THE FIRST PROGRESS REPORT ON INVESTIGATIONS OF THE SAMBOR PROJECT

OCTOBER 1963

OVERSEAS TECHNICAL COOPERATION AGENCY
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F O R W A R D

In response to the request made by the Committee for Coordination of Investigations of the Lower Mekong Basin, the Japanese Government decided to undertake its First Phase Investigations on the Sambor Site on the mainstream of the Mekong River during the fiscal year 1962.

The Overseas Technical Cooperation Agency (OTCA), having been entrusted by the Japanese Government with the execution of the investigation work, organized and despatched the Field Survey Team with the support of competent Government agencies, affiliated organizations and private enterprises whose assistance and cooperation were solicited in view of the importance of the proposed development project and in the earnest hope that the maximum results might be achieved from the Investigations.

Mr. Goro Inoue, the Chairman of the Board of Directors of Chubu Electric Power Co. and concurrently the member of OTCA's Board of Directors, who headed the Sambor Preliminary Survey Team in the previous year, continued to assume the overall responsibilities of the investigations as the project manager. The Field Survey Team consisted of 20 specialists in hydro-electric power, navigation, agriculture and electric power market and was headed by Mr. Motonaga Ohto, director of OTCA.

The Field Investigations, which lasted for approximately 2.5 months from the middle of January 1963, were successfully conducted and completed as scheduled through the support and facilities extended to the Team by the Committee for Coordination of Investigations of Lower Mekong Basin, the Cambodian Government authorities and the organizations of the cooperating countries. It may as well be added that another factor that lead to the

successful completion of the Investigations was the laborious and untiring efforts exerted by the members of the Team.

On the occasion of presenting this Progress Report, I wish to express my heartfelt gratitude to Mr. Inoue, the Project Manager, the leader and members of the Team for their elaborate efforts which made the investigations quite successful, and further acknowledge the valuable assistance and cooperation rendered by the Government agencies, affiliated organizations and private enterprises which made it possible to organize and despatch the First Phase Survey Team to the Sambor Site.

THE OVERSEAS TECHNICAL COOPERATION
AGENCY

S. Shibusawa

Shinichi Shibusawa
Director-General

C O N T E N T S

5. DRAWINGS

FIG.1 SAMBOR PROJECT LOCATION MAP

FIG.2 SAMBOR GENERAL PLAN

FIG.3 SAMBOR PROJECT INDEX MAP OF GEOLOGICAL INVESTIGATION

FIG.4 PROPOSED TRANSMISSION LINE

FIG.5 GRAPHIQUES DES CRUES DU MEKONG (1961)

FIG.6 " " (1962)

DWG.No.	HO-0201	SAMBOR PROJECT GEOLOGIC INDEX DIAGRAM
"	HO-0231	SAMBOR PROJECT GEOLOGIC PLAN OF SEISMIC PROSPECTING, 5 SHEETS
"	HO-0024	SAMBOR PROJECT PROFILE OF MEKONG RIVER (SAMBOR - KRATIE)

1. PREFACE

This report is based on the results of the first year investigations conducted by the Government of Japan from January to March 1963 upon the request of the Committee for Coordination of Investigations of the Lower Mekong Basin (hereinafter referred to as the Committee) for the development of Sambor district on the main stream of the Mekong River.

The investigations for the development of Sambor district are scheduled to be performed for three years in the future. Therefore, the Report on Comprehensive Investigations which will be the final report will be prepared after the three years investigations.

The purpose of the investigations is to study and determine the feasibility of Sambor Project from the stand point of technology, as well as, economy, and to prepare Report on Comprehensive Investigations, that will certify steadfastness and promising prospects in developing Sambor district, to be submitted to international monetary agencies. The Government of Japan assigned the execution of investigations and engineering studies with a budgetary fund of ¥ 50,000,000 to Overseas Technical Cooperation Agency (hereinafter referred to as OTCA) which is a governmental agency to undertake executive matters for the Government. Subsequently, OTCA in consideration of the purpose and scope of Sambor Project as well as social and economical influence of the Project over the adjacent countries, requested other related governmental agencies, engineering consulting firms and other organizations to cooperate in the investigations. With their cooperations, an overall engineering team consisting of twenty-one engineers and specialists of hydroelectric power, navigation, agriculture, power market, etc. was organized and dispatched to the site.

The first year investigations are a part of serial investigations to be made over years, the results of which will be the basis of the drafting, preliminary design and evaluation of Sambor Project.

Staff and members of OTCA and the investigation team take this opportunity to express profound appreciation to the members of the Committee, Government of the four riparian countries, especially the Government of Cambodia and the Government of Viet-Nam, and their local agencies who have kindly assisted and cooperated the investigation team and facilitated the engineering studies by providing precious data such as of hydrology.

2. OUTLINE OF THE PROJECT

The outline of the Development Project of Sambor District which is described in the Report on Preliminary Investigations is summed up hereinunder.

On the Main Mekong River at the downstream end of the Samboc rapids, a dam 36 m high 29 km in crest length will be constructed to store water, 1,700,000,000 m^3 in effective storage. With this stored water and head created by the dam, an electric generating capacity of 625,000 kw will be installed at a power station (4,600,000,000 kwh in possible annual production of electric energy). Attached to the dam, a navigation lock will be constructed for the improvement of navigation in the river. Furthermore, irrigation with use of water stored in the reservoir is contemplated. The effective storage by Sambor Dam was determined on the basis of power generation program and flood control was not considered in the determination. However, the final decision of the scale, construction cost and their evaluation should be made after completion of detailed investigations.

3. INVESTIGATION SCHEDULE

3-1 INVESTIGATION TEAM

Since the Development Project of Sambor District is a multipurpose project including electric power generation, navigation and irrigation and is large in scale, OTCA requested related governmental agencies, engineering consulting firms and other organizations to cooperate in the investigations. As a result, an overall investigation team could be organized for the effective performance of investigation.

3-2 COST OF INVESTIGATION

For the exectuion of investigations, the Government of Japan allotted ¥ 50,000,000 of its budget and the Government of Cambodia ¥ 1,500,000.

3-3 ITEMS OF INVESTIGATION

The first year investigations conducted on the basis of line C' program which was considered most advantageous over other programs described in the Report on Preliminary Investigations were topographic survey, geological investigation, studies on materials, hydrological investigation, etc. with respect to hydro-electric generation.

(a) Topographical survey

dam center line, powerhouse site, etc.

(b) Geological survey

borings, test pits, seismic prospecting at the proposed sites of dam and other structures and quarries; preparation of geological maps of dam center line

(c) Study on Fill Materials

materials from dam center line

(d) Hydrological investigations

observation of water level and collection of hydrological data

(e) Investigations for navigation

improvement of navigation; general investigation on navigation facilities; collection of data

(f) Agricultural Investigation

General research and collection of data on irrigation, agricultural production, etc. necessary to establish a fundamental plan to conduct investigations in the second year and thereafter

(g) Investigations for Transmission Line

Reconnaissance survey along the proposed route of transmission line

(h) Economic Study

Studies on demand-and-supply patterns of electricity in Cambodia and Viet-Nam, as well as, its future pattern; Determination of items to be investigated in the second year investigations and thereafter

3-4 ASSIGNMENT OF INVESTIGATIONS

Based on the corganization of the team, the investigations were assigned according to the phases as follows:

a) Electric Power Generation (including dam and transmission line):	Electric Power Development Co., Ltd.
b) Navigation:	Japan Port Consultant Ltd.
c) Agriculture:	the Ministry of Agriculture and Forestry
d) Economics (power market):	Overseas Electrical Industries Survey Institute, Inc.

General accountant's business was administered by OTCA. In addition, of the geological investigations, borings, test pits, permeability test were entrusted to Hazama Construction Company and seismic prospecting to Japan Geo-Physical Prospecting Company.

3-5 MEMBERS OF THE INVESTIGATION TEAM AND INVESTIGATION SCHEDULE

Members of the Investigation Team and Investigation Schedule are as follows:

Name and Mother Organization	Title or Occupation	Investigation Period From	Investigation Period To
Motonaga OHTO Director, OTCA	Chief of the Team	Jan. 13	Feb. 4
Yutaka KUBOTA Technical Adviser, OTCA General Manager, Nippon Koei Co.	Technical Adviser	Feb. 19 Mar. 14	Feb. 23 Mar. 16
Yoshio NIINOMI Section Chief, Development Survey Division, OTCA	Assistant to Chief of the Team	Jan. 20	Feb. 8
Kazuo YAMADA Development Survey Division, OTCA	Accountant Liaison	Jan. 12	Mar. 31
Jiro MATSUDA Internal Service Division General Affairs Division OTCA	Accountant	Jan. 13	Mar. 29
Yoshisuke ARAI Senior Engineer, Electric Power Development Co.	Chief Civil Engineer	Feb. 10	Feb. 28
Kiyoshi HAYASHI Deputy Chief, Electrical Department Electric Power Development Co.	Transmission Line	Jan. 27	Feb. 11

Name and Mother Organization	Title or Occupation	Investigation Period From	To
Hiroshi WATANABE Deputy Section Chief, Overseas Engineering Consulting Department, Electric Power Development Co.	Civil Engineer	Jan. 13	Mar. 27
Eishiro MIKUNI Deputy Chief, Design Section Civil Engineering Department, Electric Power Development Co.	Geological Engineer	Feb. 9	Mar. 1
Akihiro IRIE Section I, Overseas Engineering Consulting Department, Electric Power Development Co.	Civil Engineer (Hydrology)	Jan. 13	Mar. 27
Hiroshi SUETOMI Geological Section, Project Planning Department, Electric Power Development Co.	Geological Engineer	Jan. 13 Feb. 8	Jan. 26 Mar. 24
Bunya KANAHARA Section I, Overseas Engineering Consulting Department, Electric Power Development Co.	Civil Engineer (Hydrology)	Jan. 13	Mar. 27
Kiyoshi TSUNODA Civil Engineering Survey Section Project Planning Department, Electric Power Development Co.	Civil Engineer (Hydrology)	Jan. 13	Mar. 27
Takeshi KAWASHIMA Civil Engineering Survey Section Project Planning Department, Electric Power Development Co.	Civil Engineer (Hydrology)	Jan. 13	Mar. 27
Atsushi OHIRA Civil Engineering Survey Section Project Planning Department, Electric Power Development Co.	Civil Engineer (Hydrology)	Jan. 13	Mar. 27
Koichi HONDA Section I, Overseas Engineering Consulting Department, Electric Power Development Co.	Civil Engineer (Hydrology)	Jan. 13	Mar. 27
Tadao HARUTA Chief, Construction Department, Japan Port Consultant Ltd.	Navigation Engineer	Jan. 13	Feb. 9

Name and Mother Organization	Title or Occupation	Investigation Period From	To
Hideo MORI Research Coordinator, Secretariate of Agriculture, Forestry and Fisheries Research Council, Ministry of Agriculture and Forestry	Agricultural Economist	Jan. 13	Feb. 11
Hideo TAKAHASHI Deputy Chief, Section of Design Kanto Agricultural Administration Bureau, Ministry of Agriculture and Forestry	Agricultural Civil Engineer	Jan. 13	Feb. 11
Tamotsu SAITO Survey and Statistics Department, Overseas Electrical Industries Survey Institute, Inc.	Power Market	Jan. 13	Feb. 11
Shoichi KONAN Survey and Statistics Department, Overseas Electrical Industries Survey Institute, Inc.	Power Market	Jan. 13	Feb. 11

4. REPORT ON INVESTIGATIONS

4-1 HYDRO-ELECTRIC POWER

4-1-1 TOPOGRAPHICAL SURVEYS

4-1-2 GEOLOGICAL INVESTIGATIONS

4-1-3 INVESTIGATIONS ON MATERIALS

4-1-4 HYDROLOGICAL INVESTIGATIONS

4-1-5 INVESTIGATIONS FOR TRANSMISSION LINE

4-1-6 CONSIDERATIONS FOR INVESTIGATIONS TO MADE IN THE FUTURE

4. REPORT ON INVESTIGATIONS

4-1 HYDRO-ELECTRIC POWER (INCLUDING TRANSMISSION LINE)

Forward

The first year investigations were conducted on the geology, topography, hydrology, materials to be used and mtters concerning the transmission lines of the line C' program which was deemed to be the most advantageous over other programs proposed in the Report on Preliminary Investigations.

As a result of the studies made prior to the reconnaissance survey on the Report on Preliminary Investigations, the location of dam center of Sambor Project, when considered as a part of the Comprehensive Development of Lower Mekong Basin, was restricted within a few sites on the downstream reaches of Sambor rapids, of which the site designated as line C' in the Report on Preliminary Investigations was investigated since it was thought most advantageous over other sites in respect of economy and relatively less difficult in the engineering phases.

In addition, line (1)-(4) at the abutment of the line C' dam was altered before commencing the investigations.

Investigation schedule of topography, geology, materials to be used and hydrology necessary for the preliminary design was established with the dam center line C' as its object. However, data listed below were not available before the investigation, therefore, part of the investigation was incomplete and some parts are overlapped with information which we obtained later. The followings are the data we obtained during the investigations and the replenishment therewith will be covered in the Report 1964.

a) Final Report Lower Mekong River Project, Harza Co., 1962

b) Hydrographic Surveys Lower Mekong River Project, Harza Co., July 1962

c) Lower Mekong River Basin Discharge Data Prior to 1960, Harza Co. 1960

d) 1960 Hydrologic Data Makong River, Cambodia, Harza Co.

e) 1961 Hydrologic Data Mekong River Basin, Cambodia, Harza Co.

f) Geological Investigation Sambor Dam Site, Cambodia, Volume 1 Australia

g) Geological Investigation Sambor Dam Site, Cambodia, Volume 2 Australia

h) Geological Investigation Sambor Dam Site, Cambodia, Volume 3 Australia

i) Geological Investigation Sambor Dam Site, Cambodia, Volume 4 Australia

j) Topographical maps of 1/20,000 and 1/2,000 in reduced scale, prepared by Canadian Government

In addition, the team requested the Mekong Committee the expansions of the reservoir map (120,000) and dam site map (1/2,000) up to an elevation of 50.00 m above sea level for the additional areas of 1,378 km^2 and 120 km^2 respectively and it was accepted by the Committee

4-1-1 TOPOGRAPHICAL SURVEYS

(1) 1 Purpose

The topographical survey was conducted to check the map, 1/2,000 in reduced scale, which was used in the estimation of dam and power house construction costs described in the Report on Preliminary Investigations and aerial map of 1/20,000 in reduced scale, as well as, to prepare a map necessary for preliminary designing. In addition, water depth of the river was surveyed since the aerial map does not represent it but only the water surface.

(1) 2 Scope

As to the banks and the river bed, the survey was performed along line (1) on the left bank, line (4) on the right bank, line C in the river bed and upstream comparative study line.

There are reference marks of triangulation traversing conducted by the Government of Canada in the years of 1959 and 1960 on the both banks of the

Mekong River. In the investigation, H-421 and VH-422 which had been embedded within the area surveyed this time were taken to be as the base points.

(1) 3 Survey

Surveys conducted were triangulation, traversing, profile survey, cross-sectional survey and water depth survey. The locations of surveyed sites are indicated in Fig. 2 General Plan.

The reconnaissance survey was performed from 18 January to 20 March 1963. The traversing was made with △5 established on the right bank and then existing VH-422 on the left bank as the base points.

Due to the restrictions on period, number of workers and kinds of survey, closed traversing could not be performed, therefore, open traversing was adopted.

Traversing on the both banks was performed after re-examination of line (1)(4) described in the Report on Preliminary Investigations and the line was altered in order to save the quantity of embankment. The directions and distances were determined with the coordinates of each IP established on the map in which the altered line (1) (4) was plotted. Wooden poles were anchored on the center line at a spacing of about 50 m as survey points for alignment and chaining. The chaining was performed twice the duplicate by means of stadia survey, and the average value of the results was recorded.

Point △5 on the right bank was determined of its location by conducting triangulation survey at the river basin.

The traversing was extended up to an elevation of 4,500 m above sea level, and the leveling was made twice the duplicate on the wooden poles with a 50.00 m spacing on the same line. For the restriction of duplicate survey error limit was assumed to be $1.5\sqrt{S}$.

(S stands for total km length of leveling route)

The cross-sectional survey was conducted for a width of 400 m perpendicular to the center line at the traversing points which were located with a spacing of

approximately 300 m on the center line.

The triangulation was first planned to be performed on control points of H-421, VH-422 and H-525, however, since control point H-525 had been damaged, it was performed on a newly established base line. With the triangulation, △4 was established in the river as a base point of the base line for the water depth survey of river bed profile, as well as, for the connection of center lines on the right and left banks,

After completion of triangulation, triangulation points were utlized in the profile survey which was made with the base stations on islands.

The water depth survey was performed for a width of 300 m on the center line with profile survey points as its base points. The distance survey was conducted by means of stadia and the water depth survey was made by a telescopic staff for a shallow part and for the deep river bed by a rope with a sinker from an anchored boat. The boat was guided with use of radio communication in consideration of the width of river.

Bench Mark of Survey Point:

After completion of topographical survey, concrete bench marks were embedded at 7 IP's on the left bank, 7 IP's on the right bank, 5 triangulation points and 29 reference points.

(1) 4 Kinds and Quantity of Survey

Survey	Section	Quantity
Triangulation	river	7 points
Traversing	left bank	15,914 m
	right bank	14,261 m
	river	6,144 m
	quarry	2,216 m
Profile suvey	left bank	15,914 m
	right bank	14,261 m
	river	6,144 m
	quarry	2,216 m

Survey	Section	Quantity
Cross-sectional survey	left bank right bank	23,200 m 21,600 m
Water depth survey	river	2.46 km^2
Leveling	left bank right bank	6.37 km^2 5.70 km^2

(1) 5 Surveying Equipment

Equipment and machines used in the survey are as follows:

1.	Land cruiser	Toyota	3
2.	Station wagon	Toyota	1
3.	Jeep	Mitsubishi	3
4.	Steel ferry boat		1
5.	Wooden boat		2
6.	Life boat	5-passanger	1
7.	Transit	Nihon Kogaku Co.,H-5	5
8.	Level	Nihon Kogaku Co. automatic level	2
9.	Level	Nihon Kogaku Co.,E-5	2
10.	Level	Nihon Kogaku Co.,E-3	1
11.	Binoculars	Nihon Kogaku Co.	5 pairs
12.	Distance meter	Nihon Kogaku	1
13.	Telecommunication equipment	Oki Denki Okiphonet 101	2
14.	Telecommuniction equipment	Oki Denki Telepet 3 A	1
15.	Chain saw	Type 1-52	2
16.	Chain saw	Type 35-A	1
17.	Clinometer		3
18.	Branton compass		1

19.	Rock-test hammer		3
20.	Surveying equipment	telescopic staff, pole, tape, etc.	1 set
21.	Lumbering equipment	ax, saw, etc.	1 set

(1) 6 Drawings Prepared but not attached to This Report

Drawing No. HO-0022 Sambor Project Topographic Survey Plan, 25 sheets

Drawing No. HO-0023 Sambor Project Topographic Survey Profile, 8 sheets

4-1-2 GEOLOGICAL INVESTIGATIONS

(2) 1 Outline of the Results

Geological investigations were conducted by the geological survey team of Snowy Mountains Hydro-Electric Authority, Australia during the dry seasons from 1960 to 1961 and from 1961 to 1962.

The results were presented in Progress Report on Geological Investigations, Sambor Dam Site, Cambodia, 1960-1961 followed by Geological Investigation, Sambor Dam Site, Cambodia, Volume 1-4, 1960-1962. These reports cover general geological information and rock foundation of the damsite, and farther, geophisical consideration on concrete aggregate, as well as, earth and rock materials of fill type dam.

In 1963 the Japanese Preliminary Survey Team conducted investigations to supplement the Report on Preliminary Investigations for Development of the Lower Mekong River Basin - 1962 taking into consideration Progress Report on Geological Investigations of the Snowy Mountains Hydro-Electric Authority.

The conclusions are as follows:

i) The plan with dam center line C' is considered most appropriate for the construction of a dam and other related structures.

ii) In most parts along the dam center line on the both banks, rock foundations suitable for construction of structures are found existing 1 to 4 m below the

ground surface.

iii) Earth and rock materials for dam embankment are widely distributed along the dam center line.

iv) The dam center line lies across a channel about 80 m wide and 19 m deep at low water level which has been made by the erosion of water flow along the right bank in the river. Therefore, close attention should be paid to the construction of dam at the channel.

v) The dam center line on the right bank lies across the former river bed more than 2 km wide where there is a deposit 30 m thick (according to the results of seismic prospecting) mainly consisting of silt, clay and fine sand mixed with coarse sand and small gravels of sizes from 1 to 2 cm in diameter. Permeability tests were conducted of the deposit including the surface of bed rock lying underneath the deposit. It was clarified by these tests that the deposit is fairly impermeable, and, if treated properly, reliable as a dam foundation.

vi) The ground surface at the proposed power house site is about 4 to 10 m thick debris deposit underlain by bed rock which is to be the foundation.

vii) Underneath the surface deposit of spillway section lies an alternated layer of sandstone and shale. Since the muck of rock and debris to be excavated for the spillway construction may be used as fill materials of the dam, the section will be further surveyed in the second year investigations.

(2) 2 Survey Work

The geological investigations conducted were surface exploration, seismic prospecting, boring tests and observation through test pits. The boring holes and test pits were utilized in the permeability test which were performed on the geologically important part for designing the structures. As to the river bed, the geological investigations were made by conducting seismic prospecting and observing outcrops along the same line of measurement, and boring tests are scheduled for the second year investigations.

a) Outcrop Observation

The area reconnoitered by the team covers the dam site, powerhouse site and their surrounding areas. Especially, the coverage of geological sketch map, 1/2,000 in reduced scale, is as large as 10 km along the line of measurement of seismic prospecting made on the main stream and the upper reaches of former river bed.

b) Seismic Prospecting

The seismic prospecting was performed by Japan Geo-physical Prospecting Company of Tokyo from February 13 to March 11, 1963. The survey for a total length of 11,990 m was completed under the direction of three engineers with use of twelve microseismographs in series of high magnifying power.

On account of the topographical condition of the site, the prospecting in the swift streams and marsh lands was performed by shifting the blasting point and on the other parts of land by moving the seismoscope. Table 1 shows the lines of measurement, number of survey points and number of blastings and blasting points.

Table 1 Line of Measurement, Number of Survey Point and and Number of Blasting and Blasting Point

Location Line of measurement		Distance of Line of measurement(m) from	to	Length of line of mesurement	Number of survey point	Blasting point	Number of blasting
Former river bed	R/P_1	R/P_1	No.17-11.75	325.2	132	6	12
		0	325.2				
	P/P_2	No.28-0.65	R/P_2				
		1,000	4,546	3,546	1,780	39	180
Main river bed	△1-△4	△1	△4	1,836.2	543	30	139
		0	1,836.2				
	△4-△5	△4	△5	1,975.6	839	42	135
		0	1,975.6				
	△6-△5	△6	△5	2,317	984	50	154
		0	2,317				
Right bank	south of No. 14	No.14					
		0	720	720	286	16	69
		1,380	2,000	620	284	10	28
Quarry	RQ-1	0	400	400	164	7	16
Powerhouse	P.2	P.2-150	P.2+100				
		0	250	250	116	5	15
Total				11,990	5,128	205	748

c) Boring

The boring test was directed by an engineer assisted by three technicians of Hazama Construction Company from January 31 to March 19, and three UD-5 type boring machines manufactured by Tone Boring Company were used with metal crown bits for the deposit layer and diamond bits for the bedrock. The bore of pit was of size NX (76.2 mm in diameter) in the deposit layer and size AX (49.2mm in diameter) in the bedrock.

The boring drills were sunk along the dam axis on the bank and at the proposed sites for powerhouse, spillway and two possible quarries on the left

band and one on the right bank. Water used for drilling was pumped up from the main stream and carried by pick-ups.

Sand deposit on the right river bed was investigated by excavating pits down to the subterranean water level, and then, drilling bores by percussion down to 10 m below the ground surface. The results of the boring tests are shown in a profile. The locations of bores are shown in Drawing No. HO-0201 and the number of bores and bore lengths are as shown below.

Table 2 Number of Bores and Bore Lengths

	Power house	Dam		Quarry		Total
		Left bank	Right bank	Left bank	Right bank	
Number of bores	7	6	16	2	3	34
		22		5		
Bore length (m)	190	83.00	269.75	30.00	60.00	632.75
		352.75		90.00		

d) Test Pit

Test pits were excavated by Hazama Construction Company at a spacing of 500 m on average on the dam center line and the test pits for powerhouse site were selected so that they will be located between the bores. As to the upper part of spillway and possible quarries, grids with 100m to 500 m spacings were established and test pits were excavated at the intersections of the grids.

The results obtained from the test pits are profiled and the number of bores and bore lengths are shown in Table 3.

Table 3 Number of Bores and Bore Lengths

	Power-house	Dam		Mouth of spillway	Quarry				Sand quarry	Total
		Left bank	Right bank		Left bank		Right bank			
					LQ1	LQ2	RQ1, down-stream of spillway	RQ2		
Number of bores	4	34	27	7	17	7	17	5	5	123
		61			24		22			
					46					
Bore length	17.40	72.40	108.85	18.60	33.10	11.30	51.55	16.25	50	379.45
		181.25			44.40		67.80			
					112.20					

The standard profile is 1.0 m x 1.5 m.

e) Permeability Test

The permeability tests were performed upon drilling boring holes and excavating test pits. The test sites were confined to below EL 36 m on the dam axis on the banks. In the former river bed the test were made in the boring holes by stages method and other tests in the pits. In the measuration, quantity of water evaporation was taken into account but fluctuation in water level due to capillary phenomenon which took place near the ground surface was not considered. All the tests were made by injecting water into the boring holes or test pits except one testing point where it was performed by pumping up water. Table 4 shows the number of testing points and tested cross sections.

Table 4 Number of Testing Points and Tested Cross Sections

		Injection test		Pumping test		Total
		Left bank	Right bank	Left bank	Right bank	
Boring hole	Number of testing points	-	5	-	-	5
	Number of tested cross section	-	14	-	-	14
Test pit	Number of testing points	4	5	-	1	10
	Number of tested cross section	4	5	-	1	10

The locations of testing points are shown in Drawing No. HO-0201 and the results are shown in profiles and Appendix II.

(2) 3 Results of Investigation

Foundation of Structure

a) Dam Foundation

As to the dam foundation, investigations including seismic prospecting and permeability tests were conducted to clarify the depth and property of debris deposit and permeability of the foundation and to analyze geological conditions of present and former river bed. With the results of these investigations the foundation was judged to be adequate for construction of fill type dam.

a)-1 Main River Bed

In the river bed, rocks were found exposed quite widely except in the vicinities of islands where they are overlain by a thin layer of very fine sand. And the bedrock is very fresh and sound except its surface which has been loosened by the erosion of stream flow.

However, the loosened parts are confined to those rocks which will be easily disintegrated or places where calcite vein in joint is dissolved. Seismic prospecting was performed on the lines of measurement established along the alternative two dam axes. The velocities of 4.2 -3.8 km/sec to 6.0 -5.5 km/sec which indicate good quality of bedrock were recorded along lines of measurement △5 -△4, △1 -△4 and △6 -△5 except near △5 where there is a very fine sand deposit and around △4 and other places where there are sand deposits surrounding relatively large islands.

Deteriorated parts along faults and fractured zones were proved to be relatively narrow. However, of the channels scoured along weak lines, the largest one located on line of measurement △6 - △5 near the right bank is 12 m wide at the elevation of surface bedrock. Therefore, close attention should be paid to the designing and constructing a structure on this channel.

The relation between geological formation and seismic wave velocity along lines of measurement △5 -△4, △1 -△4 and △6 -△5 are shown in Drawing No. HO-0231.

From the reconnaissance survey, at the upper reaches of former river bed on the right bank, an alternated layer of sand stone, shale or silt stone was found multi-folded but no particularly large section of soft composition was observed. The geological formation at the upper reaches of former river bed is shown in Drawing No. HO-0231.

a)-2 The Former River Bed

The debris deposit in the former river bed is mainly composed of fine or middle sized reddish brown sand, and downwards the bed the sand becomes coarser. In some part coarse sand and rounded quartz gravels, about 1 cm in diameter, were found distributed. It was also noted from the test pits and borings that the layer of organic soil is very thin, at largest 1 m in thickness, for the prosperous vegitation of the district, and therefore, plants roots are not penetrating into deep soil.

The width of former river bed is approximately 2.4 km at the dam center line and the thickness of debris deposit is 30 m at maximum according to the results of seismic prospecting. This deepest part was formed by the same reason as that of the large channel in the present river bed. Distance between the shoulders of the channel is about 150 m. According to the results of drill borings, the deposit is fine and compact. From the five boring holes drilled in area, weathered zone of the bedrock is 2 to 3 m thick. As in the case of the upper reaches of former river bed the bedrock underneath the weathered zone consists of fresh silt stone, shale, sand stone, or their alternated layer.

Since it is possible for water to permeate through the deposit, bedrock or joint of the two, permeability tests were performed on them. From the tests, permeability coefficients were revealed to be in the order of 1×10^{-4} to

1×10^{-5} cm/sec in the deposit and 1×10^{-3} to 1×10^{-4} cm/sec in the bedrock and joint of bedrock and deposit. The results of tests are shown respectively in Appendix II.

Comparative study between geological formation and seismic wave velocity is shown in Drawing No. HO-0231. And according to the wave velocity, there are two channels in the former river bed.

a)3 Banks

Areas of low elevations near the Mekong River are playa, and even in the dry season there are some fens left in the playa. The playa is covered with silt and the surface layer is 10 cm to several meters thick dark grey humus.

The playa and banks excepting the former river banks are covered with residual soil weathered by the monsoonal climate. The residual soil is about 1 to 4 m thick, but in and around an upland, N-1,400 km and E-620 km, located about 8 km east of the estuary of the Prek Kabot it is further thinner. The upland is composed of Kampi conglomerate and the gravels are distinctively separated from the basin. The whole upland is covered with gravels of sizes of small pebbles to large boulders.

Lateritization is taking place, and its degree is in proportion to the flatness. There are only few up-and-downs. In the left bank which is composed of uniform layer, not only the thickness and property of weathered rock are uniform but also the layers in which laterite concretions are concentrated are of uniform thickness of about 50 cm.

Generally speaking, the deposit layer on bedrock is very compact, and in those parts where calcareous substances are largely involved it is so compact that the excavation of test pit (1.0 m x 1.5 m in cross section) did not exceed 30 cm in depth a day. With permeability test performed on this layer utilizing the test pits it was revealed that the layer is highly water-tight.

b) Powerhouse Site

The proposed powerhouse site is situated between △5 and R1P1. To investigate this site, seven drills were sunk and four test pits were excavated, as well as, seismic prospecting with a 250 m long line of measurement was conducted. From the borings it was noted that the thickness of debris deposit becomes thin towards downstream; 10.5 m thick at boring A-0 which is the upstream end of the borings and 4.4 m at boring A-4. Also, there is a tendency that it is thin near the river and becomes thick toward mountain side. At boring A-3 on the mountain side, the thickness is 4.8 m while 4 m and 6.2 m at borings A-4 and A-5 respectively. Bedrock overlain by the deposit is sand stone or shale, or else an alternated layer of the two, and the layer is thought to be dipping steeply. Surface of the bedrock is, in most cases, weathered to a depth of 2 to 3 m, and in some parts where weathering took place to a greater extent due to the development of iron-rust colored joints, it is corroded and has a clay film and the color of rock has turned out from dark grey to yellow.
Comparative study between the geological formation and seismic wave veliocity of the powerhouse site is shown in Drawing No. HO-0231.

c) Spillway Site

To investigate the foundation of concrete structures at the proposed spillway site which is located east of the former river bed, seismic prospecting was conducted along a line of measurement and five drills were sunk on a line established crossing the line of measurement near the mouth of spillway. Since it is prospected to use even the muck to be excavated from the spillway site for the embankment of dam, twenty-four test pits including quarry RQ-1 were excavated around and downstream the dam center line to investigate the thickness of debris deposit and the condition of bedrock. From the results of seismic prospecting, it was revealed that the weathered zone is generally thick and fresh bedrock which recorded 4 km/sec of seismic wave velocity lies more than 7 m belowth ground surface and in some places 15 m below the ground surface. Underneath a ford or

bar of sand the fresh rock could not be reached to a depth of 20 m. The thickest layer of debris deposit, however, is assumed to be in the channel, which is similar to the one existing in the present river bed.

According to the result of boring tests the thickness of debris deposit varies greatly from less than 1 m to 8.8 m, or 3 to 5 m on the average. Heavily weathered zone of bedrock is 2 to 3 m from the surface but at some places light weathering has taken place to as deep as 20 m. Sporadically, developed joints, fine calcite veins or shear zones which are as narrow as 10 cm are existing. Of the alternated layer of sand stone and shale, shale seems to become easily deteriorated, and the geological condition tends to worse toward the former river bed. At borings B-4 and B-5 fine veins of porphyrite and diorite are intruding and metamorphosing the surrounding rocks. From the test pits, it was observed that the debris deposit is more than 2 m thick and the bedrock contains much shale or silt stone rather than sand stone. And its surface is heavily weathered and at some parts moistened. Subterranean water level was recognized to 3.7 m below the ground surface at oring H-15 on February 12.

Geological formation and seismic wave velocities are shown in Drawing No. HO-0231 for the comparative study.

d) Results of Seismic Prospecting and Geological Formation

The seismic wave velocities obtained from the prospecting and geological formation are compared in Table 6.

Table 6 Velocity and Geological Formation

Layer	Velocity(km/sec)	Geology
1st layer	0.2 - 0.4	Regolith
2nd layer	0.9 - 1.8	Relatively compact soil consisting of silt and weathered soil deposited in playa
3rd layer	3.0 - 6.0	Bedrock

The first layer is several meters thick from the ground surface. The soil of the layer is not solidified and consists of dry sand and silt which are widely distributed in bars of river bed.

The second layer on the right bank is soil consisting of sand, silt and pebbles which had been carried down and deposited during flood seasons. The second layer includes the deposit in the former riverbed. When compared with the first layer, this second layer is fairly compact. Seismic wave velocities of these non-solidified soils generally depend to a great extent on the sizes of grains and water content. Being flat indifferent to the ground surface, the bedrock surface is identical with the demarcation line between dry layer and moistened layer. Therefore, it is thought that the seismic wave velocity is mainly subjected to the size of grain.

Generally speaking, the seismic velocities of 2.1 km/sec, 1.5 km/sec and 0.7 km/sec correspond respectively to grave, sand and silt.

Therefore, the debris deposit of this region which registered 0.9 to 1.8 km/sec of velocity can be considered to be a relatively compact stratum of sand and/or silt. And this was evidenced by the results of boring test and observation in test pits.

The deposit in the present river bed also registered a velocity of 1.5 km/sec which indicated that it is a sandy layer.

In a region where weathered rocks are exposed, velocities of 1.2 to 1.5 km/sec were recorded. This proves that the rocks were decomposed physically and mechanically by weathering. In reality they even include residual soil which involves debris produced by weathering.

In the time-distance curve there are intermediate velocities between the second and third layers, however, in the drawing of cross section they are not indicated when the thickness of transient layer is less than 2 m. At a site 400 to 550 m south from line of measurement No. 14 a layer which registered 3.0km/sec

of velocity for the thickness of 7 to 8 m was found. As shown in the drawing of cross section, the rock is considered to have developed cracks but not decomposed yet.

The third layer registeres velocities which represent snad stone, shale and silt stone, or their alternated layer. The velocity is between 3.0 and 6.0 km/sec and varies with the kind of rock, degree of development of cracks and direction of strata. In this region, however, change in velocity seems to be subjected to the geological structure much more than the kind of rock.

The fluctuation of seismic wave velocity was studied with Appendix I which shows the frequency distribution of the velocity of bedrock recorded along the four lines of measurement which are relatively long.

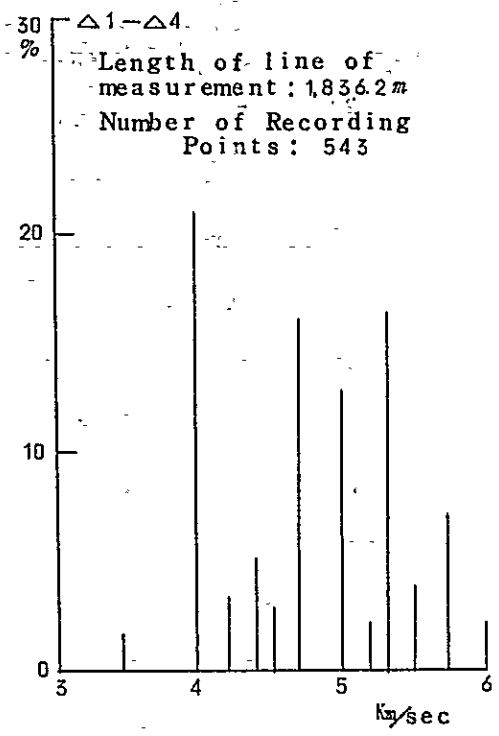
Of the lines of measurement △1 -△4, △6 -△5 and △4 -△5 where bedrocks are exposed along almost all the lines, △4 -△5 represents near normal distribution while there are many deviates in data recorded on lines △1 -△4 and △6 -△5. This is attributable to the fact that the former line is almost parallel to the strike of bed and the tectonic line and the quality of rock is uniform, while the latter lines cross the strike of bed almost at the right angle and the quality of rock is various. Especially, the registered velocity of 4.0 km/sec with frequency distribution of 20% implies that, in addition to the discontinuity of surface, the line of measurement is traversing such major geological structures as a fault and fold.

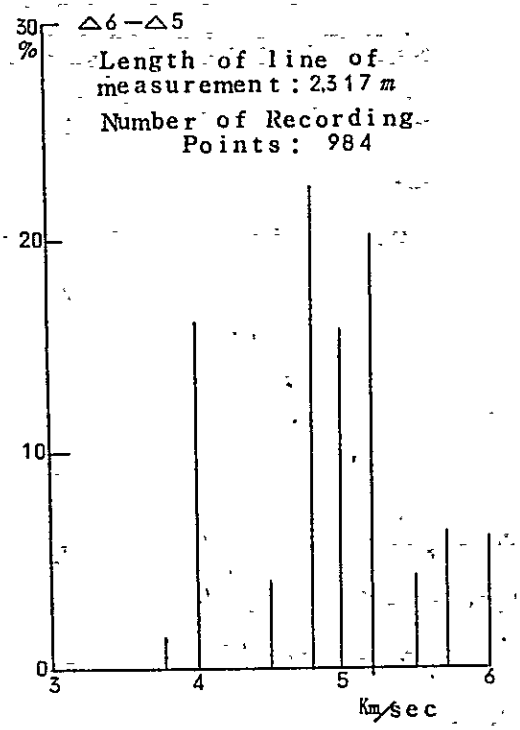
As to the relation between kind of rock and seismic wave velocity, some sand stone registered 6km/sec but shale did not register a velocity higher than 5.3 km/sec in the prospecting made on line △1 -△4 where both sand stone and shale are exposed uninterrupted.

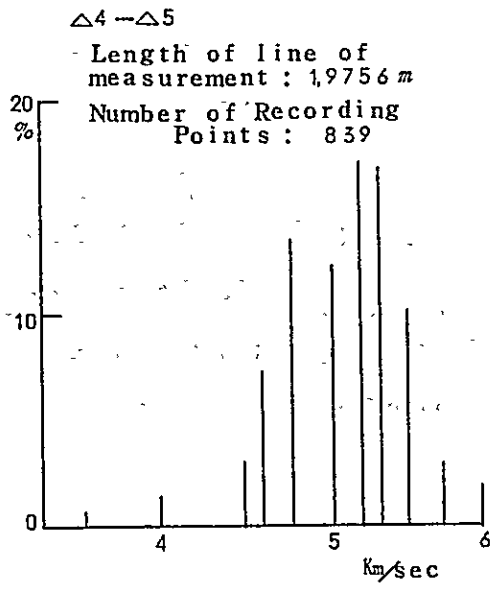
It is presumable that the highest velocity is limited by the texture of shale. In both cases, however, the lowest registered velocity is around 4.0 km/sec.

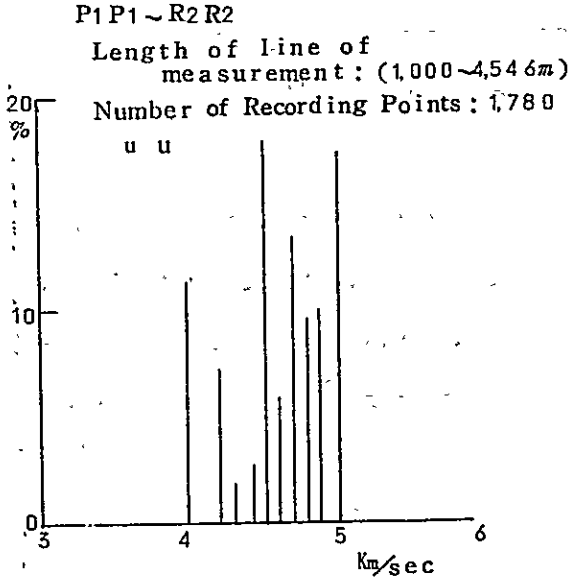
Appendix I

Seismin-Wave Velocity and its Frequency Distribution of Bedrock









According to the results of investigations, velocities between 6.0 and 5.5 km/sec imply very sound bedrock and those between 5.3 and 4.7 indicate sound bedrock. Velocities of 4.5 to 3.8 km/sec and less than 3.5 km/sec represent bedrock with developed joints or beddings and weathered zone or fractured zone respectively.

In the river bed underneath the thin deposits of sand and silt, there are sound bedrocks which registered 4.6 to 6.0 km/sec of velocities.

At the proposed sites of powerhouse, spillway and quarry on the right bank, thickness of a stratum registering 0.2 to 1.8 km/sec exceeds sometimes 10 m.

Underneath the stratum, velocities of 4.5 to 4.3 km/sec and 6.0 to 4.6 km/sec were registered, which indicates that there are rocks with developed joints and beddings, as well as, sound bedrocks. In the former river bed, low velocity strata of 0.2 to 1.8km/sec are very thick and strata over 30 m in thickness are distributed around a point 2.48 m from R1P1 toward R1P2. The bedrock in this area registered relatively low velocities of 4.2 to 3.8 km/sec and it expands for a length of about 120 m. As to the rest of the line of measurement, the thickness of layer registering 0.2 to 1.8 km/sec varies from place to place within the range of 15 to 20 m. In the former river bed, the steata overlain by debris deposit registered mostly 5.3 to 4.6 km/sec of velocity with some exceptions of 4.2 to 3.8 km/sec, and velocities of 6.0 to 5.5 km/sec were not recorded. This means that the light weathering has affected to a deeper point in the former river bed than in the present river bed.

Appendix II Permiability Coefficient Obtained by Outdoor Test

Boring	Depth (m)	Length of cross section (cm)	radius of Cross section (cm)	Permeability coefficient (cm/sec)	Geology
C-1	8-10	200	3.7	$3.5\text{-}1.3\times10^{-4}$	surface deposit
	12.5-15	250	2.3	7.0×10^{-6}	surface deposit
	18-20	200	2.3	$9.5\text{-}9.1\times10^{-1}$	surface deposit
	20-25	500	2.3	1.8×10^{-3}	surface deposit and bedrock
C-2	5-10	500	3.3	$7.2\text{-}6.7\times10^{-5}$	surface deposit
	10-15	500	3.3-2.2	$9.4\text{-}7.9\times10^{-4}$	
C-3	5-10	500	3.3	$8.0\text{-}7.2\times10^{-4}$	surface deposit
	10-15	500	2.2	$1.1\times10^{-3}\text{-}9.3\times10^{-4}$	surface deposit and bedrock
C-4	3-5	200	3.3	$3.8\times10^{-4}\text{-}3.2\times10^{-5}$	surface deposit
	5-10	500	2.2	$2.8\text{-}1.6\times10^{-4}$	surface deposit
C-5	3-5	200	3.7	$9.0\text{-}6.0\times10^{-5}$	surface deposit
	5-10	500	3.2-2.2	$2.7\text{-}1.2\times10^{-4}$	surface deposit and bedrock
	10-15	500	2.2	$7.9\text{-}5.8\times10^{-4}$	bedrock
	15-17	200	2.2	1.3×10^{-3}	bedrock

Test pit	Location	Permeability coefficient (cm/sec)
CT - 4	the former river bed on the dam center line on the right bank	5.0×10^{-4}
E - 5	dam center line on the right bank	8.1×10^{-5}
E - 7	do	1.9×10^{-3}
E - 9	do	3.0×10^{-5}
E - 11	do	5.8×10^{-6}
E - 13	do	2.9×10^{-6}
E - 27	dam center line on the left bank	1.7×10^{-5}
E - 29	do	3.3×10^{-5}
E - 31	do	3.9×10^{-7}
E - 33	do	5.9×10^{-7}

4-1-3 INVESTIGATIONS ON MATERIALS

(3) 1 Materials of Embankment

a) Scope of Investigations

There is a widespread distribution of sound sand stone which would be a proper quarry to produce rock materials for a fill type dam and concrete agregate near National Highway 13 north of Kratie air port. However, in consideration of the quarry from the dam site, survey was made only of the surface.

The main purpose in the investigation was to find out a quarry or quarries near the dam site. Selected sites of quarries are shown in Table 3.1

As to the quality of earth fill materials, investigation was made by borings and test pits along the dam center line used to investigate the dam foundation and additional borings and test pits for the quarry investigation.

Twenty-eight specimens indicated in Table 3.2 were taken from the test pits to be tested at Civil Engineering Laboratory of Electric Power Development Company in Tokyo.

This Report is to sum up the results of reconnaissance survey and the results of test on the earth fill materials will be described separately.

Table 3.1 Investigated Site for Rock Materials

Site	Location	Boring	Test pit
LQ - 1	E-1, 400 km and N-620 km in upland located about 8 km east of the estuary of the Preck Kakot on the left bank	-	17
LQ - 2	terrace (N-1,392 km and E-613 km) around a 1.5 km long part of highway between Samboc on the left bank and Sre Chay	2 G - 4 G - 5	7
RQ - 1	upland situated 0.5km south-east of B. Ang Koel which is 2.7 km downstream of the dam center line and adjacent areas upstream and downstream the upland	3 G - 1 G - 2 G - 3	17
RQ - 2	plain (N01,390 km and E-602 km) located 7 km west of the Mekong River and 3 km east of the dam center line at spillway	-	5

See Drawing No. HO-0201 and Fig 3.

Table 3.2 Specimen for Classification Test

Specimen	Test pit	Depth (m)	Specimen	Test pit	Depth (m)
S - 1	E - 2	1.0	S - 15	E - 31	1.5
S - 2	E - 2	2.5	S - 16	E - 32	2.0
S - 3	E - 5	0.5	S - 17	E - 34	2.0
S - 4	E - 5	1.5	S - 18	E - 48	0.8
S - 5	E - 5	2.5	S - 19	E - 48	1.5
S - 6	E - 13	0.8	S - 20	E - 50	1.0
S - 7	E - 13	2.0	S - 21	E - 50	2.0
S - 8	E - 16	4.5	S - 22	AT - 2	1.0
S - 9	E - 18	4.2	S - 23	AT - 2	5.0
S - 10	E - 20	0.9	S - 24	CT - 3	1.0
S - 11	E - 20	3.5	S - 25	CT - 3	4.0
S - 12	E - 25	2.0	S - 26	H - 16	0.8
S - 13	E - 25'	2.5	S - 27	H - 16	1.5
S - 14	E - 26'	2.0	S - 28	LQ - 1 - 8	

b) Summary of Results Obtained from Investigations

Along the dam axis, fine grain materials, such as silty sand, silty clay and heavy clay, which are overlain by 0.2 to 0.5 m thick surface soil inclusive of plant roots excepting one part are distributed without any mixtures of gravels for thicknesses of 1 to 4 m.

On the left bank most of these are the decomposed aqueous rock, such as sand stone and shale excepting the former river bed where thick debris deposit is lying. On the right bank, however, debris deposit was observed in addition to the decomposed aqueous rocks. They were in many cases desiccated and solidified during the time of investigation which was made in the dry season.

There were no large outcrops of sound rocks in the proposed quarry sites. It will be possible to obtain sufficient quantity of economical dam embankment materials, especially on the left bank by using the decomposed rocks as

impermeable wall or filter according to the degree of weathered conditions of the rocks, and then, cracking the underlying unweathered rock to produce riprap.

c) Investigated Sites

c)-1 Dam Axis on the Left Bank

In the test pits near the river, it was observed that the land is covered with a 0.5 to 0.8 m thick layer of silty soil, but the layer is 0.2 to 0.3 thick at L1P2 and the eastward. Underneath the layer is weathered zone of shale or siltstone. The thickness is 1.5 to 4.0 m up to around L1P4 toward east but beyond that it is less than 2.0 m. This weathered layer is locally mixed with boulders, almost 20 cm in diameter, but mostly it is desiccated and solidified silty sand or clayey substance without any coarse materials.

c)-2 Right Bank of the Present River Bed

Overlain by a 0.3 to 0.5 m thick silt layer which includes plant roots, a layer consisting of silt or heavy clay is existing for a thickness of 2 to 5 m. Although the upper part of the layer is extremely dry, subterranean water was found from place to place at depths of 3 to 5 m. In test pits excavated at such places where underlying subterranean water level is high, moistened strata were observed at the upper parts of the pits. The lower part consists of siltstone, shale and sand stone and is heavily weathered.

c)-3 The Former River Bed on the Right Bank on the Dam Center Line

In spite of the thick growth of vegetation, their roots are limited within the surface soil excepting those of large trees, and the humus is also thin. The underlying layers are silt, laterite and clay, and down to the bedrock it is silty sand of slightly large grain as compared with others. Subterranean water level is mostly around 4 m below the ground surface.

c)-4 R1P2 and the Westward of the Dam Axis on the Right Bank

Overlain by silty surface soil, there is a 1 to 3 m thick layer of clay,

and then downward there are weathered layers of shale and sand stone. The clay layer varies in its property. Some part it is silty and some other part it is heavy clay, and in most cases top 1 m is lateritized.

c)-5 LQ - 1 of Proposed Quarry

This is an upland composed mainly of conglomerate with mixtures of a fairly large amount of clay-slate and siltstone. Under the silty surface, 0.2 to 0.3 m thickness, lies a weathered layer of conglomerate or aqueous rock. Similar conglomerate was observed as a major component in another upland, N-1,394 and E-615, located on the right bank of the Prek Kampi. According to the results of soil test described in the Report on Preliminary Investigations, weathered strata of this upland are composed of relatively coarse materials and the content of silt and clay is less than 20 %. With respect to its density and permeability, the strata consist of the best materials for the dam embankment.

c)-6 LQ - 2 of Proposed Quarry

There is 4 to 7 m thick weathered layers of sand stone and shale underneath surface silt which, 0.2 to 0.5 m in thickness, includes plant roots.

c)-7 RQ - 1 of Proposed Quarry

Overlain by surface soil is an alternated layers of shale, siltstine and sand stone with spacings of 0.4 to 0.6 m, and weathering has taken place to a depth of 7 to 10 m.

c) - 8 RQ - 2 of Proposed Quarry

Since there were boulders of diorite at the site, a test pit was excavated. But, the results were unfavorable.

(3) 2 Concrete Aggregate

a) Coarse Agregate

From the results of investigations, it is noted that the quarry of solid rock materials can not be determined until after the weathered zone is excavated.

b) Fine Aggregate

Bars expanding downstream of the dam axis on the right bank were investigated through five test pits and percussion borings. The sand is very fine except that observed at pole F-4, which is relatively coarse as compared with the rest. The sands was presumed to be too fine for the fine concrete aggregate, but to examine its appropriateness five specimens indicated in Table 3.3 were brough to Civil Engineering Laboratory of Electric Power Development Company in Tokyo for testing.

Table 3.3 Specimens for Fine Concrete Aggregate Testing

Specimen	Test Pit	Depth of Collection
S - 29	F - 1	0 - 10
S - 30	F - 2	0 - 10
S - 31	F - 3	0 - 10
S - 32	F - 4	0 - 10
S - 33	F - 5	0 - 10

4-1-4 HYDROLOGICAL INVESTIGATIONS

Systematic investigations on hydrology of the river basin were conducted by Harza Engineering Company, U. S. A. since 1958, and its Final Report came to be available to us during the course of reconnaissance survey.

Of the data compiled in the Final Report, those recorded in the Mekong Basin in Cambodia, which are directly related to Sambor Project, are on the stream flow measured by water gauges established at Ban Chantangay (Se Kong), Ban Komphum (Se San), Prek Kdam (Tonle Sap), Phnom-Penh, Stung Treng, Kratie and Kompong-Cham floating silt at Stung Treng, Kratie and Phnom-Penh, precipitation at Battambang, Dap-Bat, Kompong-Cham, Kompong-Thom, Krakor Kratie,

Pailin, Snoul and Svay-Rieng, evaporation at Battambang, Snoul, Stung Treng and Takeo and wind velocity at Battambang, Snoul, Stung Treng and Takeo.

Taking into consideration the sites of observations, the hydrological data and information compiled in the Final Report by Harza Company were utilized to the fullest in the first year investigations. And to supplement the report, the following surveys were conducted.

(4) 1 Water level between the Dam Site and Kratie

Water level between the dam site and Kratie was recorded six times during the reconnaissance survey (January 26 to March 16) at eight points so that the gradient of water surface between the dam site and Kratie, water level at tailrace of powerhouse and rating curve at dam site which are indispensable data for designing the powerhouse, lock for navigation, etc. can be computed.

The data adopted for the computation include those recorded in the rainy season of September 1962.

(4) 2 Evaporation and Precipitation

A rain-gauge and vaporimeter were installed by the Preliminary Investigation Team in the premises of the Ministry of Public Works in Kratie to compute the amount of evaporation from a reservoir to be constructed.

The recording of evaporation and precipitation has been undertaken upon request of the Team by the Ministry of Public Works in Kratie and it will be continued by the said Ministry in the future.

(4) 3 Water Level at Stung Treng

Water level was recorded at Stung Treng which will be upstream end of the back-water of Sambor Dam. Also, leveling was performed in front of bungalows and a hotel for the road along the left bank.

4-1-5 INVESTIGATIONS FOR TRANSMISSION LINE

Transmission line route was investigated of its general conditions on the

basis of the Report on Preliminary Investigations assuming that electricity produced at Sambor Power Station would be transmitted to Phnom-Penh, Sihanoukville and Saigon. As far as the transmission line was concerned this was the first investigation made at site and the period of investigation was short. Furthermore, lack in transportations, such as jeep and helicopter, hindered the investigation to go into details. However, today when no concrete idea as to the consumption and transmission of electricity to be produced at Sambor Power Station has been set up, it is considered appropriate that the detailed investigations of the route and collection of information necessary for designing the transmission line be made after determination of the location receiving end, capacity of transmission line, etc.

(5) 1 General Information on the Route

As mentioned previously, the transmission line will travel from Sambor to Sihanoukville by way of Phnom-Penh. If Phnom-Penh Sub-station is constructed in the suburbs of Phnom-Penh (Western part of the city is thought appropriate) the short-cut route between Sambor and Phnom-Penh must go through the marsh land along the Mekong River, and if a round about way is taken the length will be considerably large. Therefore, before determining the route, investigations should be made of conditions of transmission tower foundations and state of rainy season. Other parts of the route are covered with sparse forests or rice paddy where there is no large obstacles to construct the transmission line.

The route between Phnom-Penh and Sihanoukville will have to go over Elephant mountain range which, some 1,000 m in height, lies along the coast line. Therefore, it is considered the best to construct the transmission line along the highway crossing Pech Nil Pass. But if it is required to transmit electricity to Kampot the sub-station may be constructed at a site east of the Elephant mountain range. Then, the transmission line will not have to cross the mountain range and the sub-station will be situated at a site convenient for connections

to both Sihanoukville and Kampot. Except for the Elephant mountain range, topography is generally flat and highways are fairly developed. The transmission line between Sambor and Saigon could not be investigated of its route in the territory of Viet-Nam due to the internal affairs of the country. In Cambodia, the proposed route of transmission line is running through forests of deciduous trees which defoliate in the dry season, or so called monsoon forests. Near the border line there are large rubber plantations from place to place and most of the rubber trees are 20 to 30 years old. Therefore, attention should be paid in determining the route of transmission line to keep it away from the rubber plantations. Otherwise, it would be extroadinarily costy to acquire the right of way.

The same seems to be true in Viet-Nam. Other than the rubber plantations, woods of deciduous trees are generally sparse and thickly wooded areas are very small. Furthermore, most timbers are not valuable. Therefore, indemnification of deforestation will not be a large problem. Since the route can be settled mostly in parallel with a highway which links Saigon, Loc Ninh and Kratie, construction work of transmission line will be made easily.

As described in the foregoing pages, areas where the transmission will pass are generally flat except for Elephant mountain range and they are mostly sparse forests of deciduous trees or else rice paddies. However, even if the route is selected along roads, at many places it will be impossible to utilize vehicle transportation to the site of construction sites, especially, in the rainy season.

Accordingly, construction works are desired to be carried out during the dry season. In the dry season, there is practically no water even in a rice paddy, and at many places roads be constructed easily to facilitate transportation of construction meterials. Soil along the route of transmission line is alluvium deposited by floods of the Mekong River and its tributaries and at highlands it is red earths. Therefore, as far as the geology is concerned there is not

much difficulty in the foundation work of transmission towers except the marsh land.

However, it is thought difficult to obtain concrete aggregate of foundation structure near the route of transmission line.

The length of each section of the transmission line is as follows:

between Sambor and Phnom-Penh:	about 190 km
between Phnom Penh and Sihanoukville:	about 190 km
between Sambor and Saigon:	about 250 km

(5) 2 Elements to be Considered in Designing Transmission Line

The climate of lower Mekong basin is affected by typhoons which originated in South China Sea or in the Pacific Ocean east of the Philippine Islands attack on Indochina several times a year. However, due to the towering mountains of Annam mountain range in the east of the Mekong river basin, the violence of typhoons are weakened and the wind velocity around the proposed site of transmission line seems to have been slowed down.

This can be proved by the fact that there is a great difference in design wind pressure of Da Nhim transmission line in Viet-Nam and Yanhee transmission line in Thailand, both of which are 220 kv lines.

The design wind pressure of the present transmission line may be of small value, however, considerate investigations are necessary since there is a possibility of violent typhoons to come around Saigon. The design pressure of transmission tower is an important factor, because construction cost of towers largely depends upon the design pressure. Therefore, wind velocity records which are insufficient today should be completed in the future.

Lightning is also an important factor in designing a transmission line. However, data on lightning is almost none. According to what people said in the district, frequency of lightning is samll, therefore, lightning protective design may be neglected of the transmission line. But for the safety's sake it

should be investigated in the future.

Since the site of transmission line is totally covered with red lateritized soil, porcelain insulators may be deteriorated by the soil dust. However, in consideration of rain in the area which is almost nill in the dry season and showers in the rainy season, flash-overs caused deterioration due to fog may not be considered.

Dielectric design of the line may be treated lightly with respect to the resistivity against erosion by salt, excepting a section running near cost line, such as Shanoukville, and against the wind velocity.

The route of transmission line will be selected so that it will be situated near highways. Along major highways, however, communication cables are installed. Therefore, since the transmission line is extra high voltage, 330 kv to 400 kv, with neutral grounding system, a large current induced by a fault in the grounding system may well occur in the cable. But the number of channels in the cable which is overhead type is small, measures can be taken by protecting the cable at a comparatively low cost.

Therefore, even in consideration of the induced current, special dielectric design, such as overhead ground wire as induction sealing ground wire is not necessary.

In determining the conductor of such an extra high voltage transmission line, the largest problem is corona noise. Although radio is quite popular in both Cambodia and Viet-Nam, along the route of transmission line population is quite few, therefore, radio interference can be neglected except in the populated areas near the receiving ends. Therefore, a conductor of minimum size in respect of the transmitting capacity can be adopted.

As described above, there is little uneconomical factors in the design conditions of topography, wind velocity, lightning, insulation, conduction, corona noise, etc. Furthermore, as long as the construction is executed during

the dry season, construction cost of the transmission line may be curtailed to a large extent in consideration of no existence of major obstacles, easy transportation and availability of less expensive labor.

4-1-6 CONSIDERATIONS FOR INVESTIGATIONS TO MAKE IN THE FUTURE

The future studies are to be made on the technical as well as economical feasibility of the project on the basis of results of the first year investigations conducted with line C' program as its objective.

In other words, in order to conduct effectively the future investigations for Sambor Project in the coming two or three years, line C' program recommended in the Report on Preliminary Investigations was taken as the basis of the first year investigations which were performed of the topography, geology, materials to be used, hydrology and transmission line.

The results are as described in the foregoing pages and attached drawings.

As a consequence, line C' program should be completed by making material tests and hydrological model tests and preparing a preliminary design taking into consideration the results of the first year investigations, geological investigations by Snowy Mountains Hydro-Electric Authority and hydrological data compiled by Harza Company.

Then, further investigations may well be necessary of the topography, geology, fill materials of dam and water depth. The final decision of dam center line should not be made until line C Program described in the Report on Preliminary Investigations has been studied on its topography, geology and fill materials of dam and compared with line C' program.

Items to be investigated at site in the future are as follows:

(6) 1 Topographical Survey

Topographical surveys to be made are supplementary survey and check traversing of line 1 and line 4 at the abutment of line C' program, profile and cross-

sectional surveys and leveling of the center line of line 3 at the left abutment of line C program, topographical surveys of quarries and proposed site for navigation lock, and sounding between dam site and Kratie.

(6) 2 Geological Survey

Supplementary surveys including permeability tests are to be made of the foundation of dam. At the same time, boring tests are to be performed to investigate faults in the main river bed, fractured zone and geological stratification.

Also, line C program indicated in the Report on Preliminary Investigations should be investigated from the geological point of view to be compared with line C' program.

In the mean time, the site of spillway is to be totally investigated on its geological formation of bedrock, and earths and rocks to be excavated from the site are to be studied of their utilization as fill materials of dam.

Besides these, continual geological investigations are necessary for the important sites, such as those of powerhouse, lock for navigation, etc.

(6) 3 Survey of Materials

Investigations on the rock materials by borings, etc. should be continued on the basis of the results of the first year investigations and the report submitted by Snowy Mountains Hydro-Electric Authority with the major purpose of finding out solid rocks to be used for the embankment on the main river bed. Since such rocks are also required as concrete aggregate, important are the investigations of the present river bed and the right bank where concrete structures will be concentrated.

Fine concrete aggregate also need be investigated continually. The distribution of soils should be surveyed upon the basis of results to be obtained from the classification test on specimens collected during the first year investigations. Additional tests necessary for design and construction work are

to be performed of the soils.

For the effective use of weathered layers according to their proporties, such as sizes, etc., the survey should be made, if it is economically permissible, through ditch digging by a bulldozer rather than through test pits.

(6) 4 Hydrological Survey

Recordings of water level, amount of evaporation and precipitation which are now being taken should be continued for years. Since Harza Company, U.S.A. requested the Government of Cambodia to take records of stream flow, evaporation precipitation silt, wind velocity, etc., these records, naturally believed to have been taken, should be sorted as systematic statistics.

(6) 5 Investigations for Transmission Line

Since the transmission and consumption of electricity produced at Sambor Power Station have not been determined in the concrete, it is considered adequate to conduct the detailed investigation on the route of transmission line, etc. after the sending ends, capacity of transmission line, and other necessary factors are determined as a result of market research of electric power and so forth. Therefore, the purpose of investigations for transmission line, if conducted in 1963, will be to seize up the general conditions of transmission line route in the rainy season by observing from a reconnaissance air craft which is the only transportation during the season excepting in some limited areas.

4-2 INLAND NAVIGATION

4-2-1 THE LOWER MEKONG BASIN AND INLAND NAVIGATION

4-2-2 OUTLINE OF THE PROGRAM FOR THE CONNECTION OF INLAND NAVIGATION AT SAMBOR

4-2-3 FUTURE DEVELOPMENT OF INLAND NAVIGATION

4-2-4 PROGRAM FOR FURTHER INVESTIGATION

4-2 INLAND NAVIGATION

In the initial year, investigation on inland navigation for the Sambor project was devoted mainly to the collection of available data to obtain a general outline of the situation. At the same time, a program was drawn up for further investigations to be carried on from the second year on. This report gives

(I) the general features of the Lower Mekong basin with its inland navigation and facilities, (II) an outline of the program to connect inland navigation at Sambor, (III) the future development of inland navigation and its problems, and (IV) a program for investigations to be carried on from the second year on.

4-2-1 THE LOWER MEKONG BASIN AND INLAND NAVIGATION

(1) 1 Salient Features of the River

The Mekong river originates in the plateaus of Tibet, collects tributaries in Laos and Thailand along the border of the two countries, flows into Cambodia, and reaches Viet-Nam with deltas at the mouth of the river. Downstream from Kratie situated near the proposed dam site,the river attains a flat slope, and the features of the river show a marked change from the upper stretch of the river to Kratie.

The difference of water level at Kratie, about 550 km from the river mouth, and the river mouth is 15-20 m in the rainy season, and 4-6 m in the dry season. At Stung Treng about 130 km upstream from Kratie, the water level records a difference of 25-30 m in the rainy season, and 30-35 m in the dry season from the water level at Kratie, indicating a sudden change in the slope of the river. Upstream from Kratie, bed rocks protrude above the water level in the dry season, and the current makes its way between the rocks running swiftly in a straight flow in sections.

Downstream from Kratie, the water depth increases, while the velocity decreases, and the river takes a sincious course with sand bars left in the middle of the river, with considerable depths along the banks.

The rainfall which floods the Mekong delta falk heavily in areas upstream from Kratie, while areas around Grand Lac and the plains downstream from Komoong Cham receive considerably less rain. However, in the wet season, the water level begins to rise from June, reaching the maximum in August, and in stretches downstream from Kompong Cham, the water overflows from the banks, flooding a vast area of land. The flood water reverses its flow at Phnom-Penh up the Tonle Sao into the Grand Lac, inundating the surrounding areas. The Grand Lac serves as the flood detention reservoir of the Mekong proper.

Though the features of the Mekong may be roughly divided into features of the stretches upstream and features of the stretches downstream from Kratie, when observed in detail, different features may be noted in different parts of the river downstream from Kratie. The features of the river in stretches downstream from Sambor will be given for each district in regard to the water depth, water level, erosion and other peculiarities in the respective stretches.

a) Water Level

The highest high water level and lowest low water level Stung Treng, Kratie, Kompong Cham, and Phnom-Penh according to the stage hydrographs recorded by the Cambodian government in 1961 and 1962 are given in Table 1-1 or 1-2.

Table 1-1 Water Level at various Stations along the Mekong
(Metres above the mean sea level at Ha Tien)

Site	Distance from River Mouth	1961		1962	
		Highest	Lowest	Highest	Lowest
	km	m	m	m	m
Stung 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

b) Water Depth and Features of the River

The Cambodian government has conducted detailed sounding surveys of the Mekong proper from Kratie to the border of Viet-Nam, but the navigation of vessels depend largely on the conditions of the mouth of the river where it enters the sea, and the depth of the river between Kratie and Sambor.

b)-1 Conditions around the River Mouth

Downstream from Phonom-Penh, navigation is possible for vessels of about 2000 tons, though the water depth is not quite sufficient in certain sections. However, as the Mekong proper with several tributaries runs through the Mekong delta into the sea, the velocity of the current decreases, causing the sand which has been carried downstream to settle around the river mouth and form a shelving bottom. According to the chart, the contour line indicating a depth of 5 m lies at a distance of 15 km from the river mouth. The bottom of the sea stretches out in a moderate slope, and the muddy water of the Mekong is porbably scattered out into the sea as far as 20 km from the river mouth. Vessels navigating the Sang Cua Tieu, the northern most tributary of the Mekong, must pass through waters with

depths of -2.5 m —— -3.5 m over a distance of 10 km from the river mouth into the open sea. Therefore, vessels of 2000 tons navigating these waters take advantage of the sea tide for necessary depths. In the course upstream the Mekong, vessels stop by the Cape St. Jacques peninsula, and near the border of the country in the course downstream to wait for favorable tides, and seek the aid of pilots to steer the vessels through difficult waters.

The tidal range at My-Tho is 3.5 m at spring tide and 2.9 m at neap tide. Even with the increase of water depth at high tide, navigation will be limited to vessels of 2000 tons.

b)-2 Viet-Nam

According to the chart, the depth of the navigating channel is generally 5-7 m, though at Song Cua Tieu, the depth is merely 3-4 m in some parts, and the width of the river decreases to 500-600 m. Further upstream at Song My Tho and Tieng Giang the river assumes a sincious course and divides into several branches.

The width of the river increases, with sand bars in the river, and the depth of the river varies along its course. Where the river makes sharp curve in the form of the letter S, the depth of the river exceeds 10 m along the outer edge of the curve, whereas in sections where the river takes a straight course, and around the junction of rivers, the depth decreases to about 5 m.

b)-3 Phnom-Penh——Border of Cambodia and Viet-Nam

Upstream from the terrestorial border line, the Cambodian government has carried on sounding surveys for navigation purposes at intervals of 500 m. According to the chart drawn from the results of these surveys, sand bars are formed at distances of 8 km, 35 km, 48 km, 53 km, 65 km, 67 km, 71 km, and 80 km from Phnom-Penh.

Around the sand bars, the width of the river increases to about 1.7 km, and particularly around the Kon Peam Peung island, the river attains a width of 2.7 km, and 3.3 km at Kas Tachor.
Excluding the sections around the sand bars the river width averages 1.0 - 1.8 km with narrow stretches in some sections. At the section 42 km from Phnom-Penh, the river is merely 600 m wide, 500 m at a section 74 km, and 800 m at a section 95 km from Phnom-Penh. The center line of stream of the river usually runs along either the right bank or the left bank of the river.
The depth decreases at points where the center line of stream proceeds from the right bank to the left bank, and also at the upper and lower ends of narrow shoals. Water depths of less than 6 m are recorded at sites 6 km, 45 km, 69 km, and 77 km from Phnom-Penh, while at sites 42 km, 53 km, 67 km, 74 km, 78 km, and 95 km, the water depths recorded exceed 25 m.

b)-4 The Vicinity of the Port of Phnom-Penh

The river Tonle Sap joints the Grand Lac and the Mekong river, and the port of Phnom-Penh is situated near the junction at the lower end of the Tonle Sap. From the junction of the Tonle Sap and the Mekong proper, the river Bassac branches off as a tributary, and the Mekong proper takes a southeast turn creating a complecated current at the conjunction. As the water level of the main river rises with the approach of the wet season, the water reverses its flow up the Tonle Sap into the Grand Lac. The strip of land between the Mekong proper and the Tonle Sap stretches narrowly downstream, and in the waters where the four rivers cross each other, the accumulation of sand decreases the

water depth to 1.5 - 2.0 m. Though sounding surveys are carried on continuously every year to accommodate vessels of 2000 tons in the port of Phnom-Penh, this section presents difficulties in navigation in the route to Phnom-Penh. The Cambodian government is improving the waterway by dredging the channel every year, and installing aides to navigation. Upstream from the junction, the Mekong has a width of approximately 1 km, and the Tonle Sap approximately 500 m. At the junction, the width is 2 km, and downstream from the junction the width of the Mekong is approximately 1.7 km, while the width of the Bassac is approximately 600 m.

b)-5 Phnom-Penh- Kompong Cham

Upstream from Phnom-Penh to Kombong Cham sufficient width and depth is maintained for the navigation of vessels and barges in operation at present, and aids to navigation are not installed in the waterway. Under the present conditions, the navigation of vessels of 2 2000 tons will be possible with the instalment of aids to navigation, but as the features of the river is variable in certain sections, continuous investigations will be advisable in determining the necessary improvements. The river follows a sincious course and the width of the river varies along the way. Islands are scattered at sites approximately 8 km, 10 km, 65 km, and 95 km from Phnom-Penh, and sand bars formed by alluvial deposits of floods are found at sites 31 km and 36 km from Phnom-Penh. The width of the river is generally 0.8 - 1.5 km and the center line of stream is deviated to either bank, along which the river is quite deep, recording a depth of over 10 m along 85 % of the total length of the river. Particularly at sites 10 km, 22-29 km, 32 km, and 44 km from Phnom Penh, the depth reaches 25 m.

The river depth decreases at points where the center line of stream runs from the right bank to the left bank. Starting from a point 22 km from Phnom-Penh, the river makes a sharp curve in the form of the letter S over a distance of approximately 12 km, and the width of the river is merely 600 m with increased water depth and velocity. Erosion and alluvium is conspicuous along the banks, and sections newly cut by erosion and fallen trees may be found at sites 14 km (left bank), 37 km (right bank), 50 km (right bank), 83 km (right bank), and 95 km (left bank) from Phnom-Penh.

b)-6 Kompong Cham- Kratie

Compared with the lower reaches of the river, the depth of water decreases in the upstream stretch from Kompong Cham with more obstacles for navigation. This section of the river takes a sinuous course, scattered with bars and shallow spots marked by numerous aids to navigation. Islands and bars are found at sites 110 km, 122 km, 127 km, 152 km, 160 km, 175 km, and 200 km north of Phnom-Penh. The center line of stream crosses the river from the left bank to the right and vice versa several times in its course. Running upstream at sites 103 km, 106 km, 118 km, 136 km 139 - 142 km, 143 km, 144 km, 145 km, 146 km, 147 km, and 194 km from Kompong Cham, the depth at the center line of stream exceeds 20 m, while at sites 112 km, 115 km, 126 km, 144 km, 157 km, 168 km, 184 km, and 206 km away, the depth is less than 3 meters. Aids to navigation are installed at several locations given in Table 2.

Table 2

Site	Aids to Navigation	
7 km south of Kratie	red and white	1.
Ph. Kg. Kor. (approx. 26 km downstream from Kratie)	red and white	1.
	black and white	2.
Ph. Thmey (approx. 170 km from Phnom-Penh)	red and white	1.
Kas Phal (approx. 161 km from Phnom-Penh)	red and white	1.
	black and white	4.
Ph. Prenbor (approx. 130 km from Phnom-Penh)	red and white	1.
Ph. Romlion (approx. 116 km from Phnom-Penh)	red and white	2.
	black and white	1.

This section upstream from Kompong Cham is also subject to erosion. Particularly at sites 112 km (north coast of the sand bar), 116 km (right bank), 157 km (right bank), and 201 km (west coast of the sand bar) from Phnom-Penh, the river banks are eroded and the neighboring waters are of considerable depth.

Vessels navigate along a course about 50 m from the river bank.

b)-7 Kratie- Sambor

Sounding surveys have not been carried on in the waters beyond Kratie, but the water depth decreases and the velocity increases with numerous rocks cropping up from the river bed. Particularly around the dam site, in the dry season, rocks protrude to the surface, and the river course winds its way between the rocks, making navigation quite dangerous in the dry season except for small fishing boats.

(1) 2 Inland Navigation

With its slow river gradient and abundant water resources, the Mekong is highly utilized as an important traffic route to the interior. In the stretches downstream from Phnom-Penh, vessels of 2000 tons navigate the waters transporting foreign trade cargo, while domestic transportation vessels, barges, fishing boats, and timber rafts compose the main traffic in stretches upstream from Phnom-Penh. In sections, the Mekong is quite sinuous, but when viewed as a whole, its sinuosity is moderate and the ratio of the distance along the waterway and the straight line joining two locations is comparatively small. The distance between Phnom-Penh and Kratie by waterway is by far shorter than the distance by highway, accounting for the high rate of utilization. Overland transport requires less time than waterway transport, but waterway transport permits great savings in transport costs and causes less damage on the cargo. The Mekong has served not only as an important traffic route, but has also been used for irrigation purposes from olden times, and has been closely connected with the livilihood of the inhabitants. Villages have developed along the river banks with a dense population in the arears, and the inhabitants depend on the Mekong to a large extent for their daily livilihood.

a) Seagoing Vessels

500-600 vessels enter the port of Phnom-Penh in one year. Showing a gradual increase in number, 525 vessels with a total tonnage of 483,468 tons entered the port in 1961, recording an increase of 50% as compared to figures of 1956.

In 1962, the number of vessels increased to 625, and overcoming difficulties in navigation and inconvenience from insufficient facilities, more vessels utilize the port for inland waterway transports. The amount of foreign trade cargo handled recorded 514,000 tons in 1958, 682,000 tons in

1959, 842,000 tons in 1960, and 742,000 tons in 1961. Exports slightly exceed imports in tonnage, but imports by for exceed exports in value. Rice and other grains occupy the larger part of the exports, together with rubber, timber, charcoal, animals, fruits, and fish. Cement, edible oil, steel, machinery, textiles, bicycles, and general goods are the main articles imported.

b) Coasting Vessels

Vessels using the river for waterway transport include liners for passenger and cargo, fishing boats, ferry boats, barges, sailers, tug boats, and timber rafts. Liners navigate the upper and lower streams of the Mekong, the river Tonle Sap and the river Bassac, with Phnom-Penh as the center of traffic. Several companies operate the liners comprising a major network of local transportation, conveying passengers and cargo with some sixty or seventy vessels. The size of vessels vary from 50 - 150 tons and each vessel carries 150 - 300 passengers. These liners also transport rice, vegetable, fruits, groceries, drinks, clothes, cement and daily necessities. Rice, vegetable, and fruits are carried from the country to the cities, and manufactured goods and daily necessities are carried from the cities to the country.

Ferry boats are operated at Neak Luong, Prek-Kdam, Kompong Cham, and Se Kong, as there are no bridges across the Mekong. Ferries at Prek-Kdam handle the largest amount of traffic, with those at Neak-Luong, Kompong Cham and Se Kong following in the order of the traffic handled. Ferry traffic at Se Kong is merely 1/10 of that at Prek-Kdam, indicating that the district is still undeveloped. At Prek Kdam 150 motor cars, 100 trucks, and 80 buses are transported on an average per day. The size of the ferry boats vary according to the traffic, but at Prek-Kdam, the ferries are large enough to transport 8 cars at a time, while at Kompong Cham, 5 cars are loaded on one

ferry.

Sailer barges navigating the Mekong are mostly of 100-200 tons, each barge tranporting a cargo of rice, fruits, timber, charcoal or cement separately. Some are self-propelling while others are tugged by tug boats in a group of two or three barges. Barges registered with the Cambodian government include 2,279 wooden barges of over 16 tons, the average tonnage of which is 50 tons, 27 steel barges with an average tonnage of 185 tons, 10 self-propelling barges with an average tonnage of 140 tons, 138 tug boats for launches with an average of 45 tons.

Not many rafts are found in the upper stream as the area has not been much developed, but in the lower stream of the river, logs from the surrounding forests are drifted down the river in rafts. Logs come largely from Choeuteal and Phdiek, but as logs from bolt districts are of hard wood with a specific gravity of 1.3, they do not float in water. Therefore bamboo stems are cut and tied together to serve as a float for the rafts. The average raft is about 8-12 meters wide, 10-15 meters long with a depth of 2 meters. 5-6 rafts are towed by a barge, and the total length from the head of the barge to the end of the last raft is about 80-110 meters.

Long distance liners navigating the stretch upstream from Phnom Penh run between Phnom Penh--Katie, Phnom-Penh—Kompong Cham, and Kompong Cham—Kratie with numerous small ferry boats running on local lines. The line between Phnom-Penh—Kratie with very few ports of call requires 13 hours and operates at nights as well. Lines between Phnom Penh— Kompong Cham, Kompong Cham—Kratie with 21 and 28 ports of call respectively, requires 8 and 9 hours and run mostly during the daytime. Small vessels operate on short distance local routes and call at ports which are not called by long distance liners.

c) Mooring Facilities for Vessels

Mooring facilities in the port of Phnom Penh are divided into facilities for seagoing vessels and those for inland traffic boats. A ferro-concrete pier and pontoons serve seagoing vessels while simple pontoons are provided for inland traffic boats.

c)-1 Facilities for Seagoing Vessels

In the port of Phnom Penh, a ferro-concrete pier with two berths and four pontoons constitute the facilities for seagoing vessels. The pier is 12 m wide and 185 m long, and stands above the maximum high water level so that the loading and unloading of cargo may be carried on at all times. However in the dry season the difference between the top of the pier and the water surface exceeds 10 m, decreasing the efficiency in cargo handling.

The four pontoons measure 20 m x 60 m, 20 m x 40 m, 20 m x 40 m, and 80 m x 20 m respectively, and each consist of a group of steel floats. A transfer bridge spans out from the shore to the pontoons, but in the dry season, there is a large difference of elevation between the pontoon and the shore. Loading and unloading of cargeo between the vessels and the pontoons are handled by derricks but depend mostly on longshoremen to convey the cargo between the pontoons and the shore. Therefore in the dry season, unloading of cargo is particularly difficult requiring a considerable amount of time and labor costs. To eliminate this inconvenience the bridges are provided with chutes, but their use is limited to cargo in bags and other small articles. As the pontoons are worn out from continuous use over a long period, the load is limited to a fixed weight, further decreasing the efficiency of cargo handling. The pontoons are also used in loading and unloading animals and general cargo.

Inadequate facilities account for the low efficiency in cargo handling,

but on the whole sufficient facilities are lacking to cope with the amount of cargo to be loaded and unloaded. Vessels entering the port must often wait offshore for butting or depend on offshore cargo handling. In 1962, for the 625 vessels entering port, the total number of days of moorage reached 2,669 days, equivalent to an average of 4 days per vessel.

c)-2 Facilities for Inland Traffic Boats

Of the inland transport lines upstream from Phnom Penh, details are not available for short distance lines, but in the ports of call of long distance lines, the facilities on the coast are of a much simpler type compared to those in the port cities of Phnom Penh, Kompong Cham, and Kratie.

In the port of Phnom Penh, further downstream from the facilities for seagoing vessels, 24 pontoons (20 are in actual use) are provided for inland traffic boats. The pontoons are mostly wooden pontoons or steel float pontoons of a shallow draught with a simple transfer bridge. The majority of the pontoons measure approximately 6 m x 10 m. With the rise of water level, the pontoons are drawn nearer to the shore as far as the draught of the boats permit.

At Kompong Cham there are four pontoons similar to those in Phnom Penh. The largest pontoon is about 15 m x 8 m, and they are also movable according to the change of water level. In Kratie there are four pontoons with bamboo poles as floaters and the largest measures about 10 m x 7 m. There is also another pontoon for official use. Due to the shortage of pontoons, some barges more directly along the coast. In the upper stretch of the river from Kratie, houseboats and fishing boats are moored along the coast. Between Phnom-Penh — Kompong Cham and Kompong Cham — Kratie, the boats call at 21 and 28 ports respectively, of which 17 and 22 are equipped with pontoons. In other ports small crafts run between the boats and the shore. The pontoons are floated by the buoyancy of bamboo poles.

About 20 poles are fastened together and floated in two positions with wooden boards fixed between the bamboo floats to complete the pontoon. The pontoons measure approximately 8 m in length and 5-6 m in width.

These inland transport boats carry besides passengers, such cargo as rice, grain, fruits, vegetables, daily necessities, cement, parts for small machinery, and the cargo handling depends entirely on the shoulders of longshoremen with simple chutes provided in some locations. Therefore in parts such as Kratie where the range of water level is particularly great, the unloading of cargo from the boats to the shore demands the service of numerous laborers. Pontoons along the river course are installed in location with sufficient water depths, and in locations which are not provided with pontoons, mainly in shallow waters, small crafts are used for transportation between the boats and the shore over a distance of 30-50 m. Even in densely inhabited areas crowded with devellings, boats do not make a call if the waters are of insufficient depth. Therefore it may be assumed that the landing places will be subject to change with the change in the depth of the river as the center line of stream shifts its course in time.

4-2-2 OUTLINE OF THE PROGRAM FOR THE CONNECTION OF INLAND NAVIGATION AT SAMBOR

With the construction of a dam at Sambor, the backwater would reach Stung Treng, extending the navigable waterway to reaches hitherto closed to navigation. However, in view of the general economic conditions, future development of the area, and undeveloped resources of the Stung Treng district, waterways which will become navigable by the construction of a dam at Sambor would not greatly affect the inland transport network as merely a portion of passengers and cargo transported overland would be aborbed. Considering the cargo expected in the future with the industrial development of the district, the traffic flow will

still be much smaller in comparison with the stretches further downstream and the vicinity of Tonle Sap. The favorable effect on navigation resulting from the construction of a dam would be small in comparison to the high cost of construction. The construction of a series of dams proposed along the middle stream of the Mekong proper in the future will lead to the generation of hydraulic power and improvement of navigation. The Khone Falls and stretches with swift currents at Kheramat will be absorbed and vessels will be able to reach Vientiane. Under these conditions a considerable amount of cargo depending on overland transportation along the upper and middle stretches of the river would be shifted to waterway transport. Improvement of navigation will lead to the possible development of natural resources hitherto undeveloped due to difficulties in transportation and expenses involved.

The contribution of the Sambor dam on the improvement of navigation will depend largely on the possibility and date of the construction of dams in the upper streams. The question of when and how these dams will be constructed will be the key in determining the importance of the Sambor dam. In planning methods for the connection of inland navigation at the Sambor dam, the scale and structure will naturally depend on whether the dam will be a single project or a project included in a series of dams in the upper stream. Therefore it would be advisable to consider a general plan or a project of a small scale providing for expansion in the future.

(2) Connection of Traffic

Generally the following three methods may be considered for the smooth transport of passengers and cargo at the site of the dam.

A. To stop the traffic at the dam site and tranship the cargo by cranes and other means.

B. To construct a slipway to transport vessels across the dam.

C. To construct a lock

Sufficient data is not available at present to determine the most appropriate method. However, as the Sambor dam is situated at the furthest downstream end of the series of dams, the method adapted at Sambor would have a considerable effect on the dams further upstream. From this point of view, method A will save the cost of construction, but the transhipment will cause inconvenience and delay, and the cargo will be subject to greater damage. Method B has the same disadvantages as method A. In the period immediately after the construction of the dam, traffic flows will include timber rafts, charcoal, agricultural products, daily necessities, and construction material, but with the development of the inland districts, shipment of mineral products, raw materials for industries, fuel and manufactured goods is expected to increase the traffic flow. The construction of a lock would best meet the demands of transporting cargo of various type and volume.

(2) Plan of the Lock

The arrangement of the lock will depend on the location of the dam and the normal line, and will also be affected by the location of the power generating plant and the intake and spillway of the dam.

The following points must be taken into consideration in determining the location of the lock. It would be advisable that,

A. The lock is in easy access from the navigable channel of the river.

B. The lock is not affected by the running water around the intake and spillway.

C. The lock is constructed on favorable foundation soil.

At the dam site of Sambor, rocks protrude to the water surface in the dry season, and the river water flows between the rocks. Sounding surveys have not been carried on in the stretches from Sambor to Kratie, but the center line of stream seems to be divoted to the right bank.

Near the site of the Sambor dam, rocks and shoals make navigation impossible during the dry season. The construction of the dam would regulate the discharge and raise the water level in the dry season. The water depth will be greatly increased but the Sambor dam alone would not contribute much to improve navigation.of other dams along the river, but in respect to this particular location, it must be planned to enable vessels to reach the lock with the construction of a single dam at Sambor.

Therefore it may be advisable to provide a canal for the navigation of vessels at the lower stream of the lock. Final judgement must be based on the investigation of water depths and bed soil in the stretch between Sambor and Kratie. If the soil consists of a rock bed, it may save expenditure to build a new canal rather than to dredge the present channel for navigation purposes.

(2) Dimensions of the Lock

The size of vessels and rafts which will pass the lock will be limited by the features of the Mekong. The current velocity of the river increases in the wet season. Large vessels are more capable of overcoming the rapid flow in the journey upstream but the limited depths of water due to a drop in the water level in the dry season impose a limit on the maximum size of vessels. The dam will serve to moderate the swift current to the advantage of navigation, but will not exercise much effect on the water depth. The improvement of the navigating channel between Sambor and Kratie will merely extend the present traffic of transport vessels, barges, fishing boats and timber rafts from Kratie to Sambor, without any substantial change in the size of vessels. Thus the dimensions of the lock will depend on the size of vessels in navigation, which in turn are limited by the features of the Mekong river.

On the other hand, from the economic point of view, the dimensions must be determined on the basis of the present economic conditions, development program, future supply and demand, and the transportation program of the Mekong basin. A coordinated study of these problems would require a wide investigation by a staff of economists and a great deal of time. The Flood Control Series No. 12 published by the ECAFE recommends that the stretch from Kratie to Vientiane be improved to accommodate 2 tugboats of 320 HP and 2 barges of 100 tons in the navigable channel. The lock must be of sufficient size to accommodate these vessels as well as timber rafts in the present traffic. As mentioned before, the logs do not float in water because of their specific gravity, depending on a bundle of bamboo poles to increase the buoyancy, so that the entire raft is about 8 - 12 m wide, 10 - 15 m long with a depth of 2 m. As they are usually towed in a group of five to six rafts in a row, the entire length of the flotilla composed of a tug boat and rafts extend over 80 - 110 m.

4-2-3 FUTURE DEVELOPMENT OF INLAND NAVIGATION

The Mekong river will obviously become the main artery of the inland transport network as river transport of passengers and cargo surpasses overland transport as waterways furnish safe, easy and economical means of transporting a large volume of cargo. The economic development of the Mekong basin will increase the demand for waterway transport. If a series of dams are completed in the upper stream, removing obstacles for navigation, the development of the upper basin will further increase the traffic flow. New industries and the development of natural resources will result in various types of cargo of different volume. The following factors will pose as problems in the future development of inland navigation.

(3) 1 The Effects of the Construction of a Dam on Navigation

The construction of a dam will regulate the discharge, decreasing the maximum flood discharge and increasing the droughty water discharge. The reduction in current velocity and increase of water levels will have a favorable effect on navigation, but on the other hand, the accumulation of sand deposits due to a moderation of the current velocity and a change in the water course is to be expected. The latter effects will be observed as a phenomenon common to the entire course of the Mekong river as well as a local phenomenon on a small scale, requiring a long range continuous investigation and study. The construction of a single dam at Sambor is not expected to give rise to any problems for navigation as there will be no significant effect on the regulation of flow. However, at Kratie only a short distance from Sambor, the river may be affected by the project. Kratie is situated 15 km from the proposed site of the Sambor project, and slightly upstream from Kratie, the width of the river expands to almost twice the upper stretches with a large shoal in the waters in front of the city of Kratie. The sand of the shoal may shift with the change in the features of the river, and dredging may be necessary to improve the navigable channel in the future.

(3) 2 Improvement of the River Course

With the increased demand for waterway transport on the Mekong in the future, the traffic will probably increase in the number and size of vessels. At present vessels of 2000 tons navigate the river only as far as Phnom Penh, but the river is navigable to a point slightly upstream from Kompong Cham. With the development of new industries in the Kompong Cham district in the future, the port will be capable of meeting requirements of seagoing vessels without any improvements of the channel.

However, further upstream there are several shallow spots, and navigation will be limited to ferry boats of the size in operation at present.

Navigability may be improved by dredging the shallow spots and constructing likes to concentrate the flow in the channel, but as the features of the river is variable in these reaches, it is doubtful whether, sufficient water depths can be maintained. It will probably be necessary to dredge the channel every year as in the case of shallow spots at the mouth of the port of Phnom Penh. The present aids to navigation will be sufficient to meet the needs of navigation during the daytime if they are relocated on the basis of surveys from time to time. However lighted buoys must be installed to provide for the increase of traffic flow at night in the future.

The difficulty in navigation in the stretch downstream from Phnom Penh lies in the sand bar extending offshore from the mouth of the river. At present, vessels of 2000 tons take advantage of the tide to pass the bars. The rate of accumulation is not clear, and the amount of sand deposited may be slight, but the accumulation is most likely to increase each year. The construction of dams in the upper stream will reduce the flushing effect of the flow, and the bars at the river mouth may be subject to the influence of the current in the navigating channel. Dredging the sand bars at the river mouth may improve the waterway but the cost involved would be unduly high. Moreover, the sea is very rough when the north east trade winds blow, and the sand at the sea bottom is liable to drift, rendering it difficult to maintain the water depths necessary for safe navigation.

(3) 3 Navigation Facilities along the River

There are numerous ports of call along the Mekong river, most of which are provided with simple pontoons to handle passengers and cargo. The relocation of the pontoon in accordance with the variation of water level is a very practical approach to the problem. Due to the steep range between high water and low water, cargo handling requires a great deal of labor and time. Improvement of facilities need not be considered at present, but the

instalment of simple chutes to load rice and other products packed in bags and boxes would help to improve the efficiency of cargo handling. The dams in the upper stream will reduce the range of high water and low water to the advantage of cargo handling, but with subsequent changes in the features of the river, the waterway in front of the pontoon may be subject to other disadvantages. The present pontoon is well adapted to the situation, and it would be advisable to study further improvement of facilities upon the completion of the dams. However, at Phnom Penh, Kratie, Kompong Cham, and also at Stung Treng further upstream, improvement of facilities may be necessary at an earlier date.

(3) 4 Port Facilities at Phnom Penh

The port of Phnom Penh prospers as a river port, capable of accomodating seagoing vessels, but possesses the following disadvantages.

A. There is a large shoal offshore the river mouth of the Mekong, and though vessels take advantage of the tidal range for navigation, the maximum size of vessels permissable is limited to 2000 tons, with prospects dim for any substantial improvement.

B. Sand drift is liable to accumulate at the confluence of the Mekong river and the Tonle Sap and Bassac rivers, necessitating maintenance dredging every year.

C. The marked variation of water level decreases the cargo handling capacity in the dry season involving a great deal of time and expenses for loading and unloading cargo.

In spite of these disadvantages, the amount of cargo handled in the port of Phnom Penh shows an increase each year, and the facilities are insufficient to cope with the increasing amount of cargo, and delay in moving and offshore cargo handling increase the cost of transportation. The Cambodian government has constructed its sole seaport for seagoing vessels at Sihanouk-Ville to divert the traffic.

However, as the Mekong is the main artery of inland transport, and as Phnom Penh, situated in the center of the Mekong plains is the center of politics, economy, and industries, the concentration of cargo in the port of Phnom Penh is expected to increase in the future. Particularly with the future development of the upper and middle basins of the Mekong and its tributaries. Phnom Penh will become the center of storage of goods, manufacturing, and transhipment of cargo from small barges to large vessels. Cargo which will benefit through this route rather than the route via Sihanouk-Ville will continue to concentrate at Phnom Penh. The position the port of Phnom Penh occupies as the base of the waterway transport network of the Mekong will not only remain unchanged, but increase its importance in the future. The construction of mooring facilities for seagoing vessels must be considered to provide for increased future traffic.

4-2-4 PROGRAM FOR FURTHER INVESTIGATION

The first step of the investigation program carried on in the initial year consisted mainly of obtaining a rough outline of the inland navigation system. Investigations to be carried on in the future from the second year on will include a study of inland navigation, features of the river, and sounding surveys and soil investigations to obtain necessary data and information to draw plans for navigation facilities at the Sambor dam. A preliminary design of the lock at the dam will be drawn on the basis of data and information obtained from the investigations.

A. Investigation of Inland Navigation

Investigation of vessels, cargo, navigation facilities and overland transport conditions will be carried on through the collection of available data.

B. Investigation of the Features of the River

The water level, discharge, and current velocity of the Mekong proper will

be studied through the collection of basic data.

C. Sounding Surveys

The water depth of the river from Kratie to the Sambor dam over a distance of 15 km will be surveyed at intervals of 500 m.

D. Topographic Surveys

Plane surveys and leveling will be carried on at the proposed site of the lock and also along the projected line of the channel.

E. Geologic Surveys

Boring will be conducted at several locations to determine the site of the lock and the line of the channel. Laboratory analysis of the soil will be made if the bed soil is found to be weak and soft. Survey by sound waves will also be conducted.

F. Plan of the Lock

Plans for the arrangement of the lock and the channel and a preliminary design of the structures will be drawn.

4-3 AGRICULTURE

4-3-1 THE PRESENT SITUATION

4-3-2 PROBLEMS OF DEVELOPMENT

4-3-3 MATTERS FOR SURVEY IN AND AFTER THE SECOND YEAR

4-3 AGRICULTURE

The agricultural development of the region along the Mekong river, from Kratie to Kompong-Cham will be expected according to the construction of the Sambor Dam. The first year agricultural survey was carried out to consider the present situation and problems of such development as well as how to proceed with agricultural surveys proposed in and after the second year. The results of the survey have been arranged in the following classes; (I) The present situation, (II) Problems of development and (III) Matters for survey in and after the second year.

4-3-1 THE PRESENT SITUATION

(1) Outline of Agriculture in Cambodia

Agriculture occupies a very high position in industrial fields in Cambodia, which is poor in underground resources and has recently entered into the early stage of light industries in some parts. Accordingly, agriculture may be said to be an only industry that supports the economy of this country. The Government is also making its best to promote agriculture. The Agricultural structure is generally so simple, that it is built up of such crops and vegetables as seen in Table 1. Rice occupying almost all part of the annual agricultural income, provides food for the people and at the same time is an important item of exports, covering about 40% of the total amount exported. Cambodia situated between lat. 11° 35' N. and lat. 15° 11' N, belongs to the tropical zone, and is suitable for the growth of crops throughout the year with the monthly mean temperature ranging from 25°C to 29°C. The distribution of rainfall, divided into two parts - the dry season and the wet season, determines the patterns of agricultural production. How to make up the shortage of water in the dry season and how to control future floods in the wet season may be factors to decide upon the future of agricultural development in this country.

Agriculture in Cambodia is supported by water of the Mekong river flowing from north to south, a little to the east of the middle part of the country and its tributaries. Cultivated lands are generally distributed on areas along the Mekong main river and its tributaries. However, cultivated lands are developed in groups in the lower reaches of the Mekong main river, below Kg.-Cham and around lake Tonle Sap. Rice is the main crop grown there.

Table 1

Agricultural Products in Cambodia

	Harvesting Area (ha)		Production (ton)	
	1959 -- 60	1960* -- 61	1959 -- 60	1960* -- 61
Rice	1,355,000	1,300,000	1,419,200	1,300,000
Maize	106,500	38,820	122,200	45,800
Sweet Potato	800	1,250	4,500	6,900
Green Peas	14,600	19,620	9,400	12,800
Soy Beans	8,400	2,000	4,600	1,200
Sugar Cane	2,100	8,500	-	-
Sugar Palm	1,013,900+	1,000,000	27,400	27,000
Peanuts	4,900	3,100	2,500	1,550
Sesame	3,300	5,200	900	2,600
Castor Beans	50	700	38	500
Coconut Palm	400,000+	803,500+	14,000,000x	32,140,000x
Jute	1,200	-	1,940	-
Remie	1,200	1,400	3,380	500
Kapok	1,273,600	978,720+	5,000	3,900
Tabacco	12,200	9,820	7,100	5,700
Pepper	1,004,400+	1,004,400	2,000	1,500
Cotton	1,300	3,200	600	1,119

+ shows the number of trees or plants.

x shows the number of fruits.

Column marked with * shows figures in the wet season alone.

(1) 2 Price culture in Cambodia

Rice is the staple food of the Cambodian people, and most important as the principal one of agricultural products exported. The condition of this crop works a great influence not only on farmers' income, but also the national economy. The production of hulled rice has recently had a tendency to increase, but the past 10-year statistics show a procution of 1,553,000 tons of hulled rice in the richest year (1960-61), while 775,000 tons in the poorest year (1954-55), reducing about a half. Such a remarkable difference between rich and poor years is caused by natural irrigation which depends on only the increased water of the Mekong river. Rice which is sown or transplanted in the proper time and grown with proper care in its early stage and blessed with a continued supply of irrigation water, shows a very favorable stand. On the other hand, rice which suffers from a shortage of water from time to time, though it can be sown or planted in the proper time, grows unfavorably. Another big cause of a unfavorable crop condition is to miss the till of sowing or transplanting, because the wet season sets in earlier or later according to the year. Rice plants sometimes grow together with weeds, and sometimes are overrun by the latter. In the worst case the plants grows only 10 cm odd tall, keeping barely alive. Farmers cannot of course get sufficient yeilds from such poor rice plants. But they sometimes give up their rice cultivation by missing the time of transplanting. Accordingly, what is most important to stabilize rice culture in this country is not to miss the time of irrigation. At present rice is grown in most provinces, but Battambang, Kg.-Cham, Preg Veng, Svay Rieng and Takeo are, as seen in Table 2, biggest rice-producing provinces. To cultivate rice Cambodia like Japan adopts the transplanting method and the direct-sowing method. The transplanting method is generally adopted, and prevailing all over the country. Rice planting is usually done in the wet season. But the other way is to transplant rice in fields one after another when water goes down enough to

make the transplantation feasible after the end of the wet season. (Receding water period rice). During the growth season irrigation is practised by a simple methods of lifting water by man-power. The variety used is a short-period one. In this case the producing cost is higher owing to irrigation and others than that of a rice crop grown in the wet season. In the case of direct-sowing, when plowing is easily done in the wet season land is plowed by two work cattle, broken to pieces and levelled. Then rice is sown thereon. In this case it is considered necessary that the early stage of growth is allowed to elapse in such condition as of upland field. If there is shallow water on the field in the early stage of growth, the water which is abnormally heated, kills young rice plants. Rice in Cambodia is divided into the following five varieties according to the time of cultivation:

Early-maturing rice Medium-maturing rice Late-maturing rice	Transplanted in wet season

Floating rice

Receding water period rice.

Rice transplanted in the wet season is most prevailing, occupying 90%, receding water period rice 1%, and floating rice 9%. As stated above, the cultivating method of rice is very extensive. This is, to be sure, because fermers are so poor that they cannot economically afford to practise intensive cultivation, but because rice plants are in deep flooding water in the most part of the growth period and left as they are without any chance of applying fertilizer being found at all. Also, a shortage of labor all over the country is a great factor to impede the practice of intensive cultivation. Accordingly the yield per ha is only 1-1.5 ton, less than 1/4 of that in Japan.

Table 2

Cropped Area By Provinces

(1,000 ha)

	1930	1955-56
Battambang	134	130
Kanpot	52	79
Kandal	43	75
K.-Cham	78	115
K.-Chchnang	21	48
K.-Speu	28	62
K.-Thom	42	57
Kratie	20	5
Stung Treng	-	2
Prey Veng	75	116
Pursat	20	34
Siem Reap	38	37
Svay Rieng	113	91
Takeo	134	149
Total	810	1,000

(1) 3 Outline of Surveyed Area

Areas along the Mekong river, from Kratie to Kg.-Cham, where a survey was recently made cannot always be called the agricultural center of this country from the viewpoint of rice cultivation. Especially, Kratie Province, covered with forests in the greater part, has recently introduced rice cultivation. In this province rice fields are only developed on a narrow zone along the Mekong river, below the planned dam site of Sambor. On the contrary, Kg.-Cham province with a great population has rice fields stretching extensive all over

the province. Besides rice culture, it has rubber plantations as a large-scale enterprise in the eastern hilly zone. Other agricultural products have gradually been on the increase in recent years. It is commonly found in the both provinces that there are a lot of cultivated lands and villages also, developed on the left-side bank. As one approaches to Kg.-Cham City from Kratie one finds more grouped cultivated lands of large area. Almost all these lands are fallow in the dry season. However, on the belt-like zone, 100-500 m in width, along the Mekong main river and its tributaries farmers were seen watering maize, tabacco, egg-plants, water-mellons and sweet potatoes grown on fields carrying pails on a pole. On the both banks of the main river there are also marshy lands-- the nearest one about 1 km, and the farthest one about 5 km distant from the main river. Within the area we reconnoitered we found several such lands. They had water remaining in the middle part even in the dry season. Around them the cultivation was being practised of rice, maize, tabacco and water-mellons. These marsy lands are about 200-300 ha in area at the smallest and more than about 1,000 ha at the largest. Notwithstanding the farmers in this country suffer from excess water, they are found desiring to cultivate by utilizing even a small amount of water on the other hand. Generally speaking, farmers in this zone are thought to belong to the poor classes in this country. We heard but simply that the annual income per household is 200,000 riels at the most and 2,000 riels at the least, and the rice crop occupies 90% of the sources of their income. As outlined above, agriculture in this zone especially in Kratie, is at a very low level in the present condition. According to the soil survey by Mr. Saheki, an instructor of Hyogo University, the alluvium on the east bank of the Mekong river, upstream of Phnom-Penh is most favorable in this country. Most desirable for rice cultivation in this zone is that the artificial regulation of water and the control of innundation are made feasible. But in order at least to stabilize rice cultivation it is important to regulate as much

water as required. And if the practice of irrigation in the dry season will make it possible to introduce other crops than rice to this zone it will not be difficult, we consider, to expect even a very promising agricultural development in the future.

Furthermore, development in the following direction would be more desirable. The Sambor Dam is not particularly planned to have a function of controlling flood, but if sufficient water for upland irrigation can be supplied from canals built directly to the dam, or irrigation can be practised with water lifted at places by utilizing electric power to be generated here these will be a fair chance for the following switchover of the method of developing this zone. That is, the "rice-- fallow" pattern as has been adopted will be converted to the "upland crops -- rice" pattern. Stress will be transfered to the production of upland crops, and rice crop will rather be put second in importance or rice cultivation will be suspended in such a zone as is to be severely damaged by flood. This means that agriculture in this country which has relied upon a rice crop alone is clearly switched over to upland crops. This will contribute a great deal to the development of the national economy and the advancement of farmers' economy. However, to fulfil this purpose what variety of upland crops should be selected and what method of production adopted? These questions should be considered from both aspects of the future agricultural production all over the East and South Asia and demands at home. If proper crops can be selected it will not be impossible that this zone be the future center of agriculture. As for facilities, Baray Occidental irrigation facilities constructed in Siem Reap through the technical assistance of the United States have been used these several years, and only a few are under planning. Other small-scale ones are in use at different places. In Kratie and Kg.-Cham Provinces, too, there were found small-scale facilities, completed and under construction, at several places. Irrigation facilities, though small in scale, are anticipated

to gradually increase in number, because the Government itself is endevouring for this purpose.

4-3-2 PROBLEMS OF DEVELOPMENT

Our recent survey was restricted by the fact that it was not always the proper time to grasp the agricultural situation in Cambodia as we worked in the middle of the dry season and a short period of survey prevented us from getting sufficient data available. However, problems of development are anyhow mentioned as follows;

A. Although agricultural production is at present very low, if the proper method can be just adopted the agricultural development of this zone will be a great possiblity. This will not only enrich the farmers' economy but also fairly contribute to the growth of the national economy.

B. The key-point to agricultural development is of course to utilize water. How to combine the Sambor Dam with water utilization must be throughly considered.

C. Agriculture which has so far been almost dependent upon nothing but rice is expected to undergo a great changeover, and it is necessary to consider both economic value and direction of the future agricultural productive structure.

D. In case agriculture in this zone has been developed highly it is a shortage of labor that will be naturally conceivable. Its countermeasure should therefore be considered.

E. In carrying out our recent survey we could not make clear the arrangement and distribution of cultivated lands. This was due to a lack of the statistics of the whole agriculture and other sufficient data. Consideration should be given to this respect in proceeding with further surveys.

F. What significance the development of this zone has in Cambodian national economy must be clarified. For the purpose is it necessary to grasp the actual

condition of agriculture in other regions.

G. Agricultural development is an urgent problem for Cambodia to solve, but how is a time lag of the contruction of the Sambor Dam dealt with? It may be impossible for this country to postpone agricultural development until the completion of the dam. If possible, an intermediate measure which connects the above two matters with each other would have to be considered as a part of the project of the dam.

4-3-3 MATTERS FOR SURVEY IN AND AFTER THE SECOND YEAR

Grasping the actual condition of agriculture in and after 1963, various considerations are given to a case where irrigation water is taken directly from the dam from the aspects of crop, livestock, soil, fertilizer, peat and insect, management, water use and land use. Making the required survey and design relating to these cases, their possibility is explored. And with a view to formulating the Sambor agricultural development plan, surveys are carried out concerning the following matters:

(3) 1 Urgent Surveys

A. Print of a 1/40,000 air photo; mapping of an air photo 1/20,000. The existing map is so in sufficient as the basic data for carrying out further surveys, that an air photo of a region of about 5,600 km^2 stretching on the both banks of the Mekong river, from Sambor to Kompong-Cham is mapped and an air photo of a region of 36,800 km^2 is printed.

B. Surveying of canal lines.

In order to develop agriculture in the region downstream of Sambor it is expected anyhow to irrigate the existing cultivated lands covering about 50,000 ha on the both banks of the Mekong river with water to be intaken directly from the dam. Therefore, consideration is given to canal lines in comparison with the air photo in (1)-a, and reconnaissance and surveying are carried out

concerning the main and branch canals and the principal structures. Then, comparing costs of irrigation water, the Sambor agricultural development plan is laid down.

C. Survey of the distribution of arable lands.

Lands benefited by irrigation water intaken directly from the Sambor Dam are anticipated to cover about 50,000 ha, but it is impossible to have an exact grasp of the distrubution of arable lands from the existing map. Therefore, the outline is grasped from the print of the air photo as well as 1/20,000 topographical map prepared by mapping the air photo, in (1)-a. If there are some points still remaining obscure, field reconnaissance and survey are carried out to clarify them.

D. Surveys of land-and water-use.

In Cambodia where artificial irrigation is not developed yet, farming practices are done only in the wet season, but more detailed investigation shows that the methods of water use and land use have their respective regional features. The rice crop condition is not stabilized according to the year in Cambodia. This is solely caused by the fact that irrigation is exclusively dependent on rainfall. So much so that there seems to be a considerably delicate problem as to what water-and land-use should be. Accordingly, a firm grasp of this actual condition together with cultivation custom is so required to lay down the future irrigation and drainage plan, that the survey should be made of regional differences at a sample place selected in the surroundings of Kratie, at two sample places on the both banks, half-way between Kratie and Kg.-Cham, and at two sample places in the suroundings of Kg.-Cham.

(3) 2 Survey of the actual agricultural condition.

In case irrigation is possible, it is desirable that agriculture in this region be greatly developed in the aspects of the introduction of new crops and

the method of intensive cultivation, which are based on water use. However, to explore a possibility of the method of such development the following surveys and investigations are to be carried out. Furthermore, to examine the concrete substance of this method, a report of experiments for a considerably long period of time must be awaited, but results to be obtained by the Battambang agricultural center might be made available.

A. Survey of the general agricultural condition.

Nation-wide data are newly collected and consolidated, and the survey in (1)-d is carried out at the same time.

B. Investigations of principal crops and live-stock.

Investigations are carried out of the cultivation methods and yields of rice, maize, soy beans, tabacco peanuts, sweet potatoes, water mellons and vegetables as well as the breeding practice of live-stock.

C. Soil survey.

Some data on soils are at present available. They are all examined and a supplementary survey is made on the field.

D. Investigation of farmers' economy and farm management

(i) Survey of the general condition

The general condition of the area is made clear by consolidating and examining all data, and comparison is made with other areas in the country at the same time. (Matters for investigation) Farmers' income and outgo from their farm management; labor; and general living condition.

(ii) Selecting method

a. Agricultural Engineering.

b. Land-and water-use

Surveys of the above are made in five areas.

(3) 3 Survey of a possibility of regional development by the encircling levee method

It is our object in view to formulate the Sambor agricultural development plan by investigating the general agricultural condition. However, the field survey we made in 1952 revealed the fact that farmers grew rice, maize, water mellons and tobacco in a zone where water was available even in the dry season. In view of this fact it is considered that if simple irrigation and drainage facilities will be constructed by using such a basin, development will be feasible by a method similar to the encircling levee method found in both Gifu and Aichi Prefectures. Therefore, the survey is carried out of a possibility of such development.

4-4 MARKET FOR ELECTRIC POWER

4-4-1 PRESENT STATE OF ELECTRIC POWER SUPPLY AND DEMAND

4-4-2 LONG RANGE PROSPECT OF ELECTRIC POWER SUPPLY AND DEMAND

4-4-3 SUMMARY OF BASIC FINDINGS OF SURVEY

4-4-4 MATTERS TO BE INVESTIGATED IN 2NDARY AND SUBSEQUENT YEARS

4-4 MARKET FOR ELECTRIC POWER

Foreword:

The initial surveys of the electric power market have been conducted primarily for the purposes of: (1) making known the existing electric power situation in Cambodia and Viet Nam, (2) collecting materials relating to these surveys and (3) framing the plan for investigations for the years to follow.

The results of these surveys have been brought together and set forth under the following captions:

(1) Present State of Electric Power Supply and Demand.

(2) Long Range Prospect of Electric Power Demand and Supply.

(3) Summary of findings of Surveys.

(4) Surveys to be made in the years that follow.

4-4-1 PRESENT STATE OF ELECTRIC POWER SUPPLY AND DEMAND

I Cambodia

The electric power industry in Cambodia is run by the three organizations. There are the "Electricite de Cambodge" with public and private joint ownership, the "CIE Franco-Khmere d'Electricite" with private ownership and the National Electric Power Enterprise under the jurisdiction of the Ministire des Travaux Publics et des Telecommunications. The total installed generating capacity of the electric power industry in Cambodia was 23,339 kw as of 1961 and the total energy generated in the same year was 71,380,000 kwh.

The "Electricite du Cambodge" was incorporated on the basis of the former Campagnie des Electricite d'Cambodge of French interest and now has

a service area including Phnom-Penh, Kampot, Siem Reap, Kompong-Cham, Kratie, Svay-Riem, Takeo, and Kompong-Thom. The Electric energy generated by this company in 1960 makes up approximately 92.6 percent of the nation's entire energy generated.

The "CIE Franco-Khmere D'Electricite now serves in the Battambang District and the electric energy generated by the company equals 4.4 percent of the national total.

The supply of power to the rest of the country including Pursat, Kompong-Chhnang, Compong-Speu, Prey Veng and Stung-Trang, the former service area of the Union Electric d'Indchine, is now taken over and administered by the Ministire des Travaux Publics et des Telecommunications.

The Electricity Bureau of the Ministire des Travaux Publics et des Telecommunications legally has power of supervising and controlling all the electric enterprises in Cambodia. However, it has not yet reached a state to enable it to exercise its power in the actual administration. Furthermore, in Cambodia, industrial power demand is generally furnished by industry-owned power plants, which the Electricity Bureau has no power to supervise and control. Consequently, nationwide statistical data concerning electrical power output from industry-owned power plants and power requirements by private industries are not available. Hence, at the present stage of surveys, there is no means of making clear the total nation-wide power demand including power requirements by private industries. Therefore, the description given below is limited to the supply and demand by the electric utility industry.

As shown in Table 1, the electric power supply and demand in Cambodia is not very great. The load growth, however, has been fairly rapid since 1955, showing an average annual increase of 16 percent over the preceding year. The main reason for this high rate of increase is attributed to the

rapid load growth attained in Phnom-Penh, Capital of Cambodia and its environs. The requirements for power in this area equal 85 percent of the total electrical power output in Cambodia.

All the power requirements are, at the present time, met by thermal power generation, the majority of which is supplied from diesel power plants. In Phnom-Penh, however, a steam power plant with a generating capacity of 3,000 kw was erected in 1960 with the financial aid of Czecho-Slovakia. This steam power plant is in operation now.

The service territory is divided into 14 areas. When the maximum power demand and the installed generating capacity in each of the 14 areas are taken together, it can be seen that the capability in each of the areas is inadequate. From this, it may be deduced that there is a large latent demand for power in each of the areas.

According to the latest 4 years' statistics concerning electric energy sold (excluding free services to the Water Supply Department and others), the energy sold to power demands show a gradual increase from 16.7 percent of F.Y. 1959 to 24.3 percent of F.Y. 1962, while the lighting (including ventilation) shows a decrease. For instance, the domestic use shows a decrease from 67.3 percent of F.Y. 1959 to 61.5 of F.Y. 1963. (See Table 2)

The increase in energy sold for power over preceding years during the past three years was so high as 33.9 percent in 1960, 44.2% in 1961 and 15.7% in 1962.

The electric rates have tended to decline gradually in recent years. However, the rates in the urban District of Phenom-Penh and its environs are still very high. For example, the rate for lighting (domestic use and for government offices inclusive) is approximately 9.1 US cents per kwh, the rate for low tension power is 6.8 US cents per kwh and the rate for high tension power is 5.4 US cents. The rates prevailing in the rural districts are amazingly high. The highest rates now in force are 20.6 US cents for

one kwh of light and 15.6 US cents for one kwh of low tension power. Both rates are applicable to the district of Battambang. (See Table 3)

TABLE I - INSTALLED GENERATING CAPACITY AND ELECTRIC ENERGY GENERATED
ELECTRIC UTILITY INDUSTRY IN CAMBODIA

FISCAL YEAR	ELECTRIC ENERGY GENERATED 1,000 KWH				ANNUAL MAXIMUM DEMAND KW				INSTALLED GENERATING CAPACITY KW				Electric Energy Generated Percentage Increase over preceding year %
	Electricite de Cambodge	National Electric Power Enterprise	CIE Franco-Khmere d' Electricite	Total	Electricite de Cambodge	National Electric Power Enterprise	CIE Franco-Khmere d' Electricite	Total	Electricite de Cambodge	National Electric Power Enterprise	CIF Franco-Khmere d' Electricite	Total	
1950	14,663	486	343	15,492	3,934	221	280	4,435	4,424	369	880	5,673	6
51	17,256	459	447	18,162	4,583	195	300	5,078	5,781	376	880	7,037	17
52	20,920	548	1,201	22,669	5,599	232	355	6,186	7,022	646	880	8,548	24
53	21,941	788	1,207	23,936	5,812	309	350	6,471	9,414	686	880	10,980	5.6
54	22,522	865	1,154	24,541	6,232	382	400	7,014	9,391	718	880	10,980	3.5
55	26,389	1,262	1,209	28,860	7,562	449	415	8,426	9,515	1,325	600	11,440	18
56	31,649	1,400	1,368	34,417	8,063	458	470	8,991	9,539	1,245	600	11,384	19
57	36,562	1,186	1,396	39,144	8,422	428	500	9,350	9,679	1,300	600	11,579	14
58	41,680	2,139	1,554	45,373	9,626	860	420	10,906	14,884	1,958	600	17,442	16
59	46,933	2,293	1,642	50,868	11,002	900	500	12,402	14,884	1,958	1,175	18,017	12
60	55,243	2,607	1,799	59,649	13,018	1,013	520	14,551	17,244	1,958	1,175	20,377	19
61	67,292	2,240	1,850	71,382	16,240	1,000	580	17,820	20,206	1,958	1,175	23,339	20

Note: The above figures are derived from the Annuaire Statistique Retrospectif du Cambodge for the years 1958 through 1961.

TABLE 2 - ELECTRIC ENERGY SOLD
BROKEN DOWN BY TYPE OF USAGE
(EXCLUDING FREE SERVICES TO WATER SUPPLY DEPT. AND OTHERS)

	1959		1960		1961		1962	
	Kwh	%	Kwh	%	Kwh	%	Kwh	%
Domestic use	24,228,522	67.3	27,105,800	65.2	30,820,873	61.7	33,653,301	61.5
Power	6,000,241	16.7	8,033,426	19.4	11,583,843	23.4	13,304,021	24.3
Use of Government Offices	5,773,993	16.0	6,348,259	15.4	7,514,883	17.9	7,727,938	14.2
Total	36,002,755	100.0	41,397,485	100.0	49,919,599	100.0	54,685,260	100.0

Note: The surveys were made by the Electricite de Cambodge.

TABLE 3 - ELECTRIC RATES IN FORCE FOR FISCAL YEAR 1962

SERVICE AREA	LIGHTING FOR GENERAL USE		LOW TENSION POWER		HIGH TENSION POWER		USE OF GOVERNMENT OFFICES	
	Riel	US Cent	Riel	US Cent	Riel	US Cent	Riel	US Cent
Phnom-Penh	3.214	9.18	2.382	6.81	1.89	5.4	3.196	9.13
Kondal	3.321	9.49	2.392	6.83	1.9	5.42	3.286	9.39
Battambang	7.205	20.58	5.53	15.8	4.553	13.01	6.676	19.07
Other Areas Served By Electricite de Cambodge	6.579	18.8	4.955	14.16	4.527	12.93	6.371	18.2
National Electric Power Enterprise	7.079	20.22					6.371	18.2

Note: The US Cent figures given herein have been calculated at the conversion rate of 35 Riels to 1 Dollar.

one kwh of light and 15.6 US cents for one kwh of low tension power. Both rates are applicable to the district of Battambang. (See Table 3)

2 Viet Nam

In Viet-Nam four power companies of French interest and one power company of Viet Namese interest, all privately owned, are carrying the electric power industry under licenses from the Government. The largest of these five companies is the CIE des Eaux et d'Electricite d'Indochine. This company serves the capital city Saigon-Cholon and Gia-Dinh, Bien-Hoa and Thu-Dau-Mot, all lying in the north of the capital. And this company gets in Dalat a supply of power from the Ankroet Hydro-electric Power Plant under government control and furnishes it to the Dalat district and construction work of Danhim Power Plant. The installed generating capacity of this company equaled 78.5 percent of that of the entire electric utility industry in Viet-Nam as at the end of 1961.

Besides this company, the Societe Central d'Eclairage et d'Energie (SCEE) and the Union Electrique d'Indochine (UNEDI) serve the delta area of the Mekong and the small towns and communities on the southern coast of City of Saigon. The combined installed capacity of these two companies was 6,300 kw, which equaled only 6.2 percent of that of the entire electric utility industry in Viet-Nam as at the end of 1961.

The Societe Indochinoise pour les Eaux et l'Electricits en Annam (SIPEA) is engaged in supplying electricity to the towns and communities on the central and northern section of the plateau. The installed generating capacity of this company was 8,500 kw or 8.4 percent of that of the entire electric utility industry in Viet-Nam as at the end of 1961.

The Societe Anonyme d'Electricite de Rachgia (SAER) is a small enterprise of Viet-Namese interest and has Rachgia, the west sea coast area in the delta of the Mekong River, as its service territory. The installed capacity of the company is negligible.

The electricity supply in districts other than those of the above five

companies is carried on by the state. Part of the electric generating facilities (those erected before 1954) are now under the jurisdiction of the Electricity Bureau of the Ministire des Travaux Publics et des Telecommunications.

The electric generating facilities other than those mentioned above (those erected on and after 1955) are run by the Office National de l'Equipment Energ de Electrique (ONDEE), which is an external organ of the same Ministry. The Electricity Bureau of the Ministire des Travaux Publics et des Telecommunications is legally a supervisory organ of all private electric utility industry but actually this Bureau does not exercise authority nor control over all the private electric utility industries.

In Viet-Nam, electric power for industries is also provided by their own power plants, in the same manner as in Cambodia. Therefore, it is difficult to make clear statistically the actual state of electric power for industries.

The electric utility industry in Viet-Nam as a whole had a installed generating capacity of 101,493 kw as of the end of 1961 and turned out 329,120,000 kwh during the same year. The electric energy generated, when separated by regions, is as shown in Table - 4 below.

The southern region which includes the capital city of Saigon is the most prosperous part having 85 percent of the nation's entire installed generating capacity and supplying 91.5 percent of the total electric energy generated.

The average annual load growth during the five year period from 1957 through 1961 was 9.2 percent but the capability of electric power systems does not keep pace with this load growth and the power supply situation in Viet-Nam is fairly tight.

Table 4 - INSTALLED GENERATING CAPACITY AND ELECTRIC ENERGY GENERATED

Broken Down By Regions

- Electric Utility Industry -

Fiscal Year 1961

REGION	Electric Energy Generated		Installed Generating Capacity	
	Thousands of Kwh	%	Kw	%
Southern Region	301,264	91.5	87,742	86.5
Plateau Region	7,167	2.2	2,793	2.7
East Coast Region	20,691	6.3	10,958	10.3
T o t a l	329,122	100.0	101,493	100.0

Except the load carried by hydro power plants amounting to 3,700 kw (3,000 kw by the Ankroet Power Plant and 700 kw by the Banmethuot), the demand for electric power, is on the whole met by thermal power generation. The ratio of the three types of power plant as at the end of 1962 was roughly 51.1% of thermal, 44.9% of diesel engine power and 4% of hydro.

When the energy consumption is broken down by usage (or by rates) it is seen that the percentage of power services tends to increase lately. (See Table - 5). The same in F.Y. 1961 is found reaching 34 percent. The remaining 66 percent is mostly for lighting and ventilation and further 50 percent of the above 66 percent, in other words 50 percent of the total power consumption, is for household use.

Regarding the electric rates in Viet-Nam as the same manner as in Cambodia, there is a great discrepancy between the capital city areas and the rural districts. Generally speaking the electric rates now in force are very high. The rates in the capital city, Saigon, are 7.74 US Cents / kwh for lighting and 6.77 US Cent / kwh for power, while the same in the rural districts are 18.5 US Cents / kwh minimum and 35 US Cents / kwh maximum for lighting and 14.0 US Cents / kwh minimum and 19.0 US Cents / kwh maximum even for power.

Regarding the total installed generating capacity in Viet-Nam including that of industry-owned power plants, no exact information is available but the total capacity as of the end of 1962 is assumed to be approximately 150,000 kw. Ninety percent of this capacity is located in the Saigon-Cholon area. The distribution ratio of the nation's total installed generating capacity is 34.8 percent in thermal, 62.6 percent in diesel engine plants and 2.6 percent in hydro (See Table - 7).

Also the Report of Day & Zimmermann Inc., U.S.A. on the geographical distribution of electric generating equipment as of 1954, indicates that the Southern Region which includes Saigon holds 89 percent of the total capacity

TABLE 5 - ELECTRIC ENERGY CONSUMPTION SEPARATED BY TYPES OF USAGE

	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	Percentage of Energy Consumption					
											1952	1956	1958	1959	1960	1961
Electric Energy Generated in 1000 Kwh	136,628	151,890	181,011	202,823	211,879	244,288	244,359	287,429	293,627	329,122						
% Increase Over Preceding Year		11	19	12	4	6	9	17	2	12						
Energy Consumption Domestic use	36,382	42,397	52,866	66,477	80,289	93,122	104,949	119,821	124,073	131,227	33.6	46.5	54.1	52.8	51.2	50.3
Use of Government Offices	22,188	24,700	32,265	34,812	32,966	24,941	22,604	24,047	28,993	30,860	20.5	19.1	11.6	10.6	12.0	11.8
Street Lighting	3,613	3,765	5,554	6,356	6,135	6,844	7,428	8,056	8,102	8,640	3.3	3.6	3.9	3.5	3.3	3.3
Sub-total	62,183	70,862	90,685	107,645	119,390	124,907	134,981	151,924	161,168	170,727	57.4	69.2	69.6	66.9	66.5	65.4
Power	44,497	49,145	51,449	53,889	51,788	51,195	57,725	73,460	79,419	88,950	41.0	30.0	29.7	32.3	32.8	34.0
Electric cars	827	398									0.8					
Others	855	1,002	999	1,396	1,319	1,318	1,456	1,538	1,610	1,675	0.8	0.8	0.7	0.8	0.7	0.6
Total	108,362	121,407	143,133	162,930	172,497	177,420	194,162	226,922	242,197	261,332	100.0	100.0	100.0	100.0	100.0	100.0

Note: The figures for the years 1952 through 1960 are derived from the USOM Report and the figures for the year 1961 are derived from the data made public by the Electricity Bureau, Ministire des Travanx Publics et des Telecommunications.

TABLE 6 - ELECTRIC RATES IN FORCE

Name of Company		Lighting Piaster	US Cent	Power Piaster	US Cent
CIE des Eaux et d'Electricite d'Indochine		2.708	7.74	2.372	6.77
Societe Centnale d'Ecairage et d'Energie	Max.	7.26	20.75	6.234	17.81
	Min.	6.627	18.9	4.921	14.07
Union Electrique d'Indochine	Max.	7.973	22.78	6.85	19.1
	Min.	6.682	19.09	6.619	18.85
Societe Anonyme d'Electricite de Rachigia		6.408	18.3	5.685	16.24
National Electric Power Enterprise	Max.	10.00	28.57		
	Min.	6.48	18.5		

Note: The US cent figures given herein have been calculated at the conversion rate of 35 Piasters to 1 Dollar.

and turns out 88.3 percent of the electric energy generated as shown in Table 8. This information does not differ much from the same in F.Y. 1961 given in Table 4.

TABLE 7 - TOTAL INSTALLED GENERATING CAPACITY IN VIET-NAM BY TYPES OF POWER PLANTS AS OF THE END OF 1962

(Including that Of Industry-Owned Power Plants)

	Aggregate Capacity, KW	Distribution Ratio %
Steam Power Plants	52,000	34.8
Diesel Power Plants	94,000	62.6
Hydro-electric Power Plants	4,000	2.6
Total Capacity	150,000	100.0

TABLE 8 - TOTAL INSTALLED GENERATING CAPACITY AND ELECTRIC ENERGY GENERATED BY REGIONS AS OF 1954

(Including Those Of Industry-Owned Power Plants

Region	Electric Energy Generated		Installed Generating Capacity	
	1,000 Kwh	%	Kw	%
Southern Region	168,598	88.5	69,522	89.0
Plateau Region	7,442	3.9	2,683	3.4
East Coast Region	14,886	9.8	5,973	7.6
Total	190,926	1,000	78,223	1,000

4-4-2 LONG RANGE PROSPECT OF ELECTRIC POWER SUPPLY AND DEMAND

1 Territory To Be Served

The territory to be served by Sambor Project will vary in accordance with the location of the central market to be created.

At present in both Cambodia and Viet Nam electric power markets are isolated individually within towns or communities and the demands are wholly met by power plants erected in respective towns or communities. Also it is a common trend in both countries that a large demand for power develops in the capital cities. The demand of such large cities equals about 80 percent of the total demands of the respective countries.

Now when the future load growth in both countries is seen in the right perspective, it can be deduced that a large power demand will develop in Phnom-Penh, Sihanouckville and its rear territory and Kampot in case of Cambodia and in the Southern region with Saigon-Cholon as its center in case of Viet-Nam.

The transmission systems expected to be completed in both countries by the time the Sambor Project will actually be developed are in the 110 kv class. These systems will link Phnom-Penh, Kampot and Sihanauchville, Prek-thnot and Phnom-Penh and also Phnom-Penh, Pursat and Battambang in case of Cambodia.

Following the completion of the 230 kv No.1 Transmission Line linking Danhim and Saigon, the No.2 Danhim-Saigon Transmission Line run along the Cam Ranh Bay coast and the Southern Sea Coast is expected in case of Viet-Nam. In addition the high tension transmission line extending from Saigon to the Delta of the Mekong is already scheduled in the current five year construction program. Therefore, during the years 1980 through 1985, in Cambodia and Viet-Nam the service territories of the new power systems to be constructed around the capital cities will be served with power from the Sambor Power

Plant.

To put it in other words, in Cambodia, the area from Sambor to Phnom-Penh through Kompong-Cham, the South-east area of Tonle Sap extending from Battambang to Phnom-Penh through Pursat, the area extending from Phnom-Penh to Kampot through Takeo and the area lying along the Phnom-Penh Sihanoukville transmission line are the territories to be served with electrical output from the Sambor. That is to say, almost the entire district of Cambodia except the northern part of Tonle Sap and the western side of the Cardamomes chain will be the service territory to be served with power from Sambor. In Viet-Nam, the southern sea coast of the Danhim-Saigon No.1 Transmission Line or the southern area of Nhatrang and the area extending from Saigon to the Delta of the Mekong is the territory to be served with power from Sambor. For surveying markets for power from Sambor, it is necessary to investigate power requirements by regions and by types of usage and draw up the long range estimate of power demand in the above mentioned areas.

However, during the primary year of survey, no information concerning the industrial development program and its prospect, the local economical development and the regional characteristics of population increase was available. It was, therefore, not possible for us to draw up a long range estimate of power demand by regions and by types of usage. However, to draw up a long range estimate of power demand, it is necessary to take an extensive view of power demand for the country as a whole. Therefore, an attempt has been made to draw up an approximate estimate of power demand on a national basis.

2 Estimate Of Aggregate Power Demand For The Whole Country.

(1) Cambodia

Because of lack of information concerning the status of industry-owned plants, it was impossible to make a precise estimate of the aggregate power demand of Cambodia as a whole in 1960, the basic year of these surveys.

However, our rough estimate was 70,000,000 kwh at the generating end.

Regarding the growth of power demand in the entire country referred to the basic year 1960, we formed independent estimates of 14% annually during the years 1961 through 1965, 12.2% for the years 1966 through 1970, 11% for the years 1971 through 1975, 10% for the years 1976 through 1980, and 9.2% for the years 1981 through 1985. We used, as reference in the estimate mentioned above, the growth rates which the Cambodian Government employed in drawing up its own long range power resources development program. These were 12% annually during the years 1963 through 1970 and 10% for the years 1971 through 1980. The result thus obtained is shown below.

According to this table, the maximum demand for power in 1980 reaches 160,000 kw in 1980 and 230,000 kw in 1985.

According to the estimate drawn up by the Cambodian Government, the electrical energy requirements in 1980 in the regions other than those covered by the electric power system developed around Phnom-Penh would not be more than 5.2 percent of the total requirements of the country. Therefore, the ratio of the requirements of the system area to those of the entire country including the energy consumption by the industries with their own power plants may be assumed not less than 95 percent.of the total.

Also in this estimate the average annual growth ratio during the 1961-1980 period and during the 1961-1985 period are assumed as 11.8% and 11.2%

TABLE 9 - ESTIMATE OF AGGREGATE POWER DEMAND IN CAMBODIA

(AT THE GENERATING END)

	ESTIMATED VALUE			
	ELECTRICAL ENERGY GENERATED -KWH		MAX. POWER - KW	
1960	70,000,000	Average Growth Rate %	19,000	Load Factor 42.0%
1965	135,000,000	14%	37,000	42.0%
1970	240,000,000	12.2%	62,500	44.0%
1975	403,000,000	11.0%	100,000	46.0%
1985	1,000,000,000	9.2%	230,000	49.5%

respectively, both of which are fairly high.

The reason why such high ratio are assumed is five-fold, namely

(1) the latest natural load growth showed remarkably high rates. The average annual growth rate for the 7 year period from 1954 to 1961 was 16.5%, taking the 1954 as the basis and the growth rate for the 5 year period from 1956 to 1961 was 16% taking the 1956 as the basis.

(2) the existence of latent demand for power in and out of the cities and towns was in such a state as to reflect directly on the load growth.

(3) Power resources development and electrification in the urban and rural districts are reasonably designed and now actively carried out.

(4) There is a very fair prospect that positive economic cooperation from overseas will continuously be given to Cambodia.

(5) The country is politically stabilized and the public peace within the country is so well maintained that there is no fear of hampering the nation's economic advancement and development.

(2) Viet-Nam:

The electric power industry in Viet-Nam is, like that of Cambodia, run with an object of serving the general public and public use. Power requirements by industries are met mostly by power generation of their own power plants. Therefore, it is difficult to collect statistical data of the total power supply and demand in the country. Hence, it is impossible to make a long range forecast of the nation's total power supply and demand. However, we have attempted a forecast up to 1985 on the basis of:

(1) the data concerning industry-owned power plants in the report elaborated by Day and Zimmerman Inc., U.S.A. in 1957,

(2) the estimated installed capacity of industry-owned power plants at the end of 1962, given in an article entitled "Electric Power Resources in Viet-Nam" by Din Quang Chieu, General Secretary, Ministry of Economic

Affairs, which was published on the Viet-Nam Press in February, 1963.

During the latest five year period from 1957 through 1961, the average annual increase of electric energy generated of the electric utility industry in Viet-Nam over the preceding year was 9.2%. However, as the Danhim Power Plant will not be put in service until the end of 1963, there is at present a fairly severe shortage of supply capability in the Saigon-Cholon area. In December 1963 the 1st stage of 80,000 kw of the Danhim Power Project is scheduled to be completed. Upon completion of the 1st stage of the project, the 80,000 kw capacity will be sufficient to meet the demand in the Saigon-Cholon area and the existing 80,000 kw thermal power plants would be put in reserve. Further in 1965 the 2nd stage of 80,000 kw of the Danhim Project is scheduled to be completed. Therefore, in Viet-Nam there is now a demand for a prompt study of disposition of power from the Danhim Power Plant. Because of reparations for the destruction during the war, financial aid and economic cooperation, there is a strong probability in Viet-Nam that strengthening of power supply capability will precede demand for power. Therefore, it is most likely that priority efforts will be made to study the economic disposal of power. From this viewpoint the growth rate between 1965 and 1975 will naturally be assumed fairly high.

In consideration of the above and the prospect of realization of the 5 year construction program, we have estimated an increase in annual energy generation at an average of 8.8% from 1961 through 1980 (20 years) and 8.5% from 1961 through 1985 (25 years). Also we have estimated the total electric energy requirements in Viet-Nam as 2,145 million kwh and the maximum power as 470,000 kw (both at the generating end) in 1980 and also the same as 3,180 million kwh and 650,000 kw respectively in 1985.

TABLE 10 - GROWTH RATE OF ELECTRIC ENERGY GENERATION 1957 THROUGH 1961

Fiscal Year	% Increase Over Preceding Year
1957	6
1958	9
1959	17
1960	2
1961	12
Average Growth Rate	9.2

It is with great regret that in Viet-Nam the development of electric power resources and construction of transmission lines are now abstructed by reason of domestic problems. However, in estimating the future growth rate, it is assumed that no serious hindrance to carrying out such works in and around Saigon and other load centers will be encountered.

TABLE 11 - GROWTH RATE OF ELECTRIC ENERGY GENERATION AT INTERVALS OF FIVE YEARS FROM 1956 THROUGH 1985

Years	5 Year Average %
1956 - 1960	8.29
1961 - 1965	8.01
1966 - 1970	9.06
1971 - 1975	9.02
1976 - 1980	8.45
1981 - 1985	8.2

TABLE 12 - ESTIMATE OF POWER DEMAND IN VIET-NAM
1960 THROUGH 1985

	Required Energy Generation-KwH	Maximum Power - kw
1960	400,000,000	100,000
1965	588,000,000	145,000
1970	930,000,000	220,000
1975	1,430,000,000	325,000
1980	2,145,000,000	470,000
1985	3,138,000,000	650,000

3. Estimate Of Required Supply Capability And Installed Generating Capacity.

(1) Required Supply Capability:

To sum up the foregoing, it is deduced that the aggregate power demand in Cambodia and Viet-Nam is 2,800 million kwh of energy and 630,000 kw of maximum power in 1980 and 4,200 million kwh of energy and 880,000 Kw of maximum power in 1985, all at generating end.

TABLE 13 - ESTIMATE OF REQUIRED SUPPLY CAPABILITY
IN CAMBODIA AND VIET-NAM IN KW

	1980		1985	
	Max. Power	Required Capability	Max. Power	Required Capability
Cambodia	160,000	200,000	230,000	280,000
Viet Nam	470,000	600,000	650,000	800,000
Total	630,000	800,000	880,000	1,080,000

To meet the aforementioned demand, a large amount of new capability is necessary. However, inasmuch as the new water resources planned and scheduled to be developed in the future will for the most past be developed for supplying water for irrigation and for generation of electric energy, there will be required a still more capability during a spell of dry weather. From this viewpoint, we estimated the required supply capability for the two countries in 1980 at 800,000 kw and the same in 1985 at 1,050,000 kw.

(2) Installed Generating Capacity:

(a) Cambodia:

The installed generating capacity in Cambodia as a whole as at the end of 1962, including that of industry-owned power plants is in round numbers 40,000 kw. Of this capacity, 30,000 kw is of electric utility industry and of thermal.

Regarding the development of new thermal power plants, one diesel unit of 2,000 kw is scheduled to be added to the Phnom-Penh Diesel Power Station in 1963, one thermal unit, 18,000 kw is scheduled to be installed in the Chak Angre Steam Power Station through the financial aid of Czecko-slovakia in 1965 and a few other diesel engine power plants are to be added to some local power plants.

Regarding the development of new hydro power plants, after the three projects on the upper stream of the Kompong Som River, which are now under construction (the total capacity is 7,000kw) with the aid of Yugo-Slavia, the power development on the Cham Chai River (the total capacity is 50,000 kw) will be started with the financial aid of the Soviet Union. Thus the hydro power resources in the south-west area of the Chain de Elephant will soon be developed. The power projects that follow according to the program of the Ministire des Travaux Publics et des Telecommunications are the Prek Thnot Project (18,000 kw), the projects on the Stung Pursat River and

the Krapeu Py River and the Stung Battambang Project (40,000 kw). The development of the last project, however, is to be started after 1980. The capacity to be developed by 1985 is roughly estimated as 146,000 kw. The estimated installed capacity since 1960 are as shown on the following Table. The installed capacity at the end of 1980 including that of industry-owned power plants will reach 225,000 kw and at the end of 1985 will reach 259,000 kw. However, as shown on the preceding Table, as the required generating capacities as of 1980 and 1985 will reach the 200,000 kw mark and the 280,000 kw mark respectively. There will be virtually a power shortage in 1985.

TABLE 14 - ESTIMATE OF INSTALLED GENERATING CAPACITY IN CAMBODIA IN KW.

FISCAL YEAR	ELECTRIC UTILITY INDUSTRY					INDUSTRY-OWNED POWER PLANTS	TOTAL
	DIESEL	STEAM POWER	TOTAL THERMAL	HYDRO POWER	TOTAL ELECTRIC UTILITY		
1960	15,000	3,000	18,000	-	18,000	8,000	26,000
1962	27,000	3,000	30,000	-	30,000	10,000	40,000
1965	32,000	21,000	53,000	5,000	58,000	13,000	71,000
1970	37,000	21,000	58,000	25,000	83,000	18,000	101,000
1975	42,000	21,000	63,000	95,000	158,000	25,000	183,000
1980	47,000	21,000	68,000	122,000	190,000	35,000	225,000
1985	52,000	21,000	73,000	146,000	219,000	40,000	259,000

(b) Viet-Nam:

The installed generating capacity in Viet-Nam as a whole as at the end of 1962 is, according to the information of Mr. Dink Quong Chieu, General Secretary, was 150,000 kw including about 40,000 kw of the industry-owned power plants.

Viet-Nam has not yet drawn up a development program nor formed a plan, the duration of which is longer than the present 5 year Program (1962-1966).

For enhancing the generating capacity now scheduled in the present 5 Year Program, in the field of hydropower, the development of the Danhim Power Plant, 160,000 kw, as well as the Dong Nai-Lagna River System at the site of Trian and Vinh-Thui the extention of the Barmethuot Project on the Eakrong River, up-stream of Srepok, and the development of small hydroprojects in the north eastern district such as Phuoclong, Baoloc, Quang Ngai and Vink Dinh are now under consideration.

In the field of thermal power plant, the development of a steam power plant (33,000 kw) scheduled to be erected in Thu Duc, north to Saigon through, US aid and Construction of the Nong Son Power Plant 25,000 kw, through the financial aid of France are now considered. In addition the 5 Year Program places special emphasis upon enhancing the diesel power plant capacity in rural towns and also upon rural electrification. The Viet-Namese Government is actively working to encourage rural electrification by establishing the Office National De l'Equipment d'Energic Electrique (ONDEE) in coordination with the United States Operation Mission (USOM).

The high tension transmission lines scheduled in the 5 year program are 230 kw transmission line extending over 257 km between Danhim and Saigon, No.2 Transmission Line linking Khon Hoa Phan Rang Phan Thiet and Saigon with Danhom on the sea coast, and the transmission line linking

Phan Rang and Pha Trang through Can Rouh. In addition, the transmission line running from Saigon to my Tho and Vinh Long on the Mekong Delta area is also scheduled in the 5 year program.

In Viet-Nam, owing to the present internal affairs, various hindrances are thrown in construction of projects especially transmission lines. These hindrances are sometimes too serious to be neglected and therefore the prospects of the 5 year program are gloomy. However, as far as the development of electric power resources is concerned, after the sucussful precedent set up for early development of the Dankim Project with reparations paid by Japan, there is a fair possibility of complection of the Trian Site along the Dong Nai River with the finantial aid of France and No.2 Unit, 124,000 kw, of the Tsu Due Thermal Power Station through US aid, in advance of the power requirement.

As described above, we have drawn up the long range estimate of the installed generating capacity making adjustments to times of plant operation by taking into consideration various affairs and also the practicability of the Viet-Namese Government's plan of power development.

That is to say, in our estimate the required supply, capability in Viet-Nam as a whole is 600,000 kw in 1980 and 800,000 kw in 1985, whereas the aggregate installed generating capacity in Viet-Nam as a whole is 747,000 kw in 1980 and 866,000 kw in 1985. If we look at this on the national basis, an adequate balance is maintained between the demand and supply of power up to 1985 even in our estimate.

However, if we consider the supply and demand of power within the power system area with Saigon as its center, which is the object of our surveys, it is practically impossible to connect the Thu Bon Hydro Power Plant scheduled to be completed between 1980 and 1985 to the power system area. Hence Saigon and its vicinity will have a shortage of power around 1985. In order to secure an adequate supply of power to the Saigon Power

System area on and after 1985, it may be necessary to develop the remaining hydro potential along the Dong Nai River system or to install the 2nd Unit at the Thu Due Thermal Power Station. However, to set off against these projects the development of the Sambor Site on the Mekong River comes up and great hopes are entertained for its realization.

4-4-3 SUMMARY OF BASIC FINDINGS OF SURVEY

The development of the Sambor Site on the lower reaches of the Mekong should be carried out in coordination of the overall development of the Mekong. In this viewpoint, the development of water resources at Sambor, if carried out independently, may involve many questions as pointed out in the provisional report. The effect of its development is conditional on the realization of large reservoirs to be constructed on the upper reaches of the Mekong and its tributaries. This development is thought worthwhile only when it serves to electrically supplement the above mentioned reservoir projects. The development is not thought to contribute to flood control, regulation of irrigation and betterment of navigation conditions all of which are most important from the viewpoint of overall development. That is to say, the development of the Sambor Site will have a significance only when relatively in expensive power obtainable therefrom will be fully utilized. It also derive significance at the time when the power obtainable will actually be needed. To put it in other words, the proper time of development will attach a significance to the project. Inasmuch as the finding of the surveys of power market directly determines the time of development of the Sambor Site, the surveys should cautiously be carried out, not affected by any happenings at the time of surveys. The surveys should be conducted with a strictly objective attitude.

Needles to say, water resources do not deserve early development only because they can provide a huge amount of inexpensive energy. The scale of development, the selection of the plant site, the order of realization and the time and method of development should be determined in such a manner that the scale shall suit the stage of economic growth in areas in the sphere of such water resources. The development method should be adequate and proper from the point of the national economy; and the order and time should be decided to produce the largest overall effect. Whilest,

as mentioned above, abundance of power and lower cost shall not constitute essential factors for hasty development, on the other hand the development of such a large project as the Mekong, being different from that of a thermal power project, is of a pioneering nature with the mission of overall economic development in the areas afore mentioned. Such a project, therefore, has to be developed ahead of energy requirement. In developing such a project, it would be rong, from the overall economy of development, to be prejudiced by the immediate power demand in view fearing how to dispose of the size of power developed and thus miss the opportunity of development that offers.

The total installed generating capacity of Cambodia and Viet-Nam, both considered as the markets for the power from the Sambor Power Project, is only 180,000 kw in total including that of the industry-owned power plants as at the end of 1962. When compared with the capacity to be developed at Sambor, the present capacity of both Cambodia and Viet-Nam is very small. However, the purpose of surveying power markets is not to rack one's brain to dispose of large power resources on the premise that the present demand is too poor, but, on the basis of the actual state of power demand and of its analytic consideration, to build up the outlook of future power market, and see whether such development is necessary, taking into consideration the peculiality of economic development in the areas concerned. We should study the proper time of development and an effective method of consumption of every developed. To attain this end it is required to collect as much necessary information as possible and mobilize every possible means thereby to draw up a long range estimate of power demand on a rational and realistic basis as viewed from the point of nation wide economy. However, it is regrettable that in the primary year of survey we have not arrived at a stage where we will be able to make known some conclusive opinion from the recent survey of power markets.

As is generally known, Sambar has a site, Stund Treng, a short distance upstream, with abundant power resources and which is important in the overall development.of the Mekong.

Therefore, the timing in development of Sambor Project has an essencially important matter. From this viewpoint, we ventured, as a preliminary step for studying the time for possible development, to estimate the required supply capabilities in 1980 and 1985 for both Cambodia and Viet-Nam and arrived at 800,000 kw and 1,080,000 kw respectively at the end of generation.

These estimates were made on the basis of incomplete statistical data concerning the total power requirements in both countries and without having any information by which to verify the relations between the long range economic development and the growth of power requirement in both countries. They are just a trial calculation by the chronological accumulation method.

Therefore, this long rang estimate of power requirement may be subject to considerable change in accordance with the results of the subsequent surveys. Also the prospect of supply capability will have to undergo reexaminations from time to time as to the scale and time for development, because some power development projects planned by both countries may precede the Sambor Project.

During the initial year of the field survey, we do not feel that we have collected adequate information to enable us to estimate the power demand in the prospective markets in Cambodia and Viet-Nam for power available from the Sambor Project. When we consider the next 20 years or more there are many factors that may affect the scale and construction of power demand in the prospective markets.

An increase in population, an extension of service territories, an advancement or change in production techniques of the agreculture and

mining industry, an increase in the national income, improvement of the cultural standard of the people, construction of harbor facilities, improvement of transportation, expansion of foreign trade -- all these factors have an intimate bearing on the electric power demand. In drawing up a long range estimate of power demand, we will have to make analytical studies of effects to be produced on power demand by these factors and then put them together to form a long range estimate. However, the progress status of our surveys is such that all the studies and analyses of this kind have been left to the full-fledged surveys to be conducted next year.

In our opinion, when such a large river as the Mekong is developed, whatever may be the main object, it is usual that the scale of power generation there far excedes the requirements of the economy in the areas concerned. It should be understood that to fully utilize such a large stream flow immediately after development has been completed is practically impossible. Presents in the history of large power development in the world indicate that surplus power often constituted a leading cause to promote the economy in the area concerned.

Therefore, during the early years immediately after the development of the Sambor Project, the power plant may be feared to be too large as against that which general markets would require. Therefore, regarding the efficient utilization of the electrical energy that would be generated by this plant, it is necessary to make more careful investigations of markets and determine a clearly defined time of development. Based upon this time of development, surplus power should be calculated to help consider invitation of most suitable heavy electricity consuming industries and to devise the other efficient and realistic plans for consumption of power available from the Sambor Project.

4-4-4 MATTERS TO BE INVESTIGATED IN 2NDARY AND SUBSEQUENT YEARS

1. Investigation Of The Actual State Of Electric Utility Industry

The date collected during the field survey of the initial year will be put in order. In addition, supplementary investigations will be made on the following matters:

(1) Analyses of Electric Power Demand by Types of Usage and by Regions.

(2) Investigations concerning Electric Rates.

(3) Investigations concerning Power Generation, Transmission and Distribution Facilities.

(4) Investigations of Electric Power Supply and Demand Situation by Regions.

(5) Investigation into License Agreements for Electric Power Industry and Agreements for Purchase and Sale of Power.

(6) Investigation of Fuel for Power Generation

(7) Investigation of Latent Demand in Urban and Rural Districts

2. Investigations Concerning Industry-Owned Power Plants And Actual State Of Self-Generation-Self-Consumption

For the purpose of analysing the total electric power demand of a country, it is necesssry to be fully informed of the industry-owned power plants. However, as statistical date is not available, investigations will have to be made of the actual state of factories having their own power plants. The supervision of industry-owned power plants falls under the jurisdiction of other authorities than those of public utility plants. Therefore, it is difficult to carry out investigations on this connection without active cooperation from the local government authorities.

lopment in both Cambodia and Viet-Nam is carried out with financial aid and cooperation from overseas, special attention should be paid to the helping countries and the terms and conditions to be offered by them. Also prospective sites and the time for development should be especially noted.

6. Survey Regarding Energy Resources And Supply And Demand Of Energy

(1) Hydro Power Resources:

Information will be collected of the hydro potential located in places other than the Mekong River drawinge area.

(2) Fuel Resources:

Survey materials will be collected of coal and firewood resources.

(3) Supply and Demand of Energy:

Surveys will be made of the supply and demand situation of petroleum, coal, firewood and chocoal. Kerosene oil and chacoal now serve as very important household energy sources. Dependent upon the progress of power development and the decline of power charges, there is a fair possibility of replacing the energy of these types by electric heat. Careful surveys, should, therefore, be made of the present energy situation and a long range program should be drawn up accordingly.

7. Survey Regarding Utilization Of Water For Farming

By the time Sambor will be developed, it is expected that the method of farming in both Cambodia and Viet-Nam will be subject to great change due to the use of artificial irrigation during the dry seasons. Advancements and changes in the farm structure will produce favorable effect an electric power requirement in the future. However, in the survey of power market in both counries, the item that has direct bearing on power

3. Long-Range Estimate Of Electric Power Demand

The long-range estimate of electric power demand drawn up during the initial survey will be reexamined from the point of types of usage. Also a separate estimate of electric power demand will be drawn up by the Macro method using the national economy indices. Such estimates, upon completion, will be checked against the estimates made up in 1962 by the chronological accumulation method.

Through this work the total electric power demand in both Cambodia and Viet-Nam before the development of the Sambor Site can be reviewed. Also the scale and structure of general markets which serve as a basis for a study of consumption of power from the Sambor Plant can be reviewed.

4. Investigation Of Conditions For Establishment Of Heavy-Electricity-Consuming Industries

During the initial period of development of the Sambor Project, it is feared that there will be a surplus of power which can not be consumed by the general markets. With a view to disposal of this surplus of power, surveys will be made on the following:

(1) Assessment of the quality and quantity of the surplus power.

(2) Solution of contra-demands corresponding to this surplus and choice of localities.

(3) Survey regarding rates at which power is supplied.

5. Survey Regarding Long Term Program Of Electric Generation And Transmission Plant

Survey will be made of the construction programs of the electric generation and transmission plant that will be constructed before the Sambor Project will be developed and their future prospects will be made known. Then, estimates of the supply capabilities in both Cambodia and Viet-Nam will be assessed. In view of the fact the electric power deve-

consumption is pump-up irrigation utilizing low cost power obtainable from the Sambor Project. Therefore, it is necessary to make surveys of the objective area and the necessary quantity of water as detailed as possible.

8. Survey Regarding Prospects Of Economic Development And Conditions Of Locations For Industries

1. Surveys regarding mineral products and agricultural and forestry precessed goods.

2. Surveys on water to be utilized.

3. Surveys regarding transportation.

4. Surveys regarding fuel and motive power.

5. Surveys regarding labor force.

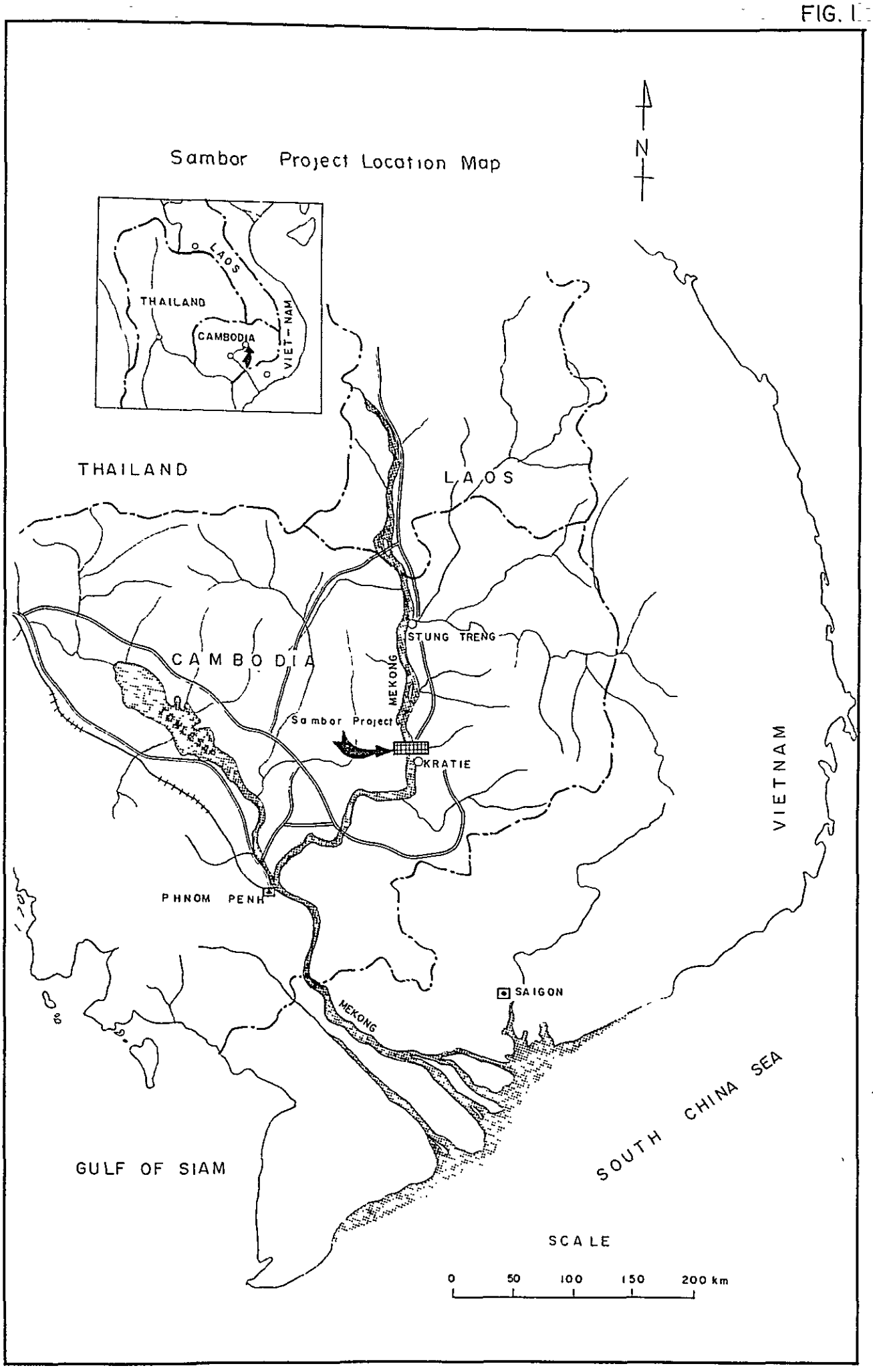
6. Surveys regarding the structure of the mining and manufacturing industry.

7. Surveys regarding the relationship between economic development and aid from foreign countries and its trend.

The above mentioned surveys concern the entire field of the national economy but they form the base for the survey of power market.

Such a broad and complicated survey can only be accomplished with careful organization and scientific method of surveys in conjunction with the active cooperation and assistance of the local government and other institutions concerned.

FIG. 1


Sambor Project Location Map
N
LAOS
THAILAND
CAMBODIA
VIET-NAM
THAILAND
LAOS
STUNG TRENG
CAMBODIA
MEKONG
Sambor Project
KRATIE
VIETNAM
PHNOM PENH
SAIGON
MEKONG
SOUTH CHINA SEA
GULF OF SIAM
SCALE
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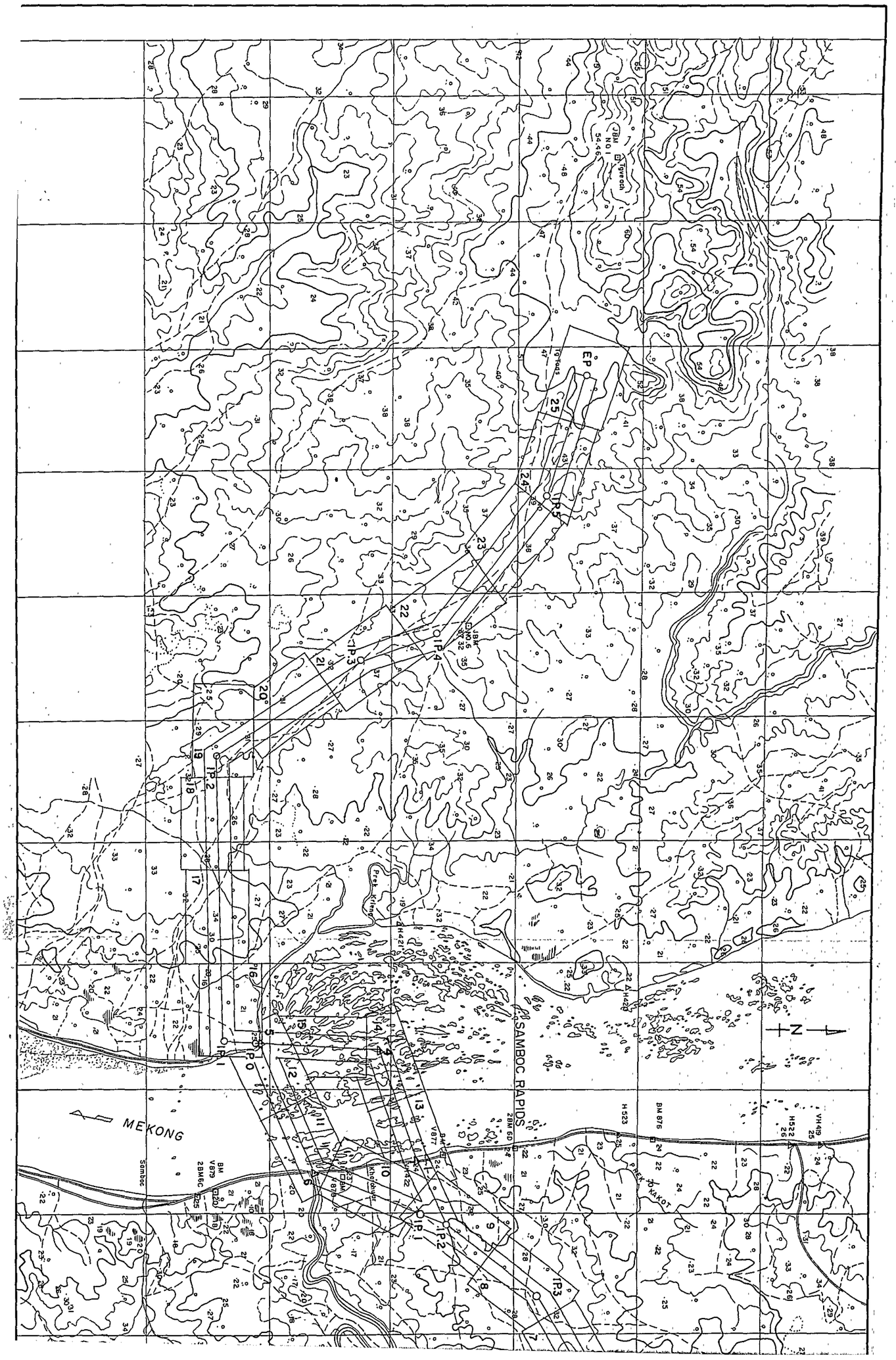
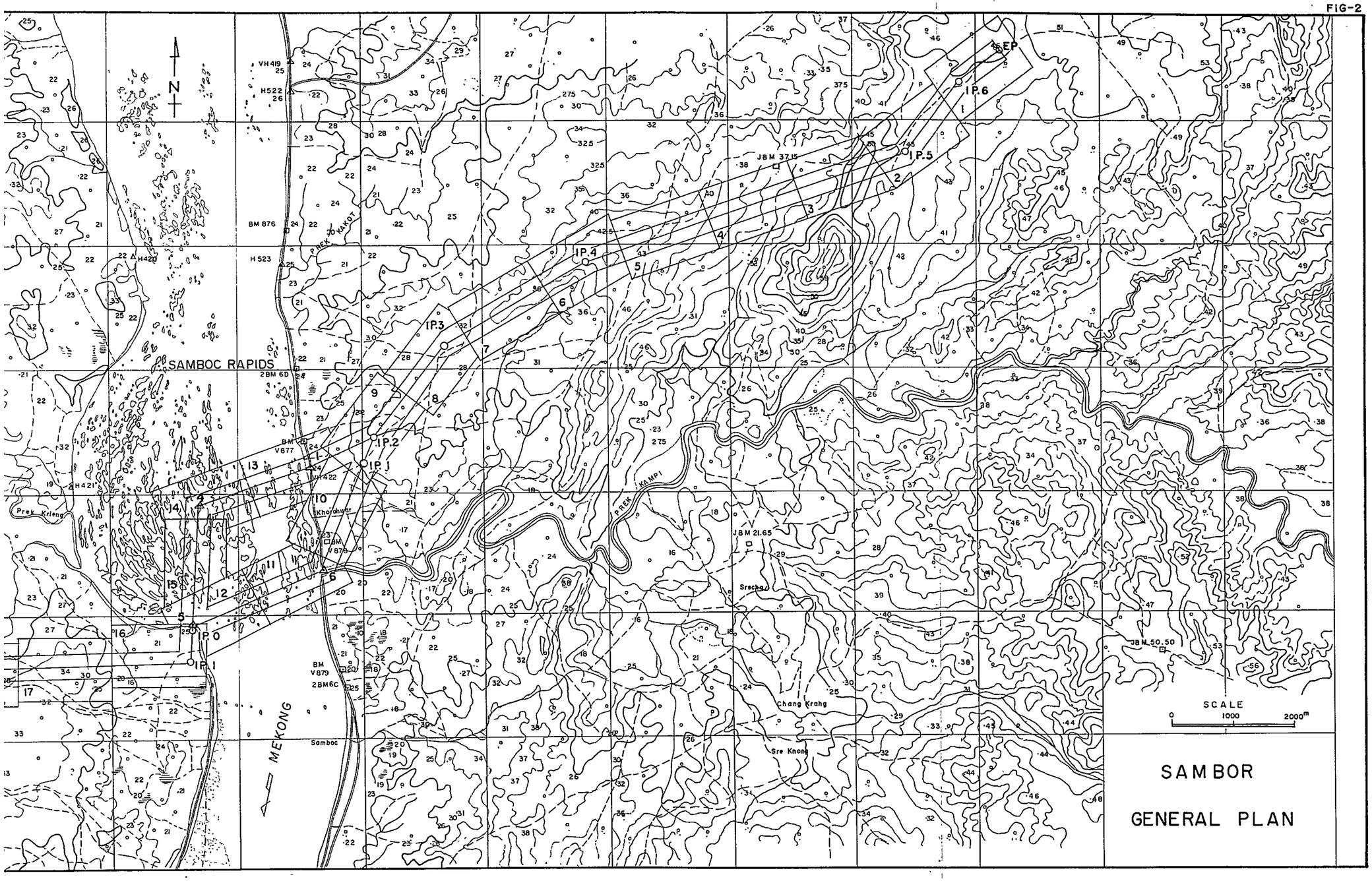

SAMBOC RAPIDS
MEKONG
N
EP
IP 1
IP 2
IP 3
IP 4
IP 5
IP 6
Samboc
Tyrroch
JBM NO 1
54.46
JBM NO 6
54.32
BM 876
H 523
H522
VH419
BM 879
2BM6C
2BM 60
BM V877
Khoi Khnar
Prek Kriang
PREK TO KAKOT

FIG-2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MEKONG
PREK KAKOT
PREK KAMPI
Prek Krieng
Khoshuar
Samboc
Sreche
Chang Krahg
Sre Knong
JBM 37.15
JBM 21.65
JBM 50.50
BM 876
H 523
H 420
H 421
H 522
VH 419
2BM 6D
BM V877
BM V879
2BM6C
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IP.1
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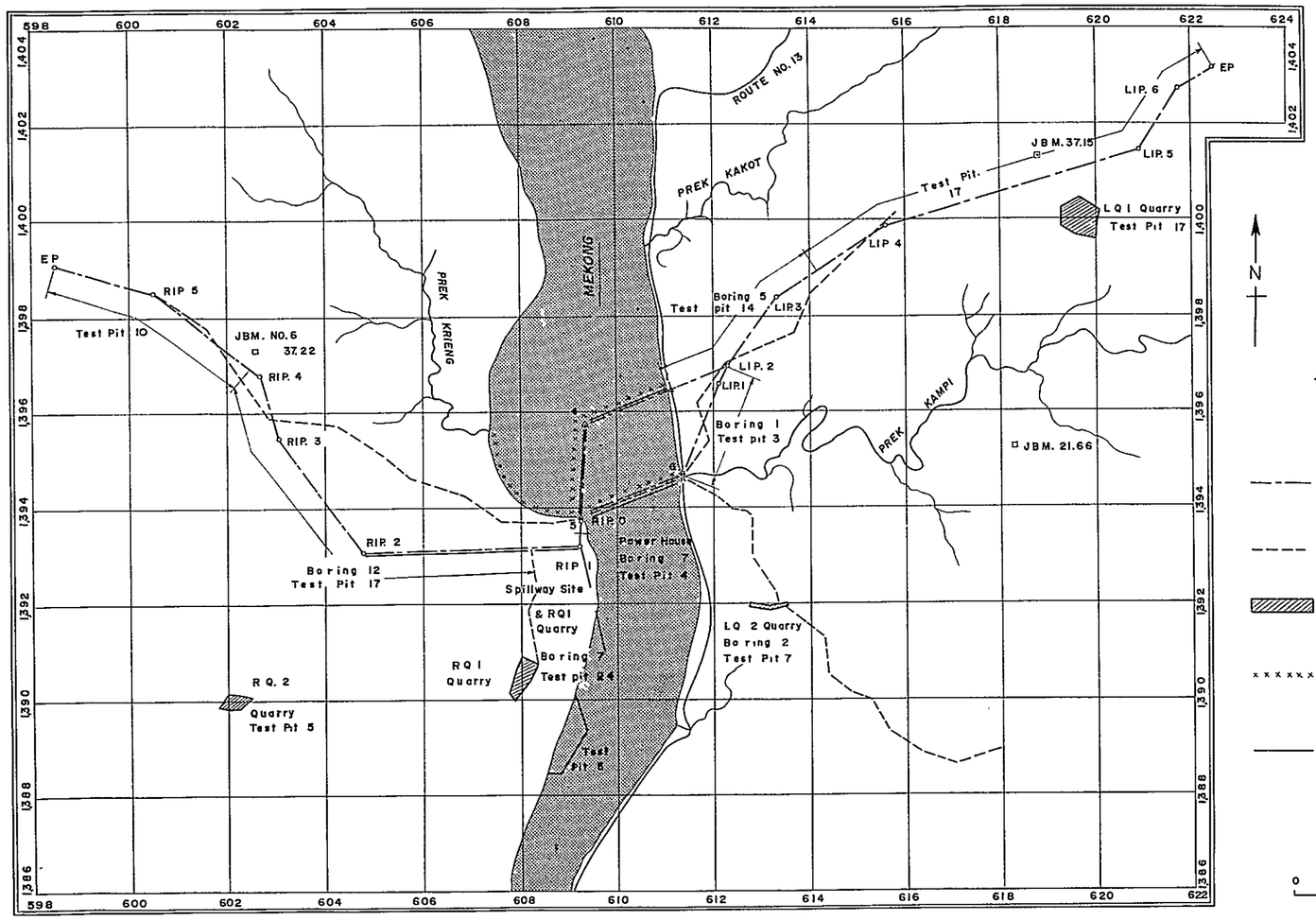
SAMBOR
GENERAL PLAN

FIG-3



LEGEND

PREFERRED DAM AXES OF JAPANESE TEAM

PREFERRED DAM AXES OF AUSTRALIAN TEAM

QUARRY

GEOLOGICAL MAPPING SCALE 1 : 2,000

MEASURERING LINES OF SEISMIC PROSPECTING

SCALE

0 1 2 3 4 Km.

OVERSEAS TECHNICAL COOPERATION AGENCY TOKYO JAPAN	
SAMBOR PROJECT	
INDEX MAP OF GEOLOGICAL INVESTIGATION	
ELECTRIC POWER DEVELOPMENT COMPANY (CONSULTING ENGINEERS)	
DRAWN OFFICE TOKYO	DWG. NO. H0-0200
CHECKED DATE MAY. 1963	
SUBMITTED RECOMMENDED	
APPROVED	SHEET No.

FIG-4

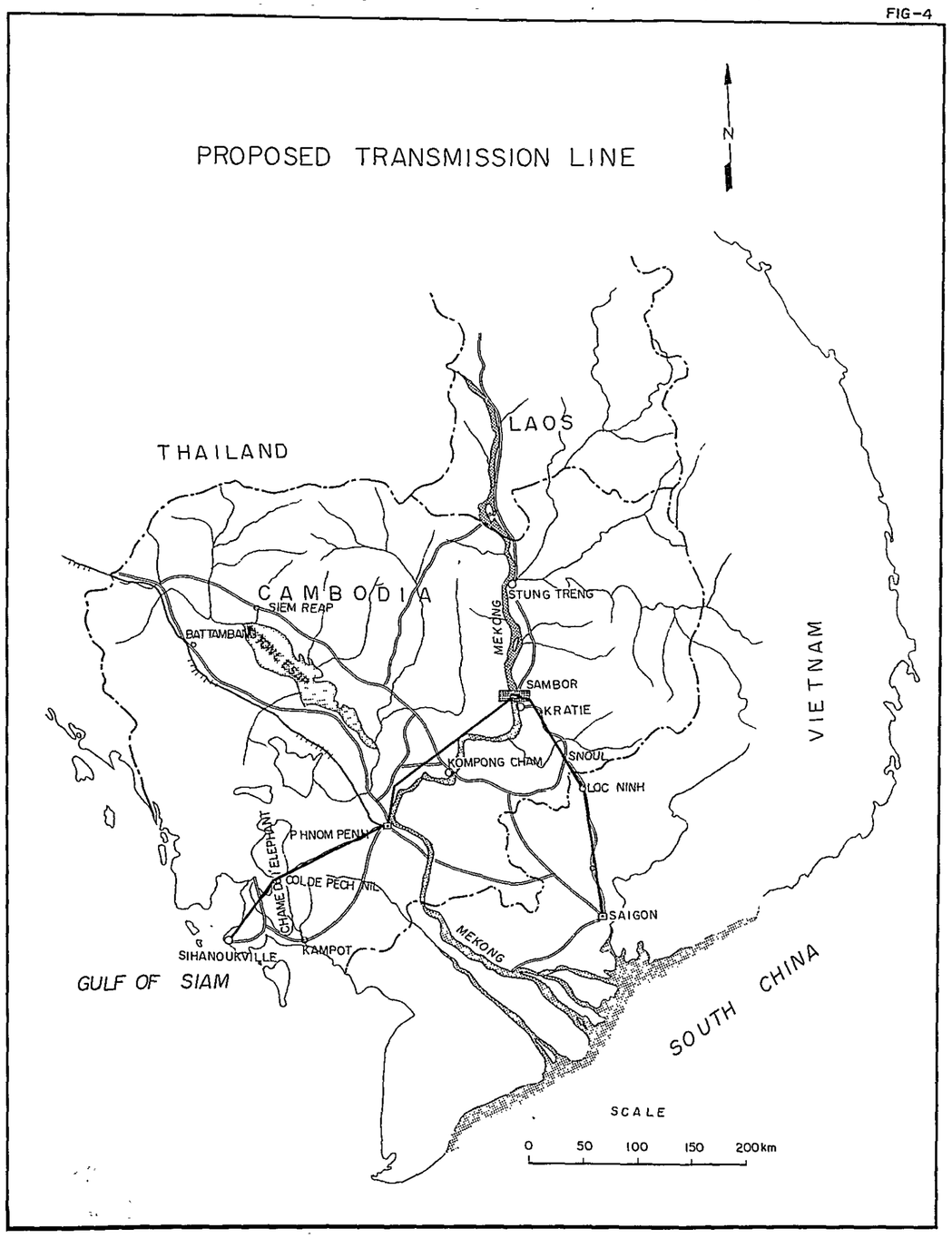
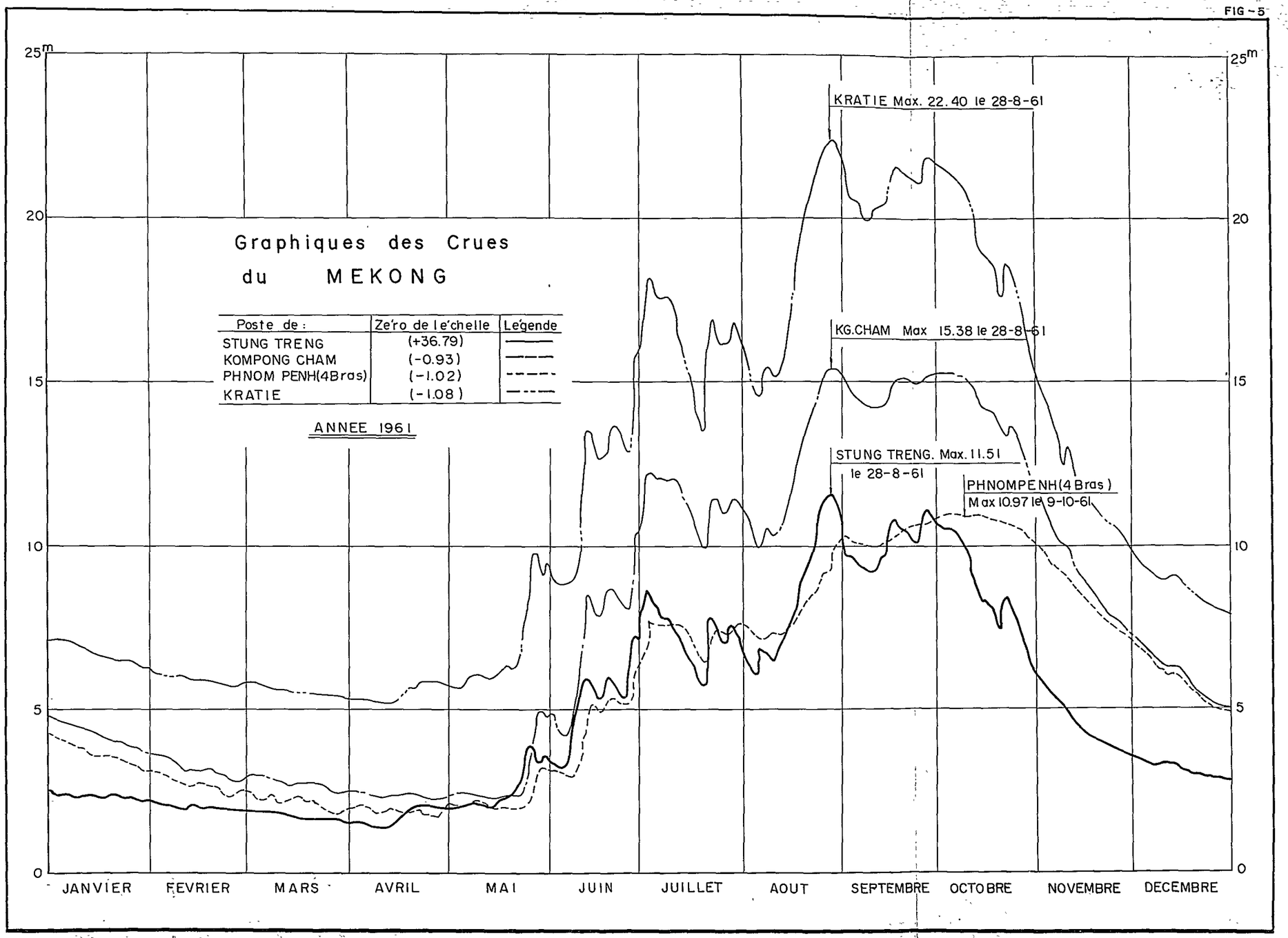

PROPOSED TRANSMISSION LINE
N
THAILAND
LAOS
CAMBODIA
SIEM REAP
BATTAMBANG
TONLE SAP
STUNG TRENG
MEKONG
SAMBOR
KRATIE
KOMPONG CHAM
SNOUL
LOC NINH
VIETNAM
PHNOM PENH
ELEPHANT
CHAMEDA
COL DE PECH NIL
SAIGON
MEKONG
SIHANOUKVILLE
KAMPOT
GULF OF SIAM
SOUTH CHINA
SCALE
0 50 100 150 200km

FIG - 5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KOMPONG CHAM | (-0.93)
PHNOM PENH(4Bras) | (-1.02)
KRATIE | (-1.08)
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KRATIE Max. 22.40 le 28-8-61
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STUNG TRENG. Max. 11.51
le 28-8-61
PHNOMPENH(4 Bras)
Max 10.97 le 9-10-61
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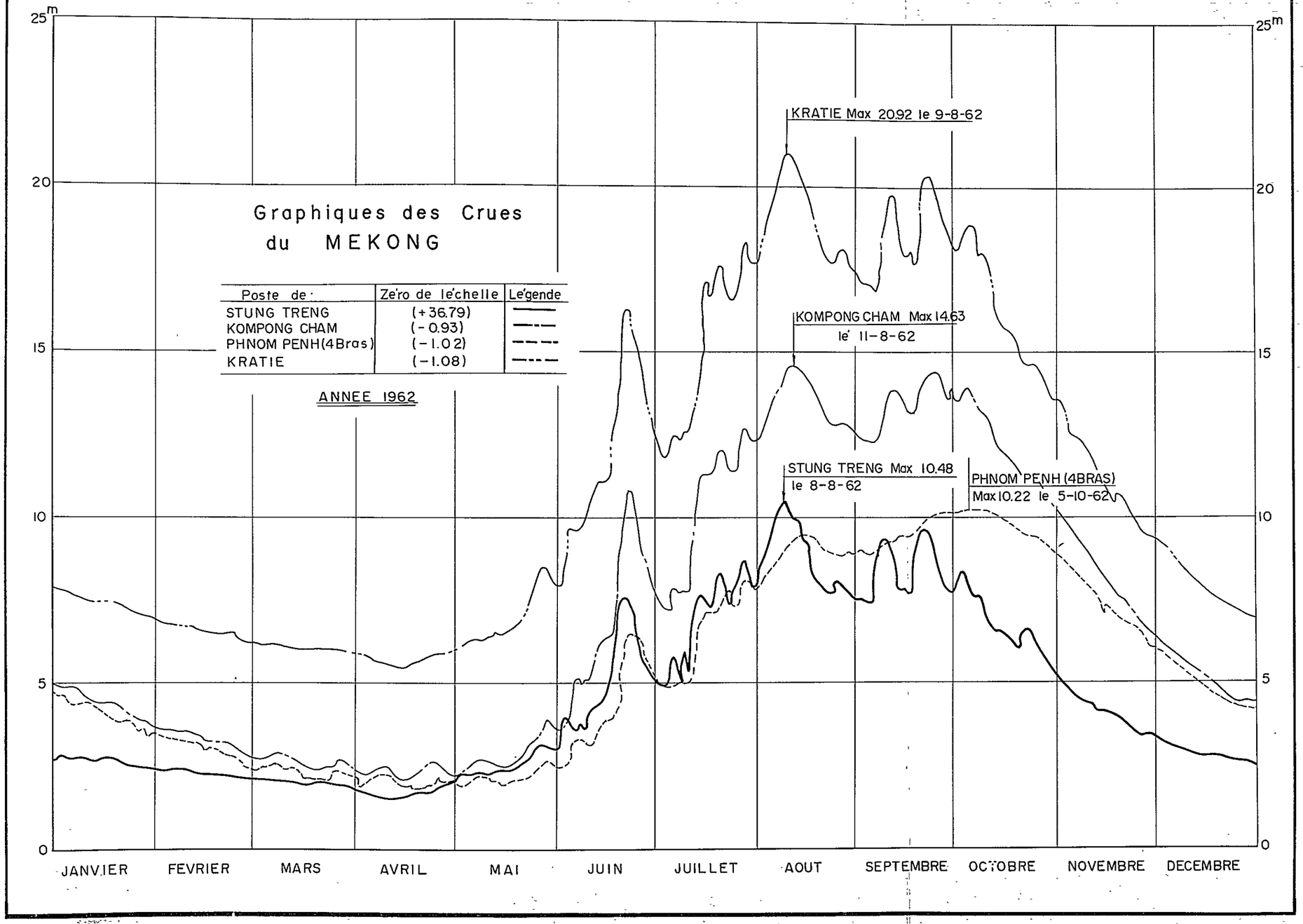
SEPTEMBRE
OCTOBRE
NOVEMBRE
DECEMBRE

FIG – 6


Graphiques des Crues
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PHNOM PENH(4Bras) | (-1.02)
KRATIE | (-1.08)
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le 11-8-62
STUNG TRENG Max 10.48
le 8-8-62
PHNOM PENH (4BRAS)
Max 10.22 le 5-10-62
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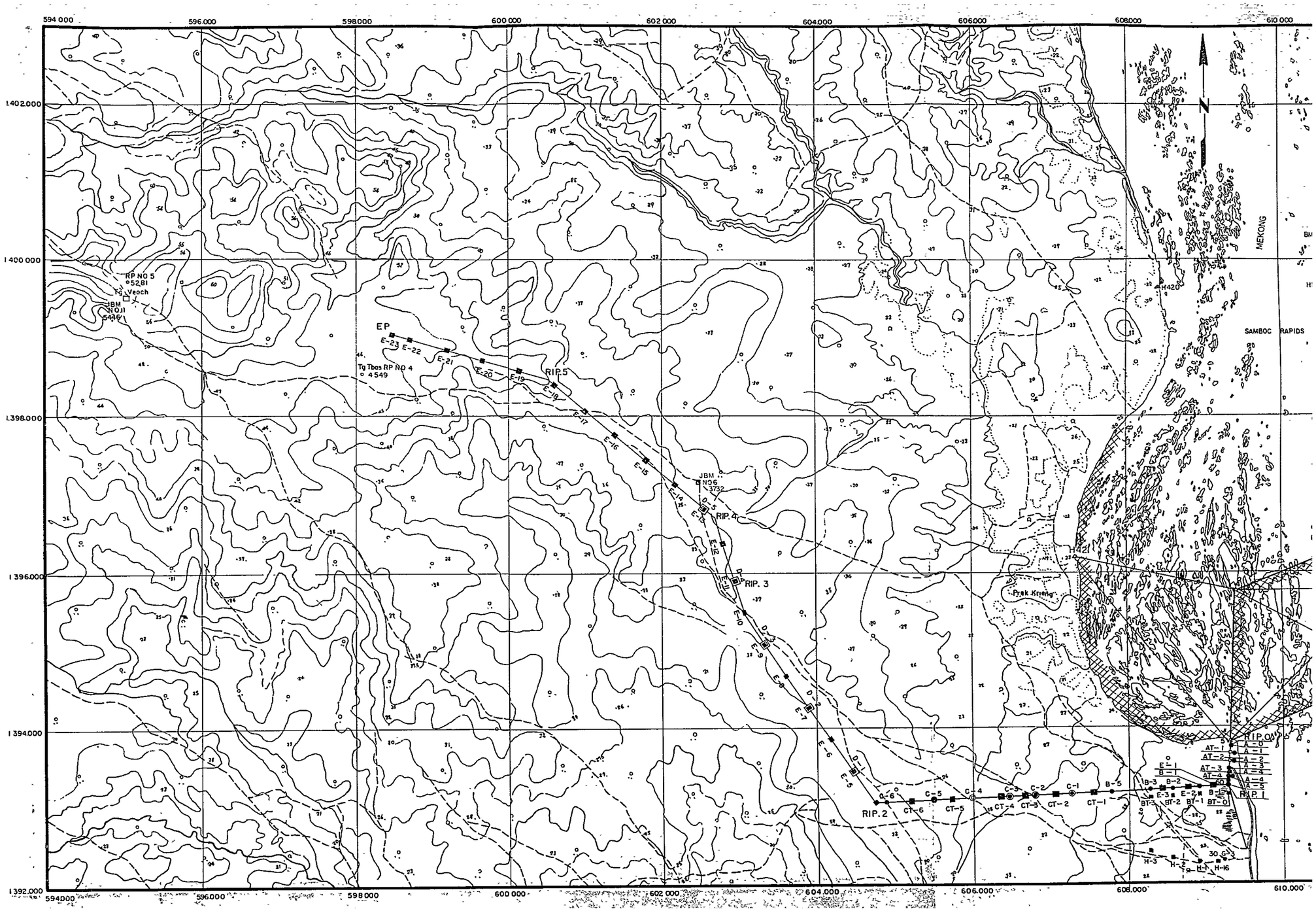
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RIP.5
JBM
NO6
3732
RIP. 4
RIP. 3
RIP. 2
Prak Kriang
H420
H421
RIP.0
RIP. 1
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C-1
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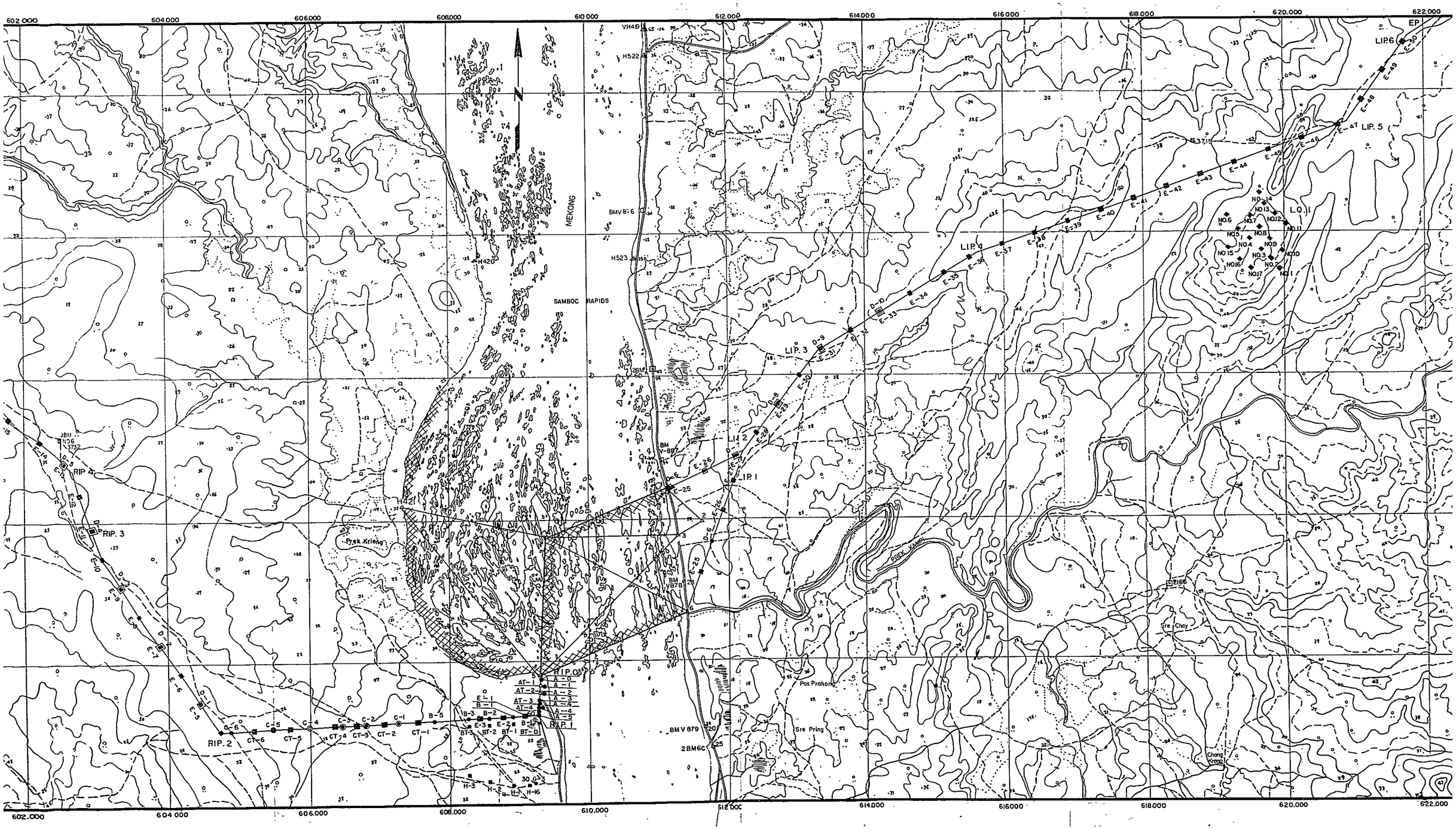
H-16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MEKONG
SAMBOC RAPIDS
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PREK KAMPI
Pos Prahong
Sre Pring
Sre Chay
Chang Vang
RIP. 1
RIP. 2
RIP. 3
RIP. 4
RIP. 0
LIP. 1
LIP. 2
LIP. 3
LIP. 5
LIP. 6
L.O. 1
EP
H522
H523
H420
H421
BMV876
BMV879
2BM6C
VH48
AT-1
AT-2
AT-3
AT-4
A-0
A-1
A-2
A-3
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A-5
A-6
E-1
B-1
B-2
B-3
B-5
C-1
C-2
C-3
C-4
C-5
C-6
CT-1
CT-2
CT-3
CT-4
CT-5
CT-6
BT-0
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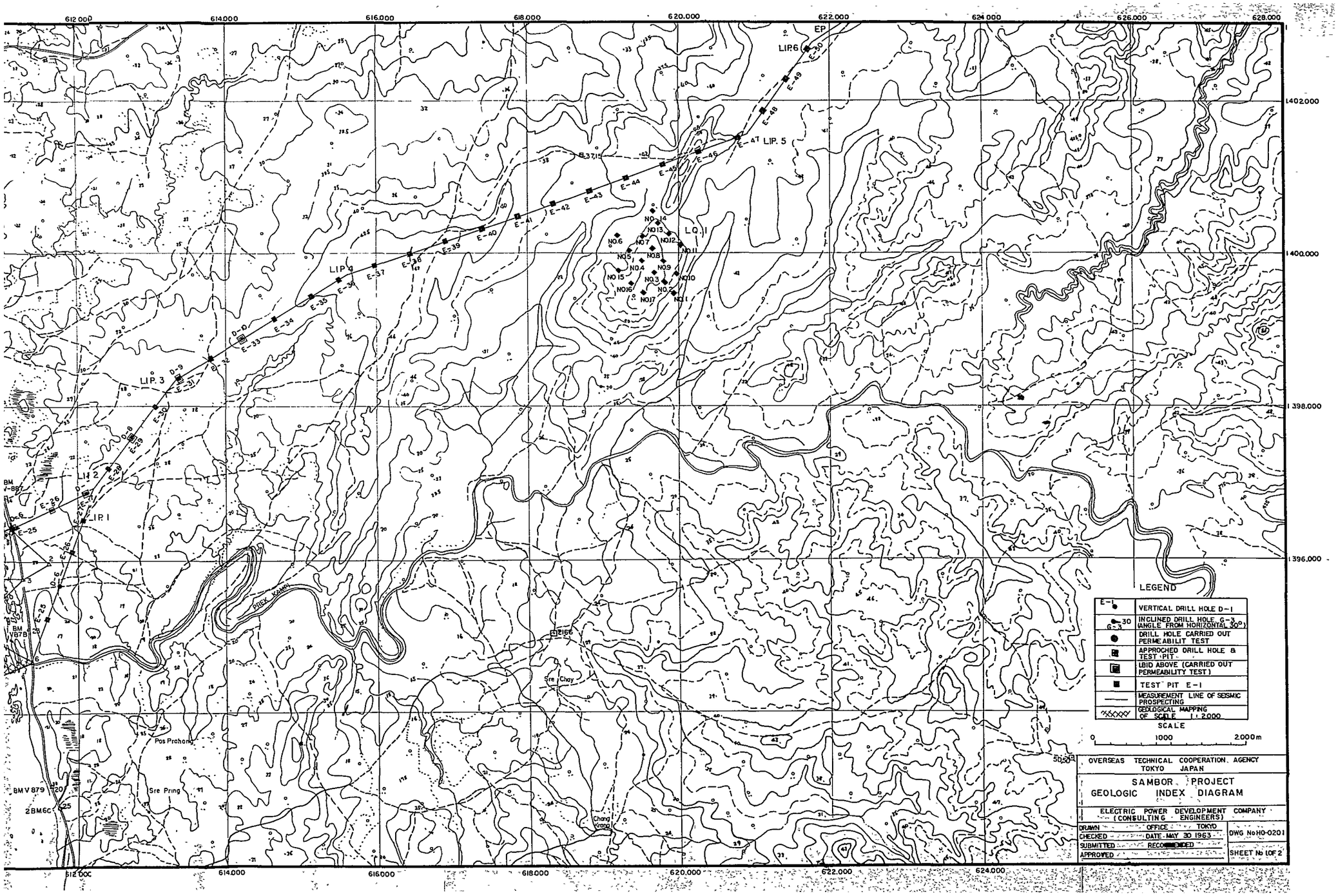
D-22
D-23
D-24
D-25
D-26
D-27
D-28
D-29
D-30
D-31
D-32
D-33
D-34
D-35
D-36
D-37
D-38
D-39
D-40
D-41
D-42
D-43
D-44
D-45
D-46
D-47
D-48
D-49
D-50
NO.1
NO.2
NO.3
NO.4
NO.5
NO.6
NO.7
NO.8
NO.9
NO.10
NO.11
NO.12
NO.13
NO.14
NO.15
NO.16
NO.17


612.000
614.000
616.000
618.000
620.000
622.000
624.000
626.000
628.000
1.402.000
1.400.000
1.398.000
1.396.000
EP
LIR6
E-50
E-49
E-48
E-47
LIP. 5
E-46
E-45
E-44
E-43
E-42
E-41
E-40
E-39
E-38
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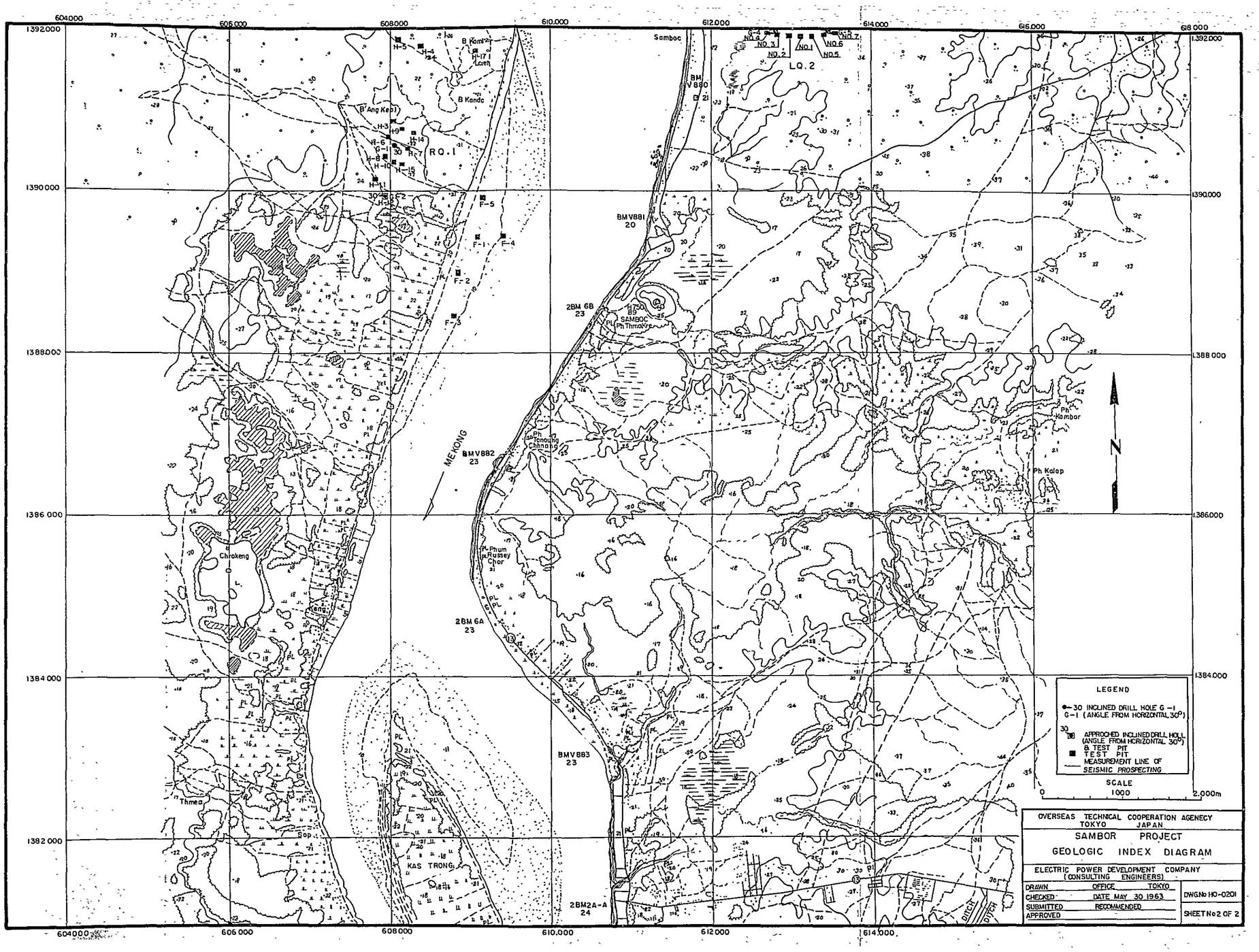
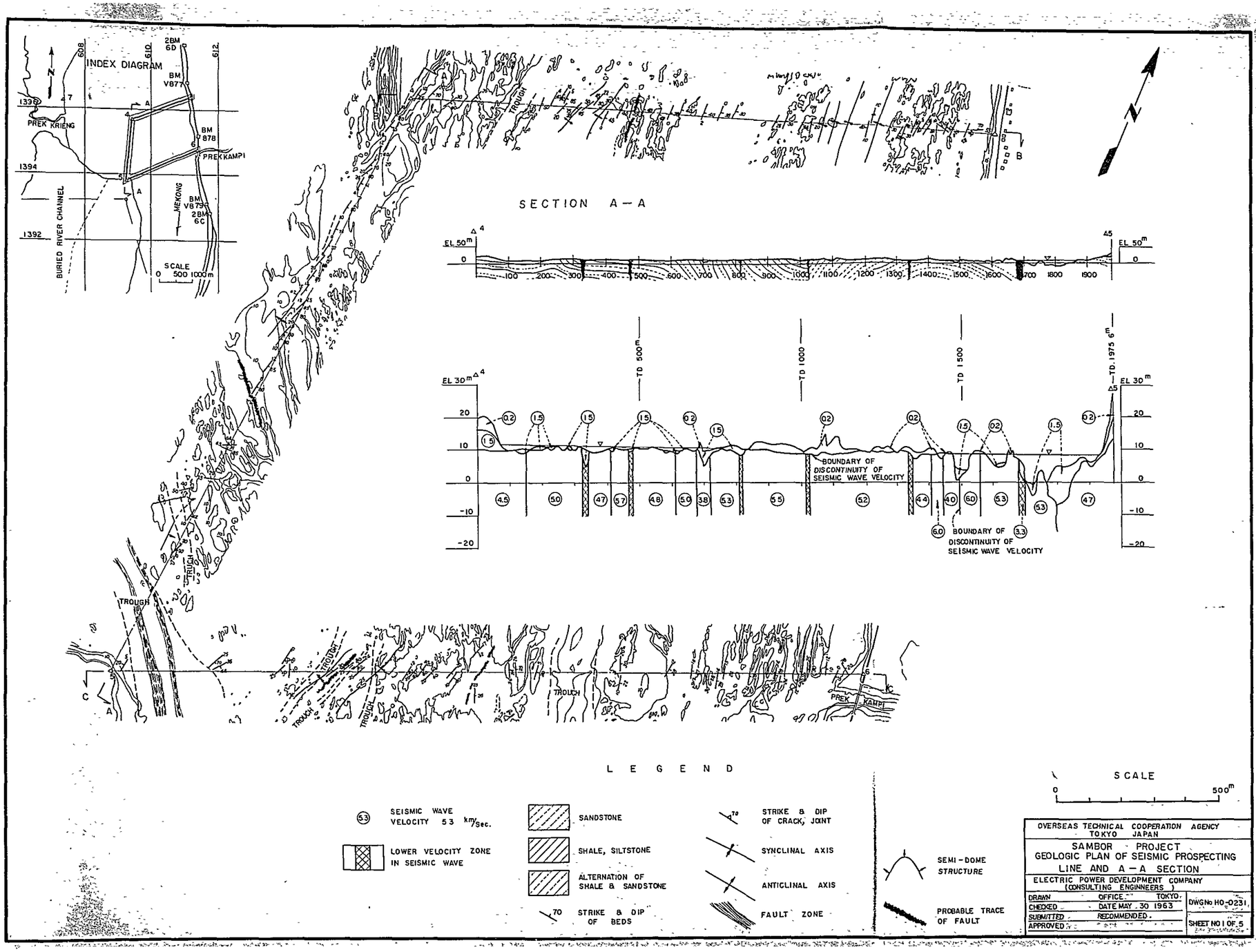
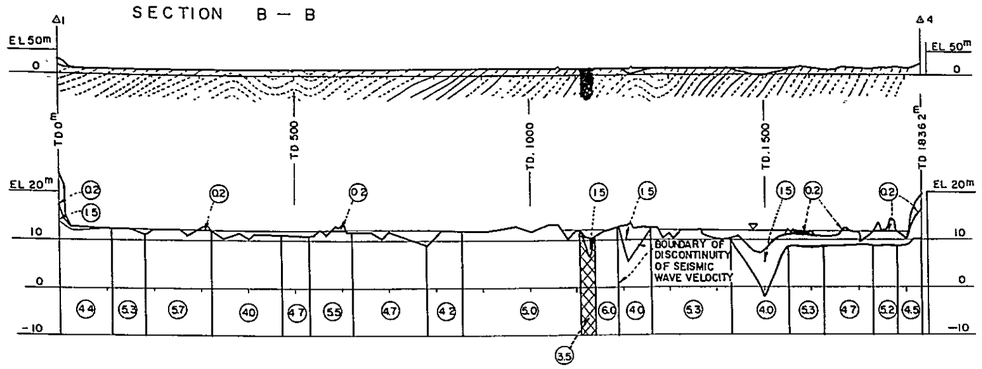
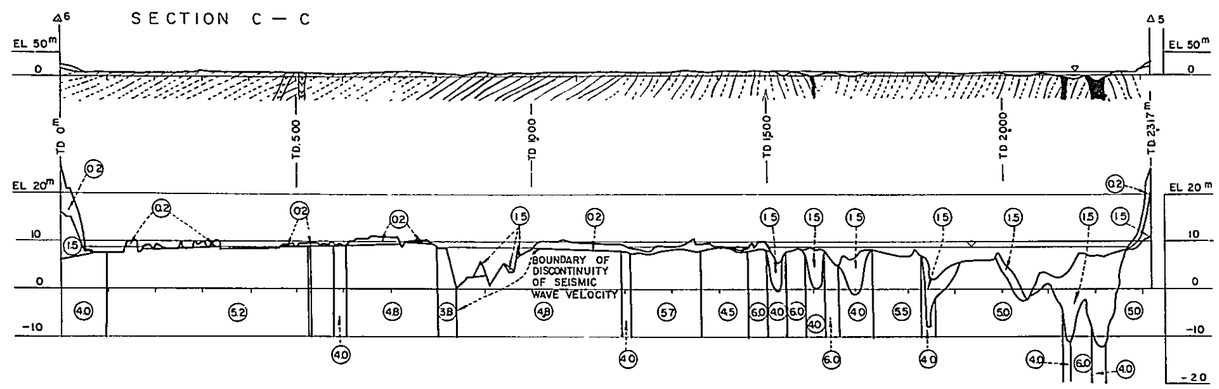
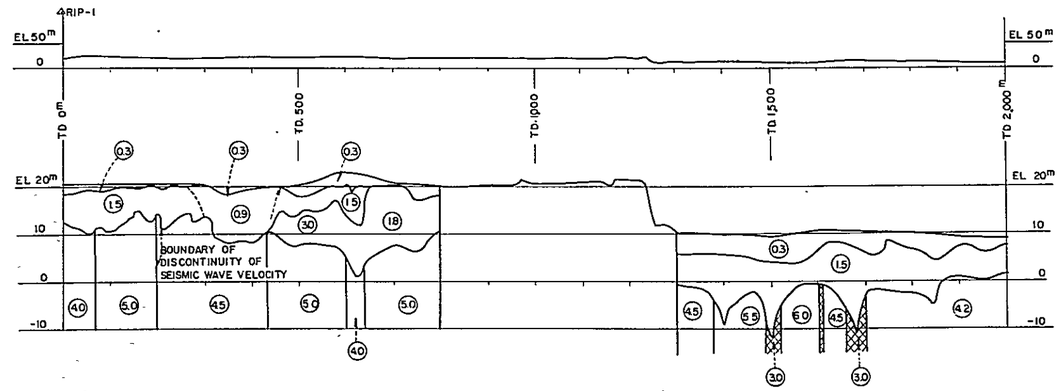
E-26
E-25
E-24
LIP. 4
LIP. 3
LIP. 2
LIP. 1
LQ. 1
NO. 1
NO. 2
NO. 3
NO. 4
NO. 5
NO. 6
NO. 7
NO. 8
NO. 9
NO. 10
NO. 11
NO. 12
NO. 13
NO. 14
NO. 15
NO. 16
NO. 17
D-9
D-8
D-6
BM V-887
BM V87B
BM V879
2BM6C
PIEK KANG
Sre Chay
Pos Prohong
Sre Pring
Chang Krang
LEGEND
VERTICAL DRILL HOLE D-1
INCLINED DRILL HOLE G-3 (ANGLE FROM HORIZONTAL 30°)
DRILL HOLE CARRIED OUT PERMEABILIT TEST
APPROCHED DRILL HOLE & TEST PIT
UBID ABOVE (CARRIED OUT PERMEABILITY TEST)
TEST PIT E-1
MEASUREMENT LINE OF SEISMIC PROSPECTING
GEOLOGICAL MAPPING OF SCALE 1:2000
SCALE
0
1000
2000m
OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN
SAMBOR PROJECT
GEOLOGIC INDEX DIAGRAM
ELECTRIC POWER DEVELOPMENT COMPANY
(CONSULTING ENGINEERS)
DRAWN
OFFICE TOKYO
CHECKED
DATE MAY 30 1963
SUBMITTED
RECOMMENDED
APPROVED
DWG No HO-0201
SHEET No 1 OF 2

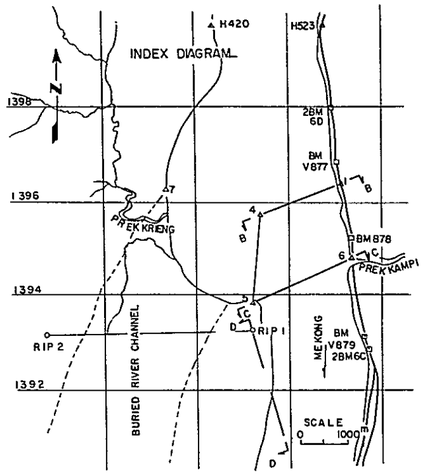

LEGEND
30 INCLINED DRILL HOLE G-1
G-1 (ANGLE FROM HORIZONTAL 30°)
APPROCHED INCLINED DRILL HOLL (ANGLE FROM HORIZONTAL 30°)
& TEST PIT
TEST PIT
MEASUREMENT LINE OF SEISMIC PROSPECTING
SCALE
1000
2,000m
OVERSEAS TECHNICAL COOPERATION AGENECY
TOKYO JAPAN
SAMBOR PROJECT
GEOLOGIC INDEX DIAGRAM
ELECTRIC POWER DEVELOPMENT COMPANY
(CONSULTING ENGINEERS)
DRAWN OFFICE TOKYO
CHECKED DATE MAY 30 1963
SUBMITTED RECOMMENDED
APPROVED
DWG No HO-0201
SHEET No 2 OF 2
MEKONG
Samboc
SAMBOC
Ph Thmoi
Ph Kombor
Ph Kalop
Chrokeng
Thmea
KAS TRONG
DITCH
N


INDEX DIAGRAM
PREK KRIENG
PREKKAMPI
BURIED RIVER CHANNEL
MEKONG
SCALE 0 500 1000m
SECTION A—A
EL 50m
EL 30m
TD 500m
TD 1000
TD 1500
TD 1975.6m
BOUNDARY OF DISCONTINUITY OF SEISMIC WAVE VELOCITY
TROUGH
PREK KAMPI
LEGEND
SEISMIC WAVE VELOCITY 5.3 km/sec.
LOWER VELOCITY ZONE IN SEISMIC WAVE
SANDSTONE
SHALE, SILTSTONE
ALTERNATION OF SHALE & SANDSTONE
STRIKE & DIP OF BEDS
STRIKE & DIP OF CRACK, JOINT
SYNCLINAL AXIS
ANTICLINAL AXIS
FAULT ZONE
SEMI-DOME STRUCTURE
PROBABLE TRACE OF FAULT
SCALE 0 500m
OVERSEAS TECHNICAL COOPERATION AGENCY TOKYO JAPAN
SAMBOR PROJECT
GEOLOGIC PLAN OF SEISMIC PROSPECTING LINE AND A—A SECTION
ELECTRIC POWER DEVELOPMENT COMPANY (CONSULTING ENGINEERS)
DRAWN OFFICE TOKYO
CHECKED DATE MAY 30 1963
SUBMITTED RECOMMENDED
APPROVED
DWG No HO-0231
SHEET NO 1 OF 5









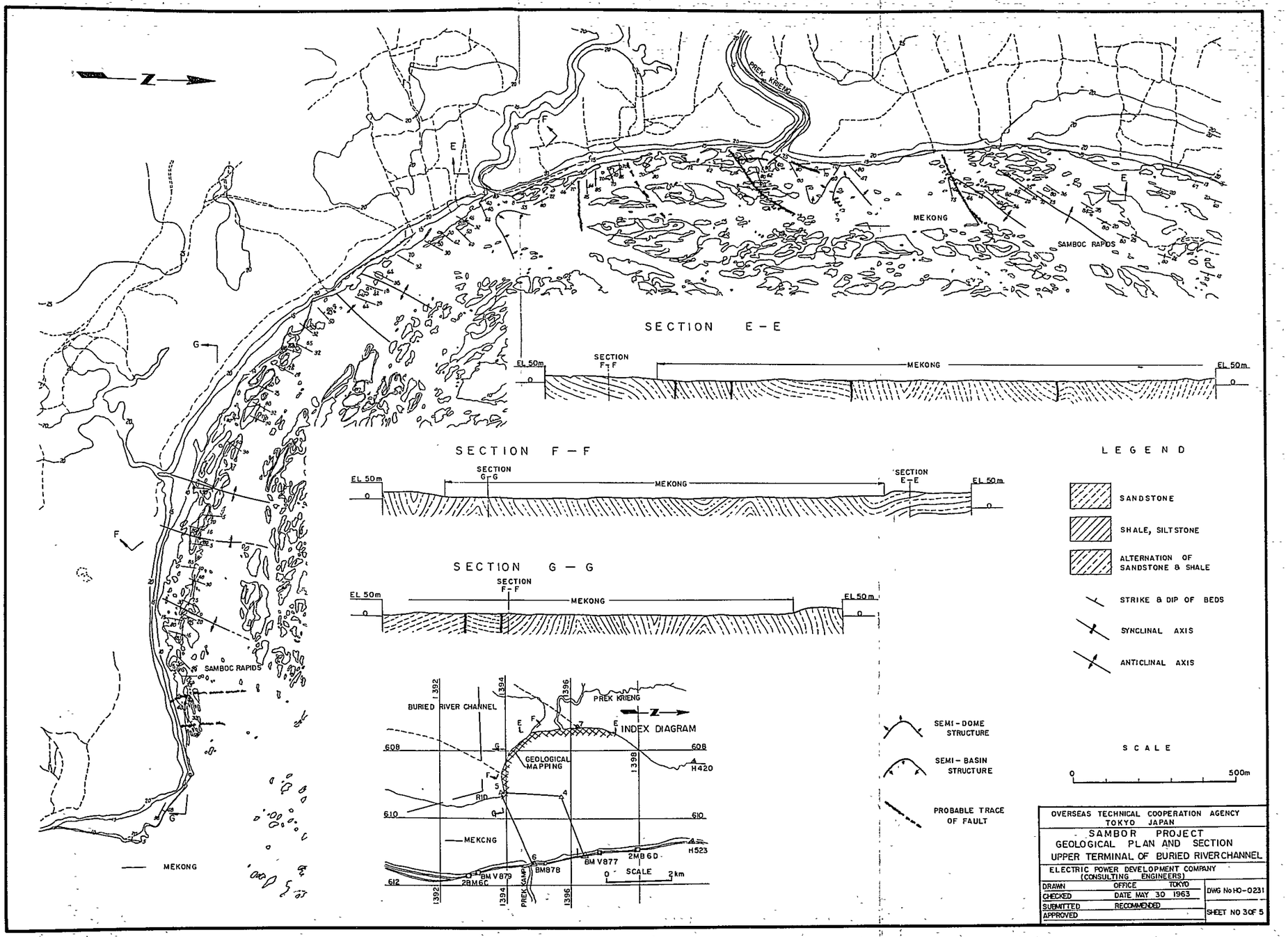
LEGEND

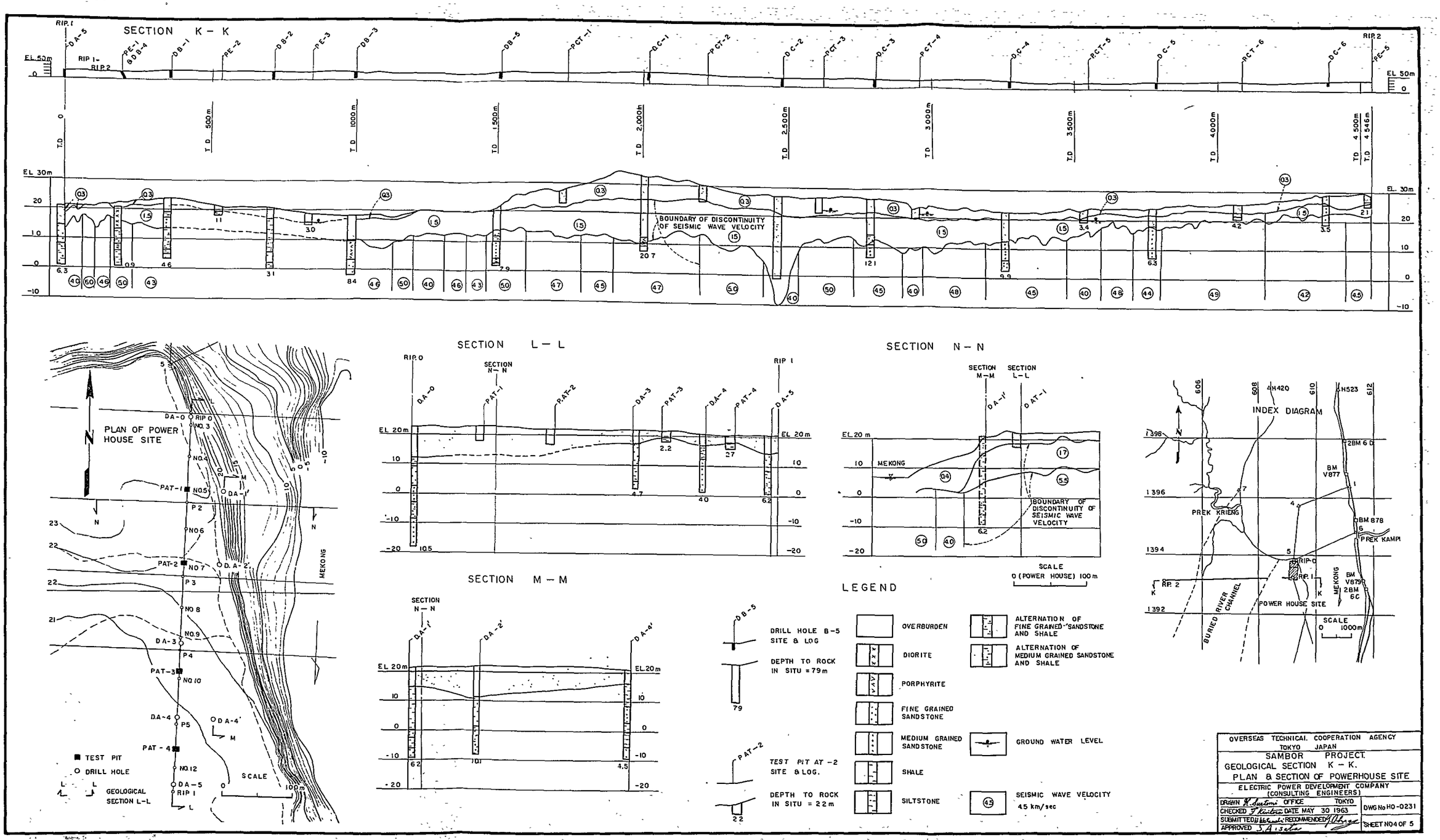
- SANDSTONE
- SHALE, SILTSTONE
- ALTERNATION OF SANDSTONE & SHALE
- DYKE ROCK
- PROBABLE FAULT
- (5.0) SEISMIC WAVE VELOCITY 5.0 KM/SEC
- LOWER VELOCITY ZONE IN SEISMIC WAVE

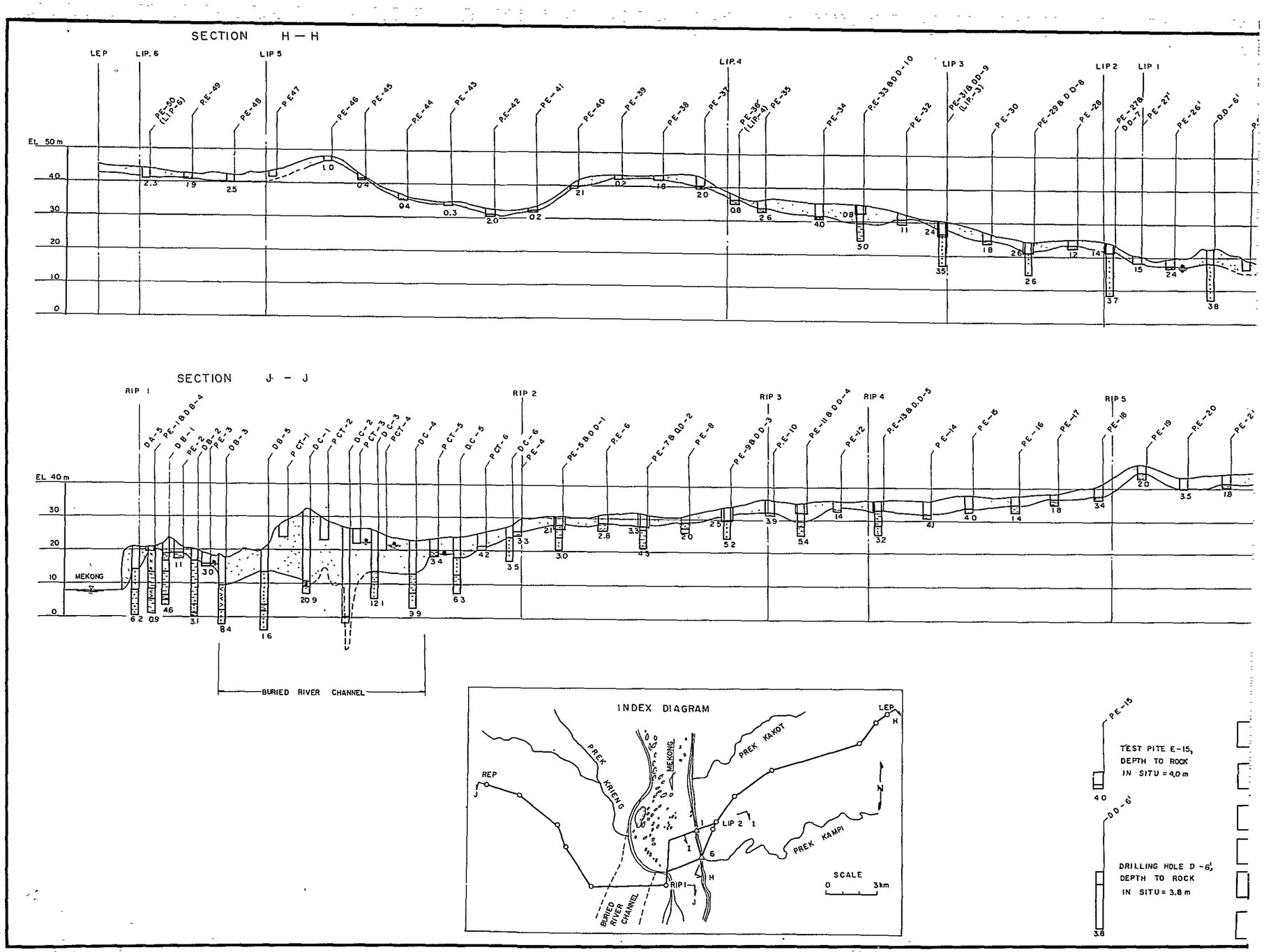
SCALE

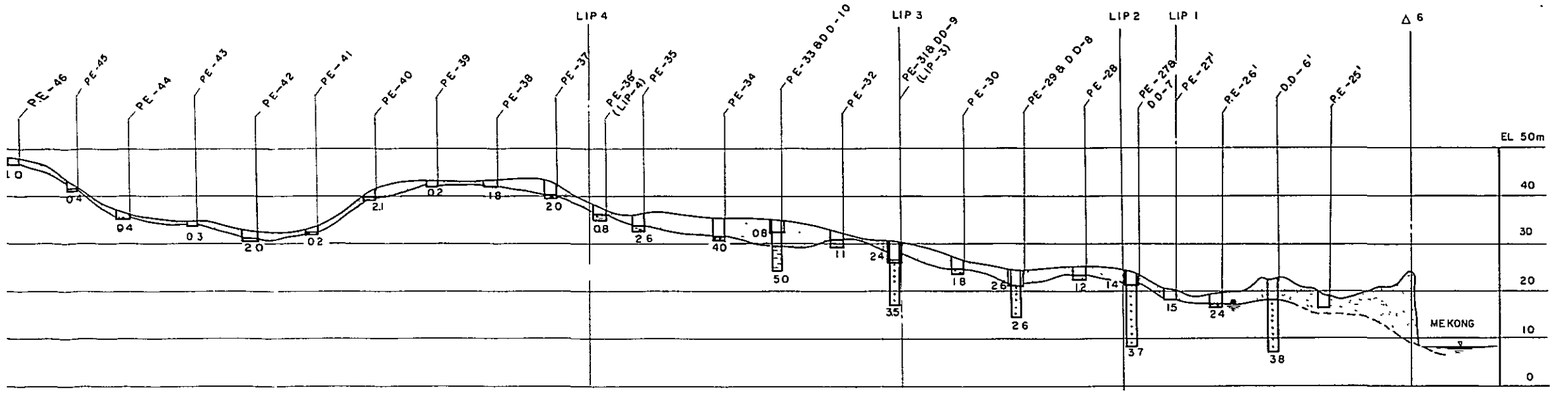
0 — 500m

OVERSEAS TECHNICAL COOPERATION AGENCY TOKYO JAPAN	
SAMBOR PROJECT GEOLOGICAL SECTION B—B. C—C & D—D	
ELECTRIC POWER DEVELOPMENT COMPANY (CONSULTING ENGINEERS)	
DRAWN OFFICE TOKYO	DWG. No HO-0231
CHECKED DATE MAY 30 1963	
SUBMITTED RECOMMENDED	
APPROVED	SHEET No 2 OF 5

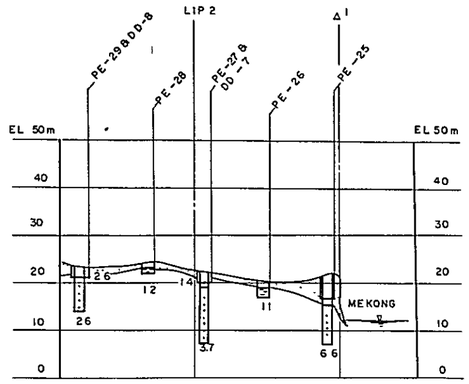

N
PREK KRIENG
MEKONG
SAMBOC RAPIDS
SECTION E-E
EL 50m
SECTION F-F
MEKONG
SECTION F-F
SECTION G-G
SECTION E-E
SECTION G-G
SECTION F-F
BURIED RIVER CHANNEL
PREK KRIENG
INDEX DIAGRAM
GEOLOGICAL MAPPING
H420
H523
BM V877
2MB6D
BM V879
2BM6C
BM878
PREK KAMP
SCALE
2km
LEGEND
SANDSTONE
SHALE, SILTSTONE
ALTERNATION OF SANDSTONE & SHALE
STRIKE & DIP OF BEDS
SYNCLINAL AXIS
ANTICLINAL AXIS
SEMI-DOME STRUCTURE
SEMI-BASIN STRUCTURE
PROBABLE TRACE OF FAULT
SCALE
0
500m
OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN
SAMBOR PROJECT
GEOLOGICAL PLAN AND SECTION
UPPER TERMINAL OF BURIED RIVER CHANNEL
ELECTRIC POWER DEVELOPMENT COMPANY
(CONSULTING ENGINEERS)
DRAWN OFFICE TOKYO
CHECKED DATE MAY 30 1963
SUBMITTED RECOMMENDED
APPROVED
DWG No HO-0231
SHEET NO 3 OF 5

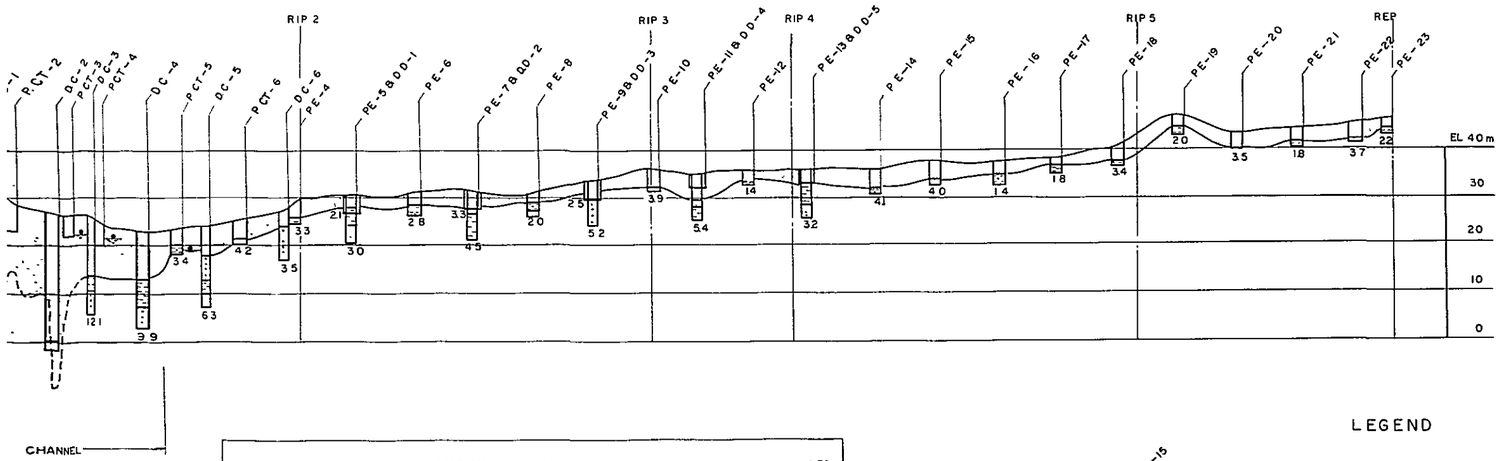

SECTION K – K
BOUNDARY OF DISCONTINUITY OF SEISMIC WAVE VELOCITY
SECTION L – L
SECTION N – N
SECTION M – M
PLAN OF POWER HOUSE SITE
MEKONG
TEST PIT
DRILL HOLE
GEOLOGICAL SECTION L-L
SCALE
INDEX DIAGRAM
PREK KRIENG
PREK KAMPI
BURIED RIVER CHANNEL
POWER HOUSE SITE
LEGEND
DRILL HOLE B-5 SITE & LOG
DEPTH TO ROCK IN SITU = 79m
TEST PIT AT -2 SITE & LOG.
DEPTH TO ROCK IN SITU = 22m
OVERBURDEN
DIORITE
PORPHYRITE
FINE GRAINED SANDSTONE
MEDIUM GRAINED SANDSTONE
SHALE
SILTSTONE
ALTERNATION OF FINE GRAINED SANDSTONE AND SHALE
ALTERNATION OF MEDIUM GRAINED SANDSTONE AND SHALE
GROUND WATER LEVEL
SEISMIC WAVE VELOCITY 4.5 km/sec
OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN
SAMBOR PROJECT
GEOLOGICAL SECTION K – K.
PLAN & SECTION OF POWERHOUSE SITE
ELECTRIC POWER DEVELOPMENT COMPANY
(CONSULTING ENGINEERS)
DRAWN OFFICE TOKYO
CHECKED DATE MAY 30 1963
SUBMITTED RECOMMENDED
APPROVED
DWG No HO-0231
SHEET NO 4 OF 5

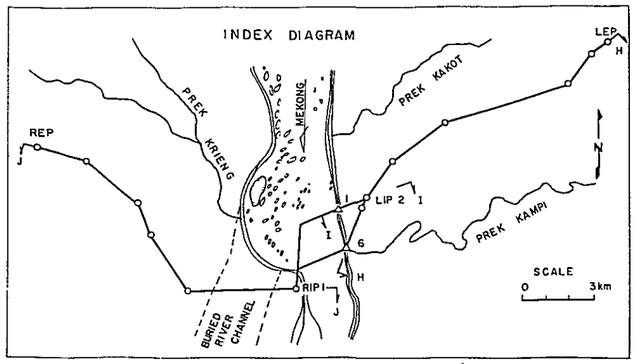

SECTION H — H
LEP
LIP. 6
LIP 5
LIP.4
LIP 3
LIP 2
LIP 1
EL. 50 m
40
30
20
10
0
SECTION J - J
RIP 1
RIP 2
RIP 3
RIP 4
RIP 5
EL 40 m
MEKONG
BURIED RIVER CHANNEL
INDEX DIAGRAM
REP
LEP
PREK KRIENG
MEKONG
PREK KAKOT
PREK KAMPI
LIP 2
RIP1
BURIED RIVER CHANNEL
SCALE
0
3km
N
TEST PITE E-15,
DEPTH TO ROCK
IN SITU = 4.0 m
DRILLING HOLE D-6',
DEPTH TO ROCK
IN SITU = 3.8 m



SECTION I – I







LEGEND

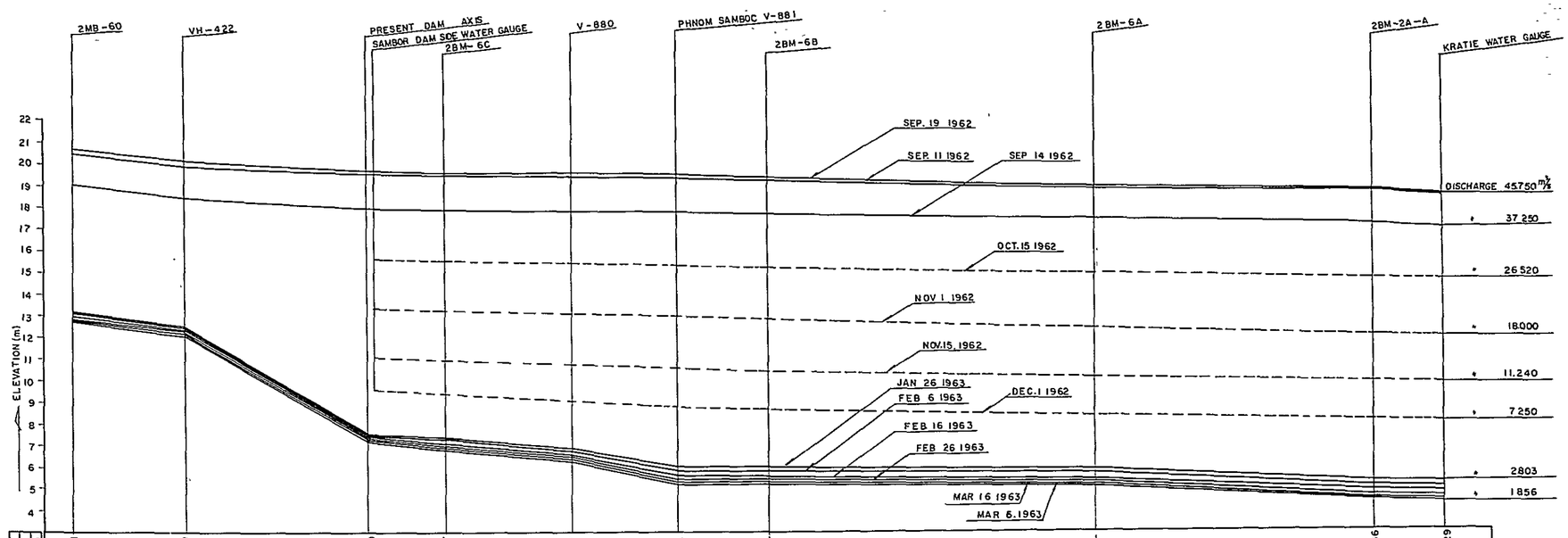
PE-15
TEST PITE E-15, DEPTH TO ROCK IN SITU = 4.0 m
4.0

D D-6'
DRILLING HOLE D-6', DEPTH TO ROCK IN SITU = 3.8 m
3.8

OVERBURDEN
DIORITE
PORPHYRITE
SHALE
SILTSTONE
SANDSTONE
ALTERNATION OF SHALE & SANDSTONE
GROUND WATER LEVEL IN TEST PIT

SCALE
0 1,000 2,000 m

OVERSEAS TECHNICAL COOPERATION AGENCY TOKYO JAPAN		
SAMBOR PROJECT GEOLOGICAL SECTION — ABUTMENTS SECTION H-H, I-I & J-J		
ELECTRIC POWER DEVELOPMENT COMPANY (CONSULTING ENGINEERS)		
DRAWN	OFFICE TOKYO	DWG No HO-0231
CHECKED	DATE MAY 30 1963	
SUBMITTED	RECOMMENDED	SHEET No 5 OF 5
APPROVED		



No	DISTANCE (km)	TOTAL DISTANCE (km)	1962 9-11	1962 9-14	1962 9-19	1963 1-26	1963 2-6	1963 2-16	1963 2-26	1963 3-6	1963 3-16
1	-1.60	-4.16	20.50	19.04	20.70	13.14	13.05	12.95	12.82	12.79	12.71
2	-2.56	-2.56	19.99	18.47	20.16	12.44	12.38	12.30	12.21	12.17	12.10
3	0	0	19.53	17.96	19.68	7.53	7.50	7.46	7.34	7.27	7.20
4	1.10	1.10	19.48	17.88	19.58	7.36	7.23	7.10	6.91	6.86	6.77
5	1.80	2.90	19.36	17.72	19.48	6.82	6.70	6.56	6.43	6.37	6.27
6	1.50	4.40	19.20	17.65	19.33	5.97	5.78	5.53	5.36	5.24	5.13
7	1.28	5.68									
8	-4.60	10.28	18.77	17.35	10.87	5.86					
9	4.00	14.28	18.73	17.19	18.76	5.30	5.07	4.82	4.61	4.47	4.36
10	1.00	15.28	18.54	17.05	18.62	5.25	5.03	4.80	4.57	4.43	4.29

SCALE

0 1000 2000 3000 4000 m

OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN

SAMBOR PROJECT

PROFILE OF MEKONG RIVER (SAMBOR-KRATIE)

ELECTRIC POWER DEVELOPMENT COMPANY
(CONSULTING ENGINEERS)

DRAWN OFFICE TOKYO
CHECKED DATE MAY 30 1963
SUBMITTED RECOMMENDED
APPROVED

DWG No HO-0024

SHEET No