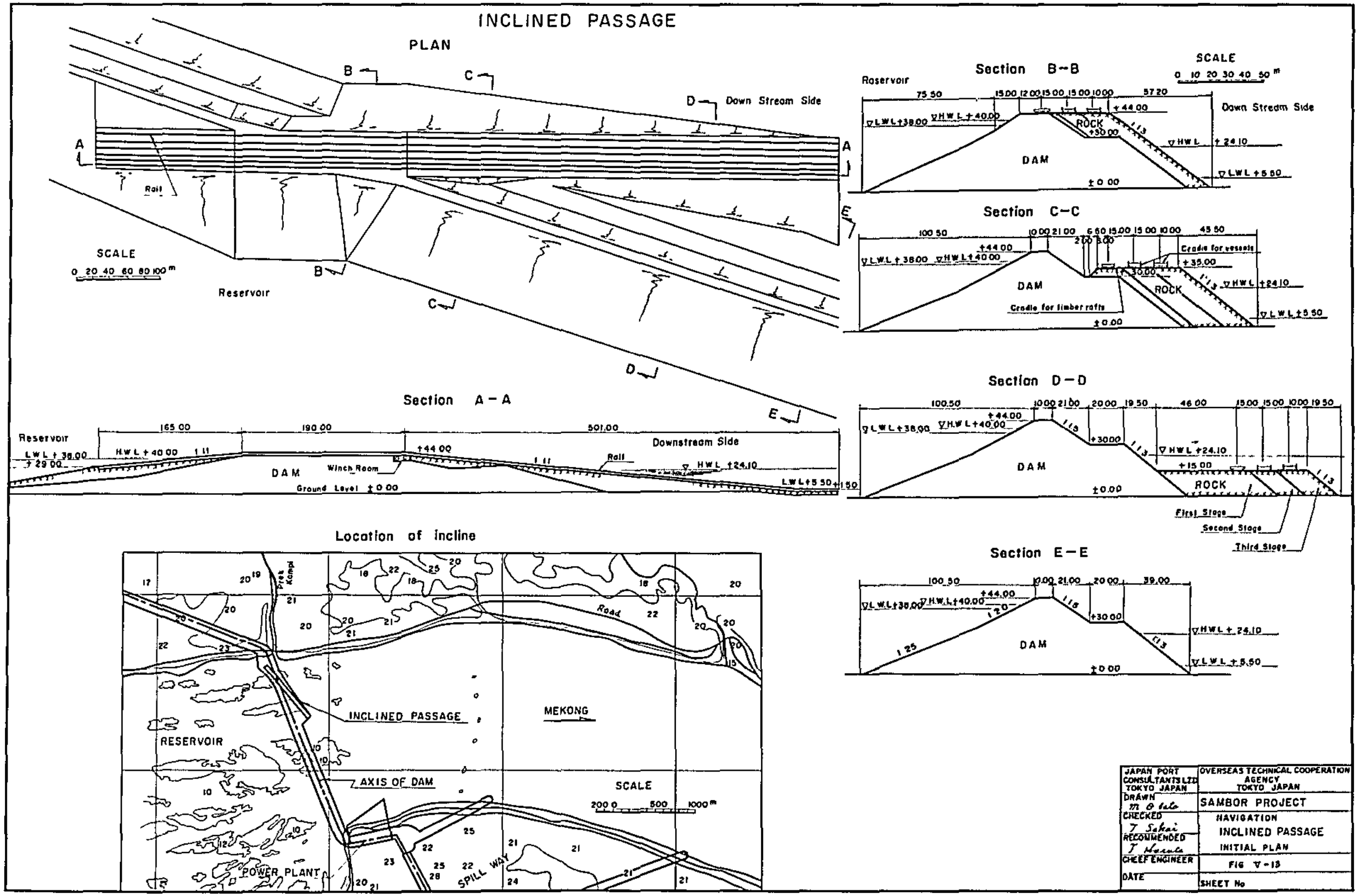
1) Slipways: Two lines of slipways will be built passing over the dam at an angle of 18 degrees to the dam axis and will be located a little near the left bank of the river as shown in Fig. V-13.

They are horizontal on the dam crest and have a slope of 11 to 1 on both side-slopes of the dam.

Each line of slipway will have a total length of 855 m that divides into the 500 m over the downstream side of the dam, the 190 m on the dam crest and the 165 m over the upstream side of the dam.

The design elevation of the downstream toe of the slipway is set at EL 3.50 as noted in paragraph G-3. The elevation of the upstream toe of the slipway is set at EL 34.40 to ensure a water depth of at least 3.6 m from the backwater level that will lie at EL 38.00 in the low-water season.

Two rows of reinforced-concrete longitudinal sleepers, each measuring 0.4 x 1.2 m by 2 m long, will be placed in a spacing of 8 m on centers on a gravel bed at least one meter thick. On each row of these sleepers, two lines of rails weighing 70 kg per meter will be laid spaced 60 cm on centers.


INCLINED PASSAGE
PLAN
SCALE
0 20 40 60 80 100 m
Reservoir
Down Stream Side
Rail
Section A – A
Reservoir
LWL + 38.00
+ 29.00
HWL + 40.00
165.00
190.00
501.00
DAM
Winch Room
Ground Level ± 0.00
+44.00
Downstream Side
Rail
HWL +24.10
LWL +5.50
+1.50
Section B – B
SCALE
0 10 20 30 40 50 m
Reservoir
Down Stream Side
ROCK
DAM
Section C – C
Cradle for vessels
Cradle for timber rafts
ROCK
DAM
Section D – D
ROCK
DAM
First Stage
Second Stage
Third Stage
Section E – E
DAM
Location of Incline
INCLINED PASSAGE
MEKONG
RESERVOIR
AXIS OF DAM
POWER PLANT
SPILL WAY
Road
Prek Kampi
SCALE
200 0 500 1000 m
JAPAN PORT CONSULTANTS LTD TOKYO JAPAN
OVERSEAS TECHNICAL COOPERATION AGENCY TOKYO JAPAN
DRAWN
CHECKED
RECOMMENDED
CHEEF ENGINEER
DATE
SAMBOR PROJECT
NAVIGATION
INCLINED PASSAGE
INITIAL PLAN
FIG V-13
SHEET No

2) Equipment and Accessories: Each slipway will be provided with a steel cradle and a 50 HP pusher. The cradle that measures 8 m wide and 30 m long rests on four pairs of 180 cm diameter wheels that roll over the rails.

Underneath the crest of the slipway, located at the downstream side, a reinforced-concrete machinery room will be constructed, in which two winches, motors, speed regulators and winding drums will be installed. The top slab of the machinery room shall be designed to sustain the load of the cradle and the vessel it has to carry.

The winches are of 260 HP and operate at a hoisting speed of 30 m per minute.

To operate the inclined passage facility, a control house shall be built one each on the downstream and upstream side of the dam. Lighting, signal and communication systems as well as loud-speaker system shall be provided.

3) Operation: When a vessel approaches the inclined passage facility, the cradle will be lowered over the slipway into the water underneath the vessel. Then the winch is set in motion and pulls up the cradle, the vessel being fixed with blocks inserted between the vessel's hull and the cradle. When the cradle reaches the slipway crest, it is moved by a pusher over the horizontal section and then slides down the slope, under the brake exerted by the winch, into the water at the other end of the slipway.

G-5-2 Slipway for Timber Rafts

At present, a small number of timber rafts are moving from Stung Treng to Kratie with the stream in the high-water season. In the future after the completion of the dam, as shown in Table V-47, about 56,000 tons a year of timber will pass the dam site. In this case, timber rafts must be towed by tugs on the backwater reach, as there will be hardly any current.

As regards handling timber rafts, a comparative study has been made between the inclined passage method, in which rafts are handled in the same way as vessels, and the mechanical transhipping, and it was found that, while the mechanical transhipping would work enough efficiently, it cannot be preferred because it will require much labor and time in disassembling and reassembling the rafts and consequently will come out costlier than the inclined passage facility.

Accordingly, it has been decided, in the initial plan, to build a line of slipway for exclusive use of timber rafts. This raft slipway will be built along the two lines of vessel slipways that may be utilized for raft transport in case raft traffic would become too congested to be handled by the raft slipway alone.

G-5-3 Handling Capacity of Inclined Passage Facility

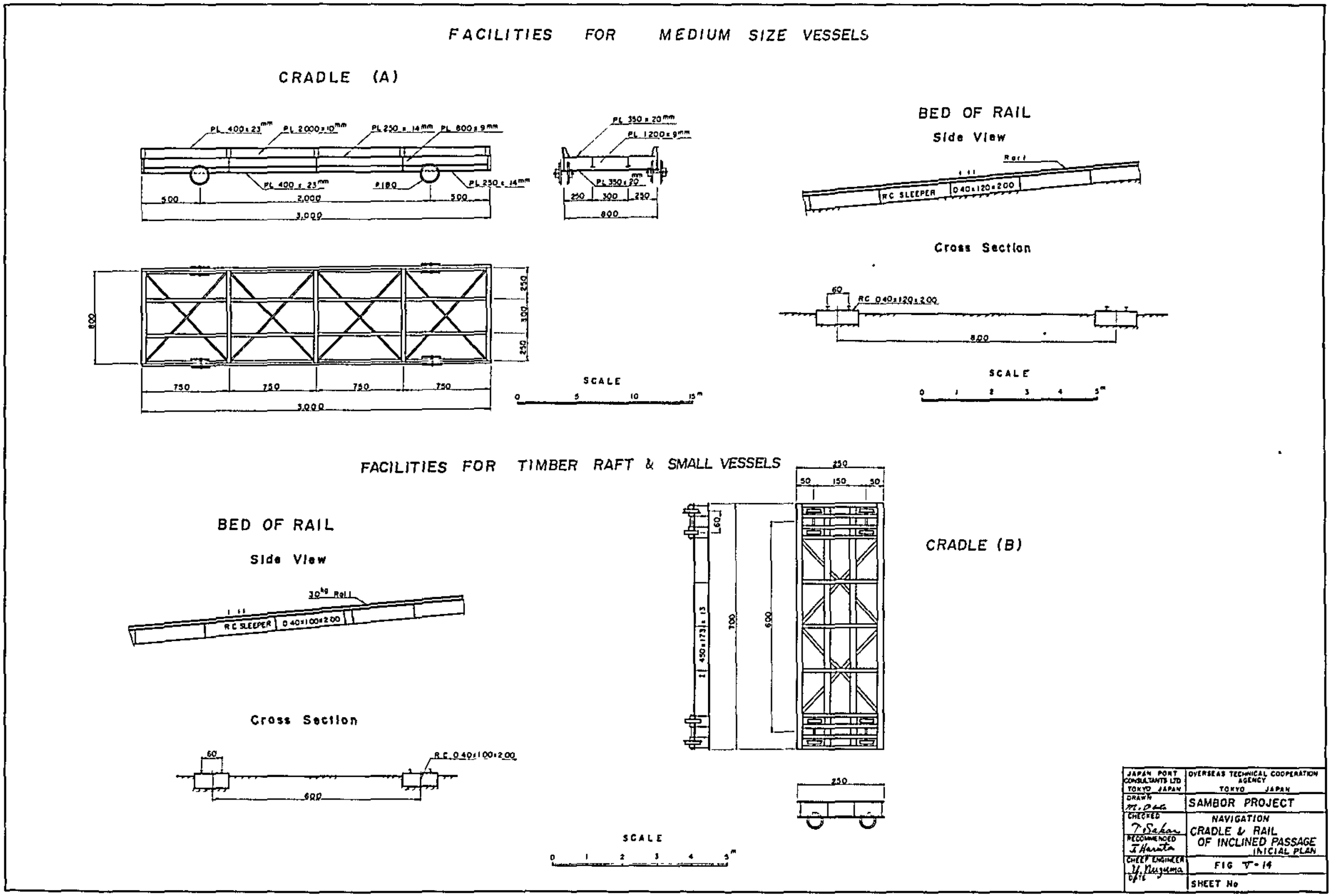
The time required to pass the inclined passage facility will comprise about 10 minutes for preparation and 27 minutes for passing the slipway in the low-water season, or 23 minutes in the high-water season. Therefore, one travel will take 35 minutes on an average, and if a margin of 5 minutes is allowed, the time of one go-and-return operation becomes 75 minutes on the average.

When calculations are made, the numbers of daily operation required for handling the possible future downstream traffic given in Table V-47 become as listed in Table V-51.

Table V-51 Number of Daily Operation for Downstream Traffic

Kind of Traffic	Annual Volume	Volume Per Operation	Total Number of Operation	Number of Daily Operations Average	Number of Daily Operations Maximum
Cruiser	100,000 Passengers	60 Passengers	1,667	5.6	7
Barge	8,000 tons	50 tons	160	0.9	2
Others	2,000 Vessel	1 Vessel	2,000	7.4	9
		Total	3,837	13.9	18
Timber Raft	56,000 tons	80 tons	700	3.9	7

Fig. V-14 Cradle and Rail of Inclined Passage Facilities



In preparing Table V-51, the following are assumed: (1) Of the annual total of 10,000 tons of commodities and miscellaneous goods, 8,000 tons will be carried by barges; 2,000 tons by cruisers together with 100,000 passengers; (2) about 2,000 vessels other than cruisers or barges shall be handled; (3) the traffic per operation was assumed as given in the table; and (4) the traffic at the dam site is not uniformly distributed throughout a year; the number of operations in an average day was assumed 1.2 times the annual mean for cruisers, 2 times for barges, 1.3 times for other vessels, and 2 times for timber rafts; and the daily maximums were assumed as shown in the table.

Since one operation will take 75 minutes as noted before, about ten operations per slipway can be made in a workday of 12 hr, so that it can be concluded that the planned two vessel slipways and one raft slipway will suffice for handling the possible future traffic.

G-5-4 Construction of Slipways

Since the slipways are to be built over the rock-fill dam body, as shown in Fig. V-13, their beds shall be constructed at the same time with the dam construction so as that they constitute a monolythic structure. Consequently, the slipways shall be executed in the same manner and with the same material as those of the dam.

The slipway side-slopes shall be covered by stone. Stone pitching shall be carried out with such care as to use larger stone at the slope top. The work on the lower part of the slipways had better be done in the low-water season as it can be done in dry work. But the work on underwater portions must of course be done, even in the low-water season, by divers. Stone for pitching can be obtained at a site about 4 km southeast of the dam site.

The slipway bed that shall sustain huge loads of the cradle and the vessel shall be well filled up and compacted with rollers. Sleepers and rails will be carried by trucks to the site and will be laid by cranes. Rails shall be anchored to the sleepers with steel fasteners. Underwater laying of sleepers and rails must be done by divers.

Coarse aggregate of concrete can be obtained by crushing rock that would be excavated when the power plant will be built on the right bank of the river, and fine aggregate from a right-bank site about 4 km downstream.

G-6 Dredging

1) Dredging of Downstream Reach: In a stretch about 3 km from the dam site, as already noted in subparagraph E-3-7, there are many rock outcrops that appear above the water surface in the low-water season and make navigation almost prohibitive except for small craft and rafts.

This stretch shall be dredged, as shown in Fig. V-15, to provide a 45 m wide fairway that shall have a depth not less than 2 m even for the minimum discharge of 1,350 m^3/sec. To ensure this depth, the river bed in the vicinity of the dam toe must be dredged to an elevation of EL 3.50. The river bed to be dredged consists mostly of rock. The rock will be blasted. A clamshell will raise the blasted pieces and haul them on barges to be dumped in the deeps of the river. The rock removal is estimated at about 95,000 m^3, relatively small volume.

2) Dredging in the Reach in the Vicinity of Stung Treng: In regions 7 km to 14 km and about 25 km downstream from Stung Treng, as noted in subparagraph E-3-8 and as shown in Fig. V-16, there lie shallows that shall be dredged to an elevation of EL 34.40 and to a width of 60 m. The river bed in these sites consists of sand that can be dredged by suction dredges or clamshell dredges. The dredging will amount to about 570,000 m^3. Dredged sand will be carried by barges and will be dumped into the deeps.

G-7 Construction Schedule

Goods and passenger traffic at Sambor will increase during the future 20 years as shown in Table V-58. Instead of completing all the above-mentioned facilities at the same time, to construct them step by step to conform to the future growth of traffic is not only economical but also rational. Accordingly the initial plan shall be implemented, for example, in the following three stages.

In the first stage that will take three years from the start, only the construction of the raft slipway and dredging will be carried out following the schedule given in Table V-52 and V-53. It was estimated in these tables that the three years divide into 15 months for investigation and detailed designing, 3 months for preparatory works, 16 months for construction and 2 months for clearing the site.

The two lines of the vessel slipways will be implemented one each in the 14th and in the 19th year from the start.

Table V-52 Construction Schedule of Inclined Passage

Items \ Year	First Year		Second Year		Third Year	
Investigation	———	—				
Detailed Design & Supervision		—	—	———	———	———
Preparatory Works			—			
Embankment				———	—	
Sleeper & Rail				—	—	
Winch				—		—
Cradle				—		—
Pusher				—		—
Machine Room					—	—
Others						———

Table V-53 Dredging Schedule

Items \ Year	First Year		Second Year		Third Year	
Investigation	———	—				
Detailed Design & Supervision		—	—	—	———	———
Preparatory Works			—	—		
Dredging				—	———	———
Others						—

Fig. V-15 Dredging near Dam Site (Initial Plan)

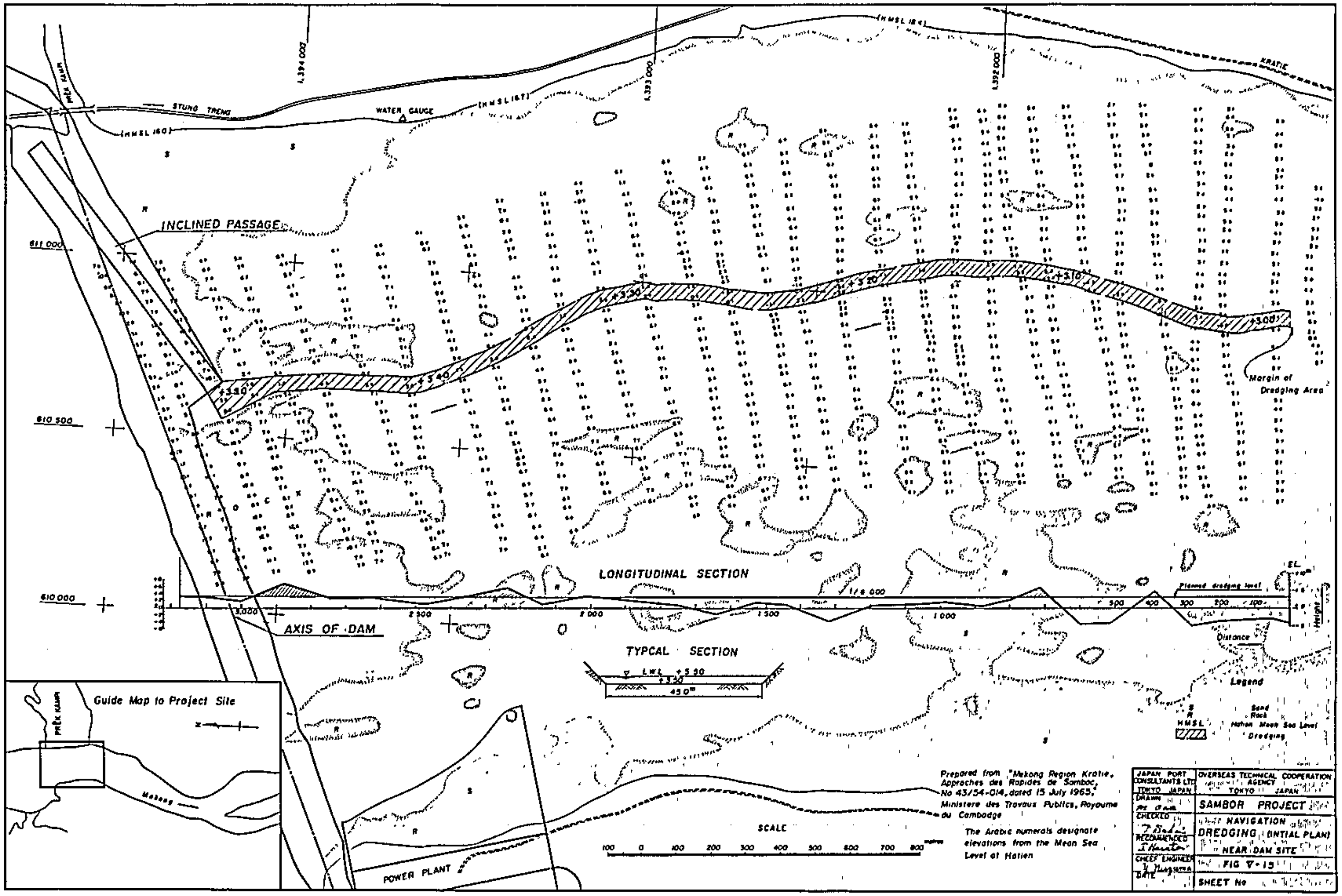
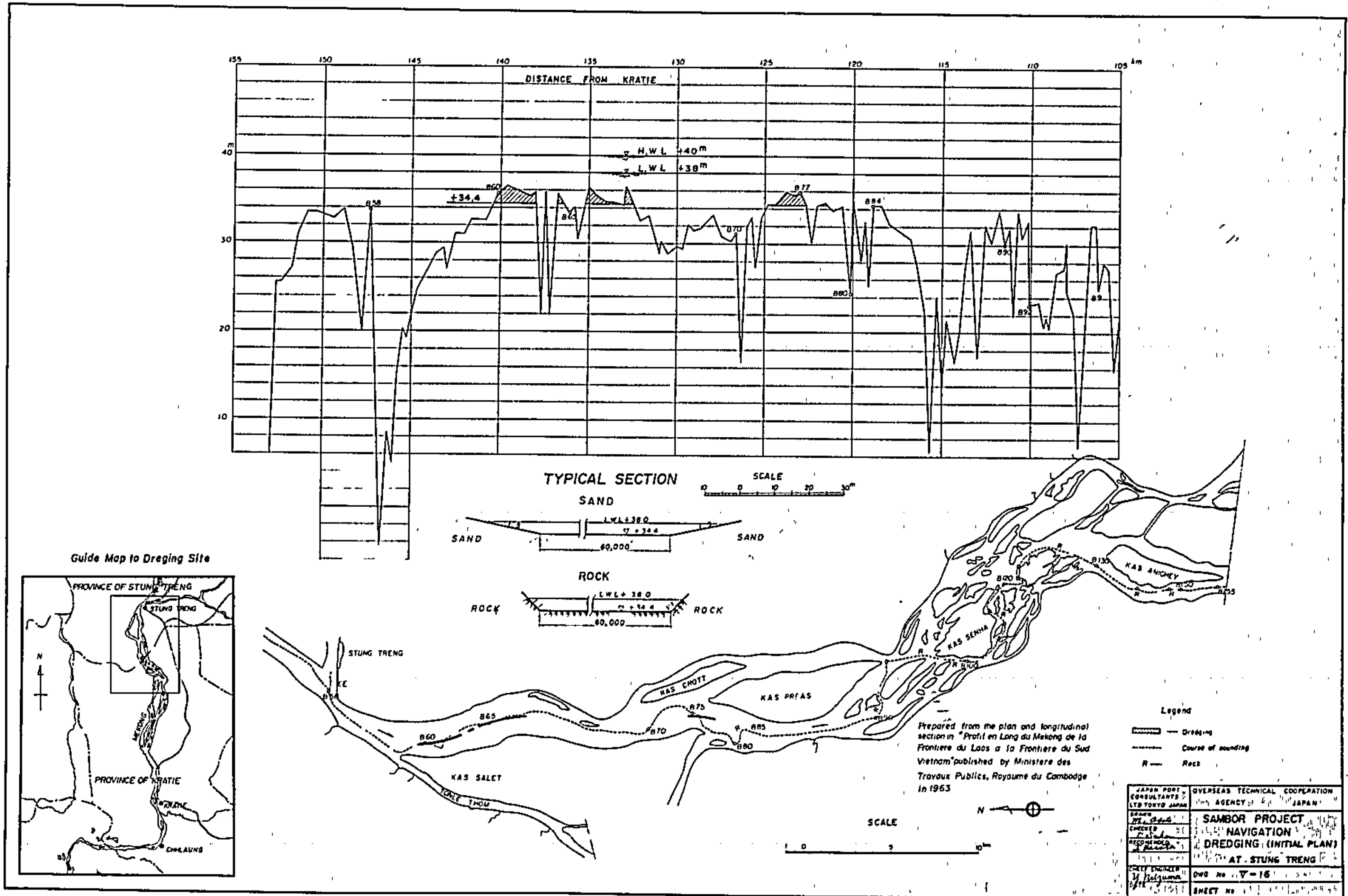


Fig. V-16 Dredging at Stung Treng (Initial Plan)



CHAPTER H.   CONSTRUCTION COST OF INITIAL PLAN PROJECT

CHAPTER H. CONSTRUCTION COST OF INITIAL PLAN PROJECT

H-1 Basis of Estimation

Estimates of the cost of construction of the initial plan project were made based on the following considerations.

i. The detailed design and supervision of the construction works will be provided by a consultant who will enter into contract with the owner of the project.

ii. The construction job will be awarded to a joint venture formed by a foreign contractor and local contractors.

iii. Works requiring a high standard of technical skill and years of experience will be undertaken by engineers and skilled workmen brought into the site by the foreign contractor, and the local contractors will be mostly assigned with other general works.

iv. The aforementioned foreign contractor shall be from Japan.

v. The estimate is based on the commodity price as of January 1967. Therefore, unusual price change in subsequent years will lead to the reappraisal of the estimates herein presented.

vi. The following items are not included in the estimate. a) Management and office expenses of the owner; b) Unexpected increase due to natural disasters, social disturbances, wars, and others; and c) Corporate tax, customs dues and taxes for business transactions which may be assessed by the Royal Government of Cambodia.

Although they are all given in U.S. Dollars, the cost estimates have been made dividing them into foreign and local currencies as listed below.

Salaries and wages: Foreign currency for engineers and skilled workmen; local currency for assistants to engineers and non-skilled laborers.

Cost of Materials: Foreign currency for steel, cement, ropes, hoses, electric motors, winches and other machinery; local currency for stone, concrete aggregates, electricity, oil and grease, gasoline, timber, etc.

Vessels and Equipment: Foreign currency for depreciation and part of repair cost; local currency for rent and majority of repair cost.

Transport Costs: Foreign currency for transport from Japan to Phnom Penh; local currency for transport from Phnom Penh to Sambor.

H-2 Cost of Construction

1) Direct Cost of Construction: The quantities of materials, equipment and works required for construction are listed in Table V-54.

Based on the quantities listed in Table V-54, the direct cost of construction has been estimated at $4,000,000 as shown in Table V-55.

In preparing Table V-55, the unit costs of labor and materials were assumed based on those in similar projects in Japan with proper reference to the conditions peculiar to Cambodia. It was also assumed that equipment and materials that are difficult of local procurement will be supplied from Japan, the transport costs being included in the costs of the respective items.

The cost of eventual compensation in regard to the execution of construction is included in the item: "Others."

Table V-54 Quantities of Materials, Equipment and Work

Item	Quantity	Remarks
Embankment	820,000 m^3	Inclined passage facility bed for three slipways
Sleeper	855 pc	0.4 x 1.0 x 2.0, for raft slipway
Ditto	1,710 pc	0.4 x 1.2 x 2.0, for ship slipways
Rail	3,420 m	30 kg per m, for raft slipway
Ditto	6,840 m	70 kg per m, for ship slipways
Winch	1 ea	180 HP, for raft slipway
Ditto	2 ea	260 HP, for ship slipways
Cradle	1 ea	For raft slipway
Ditto	2 ea	For ship slipways
Pusher	3 ea	For three slipways
Machinery Room	900 m^3	Reinforced-concrete construction
Accessories	1 set	Lighting, Signaling, etc.
Rock Removal	95,000 m^3	Lower reach of the dam
Sand Dredging	570,000 m^3	Near Stung Treng

2) Contingencies: Expenditures other than the direct cost of construction were estimated following the ECAFE standards.

Included in this item are the expenses and the increase in the construction cost, which would be brought about by unforeseen causes such as unexpected bad conditions of geology, extremes of weather or unusual high floods.

Table V-55 Direct Cost of Construction (Unit: US $)

Item	Total	In Foreign Currency	In Local Currency
Inclined Passage Facility	2,293,000	1,285,000	1,008,000
Embankment	1,445,000	740,000	705,000
Sleeper	115,200	61,200	54,000
Rail	117,000	90,000	27,000
Winch	99,600	76,500	23,100
Cradle	154,000	120,000	34,000
Pusher	16,400	13,000	3,400
Machinery Room	181,000	92,000	89,000
Others	164,800	92,300	72,500
Dredging	1,657,000	1,052,000	605,000
Sand Dredging	537,000	342,000	195,000
Rock Removal	1.120,000	710,000	400,000
Total	4,000,000	2,347,000	1,653,000

The contingencies were estimated at 15% of the direct cost of construction except winches and other machinery, of which 5% were counted into the contingencies. The contingencies will total $573,000.

3) Engineering Fee: The fee for the services that will be rendered by the consultant, such as investigation, detailed design and planning, cost estimating, preparation of tender documents and supervision of construction operations, was estimated at 5% of the direct cost of construction plus contingencies.

4) Other Expenses: This item includes miscellaneous expenses that cannot be properly charged against the individual costs and comprises field office cost and expenses, general transport costs, expenses for power, light and water, expenses for telephone and telegraph, and other miscellaneous expenses. It was estimated at 5% of the direct construction cost plus contingencies.

5) Interest during Construction Period: The interest during the construction period was estimated following the ECAFE standard.

6) Total Cost of Construction: The total cost of construction of the initial plan project amounts to $5,220,000 as shown in Table V-56. Of this total, $3,055,000 shall be paid in foreign currencies and the remaining $2,165,000 in local currency.

As noted in Paragraph G-7, the initial plan will be carried into execution in three stages. About 80% of the project will be completed in the first stage of three years at a cost of $3,912,000. The second and the third stage will each cost $654,000.

Table V-56 Estimated Cost of Construction (Initial Plan)

(Unit: $)

Item	Total Cost	In Foreign Currency	In Local Currency
Direct Cost of Construction	4,000,000	2,347,000	1,653,000
Inclined Passage facility	2,293,000	1,285,000	1,008,000
Dredging	1,657,000	1,052,000	605,000
Others	50,000	10,000	40,000
Contingencies	573,000	331,000	242,000
Engineering Fee	228,500	133,500	95,000
Other Expenses	228,500	133,500	95,000
Interest	190,000	110,000	80,000
Grand Total	5,220,000	3,055,000	2,165,000

CHAPTER I. ECONOMIC BENEFITS

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I-1 Concept of Economic Benefits

Economic benefits expected from the completion of a certain project may be classified into the direct, indirect and intangible benefits.

The direct benefit is the increments of properties, products and services that will result directly or primarily from the project; the indirect benefit is those that will stem indirectly or secondarily from the initiation of the project; and the intangible benefit is what cannot be evaluated in monetary value.

In the case of navigation, the principal items of the direct benefit are the savings in the travel cost, economy in vessel operation and the increase in carrying capacity. The indirect benefit comprises the saving of travel time as well as the effect on the socio-economic development such as increased activities of industries. The intangible benefit comprises, for instance, comfortableness in travel.

I-2 Method of Estimating Direct Benefit

For evaluating the economic feasibility of an investment project, there are the benefit-cost-ratio method and the method of internal rate of return. [1] The latter is adopted in this report.

The internal rate of return is a discount rate, at which the invested cost and the benefits will balance. If the internal rate of return is denoted by r, r must satisfy

$$K = \sum_{t=1}^{n} \frac{S_t}{(1+r)^t} \quad \dots\dots (1)$$

in which K is the present value of the invested cost, S_t is the annual net benefit in the t-th year and n is the number of years in which the analysis shall be made or the invested cost and the total benefits will balance.

I-3 Basic Assumptions and Data

In the following, the estimation will be made for the initial plan, taking only the operation benefits and transport costs into account. The invested costs, operation expenses and various benefits are estimated based on the following assumptions and data.

1. The costs and benefits will balance in 50 years. Therefore, Eq. (1) shall be analyzed for a period of fifty years, or for $n = 50$.

2. The construction cost given in Table V-56 shall be based upon. The project will be implemented in three stages with costs given in Paragraph H-2-6.

3. The inclined passage tolls, the income from transportation services and the surplus of consignors constitute the direct benefit; the operation and maintenance expense and the replacement of the inclined passage tolls are counted in the cost.

4. The possible future traffic in the target year, the 20th year from the completion of the first stage of the project, shall be assumed as given in Table V-47, which is reproduced in Table V-57 as compared with the existing traffic.

1/: *Report of the Joint Critical Examination of Feasibility Concept, Criteria and Methods with Special Reference to Pa Mong and Sambor Projects,* ECAFE, 1966.

Table V-57 Existing and Possible Future Traffic

Item	Existing Traffic		Future Traffic	
	By Water	By Land	By Water	By Land
Charcoal	–	–	5,000 tons	–
Commodities	–	10,000 tons	54,000 tons	10,000 tons
Timber	8,000 tons	–	56,000 tons	–
Other Goods	–	–	5,000 tons	–
Passengers	–	30,000	200,000	50,000

5. The direct benefit will increase in proportion to the traffic, which, after the completion of the first stage of the work, is assumed to increase at an annual rate of 11.5% from 15,000 tons of cargo and 25,000 passengers in the first year and, after reaching the level given in Table V-57 in 20 years, will remain constant as shown in Table V-58 and in Fig. V-17.

6. The useful period is assumed 40 years for the cradles, pushers, rails, winches and other equipment, 30 years for the lighting and communication systems and the like, and 50 years for the inclined passage structure.

7. Costs and benefits are expressed in terms of U.S. Dollars based on the official conversion rate of 35 Riels to one dollar.

Table V-58 Possible Future Traffic Increase

Year	Cargo, tons	Passengers	Year	Cargo, tons	Passengers	Year	Cargo, tons	Passengers
1-3	0	0	11	32,268	53,780	19	77,460	129,110
4	15,000	25,000	12	36,006	60,010	20	86,412	144,029
5	16,734	27,890	13	40,170	66,950	21	96,408	160,680
6	18,672	31,120	14	44,814	74,690	22	107,562	179,270
7	20,832	34,720	15	49,992	83,320	23	120,000	200,000
8	23,238	38,730	16	55,776	92,960	24	120,000	200,000
9	25,926	43,210	17	62,232	103,729			
10	28,926	48,210	18	69,426	115,710			

Note: Years are numbered from the start of the project, the first stage of which will be completed in three years.

I-4 Estimate of Direct Benefits

I-4-1 Incline Passage Tolls

If it is intended to finance the operation and amortization of the project wholly by inclined passage tolls, they must be set at so high a level that the advantage of the waterway as compared with land traffic will be offset because of the high tolls. Accordingly, in the estimation to follow, the tolls are set at about one-thirtieth of the difference of the cargo freights or passenger fares between the existing land traffic and the future water traffic on the section between Stung Treng and Kratie.

Thus, the tolls are assumed $0.25 per ton of cargo and $0.03 per passenger, collecting no tolls from timber rafts. At these rates, the tolls will cover only a small portion of the operation expense of the inclined passage facility.

The annual toll income will increase with the future traffic that is assumed to increase at an annual rate of 11.5%. It will reach $22,000 in the target year as shown in Table V-59.

1) Freight of Charcoal: For charcoal to be shipped in the future from Stung Treng to Phnom Penh, a reduction factor of 0.8 is assumed. Then, the future freight becomes 5.0 (350/215) 0.8 = $6.8 per ton, and if $2.5 per ton of handling is added, the transport cost becomes $9.0 per ton.

2) Freight of Commodities and Other Goods: The future transport cost of commodities can be estimated in the same manner at $6.7 per ton from Phnom Penh to Stung Treng, if the reduction factor is assumed 0.8, and at $5.8 from Kompong Cham to Stung Treng with the factor of 0.9. If it is now assumed that they will come to Stung Treng from Phnom Penh and from Kompong Cham in a ratio of four to one, the average transport cost of commodities in the future becomes $6.5 per tons.

3) Cost of Timber Rafting: The reduction factor may be assumed unity. Then, timber rafting from Stung Treng to Phnom Penh will in the future cost 1.7 (350/215) = $2.8 per ton of timber. But rafts must be towed by tugs on the backwater reach of the dam. Raft towing on this reach will require a little more cost than on the section from Kratie to Phnom Penh. Then, if a 30% more cost is assumed, the raft towing from Stung Treng to Kratie will cost 1.4 (135/215) 1.3 = $1.2 per ton. The handling cost is $1.3 per ton. Therefore, the future transport cost of timber from Stung Treng to Phnom Penh becomes $2.8 + $1.2 + $1.3 = $5.3 per ton.

4) Passenger Fares: The future passenger fares from Stung Treng to Phnom Penh, to Kompong Cham and to Kratie, if the reduction factor is assumed 0.8, will become $1.7, $1.4 and $0.85 per passenger, respectively. If it is now assumed that the passenger traffic on the above three sections will be in a ratio of 3 to 1, the average fare becomes $1.4 per passenger.

5) Annual Benefit of Transport Service: The unit transport costs having been thus estimated, the total transport cost that shippers and passengers must pay in the target year and therefore constitute the total income of transport services becomes $1,005,300 as shown in Table V-62.

To obtain the net benefit of transport services, it is necessary to estimate the expense needed for operating the service. It shall include the expense of vessel operation, the depreciation of equipment, the expense for maintenance and repair, the management expense and other expenses. The unit expenses for each item of traffic have been assumed as given in Table V-62. Then, the total expense of transport services in the target year becomes $847,300 as shown in Table V-62.

Table V-62 Annual Income and Expense of Transport Services, in the Target Year

(Unit: $)

	Quantity in tons or persons	Income		Expense	
		Unit Income	Amount	Unit Expense	Amount
Charcoal	5,000	9.0	45,000	7.8	39,000
Commodities	54,000	6.5	351,000	5.7	307,800
Timber	56,000	5.3	296,800	4.5	252,000
Other Goods	5,000	6.5	32,500	5.7	28,500
Passengers	200,000	1.4	280,000	1.1	220,000
	Total		1,005,300		847,300

Thus, the net benefit that transport services can expect in the target year becomes $158,000. The net benefits in the intermediate years are assumed to increase in proportion to the traffic volume and are listed in Table V-63.

I-4-3 Surplus of Consignors

The surplus of consignors means the benefit that goes to those who use the transport services, namely, shippers and passengers.

In general, the supply of any item will increase and the demand will decrease with the rise of the price as shown by curves S and D in Fig. V-18. Point b, at which the two curves intersect, denotes the state of equilibrium between the supply and demand, and the corresponding price (pb) and quantity (qb) denote the respective optimum values.

In the case of a traffic improvement, the demand corresponds to traffic, the quantity to the traffic volume and the price to the unit cost of traffic.

If point *a* denotes the existing state and point *b* the state after the improvement assumed just fit for the future traffic demand, the benefit that consignors will receive from the improvement is represented by a trapezoidal area shown hatched in the figure. If the curve between points *a* and *b* is assumed as a straight line, the above areas equals the mean of the present and future traffic multiplied by the decrement in the unit traffic cost from at present, which is denoted by $p = pa - pb$.

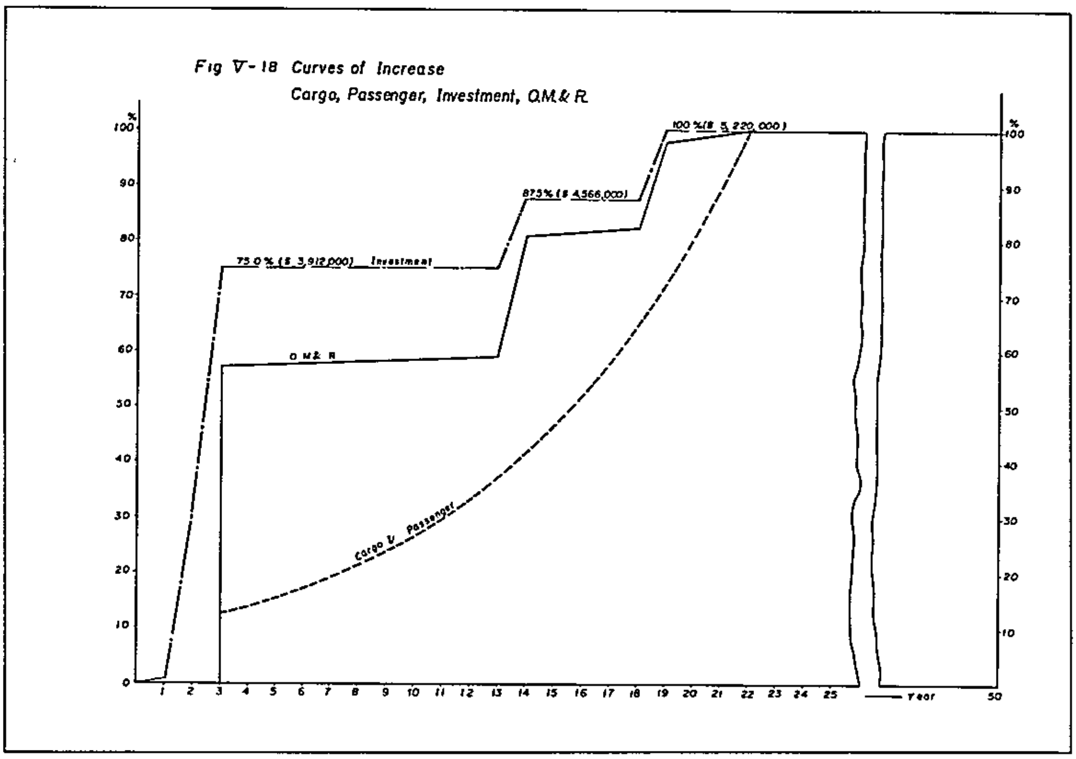
The volume of the existing and the possible future traffic are listed in Table V-57. The unit costs of the future traffic from Stung Treng downstream to sites up to Phnom Pneh are estimated in subparagraph I-4-2. It must be noted, however, that in the future consignors must paya besides transport costs the inclined passage tolls given in subparagraph I-4-1.

1) Benefit in Charcoal Transport: At present no charcoal is shipped from Stung Treng. But, if it would ever be shipped to Phnom Penh, it would likely be carried 160 km to Kratie by land at a cost of $12.8 per ton and then shipped by water from Kratie to Phnom Perh at a cost of $7.5. Thus, the transport would cost at present $20.3 per ton.

After the completion of the dam, the possible future cost of water transport of charcoal from Stung Treng to Phnom Penh is estimated at $9.0 per ton. If the inclined passage tolls of $0.25 per ton is added, the total becomes $9.25 per ton, and the decrement p becomes $11.05 per ton.

As is shown in Table V-57, in the future 5,000 tons a year of charcoal will be shipped out from Stung Treng. Therefore, the benefit that charcoal shippers would receive becomes ½ (5,000) x 11.05 or $27,600.

Fig. V-18 Curves of Increase Cargo, Passenger, Investment, O.M. & R.



2) Benefit in Commodity Transport: Commodities now carried from Phnom Penh and Kompong Cham to Kratie by water and then to Stung Treng by land require average costs of $5.7 per ton on water and $10.0 on land, totaling $15.7 per ton. The corresponding future water transport is estimated to cost $6.5 per ton. If the inclined passage toll of $0.25 and another $1.7 per ton that shippers would have to pay for handling and short land haulage are added, the unit transport cost in the future become $8.45 per ton and Δp becomes $7.25 per ton.

The future volume of commodity traffic is estimated at 64,000 tons a year. It is assumed, however, as shown in Table V-57, that even in the future 10,000 tons will be carried by land as at present. Therefore, consignors will receive no benefit from the transport of this 10,000 tons. Accordingly, the consignors' benefit comes only from the transport of 64,000 tons minus 10,000 tons, or 54,000 tons, that correspond to what will be induced by the new waterway route. Thus, theconsignors' benefit becomes ½ (54,000) x 7.25, or $195,800.

3) Benefit in Timber Transport: Water transport of timber to Phnom Penh now costs $1.7 per ton from Kratie and $2.8 from Stung Treng, as given in Subparagraph I-4-2. Land transport costs 400 Riels to 600 Riels per m^3, or about $13.0 per ton as noted in Subparagraph D-5-7. It can be assumed from this that land transport of timber from Stung Treng to Kratie will cost about $9.5 per ton.

Hence, if timber is carried by land from Stung Treng to Kratie, then composed into rafts and shipped by water to Phnom Penh, it will cost $9.5 plus about $1.6 for raft making, $1.7 for rafting and $1.3 for handling, or $14.1 in total. The future timber transport by water from Stung Treng to Phnom Penh is $5.3 per ton as estimated in Subparagraph I-4-2. Thus, the decrement of the unit traffic cost becomes $8.8 per ton.

At present, the annual total timber traffic of 8,000 tons are moving from Stung Treng to Phnom Penh by water. Suppose here that the limit of the capacity of existing water transport is 16,000 tons a year. On the other hand, the future timber traffic will increase to 56,000 tons per year as shown in Table V-57. Thus, consignors will benefit from timber transport a sum of ½ (56,000 - 16,000) x 8.8 - (8,000 x 1.2 + ½ x 8,000 x 1.2) = 161,600 (dollars) annually.

4) Benefit from Transport of Miscellaneous Goods: The cost data of the transport of miscellaneous goods can be assumed just the same as of the commodity transport. Then, the consignors' benefit from the estimated future traffic of 5,000 tons becomes ½ (5,000) x 7.25 = 18,100 (dollars).

5) Passenger's Benefit: Passengers from Stung Treng pay at present $1.70 for their land travel to Kratie and another $1.15 for their average travel on waterway downstream from Kratie. In the future, a passenger will pay for the same travel on waterway $1.40 and $0.03 for the inclined passage tolls. Thus, he can save $1.42.

The future passenger traffic is estimated at 200,000. Therefore, the annual benefit that passengers can receive totals ½ (200,000) x 1.42 = 142,000 (dollars).

6) Total Surplus of Consignors: Summing up the benefits estimated in 1) to 5), the total of consignors' surplus in the target year becomes $545,100. The figures for the intermediate years are computed based upon the traffic given in Table V-58 and are listed in Table V-63.

I-4-4 Total direct benefit

The direct benefit totals $725,100 in the target year and the figures in the intermediate years are listed in Table V-63.

Table V-63 Annual Direct Benefits of the Initial Plan

(Unit: $)

Year from the Start of the Project	Inclined passage Tolls	Benefit in Transport Services	Surplus of Consignors	Total
1-3	0	0	0	0
4	2,750	19,750	33,530	56,030
5	3,058	21,962	40.873	65,893
6	3,410	24,490	49,824	77,724
7	3,894	27,966	60,735	92,595
8	4,268	30,652	74,036	108,956
9	4,752	34,128	90,250	129,130
10	5,302	38,078	110,015	153,395
11	5,918	42,502	134,108	182,528
12	6,600	47,400	163,530	217,530
13	7,348	52,772	182,063	242,183
14	8,228	59,092	203,867	271,187
15	9,152	65,728	226,762	301,642
16	10,208	73,312	252,926	336,446
17	11,374	81,686	281,817	374,877
18	12,716	91,324	315,068	419,108
19	14,212	102,068	352,135	468,415
20	15,840	113,760	392,472	522,072
21	17,600	126,400	436,080	580,080
22	19,734	141,726	488,955	650,415
23	22,000	158,000	545,100	725,100
24	22,000	158,000	545,100	725,100
25	22,000	158,000	545,100	725,100

I-5 Estimate of Expenses

To obtain the net benefit of the project, the necessary expenses must be estimated. They comprise the operation expense, the expense for maintenance and repair and the replacement cost. These will grow with the progress of the project. But they will be computed first for the future when the whole project would have been implemented.

1) Operation expense

Wages (35 men for incline operation, $2,500 per year)	$87,500
Electricity (720,000 kwh, 0.5 cents per kwh)	$3,600
Materials ($7.5 per 1,000 tons of traffic, 120,000 tons)	$900
Management: Salaries (8 persons, $6,000 per year)	$48,000
Wear-and-tear and other expenses (5% of the above four)	$7,000
Total:	$141,000

2) Expenses for maintenance and repair (0.1% of the construction cost, $5,220,000) $5,000

3) Replacement

The annual amount of replacement for an item that has a useful lifetime of "a" years and is to be installed in the t-th year from the start of a project, R_{at}, can be computed in general by the formula[1/]

$$R_{at} = \frac{r(1+r)^n}{(1+r)^n - 1} \frac{1}{(1+r)^a} K_{at} \quad \cdots\cdots (2)$$

1/ : *Multiple-Purpose River Basin Development, Part I,* ECAFE Report, 1955. *Report of the Seventh Meeting of the Advisory Board,* Mekong Committee. *Benefit-Cost Evaluation as Applied to Aid-Financed Water or Related Land Use Projects, Supplement No. 1,* Department of State Agency for International Development Office of Engineering, U.S. Government, 1963.

in which K_{at} is the cost of the item to be installed in the t-th year, "a" is the useful life of the item in years, "n" is the number of years in which the analysis shall be made (n=50, in this case), and "r" is the annual rate of return.

The initial plan of the project at Sambor as reported herein will be implemented in three stages as stated in Paragraph G-7. The first stage will take three years after the start and the second and the third stage will be carried into execution in the 14th and the 19th year, respectively, both taking one year to be completed.

The replacement is considered for the items of 40-year useful life and those of 30-year useful life. The former consists of the cradles, pushers, winches and rails; the latter comprises the lighting, the communications system and others.

The costs of these items, as given in Table V-55, constitute the values of K_{at}. They are shown in Table V-64.

Table V-64 Amount of K_{at}

(Unit: $)

t \ a	40	30
3	123,800	104,800
15	131,600	30,000
20	131,600	30,000

To compute the replacement from Eq. (2), the value of the annual rate "r" must be known. On the other hand, to determine "r" from Eq. (1), the replacement must be known, because the replacement must be taken into account in computing the net benefit. Therefore, Eq. (1) and Eq. (2) cannot be solved independently; they must be solved simultaneously.

I-6 Internal Rate of Return

The internal rate of return of the initial plan was computed by applying the values of the annual investments, costs and benefits as obtained in accordance with the foregoing to the formula shown in the paragraph I-2. And the rate was found to be 0.052.

The rate of 5.2% seems rather small when compared with those normally submitted for the project appraisal. However, it is not at all appropriate to appraise the project by this rate alone because only the direct benefits are included in the computation. It must be noted that besides the direct benefits there are, as stated before, benefits of the development of natural resources in Stung Treng area and also such intangible benefits as the improvement of the standards of living and culture.