REPORT

ON

THE UPPER KRONG BUK IRRIGATION PROJECT

IN

THE UPPER SREPOK BASIN

VIET-NAM

MARCH 1966

THE OVERSEAS TECHNICAL COOPERATION AGENCY

TOKYO

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Preface

The Upper Srepok which is one of the major tributaries of the Mekong, is an important water resource in Viet-Nam.

In response to the request of the Committee for Coordination of Investigations of the Lower Mekong Basin (hereinafter referred to as "the Mekong Committee"), the Government of Japan had conducted the hydrologic investigations of this river in the fiscal year 1961, and the studies on the irrigation scheme of the low-lying Darlac marshy land within the Upper Srepok basin in the fiscal year 1962.

According to the results of these investigations, it was disclosed that the development of the lower reaches of this river such as the Darlac marshy land should not be projected exclusively for the basin itself, but as a part of the comprehensive development project of the over-all Upper Srepok basin including flood control and irrigation schemes of the Krong Buk, Krong Pach, Krong Boung, Krong Kno and others.

In the light of these circumstances, the Government of Japan took steps to investigate the Krong Buk irrigation scheme as an essential part of the comprehensive development project of the over-all Upper Srepok Project in compliance with the urgent request of the said Mekong Committee and entrusted the investigation work to the Overseas Technical Cooperation Agency, the executive agency of the Government, in the fiscal year 1963.

The Agency organized a survey team upon conclusion of the Service Agreement with Nippon Koei Co., Ltd. and carried out a field works during the period from mid-November 1963 to mid-February 1964.

The report on the Krong Buk Irrigation Project — — which was compiled in accordance with the "Plan of Operation" signed by the Mekong Committee and the Government of Japan for the examination of the engineering and economic feasibility of the Lower Krong Buk Irrigation Scheme, along with the provisional consideration of the comprehensive development plan of the whole Upper Srepok Basin — — was submitted by the Government of Japan to the Mekong Committee in December 1964.

However, the Mekong Committee and the Government of Viet-Nam eagerly desired the Government of Japan to extend further assistance for the preparation of other projects in the Upper Srepok Basin so that at an early date, significant development of this basin could be promoted.

In the light of this request, the Government of Japan has decided to carry on the investigations relating to irrigation of the Upper Krong Buk and the adjacent areas with its 1964-year budget.

The Agency retained Nippon Koei Co., Ltd. to carry out the field works during the period from the middle of March 1965 to the end of April 1965 under the Service Agreement concluded on March 10, 1965.

This Report is compiled in accordance with the "Plan of Operation", signed by the Mekong Committee and the Government of Japan, for the adjustment of all the results of the investigations so far made, including the suggestion for the priority of project developments.

On this opportunity, I wish to express my deep thanks for the spontaneous cooperation and assistance of a number of persons and agencies in carrying out these works.

Particularly, I reiterate my deep appreciation to the Committee for Coordination of the Investigations of the Lower Mekong Basin and the Authorities concerned of the Government of Viet-Nam for their kind support and valuable advices in the course of this investigation works.

March 1966

Shinichi Shibusawa
Director General,
The Overseas Technical Cooperation Agency

The staff engaged in the investigation works and planning are as follows:

Name	Designation
Y. Kubota	President, Nippon Koei Co., Ltd. in charge of over-all supervision.
M. Sakaita	Geologist
R. Yoshida	Civil engineer
H. Suzuki	Agronomist, team leader
M. Shiga	Geologist
M. Sugawara	Agronomist
M. Yamaguchi	Civil engineer
S. Yano	Irrigation engineer
T. Yoshimatsu	Civil engineer
I. Arimoto	Civil engineer
K. Aoto	Civil engineer
K. Yatabe	Irrigation engineer
H. Ochi	Civil engineer
T. Saito	Coordinator (O. T. C. A.)

Report

on the Upper Krong Buk Irrigation Project

of the Upper Srepok Basin

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PART I

Upper Krong Buk Development Scheme

Summary and Conclusion

Subsequent to the investigations of the Krong Buk Region conducted in 1963, the Upper Krong Buk project area/1 was investigated in 1965 under the aid of the Government of Japan.

As the result of these investigations and studies, the following facts have become clear:

(1) Viewing from the topographic features, the Upper Krong Buk project area is entirely situated on the highlands, it is, therefore, suitable to upland-livestock mixed farming.

(2) As given outline in the previous report, if the irrigation scheme involving the irrigation of 9,000 hectares of land is adopted, it would necessitate the creation of the Ea Jung reservoir/2 in addition to the Upper Krong Buk reservoir.
However, it has been found that the Ea Jung reservoir would require too much of embankment materials in proportion to its storage capacity and that the proposed site is not suitable for dam construction.

(3) On the other hand, for the purpose of effective irrigation from the Ea Jung reservoir, the construction of an intake weir on its downstream reaches would be necessary.

From the above reasons, the irrigable area limited to 6,500 hectares on the upstream reaches of the Ea Krong Buk has been selected, as the irrigation will be made possible from the Upper Krong Buk reservoir only.

Considering that, with the development, the Project lands will permit raising two to three crops a year, the investment required per

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/1 The Overall Development Scheme of the Upper Srepok Basin is summarized in Part II. The position and significance of the Upper Krong Buk Project in the Overall Development Scheme is also briefly referred to in Part II.

/2 The Ea Jung dam site is located immediately above the point where the Ea Jung, a tributary of the Krong Buk, crosses the National Road No.14

hectare will not be excessive and will amount to about 1,060 US dollars, as we estimate the total investment for the Upper Krong Buk Development Scheme at about 6,890,000 US dollars of which about 2,100,000 US dollars would be foreign exchange.

On the other hand, as the annual charge for repayment on investment, maintenance, operation and other expenses will amount to about 93.0 US dollars per hectare, it should be within the repayment abilities of the land.

However, data were not available for this report for direct determination of increased returns from agricultural production and evaluation of the Project benefits owing to the unstable social conditions prevailing during the investigation period.

Accordingly, our judgement is based on a comparison with the similar development scheme of the Upper Se San Project in Viet-Nam and estimate that the benefit-cost ratio of the Upper Krong Buk Development Scheme will be as favorable as follows:

$$\frac{\text{Benefit}}{\text{Cost}} = \frac{\text{US\$672,326}}{\text{US\$389,789}} = 1.72$$

Therefore, we may conclude that the Upper Krong Buk Scheme can be tentatively recommended as economically feasible, subject to verification by an agricultural benefit study.

CHAPTER I

INTRODUCTION

1.1 Purpose and Scope of Work

The Upper Krong Buk Irrigation Project aims at the preparation of a Report including required survey works in the Project Area.

The Project covers the following scope of work:

A. Project Investigation

(1) Survey.
Ground control survey for the upstream area of the Krong Buk.

(2) Geological investigation.
Geological boring along the proposed dam axis on the upper Krong-Buk and Krong-Boung.

(3) Agricultural investigation.
Sampling and analysis of soil, and agronomic investigations mainly for the northeastern area of Ban Me Thuot and other related areas.

(4) Hydrologic investigation.
Observation of river stages and measurement of stream discharge at the proposed dam site to be investigated for this year, as well as at the existing gauging stations. Collection of subsequent data relating to meteorology and hydrology.

B. Aerial mapping.

Aerial mapping of the irrigable area in the northeast of Ban Me Thuot, Scale of mapping irrigable area should be 1/20,000 with one meter contours.

C. Project planning.

(1) Collection and analysis of the above-mentioned data.
(2) Study on irrigation and drainage method, and layout of main canals and distribution system.

(3) Study on flood control and its related structures.

D. Project design.

(1) Design of dam, appurtenant structures and pumping station.
(2) Design of irrigation structures and main canals and preliminary design of distribution system.
(3) Design of structures for flood control.
(4) Selection of type and rating of pumps and accessories.
(5) Preparation of construction schedule.

E. Project evaluation.

(1) Estimated cost of construction of the project broken down into estimated annual budgets (local as well as foreign currencies).
(2) Estimated amount of loan and interest rate (foreign currency only), period of loan and recommended repayment schedule.
(3) Assesement of benefits to be derived from the project.
(4) Economic justification.

F. Preparation of the Project Report.

Preparation of the report with compilation and adjustment of all the results of the investigations so far made and to be made for this year, including the suggestion for the priority of development.

The above report, however, shall be able to be a feasibility report by adding further basic data of one or two years relating to hydrology and meteorology.

1.2 Previous Report.

In consideration of the Mekong Committee's acceptance of the offer from the Government of Japan to undertake investigation of the Upper Srepok as anadditional contribution to the Mekong Development Program, the hydrologic investigation of the Upper Srepok had been conducted by the contribution of the Government of Japan with its 1961-year budget.

In 1962 the Government of Japan undertook the investigation of the Upper Srepok limited to the irrigation scheme of the low-lying marshy area in the Darlac Region with its 1962-year budget.

The Feasibility report on the Darlac Irrigation Project was submitted to the Mekong Committee in December 1963. In this report it is recommended that irrigation scheme would be undertaken in the Darlac region where there were already settlements of about 500 farmers and of this scheme it is recommended that irrigation of about 1,000 hectares would first be undertaken as the first priority project at a cost of 350,000 US dollars.

The cost was subsequently re-estimated and increased to 500,000 US dollars in consideration of safety factor, and at a meeting of the Advisory Board, Mr. Kubota reported about this scheme and obtained the approval of the Board.

However, at this date it is found that settlers in the Darlac region have left for other zones because of the difficulty of carrying out cultivation in the area, and thus the priority of this scheme have rather decreased.

It is also concluded in this report that the final development scheme of the Darlac Region should be contemplated jointly with the planning of the prospective upstream basin projects, because this region is situated in the lower reaches of the Upper Srepok and has a close relation with the effect from the upstream projects.

In view of real necessity of the development of the Upper Srepok Basin and under such circumstances, the investigation of the Krong Buk, which is located in the upstream of the low-lying Darlac Region, was conducted through the contribution of the Government of Japan in the fiscal year 1963.

The Report on the Krong Buk Irrigation Project was compiled and presented to the Mekong Committee in December 1964.

In this report, the irrigation of 3,500 hectares is proposed by creating one reservoir at the site located just upstream of the point where the National Road No. 21 (Ban Me Thuot/Ninh Hoa) crosses the Krong Buk River.

In and around the Krong Buk Basin, there are many existing farmlands including rubber, tea and coffee plantations, and the development of more areas in this region is desired.

However, the Lower Krong Buk reservoir is not enough to irrigate the areas and moreover it is not so economical to provide lift irrigation by this reservoir alone, because most of the said areas are located higher than the Lower Krong Buk reservoir.

Under such circumstances, it was recommended that the Lower Krong Buk Irrigation Scheme, which was the main object of our investigations carried out in 1963, be left out for future development and the detailed investigations in the Upper Krong Buk project area be carried out as early as possible for studying the feasibility of the project in detail.

1.3 Need of Future Studies and Investigations

The preliminary studies of the Overall Development Scheme of the Upper Srepok have been made on the basis of the data obtained by our investigations of the Upper Krong Buk area and by utilizing every and all data obtained by various kinds of investigations of the Upper Srepok Project area carried out by us before. Maps of the whole Srepok area on a scale of 1:50,000, which had recently been provided us for use, were also used. They are summarized in Part II.

As can be understood in Part II, in the Upper Srepok Basin, more than 20 individual projects are now contempleted for its final stage. From the viewpoint of coordinated development projects, it is essential to establish more reliable Overall Basin plan.

It is therefore required to complete the said Overall Basin plan for the entire Upper Srepok by continued studies and investigations. At the same time it is also recommended to prepare a feasibility report on two or three selected projects for their early realization.

The investigations needed for completing these future works are briefly referred to in 5, Part II. The investigations will cost about 300,000 US dollars plus some local cost 60,000 US dollars equivalent, and takes 3 years period without taking into consideration the security condition.

CHAPTER II

GENERAL DESCRIPTION

2.1 Whole Upper Srepok Project Area

The Upper Srepok Project Area, which has great possibility of the development of power or irrigation or of both, is situated in the High Plateau region of Central Viet-Nam.

The Upper Srepok Project Area consists of drainage areas of the Ea Krong, the Ea Krong Ana, the Ea Krong Kno, the Ea Krong Buk, the Ea Krong Pach and so on. In view of topographic features, these whole areas can be widely divided into two, namely, the flat alluvial lowland and gently undulating upland. The lowland extending on both banks of each river is located at elevation ranging from EL. 410 to EL. 450 meters in general, while the upland ranges mainly from 450 to 580 meters in elevation.

The climate is tropical but characterized by two distinct seasons, i.e. the dry season and the rainy season. The annual precipitation average 1,500 to 2,000 millimeters. The mean monthly temperature varies from 22^{o} C to 27^{o}C.

Basically the economy of this province is agricultural with rice as the most important crop. During the dry season covering the period of November through April, however, the agriculture becomes impossible for want of soil moisture. Only in the rainy season, rice is cultivated in the lowland which is affected frequently by the periodic flood.

Other crops such as vegetables, fruits, corn, peanut, kenaf, etc., are grown in many of the small stream valleys. Besides, there are several rubber, tea and coffee plantations as a private commercial farming. Most of the upland is covered with grass and forest and is not cultivated. In recent years, the Government policy of encouraging settlement and ownership of the land cultivated has been taken up within the Project Area for the agricultural development of this province. Under such circumstances, the present agricultural productivity in this area is very poor. Therefore, the adequate irrigation farming is required.

The Government is making a determined effort to establish development centers in this area and places an emphasis upon intensification and diversification of production in the settlement areas for refugees from the north or overpopulated areas. This area is one of the designed resettlement areas.

The principal city of the Upper Srepok Project Area, Ban Me Thuot, is about 275 kilometers northeast of Saigon and 150 kilometers northwest of Nha Trang on the coast. It has good highway connections with each.

2.2 Upper Krong Buk Basin

The Krong Buk is one of the tributaries of the Srepok. It rises in the mountain located in a center part of the Central Highland region in Viet-Nam and runs southward through the center of basin to drain into the Ea Krong Ana. It has a total length of about 70 kilometers and a total drainage area of about 740 square kilometers.

The Upper Krong Buk project area is situated on the right bank of the Ea Krong Buk lying at the elevations ranging from 600 to 680 meters above the sea-level.

The project area belongs to the highland which presents an undulating topography on account of vast basaltic lava flow covering the catchment basin, and is being opened for new communities and many hamlets have been established already.

Under these circumstances, the development of water resources in this area has been a long pending desire of Viet-Nam.

CHAPTER III

BASIC STUDIES

3.1 Water studies

3.1.1 Hydrologic record

There was no hydrologic data available for the Upper Srepok before the hydrologic investigation of the Srepok was carried out by the Government of Japan in 1961. By the contribution of the Government of Japan, the water gauging stations were first established at the two places, namely at Ban Bur and Kana respectively, for collection of the hydrologic data concerning the Upper Srepok.

In addition to these stations, others gauging stations were set up in 1963 at the two proposed dam sites, the Ea Krong Buk and Ea Krong Pach to observe the water level of these two rivers.

Accordingly, water gauging was undertaken at four stations, where the daily recording of the water level and periodical measurement of stream discharge by current-meter were undertaken.

By these observations, the discharge data of the Srepok and its tributaries, i.e. the Ea Krong Ana, Ea Krong Buk and Ea Krong Pach, were obtained as shown in Table 3.1.These observations are still being continued by the local personnel for obtaining more accurate and reliable flow data.

As for the meteorology within the project area, only meteorological data of rainfall, temperature, evaporation and relative humidity at the Ban Me Thuot Station are available for a period from 1959 up to the middle of 1965 although there are some gaps in these data, all of which are presented in the Data Books.

3.1.2 River run-off and available discharge

According to the result of survey, the characteristics of the catchment basin of the Upper Krong Buk dam site, as compared with those of the Krong Buk gauging station, are:

1) topographically rather steep
2) rather dense in the growth of plants
3) the catchment area of the Upper Krong Buk dam site covers 149 square kilometers as against the 460 square kilometers covered by the Krong Buk gauging station

Moreover, there are no low-lying lands which form puddle or prevent drainage in the rainy season. And according to our soil survey, there is little difference in soil properties in both areas.

From such characteristics, the annual run-off at the Upper Krong Buk dam site per unit area may be presumed to be a little more than that at the Krong Buk gauging station per unit area.

Thus, the discharge at the Upper Krong Buk dam site computed on the basis of discharge data at the Krong Buk gauging station may safely serve as a design value for the Upper Krong Buk irrigation purpose.

However, since there is no water gauging station in the vicinity of the Upper Krong Buk dam site, only the stream flow data covering a period of 20 months are available at the Krong Buk gauging station located about 45 kilometers downstream of the dam site, but they may not be sufficient for the study of water resources development, and especially for the study of flood control. Thereupon, an attempt was made for the estimation of the stream discharge at the Krong Buk gauging station from available rainfall record.

Thereupon, the run-off precipitation relationships were established by correlation of actual monthly run-off observed at the Krong Buk gauging station with concurrent monthly rainfall at Ban Me Thuot as stated in detail in Appendix III. By applying these relationships to the available monthly rainfall data, the monthly discharges at the Krong Buk gauging station for the period of 1955 through 1965 were estimated.

From these data, the monthly discharge at the Upper Krong Buk dam site and the Lower Krong Buk dam site are computed by using the respective area ratio as shown in Table 3.2 and Table 3.3.

According to these tables, the annual mean run-off at the Upper Krong Buk dam site is 2.92 cubic meters per second, i.e., about 92 million cubic meters per year, and at the Lower Krong Buk dam site 6.04 cubic meters per second, i.e., about 191 million cubic meters per year. The values are, however, merely calculated from the respective area ratio, and may have been estimated at somewhat smaller values than actual run-off at the Upper Krong Buk damsite. On the contrary, at the Lower Krong Buk dam site, at somewhat larger values than the remaining actual run-off.

As stated in Section 4.3, Chapter IV, the maximum required storage capacity for the Upper Krong Buk irrigation system will be 21.88 cubic meters per second per month, which may be considered to be the required storage capacity in a probable droughty year at recurrence intervals of 10 years. In order to secure irrigation water mentioned above, the creation of a reservoir of storage capacity of 60 million cubic meters would be required.

On the other hand, as seen in Section 5, Appendix III, the calculated specific discharge of the droughty year at the Kana gauging station which may occur once in 20 years would be more than 1.622 cubic meters per second per 100 square kilometers. It may be less than the specific discharge at the Upper Krong Buk dam site.

The annual run-off may be calculated with a view of conservative estimation on the basis of the above specific discharge, as follows:

$$\frac{149}{100} \times 1.622 \times 365 \times 86,400 = 76,000,000 \ (m^3)$$

Therefore, this estimated run-off could fill the reservoir with the storage capacity of 60 million cubic meters.

Table 3.1 Monthly discharge at each gauging station (measured)

(discharge in m^3/sec)

Year		Kana gauging station (3,210 km^2)			Ban Bur gauging station (8,650 km^2)			Krong Pach gauging station (490 km^2)			Krong Buk gauging station (460 km^2)		
		Mean discharge	Maximum discharge	Minimum discharge	Mean discharge	Maximum discharge	Minimum discharge	Mean discharge	Maximum discharge	Minimum discharge	Mean discharge	Maximum discharge	Minimum discharge
1961	O	85.6	139.0	30.5	487.4	822.0	266.0						
	N	59.4	72.5	43.0	199.3	296.0	160.0						
	D	31.8	45.5	25.0	120.0	160.0	90.0						
1962	J	25.5	36.5	20.0	64.2	103.0	41.5						
	F	18.1	21.5	15.0	50.1	61.0	38.0						
	M	12.9	16.5	10.5	45.0	57.0	41.5						
	A	9.8	11.5	8.5	42.3	50.0	39.0						
	M	13.0	24.5	8.0	62.0	100.0	41.0						
	J	14.4	35.5	9.5	83.6	123.0	63.0						
	J	37.8	91.0	12.0	211.6	416.0	59.0						
	A	88.7	158.0	41.0	259.3	403.0	57.0						
	S	94.8	185.0	35.0	(280)	(555)	(66)						
	O	(110.0)	(71.0)	(71.0)	336.5	1,040.0	121.0						
	N	286.4	400.0	133.0	627.1	1,000.0	305.0						
	D	172.9	395.0	51.0	283.3	482.0	114.0						
1963	J	35.0	54.0	24.5	88.5	111.0	73.0						
	F	19.9	24.0	16.0	60.8	73.0	51.0						
	M	13.1	15.0	12.0	44.2	49.0	41.0						
	A	11.1	12.0	10.0	35.6	40.0	31.0						
	M	11.0	15.0	10.0	36.7	61.7	28.7						
	J	11.6	16.9	10.0	48.4	98.1	31.0						
	J	33.6	39.2	29.2	59.4	78.3	43.8						
	A	72.0	104.0	34.1	158.0	260.2	61.7				10.85	31.49	3.57
	S	120.2	240.0	34.1	334.8	555.1	176.6				11.69	42.06	4.59
	O	214.7	355.9	39.3	466.7	764.2	271.9				24.54	79.63	5.89
	N	57.0	116.4	32.3	161.5	260.2	96.0				11.01	31.09	5.21
	D	(31.3)	(95.0)	(22.0)	84.6	118.6	58.7	11,68	27.53	5.58	4.68	6.64	4.15
1964	J	(17.9)	(48.0)	(15.0)	46.4	60.2	38.0	4.99	5.58	4.46	3.63	4.15	2.84
	F	15.6	19.8	12.7	38.9	42.7	35.6	4.42	5.15	9.09	2.43	3.06	2.25
	M	12.5	14.2	11.8	32.4	34.6	28.3	4.36	4.63	4.21	2.44	3.06	2.25
	A	11.3	11.9	10.9	28.5	31.5	26.4	3.44	4.21	2.86	2.59	3.21	2.25
	M	13.2	15.9	10.9	49.3	84.0	26.4	4.29	6.12	3.12	3.45	5.21	2.25
	J	16.5	20.3	12.7	60.5	87.8	41.7	4.60	6.35	3.54	3.12	3.57	2.48
	J	15.9	26.0	12.8	79.1	92.9	64.7	4.86	13.38	3.28	3.68	6.48	2.77
	A	30.7	54.4	14.2	141.5	209.2	91.8	4.10	5.03	3.12	5.27	16.24	2.77
	S	32.9	46.7	17.4	135.1	264.0	89.8	8.36	19.96	4.13	10.63	37.20	3.57
	O	44.6	75.1	23.7	93.4	233.9	152.9	8.54	41.08	4.04	12.21	29.18	5.21
	N	(222.7)	(324.0)	(89.3)	(600.0)	(873.0)	(155.7)				41.18	235.61	7.43
	D	(131.1)	(187.0)	(75.6)	421.5	592.7	317.4				19.44	224.70	4.04
1965	J	59.6	115.7	36.3	144.5	352.9	60.2				3.99	4.59	3.57
	F	29.2	38.0	23.2	54.1	60.2	48.2				3.45	4.47	2.84
	M	19.9	27.9	15.6	46.0	48.2	42.7				2.46	3.46	2.02

( ) : Estimated discharge

Table - 3.2 Estimated mean monthly discharge at the Upper Krong Buk dam site (unit: m^3/s)

(catchment area 149 Km^2)

Year	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	(Next year) Jan.	Feb.	Mar.	Mean
1955	1.07	1.25	1.45	2.10	3.02	4.16	6.89	6.60	3.53	1.46	1.09	0.91	2.79
1956	1.47	1.73	2.00	2.13	3.05	4.21	6.31	6.04	3.22	1.46	1.13	0.92	2.81
1957	1.27	1.50	1.73	2.15	3.09	4.26	10.93	6.37	3.40	1.41	1.09	0.88	3.17
1958	1.07	1.26	1.45	1.98	2.84	3.91	6.67	6.39	3.42	1.43	1.10	0.90	2.70
1959	1.26	1.48	1.71	2.04	2.93	4.04	6.62	6.35	3.39	1.40	1.05	0.88	2.76
1960	1.39	1.62	1.87	2.38	3.42	4.72	11.21	6.87	3.67	1.57	1.21	0.99	3.41
1961	1.70	2.00	2.31	2.56	3.68	5.07	7.93	7.60	4.06	1.68	1.30	1.05	3.41
1962	0.74	0.87	1.00	1.92	2.76	3.80	6.58	6.30	3.37	1.39	1.07	0.87	2.56
1963	0.64	0.75	0.87	2.10	3.51	3.79	7.95	3.57	1.51	1.17	0.79	0.79	2.58
1964	0.84	1.12	1.01	1.19	1.71	3.44	3.95	13.34	6.29	1.29	1.12	0.80	3.01
Mean	1.15	1.36	1.54	2.06	3.00	4.14	7.50	6.94	3.59	1.43	1.10	0.90	2.92

Table - 3.3 Estimated mean monthly discharge at the Lower Krong Buk dam site (unit: m^3/s)

(Remaining catchment area 311 Km^2)

Year	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	(Next year) Jan.	Feb.	Mar.	Mean
1955	2.23	2.61	3.02	4.39	6.30	8.68	14.38	13.78	7.37	3.04	2.27	1.90	5.83
1956	3.07	3.61	4.18	4.45	6.37	8.80	13.17	12.61	6.73	3.05	2.35	1.92	5.86
1957	2.65	3.12	3.61	4.49	6.46	8.89	22.81	13.28	7.11	2.94	2.28	1.85	6.62
1958	2.23	2.62	3.02	4.13	5.93	8.16	13.93	13.34	7.14	2.98	2.30	1.88	5.64
1959	2.63	3.09	3.58	4.26	6.12	8.42	13.83	13.25	7.08	2.93	2.18	1.83	5.77
1960	2.89	3.39	3.91	4.97	7.14	9.84	23.41	14.34	7.66	3.29	2.53	2.07	7.12
1961	3.55	4.17	4.81	5.35	7.67	10.58	16.57	15.86	8.49	3.51	2.71	2.19	7.12
1962	1.54	1.81	2.09	4.01	5.76	7.93	13.73	13.15	7.04	2.90	2.24	1.82	5.34
1963	1.34	1.57	1.81	4.38	7.33	7.91	16.59	7.44	3.16	2.45	1.64	1.65	4.77
1964	1.75	2.33	2.11	2.48	3.56	7.19	8.25	27.84	13.14	2.69	2.33	1.66	6.28
Mean	2.39	2.83	3.21	4.29	6.26	8.64	15.67	14.49	7.49	2.98	2.28	1.88	6.04

3.2 Agricultural Studies

3.2.1 General

The Upper Krong Buk project area, which was the main object of the investigation carried out in 1965, covers a net area of 6,500 hectares of lands on the right bank of the Ea Krong Buk lying at the elevations ranging from 600 to 680 meters above the sea-level, although the project area was originally contemplated to be 9,000 hectares.

The project area, as well as the whole catchment basin of the Upper Krong Buk, belongs to the highland and presents an undulating topography on account of vast basaltic lava flow covering the catchment basin.

This lava flow is, however, covered with the usual tropical soil called "Terre Rouge" (Red Earth), which is formed by decomposition of basaltic lava under the tropical monsoon climate and is generally told to be a good soil especially for rubber plantation, although the analysis of its chemical compositions does not always show special fertility of such soil.

The project area is crossed by the National Road No.14, which connects it with Ban Me Thuot -- the nearest major town located approximately at 40 kilometers on the Southwest -- and occupies the central part of the Darlac Province.

3.2.2 Climate

As stated above, the project area is under the influences of the tropical monsoons and the total rainfall during the dry period from November to April averages to 244.5 millimeters (undistributed over 6 months), while it averages to 1,527 millimeters (undistributed over the remaining 6 months) in the rainy season.

The annual mean temperature is 24.24°C and the highest monthly mean temperature is 26.5°C in May, while the lowest is 21.7°C in January.

3.2.3 Present Agriculture

As already explained, no definite values could be established for the present or future crop yields from the lands in the project area owing to the prevailing conditions which were an insuperable obstacle to the success of our work.

However, according to the Agricultural Statistics Yearbook 1961 issued by the Government of Viet-Nam, the population of the Darlac Province -- including a part of the newly established Phu-Bon Province for which no data were yet available -- was reported at 146,900 for the cadastral survey area of 12,808.40 square kilometers as of July 1, 1960, and more than 35,000 of them were estimated to be in Ban Me Thuot, the nearest major town of this province.

Of this total area, it is estimated that about 32,386 hectares are cultivated or planted with paddy (yield 1.062 ton/ha), coffee-plant (yield 0.864 ton/ha), peanut (yield 1.323 ton/ha), sweet potatoes (yield 11.702 ton/ha), tobacco-plant (yield 0.870 ton/ha), maize (yield 1.600 ton/ha), rubber (0.999 ton/ha) and other crops. No vegetables were reported to have been planted according to the above-mentioned Yearbook.

Although the climate is favorable for farming, the production is so limited in area and the yield is still not so sufficient to meet the need of the population that every year paddy, rice and broken rice are brought in from Saigon.

Such existing state is due to the fact that rice is planted only once a year depending entirely upon rainfall in the rainy season and the same holds good in respect of other crops, besides no rotation system is practised and no fertilizer is used.

In the light of such facts, it may be presumed that the same condition should reflect upon the project area under review, where the present farmers are still completely unfamiliar with modern methods of cultivation and the use of modern equipment, since the implements used for cultivation are still traditional.

The population of livestock and poultry in the Darlac Province in 1961 was estimated roughly as follows:

Buffaloes 11,300 heads, cattle 11,000 heads, swine 21,100 heads, goats 3,700 heads, chickens 50,000 heads.

In addition, ducks, horses and sheeps are bred to some extent.

Cattle and buffaloes are mostly used for agricultural labour and subsist on grass growing in the fields, while swine and fowl are raised for good use of crop wastes.

By presuming that the environmental conditions of the project area is similar to those prevailing in the upland area of the Upper Se San Project Area, it may be assumed that the annual average gross value of farm products was about 133.80 U.S. dollars per farm (Total amount of US$107.20 for crop products including by-products of crop and US$26.60 for stock products), while the annual average expenses were about 133.80 U.S. dollars, as shown Table-3.4.

According to this table, it may be presumed that most existing farmers hold their low living standards with an average amount of about 86.06 U.S. dollars per annum without any reserve to be used for their farming development in future.

3.2.4 Soil conditions

The project area in the Darlac Province is covered mostly with reddish brown latosol of basaltic origin, which forms level or undulating relief in the main.

In proportion to the degree of erosion and leaching, some soil varieties with different physical properties are found in the same soil series, which may be classified into several soil types, namely the Eakmat soil types and Kotam soil type in the main owing to the phases of land inclination and drainage condition of the project area.

Among these soil types, the Eakmat soil types occupy more than 90 per cent of the project area and is considered as the most important soil in the project area.

These soils may be further divided into several soil subdivisions according to the land slope, but the soil of flat phase has superior properties, especially from the physical viewpoint. Thus, these soils have been utilized mostly for rubber and coffee plantations.

The soil of flat phase has a clay or loamy clay texture, an acidity ranging from 4.9 to 5.5 in pH, a cation exchange capacity of about 6.5 to 14.9 milligrams equivalent per 100 grams of soil and a base saturation degree of about 12 to 30 per cent.

As to the irrigation engineering characteristics, such soil has an available water holding capacity of 20 per cent by volume of soil and a basic intake rate of about 90 millimeters per hour. Therefore, the most adapted irrigation method, under such circumstances, should be selected among the following adaptable methods such as downhill furrow method, contour furrow method, contour ditch method, border irrigation method and sprinkler irrigation method, in due consideration of the irrigation engineering characteristics of the soil together with land gradient, kind of crop, period of crop growth and other essential factors for the design of application method on the spot.

Although the reddish brown latosol soils contain rather a small quantity of plant nutrients, the optimum physical properties and fairly high base exchange capacities of these soils show that they still have potentials of turning into rich agricultural soils by means of proper fertilization.

3.2.5 Standard farm on highland

To speak in general, the best solution for the problem of agricultural development in unexploited area lies in the extension of an adequate number of the most adapted standard farm all over the area as fast as possible.

As Asian farmers are accustomed to a small scale farming on narrow land and have a long experience on it, the adapted type of standard farm for the project area is an upland-livestock mixed irrigation farming with area of 4.5 hectares, which is a type of irrigation farming in which livestocks are raised as a subsidiary work by the farmer whose principal work is crop culture.

The essentials of the proposed type of standard farm are described hereunder:

1) Land use

Among 4.50 hectares in total, 4.20 hectares of land are used for cropping including 1.50 hectares for rubber plant, while 0.15 is used for homestead and the remaining 0.15 for grassland with forest around the premises.

2). Adapted crops and cropping pattern

The adapted crops are selected among the various tropical and sub-tropical crops for the sustainable and profitable irrigation farming as follows:

On such farming unit, the self-sufficiency of foods for the farmer's home consumption is the foundation for stabilizing the farmer's livelihood and is the most important matter from the economical viewpoint. So, about 0.17 hectare of rice, 0.005 hectare of fruit-trees, and 0.007 hectare of vegetables should be apportioned for the production of self-supplied foods including 500 kilograms of paddy, 44 kilograms of fruits, 100 kilograms of vegetables needed by a family of 5 members (including 3 children which correspond to 2.5 adults).

Next to self-supplied food-crops, 0.40 hectare of maize, 0.65 hectare of bean and 0.75 hectare of pasture-grass are appropriated for the production of self-supplied feed for livestocks raised in the farm for obtainment of stable manure and stock products.

In addition to the above-mentioned crops, green manure is cultivated for application on the farmland in view of increasing the soil fertility.

Beside the crops selected for self-supplied food and feed, several cash crops such as rice plant, peanut, kenaf, tobacco, sugar cane, fruits, vegetables and rubber plant are cultivated respectively.

Among them, rice plant is selected as rice is the staple food of inhabitants in the project area and its increased production is urgently required to substitute it for the rice transported from Saigon and other distant places at present.

Peanut and tobacco hold rather high sale prices on farm, and they are still insufficient to meet the domestic demand despite their high possibility of rich production on most farms in Viet-Nam.

Various fruits such as banana, papaya, pineapple etc. and some vegetables such as cabbage, rape, onion, tomato etc. are taken up for sale at local market in Ban Me Thuot. In addition to them, sugar cane is planted for chewing.

Kenaf is taken up especially as an adapted cash crop on a standard farm, because the culture of this crop is strongly encouraged by the Government and the product is purchased by the Government at official quotation of 12 piastres/1 per kilogram (corresponding to about 200 US dollars per ton). The fiber of kenaf is used for the preparation of kenaf bag as the substitution of gunny bag which is imported from Pakistan and other countries up to now.

The planting of rubber trees is also encouraged by the Government since 1957, and the average area of land grown by the plant attains to about 0.5 hectare per farmer in this Project area in 1963. Moreover, the planted area of rubber trees should be extended because of its favorable economic profitability as shown in Appendix V.

The adequate cropping program is framed so as to harvest rice twice a year, common dry field crop once a year as the third crop after rice harvesting, and so that most vegetables yield two or three times a year. Fruit-trees as well as rubber-plant are planted as perennial crops.

Consequently, the following areas are apportioned for the above crops:

Kind of crop	Cultivated area(ha.)
Paddy(in rainy season)	0.75
Paddy(in dry season)	0.75
Maize	0.40
Beans	0.65
Peanut	0.40
Pasture grass	0.75
Green manure	0.40
Kenaf	0.50
Tobacco	0.30
Sugar cane	0.10
Fruits	0.10
Vegetables	0.20
Rubber plant	1.50
Total	6.80
(Multi-cropping index)	(1.62)

/1 Price on farm of products is estimated upon the base of our agricultural research in field from 1961 to 1963.
Piastre is converted to US dollar at the rate of 1 US dollar equals to 60 piastres.

The adapted cropping pattern for such standard farm is schematicaly shown in Fig. 3.1.

3) Adapted livestock

Livestock raising is an essential work on an improved irrigation farm not only to increase the farm income derived from stock products, but also to elevate the land productivity by applying sufficient stable manure on farmland including very few humus less than 2 per cent by weight in general.

According to the results of our soil study and fields experiments on the upland area of the Upper Se San Project, it was clarified that the upland soils require about 10 tons of organic manures such as stable manure, compost or green manure to be applied annually for sustaining their fertility at optimum level.

Then, on this adapted standard farm, 3.0 heads of cow, 0.9 heads of calf, 2.0 heads of swine, 0.4 heads of shoats, 21.0 heads of fowl and 21.0 heads of chicken are raised to get about 30 tons of stable manure which nealy correspond to the annual organic manure requirement of cropping field./1

4) Adapted fertilization

Based upon the results of field experiments carried out on the upland area of the Upper Se San Project Area, we estimated the design value of chemical fertilizer requirement on farmland at about 50 kgs/ha. of ammonium sulphate or equivalent amount of other nitrogeneous fertilizers and

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/1 Annual amount of stable manure produced by domestic animal is estimated as follow:

Buffalo	2,000 kg/head
Young buffalo	800 kg/head
Cow(or cattle)	5,000 kg/head
Calf (2 years old)	2,000 kg/head
Calf(yearling)	800 kg/head
Calf(younger than 1 year)	320 kg/head
Swine	2,000 kg/head
Shoat	800 kg/head
Fowl	30 kg/head

30 kgs/ha. of calcium superphosphate.

5) Regulation of soil moisture level

The regulation of soil moisture level on farmland can be performed by adapted irrigation methods such as downhill furrow method, contour furrow method, contour ditch method, border irrigation method and sprinkler irrigation method, taking into consideration the essential conditions of irrigable land.

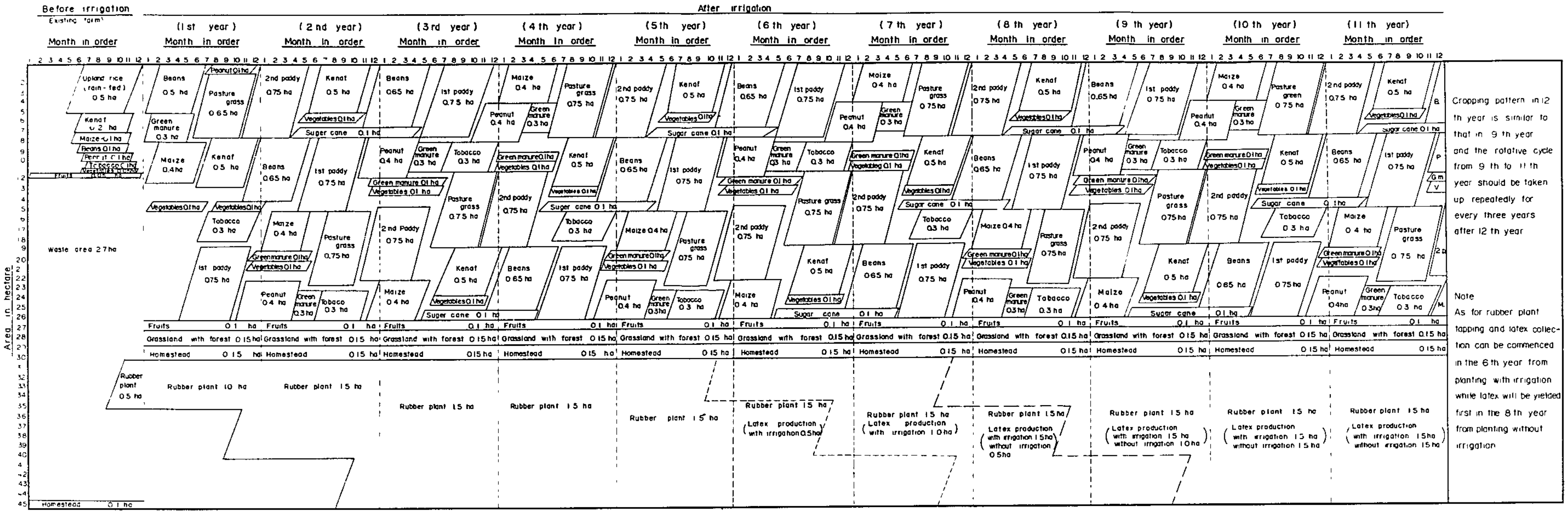
Some simple drainage ditch should be provided so as to protect the soil against erosion caused by heavy rainfalls in the rainy season.

Table - 3.4 <u>Annual average farming budget on an existing farm</u>

	Item	Annual amount (US$)
I)	Annual gross income	
	1) Receipts from sale of crop products	77.66
	2) Receipts from sale of livestock products	23.40
	3) Crop products for self-supplied foods	25.34
	4) Livestock products for self-supplied foods	3.20
	5) Crop products for self-supplied seeds	0.50
	6) Crop products for self-supplied feeds	3.70
	7) Stable manure	-
	8) Green manure	-
	Total (gross income)	133.80
II)	Farm operating expenses	
A)	Overheads	
	1) Farmer's consumption of goods produced on farm /1	28.54
	2) Tax and public impost	-
	3) Insurance	-
	4) Depreciation of buildings	-
B)	Crop operating cost	22.50
C)	Livestock operating cost	6.70
	Total (operating cost)	57.74
III)	Farmer's consumption of goods and services not produced on farm /2	76.06
	Total expenses	133.80

/1, /2: The sum of these two values corresponds to annual living expense.

Fig - 3 1 Cropping pattern on an upland-livestock unit farm of 45 hectares in the Upper Srepok Project area during 11 years after the beginning of irrigation



3.2.6 Anticipated increase in farm production

It is estimated that, when water for irrigation is available, the yield per hectare of each crop in the upland-livestock mixed farm with a standard acreage of 4.5 hectares under the proposed cropping pattern will be annually as shown on Table 3.5.[/1]

According to this table, the annual unit yield by crop of an irrigated farm as compared with that of an unirrigated farm will show the annual progression rate as given on the Table 3.6.[/1]

As for the stock-breeding, the number of livestock annually raised on the standard farm will increase to 3.30 heads of cow, 2.10 heads of calf, 2.40 heads of swine, 20 heads of shoat, 42 heads of fowl and 21 heads of chicken in and after the 15th year with irrigation as against the number of livestock raised on an existing farm without irrigation including 0.06 head of buffalo, 0.01 head of young buffalo, 0.51 head of swine, 3.00 heads of shoat, 10.00 heads of fowl and 11.00 heads of chicken as shown on Table 3.7.

Accordingly, the annual livestock products for sale and home consumption on the irrigated farm will increase to 0.30 head of cow, 1.20 heads of calf, 3,000 litres of milk, 0.40 head of swine, 19.60 heads of shoat, 21.00 heads of fowl, 2,000 eggs in and after the 15th year as against those on the unirrigated farm including 0.01 head of swine, 3.00 heads of shoat, 5.00 heads of fowl, and 50 eggs as shown on Table 3.8.

/1 According to the results on our experimental farm at Pleiku in 1963, and on the field of the Government Experimental Station at Eak Mat from 1959 to 1961, the presumable rate of increase of principal crop products resulted from improved irrigation farming is estimated as shown in these tables. As for the economic effect of irrigation on rubber-tree, detailed experiment should be conducted for substantiating the feasibility of rubber planting by irrigation.

3.2.7 Anticipated increase in gross value of farm products

With irrigation, the annual gross value of farm products on an irrigated farm will increase year by year and attain to the possible maximum in and after the 15th year under irrigation as shown on Table 3.9.

As shown on Table 3.9 the annual total gross value of the farm products will amount to US$ 1,756.48 (equivalent to about US$ 390.32 per hectare), which is the sum of US$ 1,336.88 (equivalent to about US$ 297.08 per hectare) of crop production and US$ 419.60 (equivalent to about US$ 93.24 per hectare) of livestock production on an irrigated farm from the 15th year with irrigation, as compared with US$ 583.80 (equivalent to about US$ 129.73 per hectare) which is the total amount of US$ 557.20 (equivalent to about US$ 123.82 per hectare) of crop production and US$ 26.60 (equivalent to about US$ 5.91 per hectare) of livestock production on an unirrigated farm from the same time without irrigation.

Therefore, it may be anticipated that the increase in farm production on the upland-livestock mixed irrigation farm with area of 4.5 hectares will be about 3 times higher than that on the existing farm without irrigation.

Table-3 5 Annual Gross Value of Total Crop Products on a Standard Farm of 4.5 Hectares with an Upland—Livestock mixed Farming Unit under unirrigated and irrigated Conditions

Kind of crop		Without irrigation Area (ha)	Unit yield (ton/ha)	Total yield (ton)	Unit price (US$/ton)	Total price (US$)	After irrigation 1st year Area (ha)	Unit yield (ton/ha)	Total yield (ton)	Unit price (US$/ton)	Total price (US$)	2nd year Area (ha)	Unit yield (ton/ha)	Total yield (ton)	Unit price (US$/ton)	Total price (US$)
Rain-fed upland rice		0.50	0.90	0.45	50	22.50	—	—	—	—	—					
1st paddy (rainy season)		—	—	—	—	—	0.75	1.40	1.05	50	52.50	0.75	1.80	1.35	50	67.50
Straw of above rice	∠1		1.80	0.90	1	0.90		2.80	2.10	1	2.10		3.60	2.70	1	2.70
Chaff of above rice	∠2		0.09	0.05	1	0.05		0.14	0.10	1	0.10		0.18	0.13	1	0.13
2nd paddy (dry season)		—	—	—	—	—	—	—	—	—	—	0.75	1.20	0.90	50	45.00
Straw of above rice	∠1		—	—	—	—		—	—	—	—		2.40	1.80	1	1.80
Chaff of above rice	∠2		—	—	—	—		—	—	—	—		0.12	0.09	1	0.09
Maize		0.10	0.50	0.05	50	2.50	0.40	0.80	0.32	50	16.00	0.40	1.00	0.40	50	20.00
Residue of maize	∠3		0.50	0.05	1	0.05		0.80	0.32	1	0.32		1.00	0.40	1	0.40
Beans		0.10	0.80	0.08	100	8.00	0.50	1.00	0.50	100	50.00	0.65	1.20	0.78	100	78.00
Residue of beans	∠4		0.80	0.08	1	0.08		1.00	0.50	1	0.50		1.20	0.78	1	0.78
Peanut		0.10	0.90	0.09	200	18.00	0.10	1.00	0.10	200	20.00	0.40	1.20	0.48	200	96.00
Residue of peanut	∠5		0.90	0.09	1	0.09		1.00	0.10	1	0.10		1.20	0.48	1	0.48
Pasture grass		—	—	—	—	—	0.65	30.00	19.50	1	19.50	0.75	40.00	30.00	1	30.00
Green manure		—	—	—	—	—	0.30	15.00	4.50	1	4.50	0.40	18.00	7.20	1	7.20
Kenaf		0.20	0.80	0.16	200	32.00	0.50	0.90	0.45	200	90.00	0.50	1.00	0.50	200	100.00
Tobacco		0.10	0.80	0.08	200	16.00	0.30	0.90	0.27	200	54.00	0.30	1.00	0.30	200	60.00
Sugar cane		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Residue of sugar cane	∠6		—	—	—	—		—	—	—	—		—	—	—	—
Fruits		0.05	2.00	0.10	40	4.00	0.10	4.00	0.40	40	16.00	0.10	6.00	0.60	40	24.00
Vegetables		0.05	6.00	0.30	10	3.00	0.20	10.00	2.00	10	20.00	0.20	12.00	2.40	10	24.00
Residue of vegetables	∠7		0.60	0.03	1	0.03		1.00	0.20	1	0.20		1.20	0.24	1	0.24
Rubber plant (latex)	∠8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
(planted area)		(0.50)					(1.00)					(1.50)				
Total		1.20				107.20	3.60				345.82	5.20				558.32
(for sale)						77.66					223.16					386.16
(for consumption at home as food)	∠9					25.34					25.34					25.34
(for consumption on farm as seed)	∠10					0.50					4.00					5.00
(for consumption on farm as feed)	∠11					3.70					88.82					134.62
(for consumption on farm as manure)	∠12					—					4.50					7.20

Kind of crop	3rd year Area (ha)	Unit yield (ton/ha)	Total yield (ton)	Unit price (US$/ton)	Total price (US$)	4th year Area (ha)	Unit yield (ton/ha)	Total yield (ton)	Unit price (US$/ton)	Total price (US$)	5th year Area (ha)	Unit yield (ton/ha)	Total yield (ton)	Unit price (US$/ton)	Total price (US$)
Rain-fed upland rice															
1st paddy (rainy season)	0.75	2.08	1.56	50	78.00	0.75	2.80	2.10	50	105.00	0.75	3.00	2.25	50	112.50
Straw of above rice		4.16	3.12	1	3.12		5.60	4.20	1	4.20		6.00	4.50	1	4.50
Chaff of above rice		0.21	0.15	1	0.15		0.28	0.21	1	0.21		0.30	0.22	1	0.22
2nd paddy (dry season)	0.75	1.40	1.05	50	52.50	0.75	1.60	1.20	50	60.00	0.75	2.00	1.50	50	75.00
Straw of above rice		2.80	2.10	1	2.10		3.20	2.40	1	2.40		4.00	3.00	1	3.00
Chaff of above rice		0.14	0.10	1	0.10		0.16	0.12	1	0.12		0.20	0.15	1	0.15
Maize	0.40	1.30	0.52	50	26.00	0.40	1.50	0.60	50	30.00	0.40	1.50	0.60	50	30.00
Residue of maize		1.30	0.52	1	0.52		1.50	0.60	1	0.60		1.50	0.60	1	0.60
Beans	0.65	1.30	0.84	100	84.00	0.65	1.40	0.91	100	91.00	0.65	1.40	0.91	100	91.00
Residue of beans		1.30	0.84	1	0.84		1.40	0.91	1	0.91		1.40	0.91	1	0.91
Peanut	0.40	1.30	0.52	200	104.00	0.40	1.40	0.56	200	112.00	0.40	1.50	0.60	200	120.00
Residue of peanut		1.30	0.52	1	0.52		1.40	0.56	1	0.56		1.50	0.60	1	0.60
Pasture grass	0.75	50.00	37.50	1	37.50	0.75	50.00	37.50	1	37.50	0.75	50.00	37.50	1	37.50
Green manure	0.40	25.00	10.00	1	10.00	0.40	25.00	10.00	1	10.00	0.40	25.00	10.00	1	10.00
Kenaf	0.50	1.30	0.65	200	130.00	0.50	1.40	0.70	200	140.00	0.50	1.50	0.75	200	150.00
Tobacco	0.30	1.20	0.36	200	72.00	0.30	1.20	0.36	200	72.00	0.30	1.20	0.36	200	72.00
Sugar cane	0.10	60.00	6.00	3	18.00	0.10	60.00	6.00	3	18.00	0.10	60.00	6.00	3	18.00
Residue of sugar cane		60.00	0.60	1	0.60		6.00	0.60	1	0.60		6.00	0.60	1	0.60
Fruits	0.10	7.00	0.70	40	28.00	0.10	10.00	1.00	40	40.00	0.10	10.00	1.00	40	40.00
Vegetables	0.20	13.00	2.60	1	26.00	0.20	15.00	3.00	10	30.00	0.20	15.00	3.00	10	30.00
Residue of vegetables		1.30	0.26	1	0.26		1.50	0.30	1	0.30		1.50	0.30	1	0.30
Rubber plant (latex)	—	—	—	—	—	—	—	—	—	—	0.50	1.50	0.75	100	75.00
(planted area)	(1.50)					(1.50)					(1.50)				
Total	5.30				674.21	5.30				758.40	5.80				871.88
(for sale)					480.54					549.16					657.74
(for consumption at home as food)					26.52					27.44					28.36
(for consumption on farm as seed)					6.00					7.00					7.00
(for consumption on farm as feed)					151.15					167.80					168.78
(for consumption on farm as manure)					10.00					10.00					10.00

Kind of crop	6th year Area (ha)	Unit yield (ton/ha)	Total yield (ton)	Unit price (US$/ton)	Total price (US$)	7th year Area (ha)	Unit yield (ton/ha)	Total yield (ton)	Unit price (US$/ton)	Total price (US$)	8th year Area (ha)	Unit yield (ton/ha)	Total yield (ton)	Unit price (US$/ton)	Total price (US$)	9th year Area (ha)	Unit yield (ton/ha)	Total yield (ton)	Unit price (US$/ton)	Total price (US$)	10th year
Rain-fed upland rice																					
1st paddy (rainy season)	0.75	3.00	2.25	50	112.50	0.75	3.00	2.25	50	112.50	0.75	3.00	2.25	50	112.50	0.75	3.00	2.25	50	112.50	
Straw of above rice		6.00	4.50	1	4.50		6.00	4.50	1	4.50		6.00	4.50	1	4.50		6.00	4.50	1	4.50	
Chaff of above rice		0.30	0.22	1	0.22		0.30	0.22	1	0.22		0.30	0.22	1	0.22		0.30	0.22	1	0.22	
2nd paddy (dry season)	0.75	2.00	1.50	50	75.00	0.75	2.00	1.50	50	75.00	0.75	2.00	1.50	50	75.00	0.75	2.00	1.50	50	75.00	In and after this year, the gross value of crop products is similar to that in previous year
Straw of above rice		4.00	3.00	1	3.00		4.00	3.00	1	3.00		4.00	3.00	1	3.00		4.00	3.00	1	3.00	
Chaff of above rice		0.20	0.15	1	0.15		0.20	0.15	1	0.15		0.20	0.15	1	0.15		0.20	0.15	1	0.15	
Maize	0.40	1.50	0.60	50	30.00	0.40	1.50	0.60	50	30.00	0.40	1.50	0.60	50	30.00	0.40	1.50	0.60	50	30.00	
Residue of maize		1.50	0.60	1	0.60		1.50	0.60	1	0.60		1.50	0.60	1	0.60		1.50	0.60	1	0.60	
Beans	0.65	1.40	0.91	100	91.00	0.65	1.40	0.91	100	91.00	0.65	1.40	0.91	100	91.00	0.65	1.40	0.91	100	91.00	
Residue of beans		1.40	0.91	1	0.91		1.40	0.91	1	0.91		1.40	0.91	1	0.91		1.40	0.91	1	0.91	
Peanut	0.40	1.50	0.60	200	120.00	0.40	1.50	0.60	200	120.00	0.40	1.50	0.60	200	120.00	0.40	1.50	0.60	200	120.00	
Residue of peanut		1.50	0.60	1	0.60		1.30	0.60	1	0.60		1.50	0.60	1	0.60		1.50	0.60	1	0.60	
Pasture grass	0.75	50.00	37.50	1	37.50	0.75	50.00	37.50	1	37.50	0.75	50.00	37.50	1	37.50	0.75	50.00	37.50	1	37.50	
Green manure	0.40	25.00	10.00	1	10.00	0.40	25.00	10.00	1	10.00	0.40	25.00	10.00	1	10.00	0.40	25.00	10.00	1	10.00	
Kenaf	0.50	1.50	0.75	200	150.00	0.50	1.50	0.75	200	150.00	0.50	1.50	0.75	200	150.00	0.50	1.50	0.75	200	150.00	
Tobacco	0.30	1.20	0.36	200	72.00	0.30	1.20	0.36	200	72.00	0.30	1.20	0.36	200	72.00	0.30	1.20	0.36	200	72.00	
Sugar cane	0.10	60.00	6.00	3	18.00	0.10	60.00	6.00	3	18.00	0.10	60.00	6.00	3	18.00	0.10	60.00	6.00	3	18.00	
Residue of sugar cane		6.00	0.60	1	0.60		6.00	0.60	1	0.60		6.00	0.60	1	0.60		6.00	0.60	1	0.60	
Fruits	0.10	10.00	1.00	40	40.00	0.10	10.00	1.00	40	40.00	0.10	10.00	1.00	40	40.00	0.10	10.00	1.00	40	40.00	
Vegetables	0.20	15.00	3.00	10	30.00	0.20	15.00	3.00	10	30.00	0.20	15.00	3.00	10	30.00	0.20	15.00	3.00	10	30.00	
Residue of vegetables		1.50	0.30	1	0.30		1.50	0.30	1	0.30		1.50	0.30	1	0.30		1.50	0.30	1	0.30	
Rubber plant (latex)	1.00	2.25	2.25	100	225.00	1.50	2.70	4.05	100	405.00	1.50	3.40	5.10	100	510.00	1.50	3.60	5.40	100	540.00	
(planted area)	(1.50)					(1.50)					(1.50)					(1.50)					
Total	6.30				1,021.88	6.80				1,201.88	6.80				1,306.88	6.80				1,336.88	
(for sale)					807.74					987.74					1,092.74					1,122.74	
(for consumption at home as food)					28.36					28.36					28.36					28.36	
(for consumption on farm as seed)					7.00					7.00					7.00					7.00	
(for consumption on farm as feed)					168.78					168.78					168.78					168.78	
(for consumption on farm as manure)					10.00					10.00					10.00					10.00	

Under unirrigated condition, the gross income on an existing farm will be increased by yielding latex from grown-up rubber plant in and after the 9th year as follows

Year in order corresponding to the year after irrigation

Kind of crop	9th year Area (ha)	Unit yield (ton/ha)	Total yield (ton)	Unit price (US$/ton)	Total price (US$)	10th year Area (ha)	Unit yield (ton/ha)	Total yield (ton)	Unit price (US$/ton)	Total price (US$)	11th year Area (ha)	Unit yield (ton/ha)	Total yield (ton)	Unit price (US$/ton)	Total price (US$)	12th year Area (ha)	Unit yield (ton/ha)	Total yield (ton)	Unit price (US$/ton)	Total price (US$)	13th year Area (ha)	Unit yield (ton/ha)	Total yield (ton)	Unit price (US$/ton)	Total price (US$)
Rubber plant (latex)	0.50	0.60	0.30	100	30.00	0.50	2.00	1.00	100	100.00	0.50	2.40	1.20	100	120.00	0.50	2.40	1.20	100	120.00	0.50	2.40	1.20	100	120.00
	(0.50)	—	—	—	—	0.50	0.60	0.30	100	30.00	0.50	2.00	1.00	100	100.00	0.50	2.40	1.20	100	120.00	0.50	2.40	1.20	100	120.00
	(0.50)	—	—	—	—	(0.50)	—	—	—	—	0.50	0.60	0.30	100	30.00	0.50	2.00	1.00	100	100.00	0.50	2.40	1.20	100	120.00
	0.50	0.60	0.30	100	30.00	1.00	1.30	1.30	100	130.00	1.50	1.68	2.50	100	250.00	1.50	2.23	3.40	100	340.00	1.50	2.40	3.60	100	360.00
Other crops ∠13	1.20				137.20					142.20					172.20					172.20					197.20
Total					167.20					272.20					422.20					512.20					557.20

	1st year	2nd year	3rd year	4th year	5th year	6th year	7th year	8th year	9th year	10th year	11th year	12th year	13th year	14th year and after
Gross value of crop products under irrigation by year	345.82	558.32	674.21	755.40	871.88	1,021.88	1,201.88	1,306.88	1,336.88	1,336.88	1,336.88	1,336.88	1,336.88	1,336.88
Gross value of crop products under unirrigation by year	107.20	107.20	107.20	107.20	107.20	137.20	137.20	137.20	167.20	272.20	422.20	512.20	557.20	557.20
Increase of gross value of crop products due to irrigation	238.62	451.12	567.01	648.20	764.68	884.68	1,064.68	1,169.68	1,169.68	1,064.68	914.68	824.68	779.68	779.68

∠1 Yield of rice straw is twice of yield of paddy
∠2 Yield of chaff is 10 per cent of paddy
∠3 Residue of maize is similar to the weight of maize
∠4 Residue of beans is similar to the weight of beans
∠5 Residue of peanut is similar to the weight of peanut
∠6 Residue of sugar cane is similar to the weight of stem for chewing
∠7 Residue of vegetables is 10 per cent of yield for sale
∠8 Under irrigated condition, latex will be yielded in and after the 5th year of the new planting of rubber seedling, while, under unirrigated condition, (it will be yielded in and after the 9th year of new planting)
∠9 Out of crop products, 500 kilograms of paddy, 3 kilograms of fruits, and 22 kilograms of vegetables are consumed at home as self-supplied food in the year without irrigation as well as in the 1st year and 2nd year with irrigation (and 500 kilograms of paddy, 13 kilograms of fruits, 100 kilograms of vegetables in the 3rd year,) 500 kilograms of paddy, 36 kilograms of fruits, 100 kilograms of vegetables in the 4th year; 500 kilograms of paddy, 44 kilograms of fruits, 160 kilograms of vegetables in and after the 5th year
∠10 About 1 per cent of crop products is used on farm as seed or seedling
∠11 Total amount of rice straw and chaff, maize and beans, residues of maize, beans, peanut, sugar cane, vegetables, pasture grass are used on farm as self-supplied feed
∠12 Total amount of green manure is used together with stable manure on farm as self-supplied manure
∠13 Out of the crops except rubber plant, the cultivated areas of kenaf and tobacco will increase under unirrigated condition as shown below.

	1st to 5th year		6th to 9th year		10th year		11th and 12th year		13th year, after	
Kenaf	0.20	(ha)	0.32	(ha)	0.35	(ha)	0.47	(ha)	0.60	(ha)
Tobacco	0.10		0.18		0.17		0.24		0.28	

Table 3.6

Progression rate of unit yield

Kind of crop	Without irrigation		With irrigation									
			1st year		2nd year		3rd year		4th year		5th year/2	
	Unit yield (ton)	Rate (%)	Unit yield (ton)	Rate (%)	Unit yield (ton)	Rate (%)	Unit yield (ton)	Rate (%)	Unit yield (ton)	Rate (%)	Unit yield (ton)	Rate (%)
Unhulled rice (rainy season)	0.90	100	1.40	156	1.80	200	2.40	267	2.80	311	3.00	333
Unhulled rice (dry season)	-	-	-	-	1.20	*/1	1.40	*	1.80	*	2.00	*
Maize	0.50	100	0.80	160	1.00	200	1.30	260	1.50	300	1.50	300
Bean	0.80	100	1.00	125	1.20	150	1.30	163	1.40	175	1.40	175
Peanut	0.90	100	1.00	111	1.20	133	1.30	144	1.40	156	1.50	167
Pasture grass	-	-	30.00	*	40.00	*	50.00	*	50.00	*	50.00	*
Green manure	-	-	15.00	*	18.00	*	25.00	*	25.00	*	25.00	*
Kenaf	0.80	100	0.90	113	1.00	125	1.30	163	1.40	175	1.50	188
Tobacco	0.80	100	0.90	113	1.00	125	1.20	150	1.20	150	1.20	150
Sugar cane	-	-	-	-	-	-	60.00	*	60.00	*	60.00	*
Fruits	2.00	100	4.00	200	6.00	300	7.00	350	10.00	500	10.00	500
Vegetables	6.00	100	10.00	167	12.00	200	13.00	217	15.00	250	15.00	250
Rubber plant/3												

/1 : Sign * shows the progression rate of the newly introduced crops, which cannot be evaluated.

/2 : Crop products of an irrigated farm nearly attain to their allowable maximum in the 5th year of the cropping schedule with irrigation.

/3 : As rubber plant is still young, no latex production is yet expected.

Table: 3.7 Annual Gross Value of Total Livestock Products on a Standard Farm of 4.5 Hectares with an Upland - Livestock mixed Farming Unit.

Kind livestock product	Before irrigation (Existing farm) Number	Unit price (US$/unit)	Total price (US $)	After irrigation: 1st year Number	Unit price (US$/unit)	Total price (US $)	2nd year Number	Unit price (US$/unit)	Total price (US $)	3rd year Number	Unit price (US$/unit)	Total price (US $)	4th year Number	Unit price (US$/unit)	Total price (US $)
Buffalo, for sale	0.01	30/head	0.30	0.05	30/head	1.50	—	—	—	—	—	—	—	—	—
Buffalo, young, for sale	0.01	10/head	0.10	0.01	10/head	0.10	—	—	—	—	—	—	—	—	—
Cattle, for sale	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Calf, for sale	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Milk, for sale	—	—	—	—	—	—	—	—	—	—	—	—	1,940 ℓ	30/kl	58.20
Milk, for home consumption	—	—	—	—	—	—	—	—	—	—	—	—	60 ℓ	30/kl	1.80
Swine, for sale	0.01	20/head	0.20	1.00	20/head	20.00	1.00	20/head	20.00	—	—	—	—	—	—
Shoat, for sale	1.80	10/head	18.00	1.80	10/head	18.00	8.80	10/head	88.00	11.60	10/head	116.00	13.50	10/head	135.00
Shoat, for home consumption	0.20	10/head	2.00	0.20	10/head	2.00	0.20	10/head	2.00	0.40	10/head	4.00	0.50	10/head	5.00
Fowl, for sale	4.00	1/fowl	4.00	4.00	1/fowl	4.00	20.00	1/fowl	20.00	20.00	1/fowl	20.00	20.00	1/fowl	20.00
Fowl, for home consumption	1.00	1/fowl	1.00	1.00	1/fowl	1.00	1.00	1/fowl	1.00	1.00	1/fowl	1.00	1.00	1/fowl	1.00
Egg, for sale	40	0.02/egg	0.80	480	0.02/egg	9.60	950	0.02/egg	19.00	1,900	0.02/egg	38.00	1,900	0.02/egg	38.00
Egg, for home consumption	10	0.02/egg	0.20	20	0.02/egg	0.40	50	0.02/egg	1.00	100	0.02/egg	2.00	100	0.02/egg	2.00
Stable manure by animals	—	—	—	—	—	—	4.8	1/ton	4.80	6.8	1/ton	6.8	10.2	1/ton	10.20
Stable manure by fowls	—	—	—	—	—	—	0.9	4/ton	3.60	0.9	4/ton	3.60	0.9	4/ton	3.60
Total			26.60			56.60			159.40			191.40			274.80
(for sale)			(23.40)			(53.20)			(147.00)			(174.00)			(251.20)
(for consumption at home as food)			(3.20)			(3.40)			(4.00)			(7.00)			(9.80)
(for consumption on farm as manure)			(—)			(—)			(8.40)			(10.40)			(13.80)

Kind livestock product	5th year Number	Unit price (US$/unit)	Total price (US $)	6th year Number	Unit price (US$/unit)	Total price (US $)	7th year Number	Unit price (US$/unit)	Total price (US $)	8th year Number	Unit price (US$/unit)	Total price (US $)	9th year Number	Unit price (US$/unit)	Total price (US $)
Buffalo, for sale	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Buffalo, young, for sale	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cattle, for sale	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Calf, for sale	—	—	—	1.00	20/head	20.00	1.00	20/head	20.00	1.50	20/head	30.00	1.50	20/head	30.00
Milk, for sale	1,940 ℓ	30/kl	58.20	1,940 ℓ	30/kl	58.20	1,940 ℓ	30/kl	58.20	2,900 ℓ	30/kl	87.00	2,900 ℓ	30/kl	87.00
Milk, for home consumption	60 ℓ	30/kl	1.80	60 ℓ	30/kl	1.80	60 ℓ	30/kl	1.80	100 ℓ	30/kl	3.00	100 ℓ	30/kl	3.00
Swine, for sale	—	—	—	2.00	20/head	40.00	—	—	—	—	—	—	—	—	—
Shoat, for sale	13.50	10/head	135.00	13.50	10/head	135.00	15.00	10/head	150.00	15.00	10/head	150.00	15.00	10/head	150.00
Shoat, for home consumption	0.50	10/head	5.00	0.50	10/head	5.00	1.00	10/head	10.00	1.00	10/head	10.00	1.00	10/head	10.00
Fowl, for sale	20.00	1/fowl	20.00	20.00	1/fowl	20.00	20.00	1/fowl	20.00	20.00	1/fowl	20.00	20.00	1/fowl	20.00
Fowl, for home consumption	1.00	1/fowl	1.00	1.00	1/fowl	1.00	1.00	1/fowl	1.00	1.00	1/fowl	1.00	1.00	1/fowl	1.00
Egg, for sale	1,900	0.02/egg	38.00	1,900	0.02/egg	38.00	1,900	0.02/egg	38.00	1,900	0.02/egg	38.00	1,900	0.02/egg	38.00
Egg, for home consumption	100	0.02/egg	2.00	100	0.02/egg	2.00	100	0.02/egg	2.00	100	0.02/egg	2.00	100	0.02/egg	2.00
Stable manure by animals	13.20	1/ton	13.20	14.80	1/ton	14.80	17.00	1/ton	17.00	19.00	1/ton	19.00	22.00	1/ton	22.00
Stable manure by fowls	0.9	4/ton	3.60	0.9	4/ton	3.60	0.9	4/ton	3.60	0.9	4/ton	3.60	0.9	4/ton	3.60
Total			277.80			339.40			321.60			363.60			366.60
(for sale)			(251.20)			(311.20)			(287.20)			(325.00)			(325.00)
(for consumption at home as food)			(9.80)			(9.80)			(14.80)			(16.00)			(16.00)
(for consumption on farm as manure)			(16.80)			(18.40)			(19.60)			(22.60)			(25.60)

Kind livestock product	10th year Number	Unit price (US$/unit)	Total price (US $)	11th year Number	Unit price (US$/unit)	Total price (US $)	12th year Number	Unit price (US$/unit)	Total price (US $)	13th year Number	Unit price (US$/unit)	Total price (US $)	14th year Number	Unit price (US$/unit)	Total price (US $)	Annual average after 15th year Number	Unit price (US$/unit)	Total price (US $)
Buffalo, for sale	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Buffalo, young, for sale	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cattle, for sale	—	—	—	—	—	—	—	—	—	—	—	—	1.00	30/head	30.00	0.30	30/head	9.00
Calf, for sale	1.50	20/head	30.00	0.50	20/head	10.00	1.50	20/head	30.00	0.50	20/head	10.00	1.50	20/head	30.00	1.20	20/head	24.00
Milk, for sale	2,900 ℓ	30/kl	87.00	2,900 ℓ	30/kl	87.00	2,900 ℓ	30/kl	87.00	2,900 ℓ	30/kl	87.00	2,900 ℓ	30/kl	87.00	2,900 ℓ	30/kl	87.00
Milk, for home consumption	100 ℓ	30/kl	3.00	100 ℓ	30/kl	3.00	100 ℓ	30/kl	3.00	100 ℓ	30/kl	3.00	100 ℓ	30/kl	3.00	100 ℓ	30/kl	3.00
Swine, for sale	—	—	—	2.00	20/head	40.00	—	—	—	—	—	—	—	—	—	0.40	20/head	8.00
Shoat, for sale	15.00	10/head	150.00	17.00	10/head	170.00	17.00	10/head	170.00	17.00	10/head	170.00	17.00	10/head	170.00	18.60	10/head	186.00
Shoat, for home consumption	1.00	10/head	10.00	1.00	10/head	10.00	1.00	10/head	10.00	1.00	10/head	10.00	1.00	10/head	10.00	1.00	10/head	10.00
Fowl, for sale	20.00	1/fowl	20.00	20.00	1/fowl	20.00	20.00	1/fowl	20.00	20.00	1/fowl	20.00	20.00	1/fowl	20.00	20.00	1/fowl	20.00
Fowl, for home consumption	1.00	1/fowl	1.00	1.00	1/fowl	1.00	1.00	1/fowl	1.00	1.00	1/fowl	1.00	1.00	1/fowl	1.00	1.00	1/fowl	1.00
Egg, for sale	1,900	0.02/egg	38.00	1,900	0.02/egg	38.00	1,900	0.02/egg	38.00	1,900	0.02/egg	38.00	1,900	0.02/egg	38.00	1,900	0.02/egg	38.00
Egg, for home consumption	100	0.02/egg	2.00	100	0.02/egg	2.00	100	0.02/egg	2.00	100	0.02/egg	2.00	100	0.02/egg	2.00	100	0.02/egg	2.00
Stable manure by animals	28.00	1/ton	28.00	28.00	1/ton	28.00	28.00	1/ton	28.00	28.00	1/ton	28.00	28.00	1/ton	28.00	28.00	1/ton	28.00
Stable manure by fowls	0.9	4/ton	3.60	0.9	4/ton	3.60	0.9	4/ton	3.60	0.9	4/ton	3.60	0.9	4/ton	3.60	0.9	4/ton	3.60
Total			372.60			412.60			392.60			372.60			422.60			419.60
(for sale)			(325.00)			(365.00)			(345.00)			(325.00)			(375.00)			(372.00)
(for consumption at home as food)			(16.00)			(16.00)			(16.00)			(16.00)			(16.00)			(16.00)
(for consumption on farm as manure)			(31.60)			(31.60)			(31.60)			(31.60)			(31.60)			(31.60)

Table - 3.8

Annual stock-products on an irrigated farm in comparison with those on an unirrigated farm

Kind of stock product	Unirrigated farm (number)	Irrigated farm in and after the 15th year /1 (number)
Buffalo	0.01 /2	- /3
Young buffalo	0.01	-
Cattle	-	0.30
Calf	-	1.20
Swine	0.01	0.40
Shoat	2.00	19.60
Fowl	5.00	21.00
Egg	5.00	2,000.00
Milk	-	3,000.00 litres

/1 : It is estimated that the average number of livestocks raised on an irrigated farm will attain to the satisfactory number adapted to the farm size from the 15th year of the beginning of irrigation farming.

/2 : Buffalos are raised rather nomadically on existing farms without irrigation and used for agricultural labour and production of butcher's meat.

/3 : Buffalo is replaced on the irrigated farm by cow, which is far superior than the former in the rate of reproduction, productivity of stock products including stable manure, efficiency of working, and in the resisting power to disease.

Table 3.9 Comparison between the annual gross value of an unirrigated farm with that of an irrigated farm

Crop product	Unirrigated farm (A) (in and after 15th year without irrigation)			Irrigated farm (B) (in and after 15th year with irrigation)			Increase (B - A)	
	Total yield (Ton)	Unit price/1 (US$/T)	Total price (Ton)	Total yield (US$/T)	Unit price/1 (Ton)	Total price (US$/T)	Total yield (Ton)	Total price (US$/T)
Paddy	0.45	50.00	22.50	3.75	50.00	187.50	3.30	165.00
By-product of paddy	0.95	1.00	0.95	7.87	1.00	7.87	6.92	6.92
Maize	0.05	50.00	2.50	0.60	50.00	30.00	0.55	27.50
By-product of maize	0.05	1.00	0.05	0.60	1.00	0.60	0.55	0.55
Beans	0.08	100.00	8.00	0.91	100.00	91.00	0.83	83.00
By-product of beans	0.08	1.00	0.08	0.91	1.00	0.91	0.83	0.83
Peanut	0.09	200.00	18.00	0.60	200.00	120.00	0.51	102.00
By-product of peanut	0.09	1.00	0.09	0.60	1.00	0.60	0.51	0.51
Pasture grass	-	-	-	37.50	1.00	37.50	37.50	37.50
Green manure	-	-	-	10.00	1.00	10.00	10.00	10.00
Kenaf	0.48	200.00	96.00	0.75	200.00	150.00	0.27	54.00
Tobacco	0.21	200.00.	42.00	0.36	200.00	72.00	0.15	30.00
Sugar-cane	-	-	-	6.00	3.00	18.00	6.00	18.00
By-product of Sugar-cane	-	-	-	0.60	1.00	0.60	0.60	0.60
Fruits	0.10	40.00	4.00	1.00	40.00	40.00	0.90	36.00
Vegetables	0.30	10.00	3.00	3.00	10.00	30.00	2.70	27.00
By-product of vegetables	0.03	1.00	0.03	0,30	1.00	0.30	0.27	0.27
Rubber-plant (Latex)	3.60	100.00	360.00	5.40	100.00	540.00	1.80	180.00
Sub-total for crop production			557.20 (123.82/ha)			1,336.88 (297.08/ha)		779.68 (173.26/ha)

(to be continued)

Stock product	Unirrigated farm (A) (in and after 15th year without irrigation)			Irrigated farm (B) (in and after 15th year with irrigation)			Increase (B - A)	
	Total qty	Unit price/1 (US$/qty)	Total price (US$)	Total qty	Unit price/1 (US$/qty)	Total price (US$)	Total qty	Total price (US$)
Buffalo	0.01	30/head	0.30	-	-	-	0.01	0.30
Young buffalo	0.01	10/head	0.10	-	-	-	0.01	0.10
Cattle	-	-	-	0.30	30/head	9.00	0.30	9.00
Calf	-	-	-	1.20	20/head	24.00	1.20	24.00
Milk	-	-	-	3.00 kl.	30/kl.	90.00	3.00	90.00
Swine	0.01	20/head	0.20	0.40	20/head	8.00	0.39	7.80
Shoat	2.00	10/head	20.00	19.60	10/head	196.00	17.60	176.00
Fowl	5.00	1/fowl	5.00	21.00	1/head	21.00	16.00	16.00
Egg	50.00	0.02/egg	1.00	2,000.00	0.02/egg	40.00	1,950.00	39.00
Stable manure	-	-	-	28.00	1/ton	28.00	28.00	28.00
Manure (fowl)	-	-	-	0.90	4/ton	3.60	0.90	3.60
Sub-total for livestock production			26.60 (5.91/ha)			419.60 (93.24/ha)		393.00 (87.33/ha)
Total			583.80 (129.73/ha)			1,756.48 (390.32/ha)		1,172.68 (260.59/ha)

/1 : Unit price of each product is estimated rather conservatively upon the base of our agricultural research on the price on farm in the Upper Se San Project area with reference to the market price at Kontum, Pleiku and Saigon from 1961 to 1963.

3.3 Net Farm Income on a Standard Farm

The prospective irrigation farming budget of a standard farm can be estimated upon the base of expected increase of farm products, increased gross value of farm products, increase of farm operating expenses on the farm with irrigation in comparison with those on the existing farm without irrigation. With the advance of improved irrigation farming, the annual crop production will be increased year by year. In the other hand, the annual amount of livestock products on a standard farm with irrigation increases year by year with the advance of irrigation farming. Thus, in the upland area, the annual total gross value of farm products on a standard farm will increase to 1,756.48 US dollars as the sum of 1,336.88 US dollars of crop products and 419.60 US dollars of livestock products in and after the 15th year. To speak in short, the annual total gross value on a standard farm with unit area of 4.5 hectares in the upland area with irrigation increase about 3.0 times the corresponded value on the farm without irrigation.

For the practice of improved irrigation farming on a standard farm under this project, the farm operating expenses increase necessarily as compared with the said expenses needed for the primitive rain-fed culture on existing farmsteads. Thus, in upland area, the farming expenses on an irrigated standard farm are increased to about 402.74 US dollars as against about 56.24 US dollars of the farming expenses on an unirrigated farm as shown in Table 3.10.

Annual net profit resulted from the farming operations on a farm can be estimated as the difference of annual gross value of farm products and annual farming expenses. This net profit on a farm is the annual amount of money which the irrigated farmer can set aside to pay the water charge or the assessment on the farmer including annual amount of interest and amortization of loan for irrigation system conrtruction cost, for initial farm investment, for foreign expert service on irrigation farming guidance, annual operation and maintenance cost of irrigation works. This is shown in Table-3.11

Table – 3. 10 Annual farming expenses on both irrigated and unirrigated farms

	1st year	2nd year	3rd year	4th year	5th year	6th year	7th year	8th year	9th year	10th year	11th year	12th year	13th year	14th year	Annual average after 15th year
Unirrigated farm															
A) Overheads															
1) Farmer's consumption of goods produced on farm	28 54	28 54	28 54	28 54	28 54	28 54	28 54	28 54	28 54	28 54	28 54	28 54	28 54	28.54	28 54
2) Tax and public impost	—	—	—	—	—	—	—	—	1 00	2 00	3 00	4 00	5 00	5 00	5 00
3) Insurance	—	—	—	—	—	—	—	—	6 00	6 00	6 00	6 00	6.00	6 00	6 00
4) Depreciation of buildings	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
B) Crop operating cost	22 50	22 50	22 50	22 50	22 50	22 50	22 50	22 50	22 50	22 50	22 50	22 50	22 50	22 50	22 50
C) Livestock operating cost	4 20	4 20	4 20	4 20	4 20	4 20	4 20	4 20	4 20	4 20	4 20	4 20	4 20	4 20	4 20
Total (Operating cost)	55 24	55 24	55 24	55 24	55 24	55 24	55 24	55 24	62 24	63 24	64 24	65 24	66 24	66 24	66 24
Irrigated farm															
A) Overheads															
1) Farmer's consumption of goods produced on farm	28 74	29 34	33 52	37 24	38 16	38 16	43 16	44 36	44 36	44 36	44 36	44 36	44 36	44.36	44 36
2) Tax and public impost	—	—	—	—	6.00	6 00	7 00	7 00	8 00	8 00	10.00	10 00	10 00	10 00	10.00
3) Insurance	—	—	—	—	10 70	10 70	10 70	10 70	10 70	10 70	10 70	10 70	10 70	10 70	10 70
4) Depreciation of buildings	7 00	7 00	7 00	7 00	7 00	7 00	7 00	7 00	7 00	7 00	7 00	7 00	7 00	7 00	7 00
5) Annual equivalent of land reformation cost	—	—	—	—	1 30	1 30	1 30	1 30	1 30	1 30	1 30	1 30	1 30	1 30	1 30
B) Crop operating cost	76 50	103 60	117 40	127 80	130 80	132 40	133 60	136 60	139 60	150 60	150 60	150 60	150 60	150 60	150 60
C) Livestock operating cost	122 82	140 62	189.15	175 80	206 78	176 78	176 78	176 78	178 78	178 78	178 78	178 78	178 78	178 78	178 78
Total (Operating cost)	235 06	280 56	347 07	347 84	400 74	372 34	379 54	383 74	389 74	400 74	402 74	402 74	402 74	402 74	402 74

Table 3.11

Annual farming income and expenditure budget of a standard farm

Item	Upland-livestock mixed farming unit (4.5 hectares)	
	(without irrigation) (US$)	(in 15th year after irrigation) (US$)
Annual gross income		
Crop products	557.20 /1	1,336.88
Livestock products	26.60	419.60
Sub-total	583.80 /1	1,756.48
Annual farming expenses		
Overheads	39.54	73.36
Crop operation costs	12.50	150.60
Livestock operation costs	4.20	178.78
Sub-total	56.24	402.74
Net income on farm	527.56 /1	1,353.74
Farmer's consumption of goods and services not produced on farm	88.56	250.00
Total net profit	439.00 /1	1,103.74
(farm profit per hectare)	(97.56) /1	(245.28)

In contrast with net profit shown in the above table the amount of annual water charge to be assessed on an irrigated standard farm is estimated at about 395 US dollars (correspond to about 88 US dollars per hectare) in upland area. Therefore, the irrigated farmer on a standard farm will be able to reserve /2 about 709 US dollars (correspond to about 157 US dollars per hectare) per annum in the upland area in the 15th year under irrigation.

These reserve will be available for service credits by the farmer to proceed coming development and improvement of the farm.

/1 Relatively high net profit on the standard farm in upland area is derived from the gross income due to latex products from rubber trees which are planted and grown without irrigation, though the yield of latex is less than the yield from irrigated rubber trees.

/2 The annual reserve on a farm in upland area is estimated as follows:

1. Total net profit	US$ 1,104
2. Water charge	395
a) Annual equivalent of capital cost	282
b) Operation and maintenance cost	113
3. Annual reserve (per hectare)	709 (158)

3.4 Primary Benefit due to Irrigation Farming on a Standard Farm

Primary benefit for irrigation attributable to the project from increased production is the value of the increased production after allowances for increased associated costs. In this report, primary benefit or direct benefit is estimated as the increased net farming income on the farm as compared with that on the farm without irrigation by the use of following formula.

Primary benefit due to irrigation = (Net farm income on irrigated farm) - (Net farm income on unirrigated farm)

Where, Net income on irrigated farm ... Gross farm income minus farming expenses on irrigated farm.

Net income on unirrigated farm ..Gross farm income minus farming expenses on unirrigated farm.

Then, the primary benefit due to irrigation works on the standard farm is determined upon the base of the farming income and expenditure budget for the farm on upland as follows. (Table-3.12)

Table-3.12 Estimation of primary benefit due to irrigation on upland on a standard farm in upland area

Item	Unirrigated farm (US$)	Irrigated farm (US$)
Annual gross income	583.80	1,756.48
Annual farm expenses	56.24	402.74
Annual farm consumption not produced on farm	88.56	250.00
Net farming profit	439.00(A)	1,103.74(B)
Primary benefit due to irrigation (B - A)		664.74 (say 665)

As shown in above table, the annual primary benefit on a standard farm due to irrigation works is estimated at about 665 US dollars. This value of annual primary benefit on a standard farm can be used for the basic figures on evaluating Benefits-Costs Ratio of the Project.

CHAPTER IV

IRRIGATION

4.1 General

As described in the previous chapter, the Upper Krong Buk project area can obtain the greatest increase in farm production by providing irrigation water in the dry season to lands which, otherwise, remain undeveloped during half year approximately.

For this purpose, we propose the irrigation of 6,500 hectares by gravity flow.

4.2 Water requirements

Based on the proposed cropping pattern shown in Fig. 3.1, the monthly consumptive use of water in the proposed farm unit of the project area is estimated as shown on Table 4.1.

As seen in this table, the maximum monthly consumptive use of water occurs in January when the value reaches 121 millimeters.

For the proper planning of the irrigation scheme, the maximum water requirement as shown below has been determined by adding water application losses and conveyances losses to the maximum consumptive of water :

1. Maximum consumptive use of water	121 mm
2. Water application losses	116 mm
3. Conveyance losses	77 mm
4. Maximum water requirement	314 mm
or	1.17 m^3/sec/1,000 ha.

Based on the maximum water requirement and the proposed irrigation scheme, the diversion water requirement is calculated as follows :

Farm Unit   Upland livestock farming unit

Table – 4 1   Calculation sheet of consumptive use of water

Crop	Length of Growing	K	Irrigation Area (ha)	Irrigation Period JAN			FEB			MAR.			APR.			MAY			JUNE		
Rice	120	1 00	0 75	1 260	1.260	1 192	1 050	0.863	0.638		0 195	0 420	0.660	0.900	1 087	1 192	1.260	1.260	1 192	1 050	0.863
Kenaf	150	0 75	0 50																	0.094	0 176
Vegetables	90	0 55	0 10							0.016	0.038	0.060	0.076	0.087	0.092				0.016	0.038	0.060
Beans	120	0 65	0 65	0 710	0.710	0 672	0.592														
Peanut	120	0 70	0 40	0 470	0 470	0.445	0.392	0.322	0.238												
Maize	120	0 70	0 40	0.445	0 470	0.470	0.445	0.392	0.322	0.238			0.045	0.085	0 131	0.175	0 218	0 252	0.279	0.295	0.304
Tobacco	150	0 70	0 30																		
Green manure	150	0 60	0 10	0.039	0.098	0 101				0.015	0 028	0.044	0.058	0.073	0.084	0.093	0.098	0 101			
Pasture	120	0 55	0 75																0 107	0.231	0.363
Furuit	360	0 55	0 10	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055
Sugar cane	360	1 00	0 10	0 100	0 100	0 100	0 100	0 100	0 100	0 100	0 100	0 100	0 100	0 100	0 100	0 100	0 100	0 100	0.100	0.100	0 100
Rubber plant	360	0 50	1 50	0 750	0.750	0 750	0.750	0.750	0.750	0.750	0 750	0.750	0.750	0 750	0.750	0 750	0.750	0.750	0.750	0 750	0 750
Total				3.883	3 913	3.785	3.384	2.482	2 103	1 174	1 166	1 429	1 744	1.050	2 299	2.365	2 481	2 518	2.499	2 613	2.671
f					0.919		0.632				0 299			0.404			0.584			0.406	
E					132		140				182			168			107			77	
U = Exf					121		88				54			68			62			31	

Crop	JUL			AUG			SEP			OCT.			NOV			DEC		
Rice	0.638												0 195	0.420	0 660	0.900	1 087	1 192
Kenaf	0.274	0.364	0.454	0.525	0.581	0.615	0.634	0.630	0 611									
Vegetables	0.076	0.087	0.092				0.016	0.038	0.060	0.076	0.087	0.092					0.016	0.038
Beans																0 110	0.237	0.372
Peanut										0.073	0 157	0.246	0.336	0.406	0.445	0.470	0 470	0.445
Maize																		
Tobacco		0.053	0.099	0.153	[illegible]	0.254	0.294	0.326	0.344	0.355	0.353	0.342						
Green manure																		0.015
Pasture	0.494	0.597	0.655	0.692	0.692													
Furuit	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0 055	0.055	0.055	0.055	0.055
Sugar cane	0.100	0.100	0 100	0 100	0 100	0.100	0 100	0 100	0 100	0.100	0 100	0.100	0 100	0.100	0.100	0.100	0 100	0.100
Rubber plant	0.750	0 750	0.750	0 750	0.750	0.750	0 750	0 750	0.750	0 750	0 750	0 750	0 750	0.750	0 750	0.750	0.750	0.750
Total	2.387	2.006	2.205	2.275	2.382	1 774	1 849	1 899	1 920	1 409	1 502	1.585	1 436	1.731	2.010	2.385	2 715	2.967
f		0.524			0.510			0.450			0.357			0.411			0.640	
E		57			60			52			67			84			102	
U = Exf		30			31			23			24			35			65	

K Normal seasonal consumptive use coefficient

E Average monthly evaporation (mm)

f Ratio of consumptive use to evaporation

U Average monthly consumptive use of water per hectare

Maximum water requirement	1.17 m^3/sec/1,000 ha.
Irrigation area	6,500 ha.
Diversion water requirement	7.61 m^3/sec.

4.3 Design of reservoir

In order to determine the required capacity of the Upper Krong Buk reservoir, the following basic factors are required.

4.3.1 Irrigation net water requirements

The water requirements in each month are computed from the Table 4.1 "Calculation of consumptive use of water". The results of that computation are shown in Table 4.2. Figures in this table are net water requirements.

Table 4.2 Net water requirements in each month (mm)

Irrigable area	Jan.	Feb.	Mar.	Apr.	May	June	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
6,500 ha.	121	88	54	68	62	31	30	31	23	23	35	65

4.3.2 Effective rainfall on farmland

The effective rainfall in each month on farmland is assumed at 60 per cent of the monthly rainfall, while it is assumed to be zero in case the monthly rainfall is less than 15 millimeters.

4.3.3 Annual water requirement

By using the result described in the preceding paragraphs, water requirement on the Upper Krong Buk irrigation area is shown on Table 4.3.

4.3.4 Estimated runoff at the dam site

The monthly discharge at the Krong Buk gauging site for the period of 1955 through 1964 were estimated by applying the runoff precipitation relationships; from this data, the monthly discharge of the Upper Krong Buk dam site were computed using the ratio of the catchment area of two sites, as shown in Table 3.2.

4.3.5 Calculation of reservoir evaporation and leakage

In calculating the reservoir evaporation from the pan records, the appropriate conversion coefficient will be required. In general, about 65 to 85 percent of values observed in the pan would be the amount of the reservoir evaporation. Furthermore, the reservoir surface area by which is affected the reservoir evaporation varies with storage capacity, and about 30 to 50 percent of the full water surface area would be the mean water surface area both in dry season and rainy season. Therefore, the amount of the reservoir evaporation Q during storage can be expressed by the following equation.

$$Q = C_1 . C_2 . A . E.$$

where E : Evaporation in the pan at Ban Me Thuot { dry season 760 mm, rainy season 430 mm }

C_1 : Conversion coefficient for E = 70 %

C_2 : Conversion coefficient for A = 40 %

A : Full water surface area of the reservoir in square meters

Table 4.3 Annual water requirement on Upper Krong Buk irrigation area

Month	(1) Net water requirement (mm)	(2) Effective rainfall (mm)	(3) (1)-(2) (mm)	(4)/1 Monthly water requirement (mm)	(5) m^3/sec/ 1,000 ha.	(6) m^3/sec/ 6,500 ha.
Jan.	121	-	121	314	1.17	7.61
Feb.	88	-	88	229	0.95	6.18
Mar.	54	-	54	140	0.52	3.38
Apr.	68	11	57	148	0.57	3.71
May	62	70	-	-	-	-
June	31	88	-	-	-	-
July	30	139	-	-	-	-
Aug.	31	230	-	-	-	-
Sept.	23	274	-	-	-	-
Oct.	24	106	-	-	-	-
Nov.	35	12	23	60	0.23	1.50
Dec.	65	-	65	169	0.63	4.10

/1 : Including application losses on the farmplots and conveyance losses in the irrigation canal system.

By substituting these values into the above equation:

$Q = 0.7 \times 0.4 \times 0.76 \times A = 0.213A$ in dry season

$Q = 0.7 \times 0.4 \times 0.43 \times A = 0.120A$ in rainy season

Therefore, the total amount of the reservoir evaporation during storage can be calculated by using the above equation.

On the other hand, the loss of water by leakage can be estimated on the assumption that it is equivalent to 15 percent of the total storage capacity at a given water surface.

4.3.6 Calculation of the required storage capacity of the reservoir

The amount of water to be supplied from the reservoir during irrigation period is computed by deducting the monthly effective rainfall on farmland, and the monthly inflow into the reservoir from the irrigation water requirements in each month. Therefore, the required storage capacity of the reservoir is calculated by accumulating these supplies of water in each month during irrigation period. Then, we have made estimation of the required storage for a period of 10 years from 1955 to 1964.

Fig. 4.1 shows the results and process of such computation for the Upper Krong Buk irrigation system. As can be seen in this figure, the maximum required storage capacity of 21.88 cubic meters per second per month, which is equivalent to about 60 million cubic meters, appears in 1963. It may be considered that this is the required storage capacity in a probable drought year at recurrence interval of 10 years.

4.3.7 Design storage capacity

From the standpoint of the economical planning of the reservoir, it is generally desirable to calculate the design storage capacity on the basis of an extent of water shortage in a probable dry year at recurrence interval of 10 years. As shown in the Fig. 4.1 the net necessary storage capacity is estimated at about 60 million cubic meters including the evaporation and seepage losses.

Furthermore, it is necessary to take into account the flood volume of 10 million cubic meters and the dead water of 12 million cubic meters. Therefore the total storage capacity of Upper Krong Buk reservoir is calculated at

60,000,000+10,000,000+12,000,000= 82,000,000 cubic meters

Accordingly, we have determined that the design total storage capacity is 82 million cubic meters, as shown on Fig. 4.2.

4.4 Irrigation headworks and method of water conveyance

4.4.1 General

For the irrigation by gravity flow of the Upper Krong Buk project area, located within the Upper Srepok project area as shown on Plate No.1, it is necessary to raise the river water of the Upper Krong Buk up to an elevation of 699.8 meters by constructing an earth dam with a height of about 25 meters at the Upper Krong Buk dam site.

The necessary irrigation water of 7.61 cubic meters per second supplied from the Upper Krong Buk reservoir will be distributed into the irrigable area by means of three main canals as shown on Plate No.3. First, the water will be conveyed through the I main canal to the lands of 580 hectares lying North of the Ea Jung and of 1,220 hectares around B.Brieng Village; second, the water supplied through the II main canal will irrigate the land of 1,700 hectares extending between the Ea Jung and the Ea Hlang; third, the water for the irrigation of the land of 3,000 hectares East of the National Road No.14 will be conducted through the III main canal stretching along the foot of the Kmrang Kdrieng hill.

4.4.2 Geology of the dam site and selection of type of dam

By four test pits, it was roughly confirmed that basalt rockbed could be reached beneath the sand and gravel deposits about 4 to 6 meters in thickness. The results of test pitting are shown in appended Plate No.6.

The basaltic lava in this region is supposed to have flowed out in several times. Sometimes, gravel and sand form a permeable layer in the major flow planes between old and new lava flows. Therefore, it was necessary to observe the bedding condition of lava by test drilling. However, granted that such a permeable layer is latent underground (Almost horizontal) it is possible by advanced modern grouting technique, to prevent water leakage by forming a grout curtain.

Samples collected during test pitting were sent to the Soil Laboratory of the Government of Viet-Nam for analysis. According to the analysis, the samples contain 30 to 40 percent of clay component. As the fill material for an earth dam, it is suitable, although clay component is a little more than the earth material desired for execution.

4.4.3 Reservoir

We compiled the topographic maps of the Project area on the scale of 1:20,000 from aerial photos with ground control as shown in Fig. 4.2.

The reservoir with a high water level of 699.8 meters from sea level and a flood water level of 700.8 meters will spread over an area of 10.4 square kilometers. It impounds an effective storage of 70 million cubic meters, that is 60 million cubic meters with a drawdown of 9.8 meters for irrigation of 6,500 hectares of land in the dry season and 10 million cubic meters for perfect flood control at the end of rainy season.

Below 690.0 meters in elevation, the low water level of the reservoir, the storage capacity will be estimated at 12 million cubic meters which is considered as the dead storage.

4.4.4 Dam and spillway

Upper Krong Buk dam is of homogeneous rolled earth-fill type. The crest length will be 600 meters and the height of dam from the river bed to dam crest with an elevation of 703.0 meters will be 25 meters.

The plan and section of the dam are shown on Plate No.5.

The cross section of the dam consists of homogeneous rolled earth-fill in the main, center drain layer, offset drain layer, toe rockfill, and riprap on upstream surface.

The spillway of side-ditch type will be constructed on the left bank of the river. The crest elevation of the spillway is determined at EL.699.8 meters and the crest length at 120 meters.

4.4.5 Outlet work

Outlet work consists of the intake conduit of reinforced concrete of about 240 meters in length. The maximum discharge through the conduit is estimated at 7.61 cubic meters per second. A Howell Bunger valve will be installed at the end of the conduit.

4.4.6 Canal and lateral

In the Upper Krong Buk area, three main canals with a total length of 66.0 kilometers will be required to supply the irrigation water for an area of 6,500 hectares.

The length and the commanding area of these canals are as follows:

(1)	I Main canal	41.50 km	1,800 ha
(2)	II Main canal	8.90 km	1,700 ha
(3)	III Main canal	15.60 km	3,000 ha
	Total	66.00 km	6,500 ha

These canals will be of concrete lining canal type, and their capacities have been determined on the basis of the diversion water requirement.

The number and the total length of laterals branching off each main canal are as follows :

I Main canal	20 laterals	45.60 km
II Main canal	28 laterals	46.40 km
III Main canal	26 laterals	55.40 km
Total	74 laterals	147.40 km

All of these laterals will be of earth canal type.

4.4.7 Main structures

The main structures for the main canals and laterals are turnouts, siphons, cross drains, check gates, wooden bridges, box culverts, spillways, chutes and a tunnel.

Canals	I Main canal	II Main canal	III Main canal	Total
Turnout	12	14	13	39
Siphon	2	1	1	4
Cross drain	14	0	10	24
Check gate	8	0	0	8
Wooden bridge	40	16	24	80
Box culvert	3	0	1	4
Spillway	2	0	2	4
Chute	1	7	0	8
Tunnel	1	0	0	1

4.4.8 Principal Features of Main Facilities

Principal features of the main irrigation facilities are summarized as follows :

Head works :

1. Reservoir

High water level	EL. 699.8 m
Total storage capacity	82 million m^3
Effective storage capacity	60 million m^3
Drawdown	9.8 m

2. Dam

Crest elevation	EL. 703.0 m
Height	25 m
Type	Homogeneous earth-fill type
Earth volume	650,000 m^3

Water conveying facilities :

1. No.1 area (irrigation area 1,800 ha.)

Canal

i) Main canal

Length	41.50 km
Discharge	7.61 m^3/sec. & 1.44 m^3/sec.
Type	Concrete lining canal
Related structures	83 nos.

ii) Laterals

Number of laterals	20 lines
Total length	45.60 km
Type	Earth canal

2. No.2 area (irrigation area 1,700 ha.)

Canal

i) Main canal

Length	8.90 km
Discharge	1.92 m^3/sec.
Type	Concrete lining canal
Related structures	38 nos.

ii) Laterals

Number of laterals	28 lines
Total length	46.40 km
Type	Earth canal

3. No.3 area (irrigation area 3,000 ha.)

Canal

i) Main canal

Length	15.60 km
Discharge	3.57 m^3/sec.
Type	Concrete lining canal
Related structures	51 nos.

ii) Laterals

Number of laterals	26 lines
Total length	55.40 km
Type	Earth canal

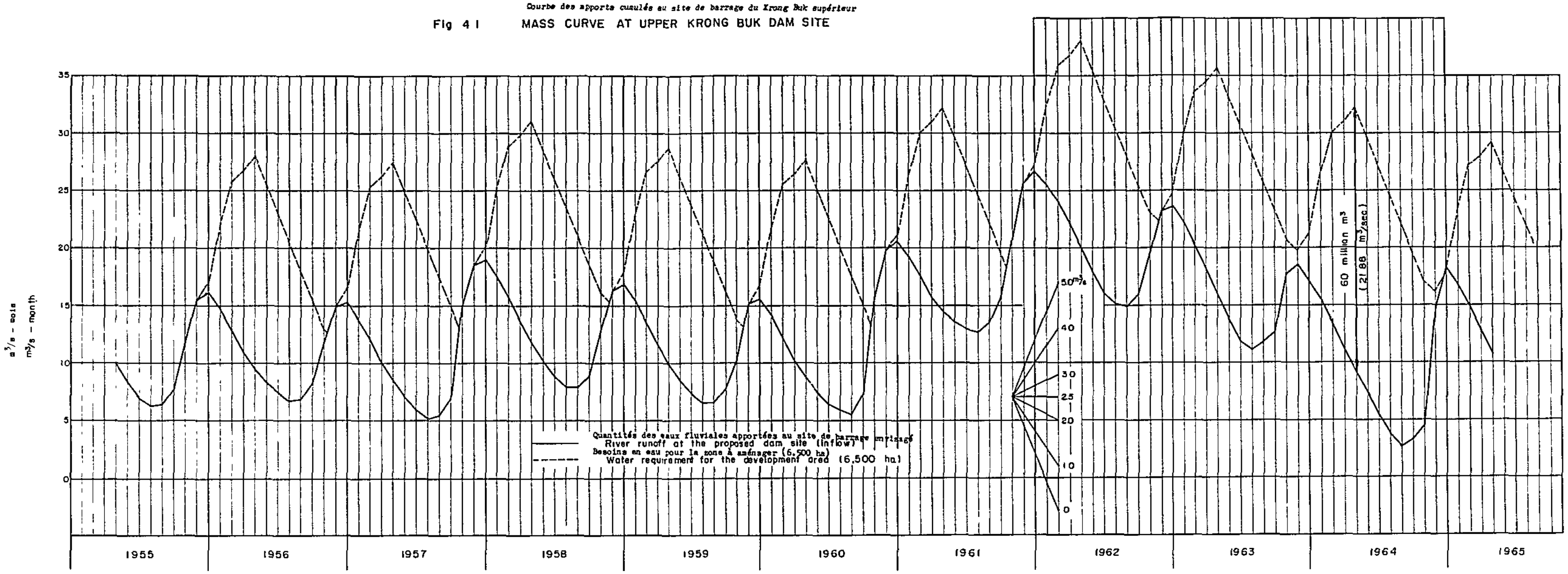
4.4.9 Drainage Problem

Generally speaking, drainage problem is not so serious on irrigable fields under the development scheme in Upper Krong Buk area as the undulating topographical features provide very favorable drain system naturally.

Some simple drain ditches should be prepared, however, to protect farmland soils against erosion caused by heavy rainfalls in the rainy season.

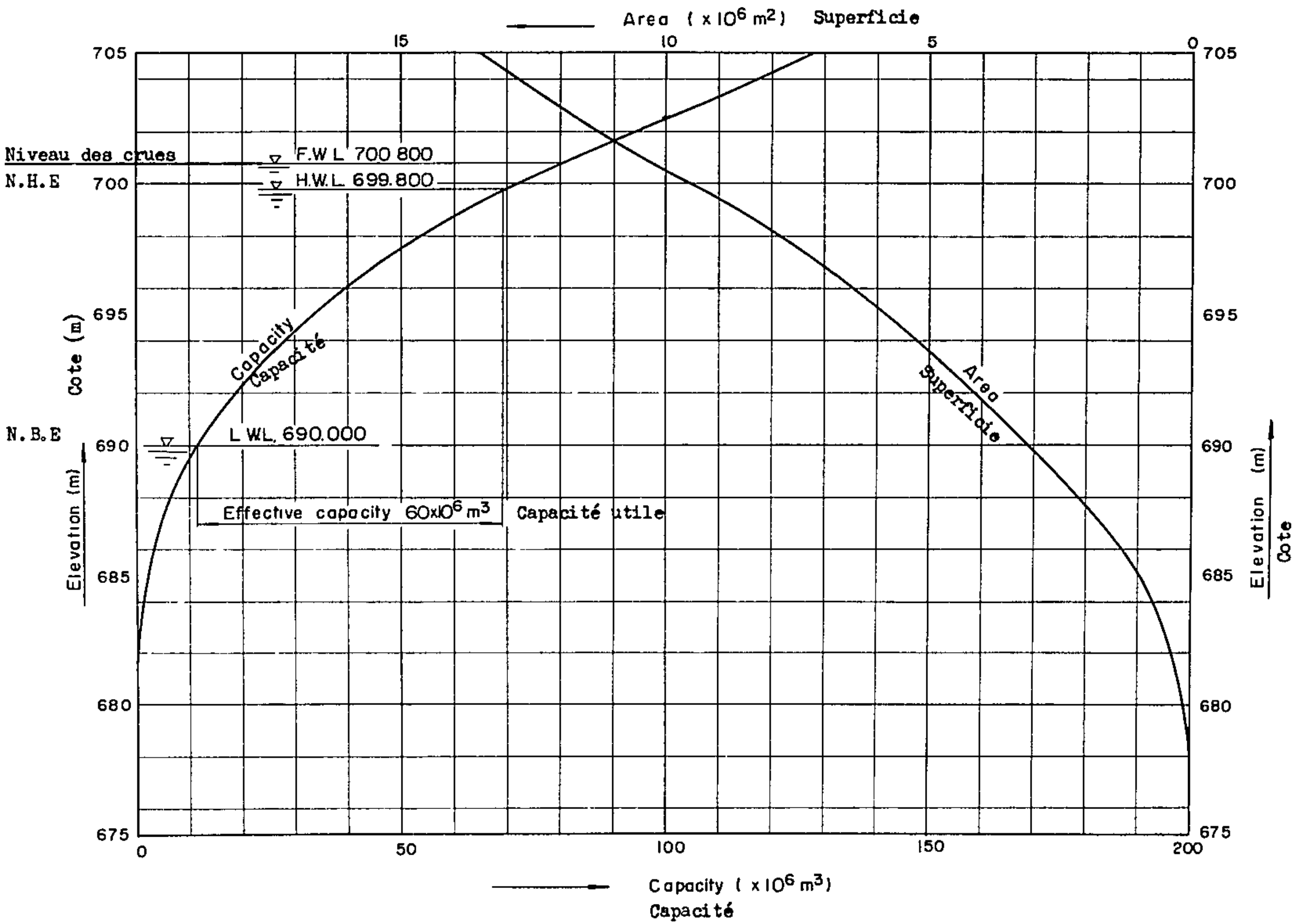
Courbe des apports cumulés au site de barrage du Krong Buk supérieur

Fig 4 I MASS CURVE AT UPPER KRONG BUK DAM SITE



RESERVOIR DU KRONG BUK SUPERIEUR

Fig 4.2 UPPER KRONG BUK RESERVOIR



CHAPTER V

COST ESTIMATES

5.1 Project investment

The initial investment needed for the irrigation development in the project area is estimated at about 6,890,000 U.S. dollars (7,237,000 U.S. dollars if 3% interest rate during construction period are added) including the construction cost of irrigation system, initial farm investment for irrigation farming, and the cost for invitation of foreign experts, and is roughly summarized hereinafter.

5.2 Construction schedule

The construction of the Upper Krong Buk irrigation system exclusively will take about 33 months in total, including the period of preparatory works and the priming period of irrigation system after its completion.

The following Figs.5.1 and 5.2 illustrate the Schedule for the irrigation system construction and the Schedule for irrigation farming development respectively.

The major works in this irrigation scheme are the construction of the Upper Krong Buk dam, main canals of about 147.40 kilometers in length and reclamation of about 3,000 hectares of waste grassland.

In the Upper Krong Buk dam construction works, the river water should be drained through the diversion way which will be constructed prior to embankment of the dam; therefore, the construction works of the outlet works shall be first started in the dry season.

The earth materials derived from the canal excavation will be used for embankment of canal banks. The excavation of canal will be done as much as possible by manpower so as to profit the villagers with an extra income. Mechanical power shall be used mainly for the transportation of materials and for the compaction of the embankment.

In addition, the irrigation farm management will be commenced by farmers under the guidance of foreign experts in the 4th year after the beginning of the construction works and continued for 5 years. Then, the irrigated farmers will manage their farms by themselves.

5.3 Construction cost of the irrigation system

The construction cost is estimated at 6,120,000 /1 U.S.dollars of which 2,030,000 U.S.dollars is required in foreign exchange and the remaining 4,090,000 U.S.dollars in local currency. Table 5.1 shows the breakdown of the estimated cost.

These estimates are exclusive of any import duties or other taxes on equipment, materials and supplies, and also of any taxes which might be imposed on the Engineer's foreign employees, the contractors, contractor's equipment, or contractor's foreign employees.

Providing that the investment is integrally financed by an international or foreign loan agency at an effective 3 percent interest rate and with a 40 year maturity period inclusive of first 5 years of unredeemable period, second 5 years of only interest payable period, and remaining 30 years of interest and amortization period, the annual total repayment and the assessment on an irrigated standard farm and or 1 hectare of irrigated field are estimated as shown on Table 5.2.

/1 : In accordance with the construction schedule as stated in the preceding paragraph, the fund required in each year are estimated as follows;

Year	Loan	Remarks
1967	US$ 1,080,000	
1968	3,080,000	
1969	1,960,000	
1970	-	beginning of irrigation farming
Total	US$ 6,120,000	

Fig. 5. 1 Schedule for irrigation system construction for Upper Krong Buk area

Item	Amount	1st year (1967)	2nd year (1968)	3rd year (1969)
Irrigation system				
1. Preparatory works				
Purchase of machinery and equipment				
Supplementary survey				
Accomodation of construction use				
Purchase of land				
2. Reservoir				
Dam, Coffering	15,000 m^3			
Excavation	77,500 m^3			
Embankment	580,000 m^3			
Riprap and sod facing	21,000 m^3			
Ancillary works				
Spillway, Excavation	44,000 m^3			
Concrete works	12,400 m^3			
Ancillary works				
Outlet works				
Excavation	13,500 m^3			
Concrete works	13,000 m^3			
Ancillary works				
3 Main irrigation canal				
Earth works	245,300 m^3			
Concrete works	25,980 m^3			
Related structures				
4 Lateral canal				
5 Reclamation of land	3,000 ha			
6 Priming test canals and trial water distribution in field				

Fig. 5. 2 Schedule for irrigation farming development for Upper Krong Buk area.

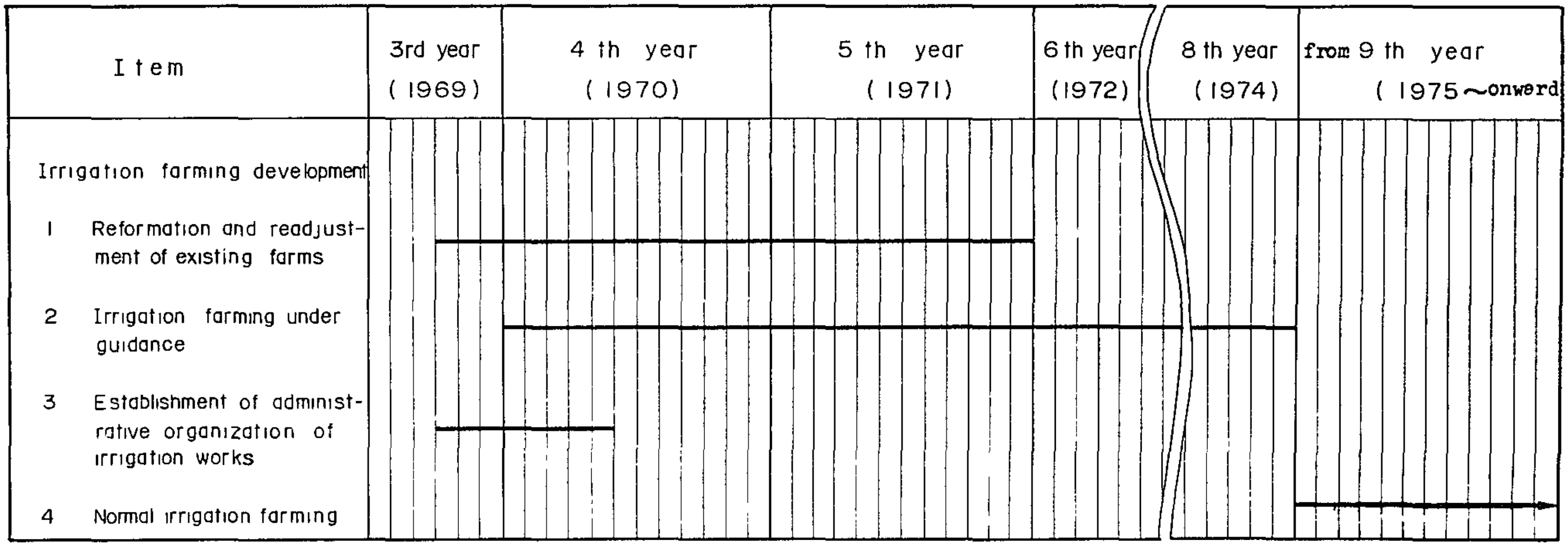


Table 5.1 Estimates of Construction Cost for the Upper Krong Buk Irrigation Scheme

Item	Cost in 1,000 U.S. Dollars			Remarks
	Foreign exchange	Local currency	Total	
(A) Preparatory works	23	47	70	Including about 1,000 m^2 of office, Engineer's camp, etc.
(B) Reservoir	407	973	1,380	Including spillway
(C) Intake	72	96	168	Including intake gate and Howell-Bunger volve at the end of waterway
(D) Construction machineries	445	25	470	-
(E) Main canal				
a) Earth works	103	156	259	Excavation and embankment
b) Concrete works	13	598	611	Concrete lining
c) Related structures	334	403	737	Turnouts, check gates, inverted siphons and so on
(F) Lateral				
a) Earth works	71	112	183	-
b) Related structures	30	131	161	-
(G) Reclamation of lands	108	693	801	Including the construction small distribution ditches
Sub Total	1,606	3,234	4,840	

Item	Cost in 1,000 U.S. Dollars			Remarks
	Foreign exchange	Local currency	Total	
Add about 15% for contingency items and reserve	240	480	720	
Sub Total	1,846	3,714	5,560	
Add about 10% for general expenses and engineering expenses	184	376	560	
Total	2,030	4,090	6,120	
Interest 3% during construction period			347	
Grand Total			6,467	

Table 5.2 Annual repayment of irrigation system construction cost and the assessment on an irrigation farm

Year in order after irrigation	Annual repayment (US$)	Under irrigation (Farm) (No.)	(Area) (ha)	Annual assessment (per farm) (US$)	(per ha) (US$)	Remarks
1st to 2nd year	-	1,444	6,500	-	-	Unredeemable.
3rd year	37,600	1,444	6,500	26.03	5.78	Interest payable.
4th year	144,700	1,444	6,500	100.21	22.26	"
5th to 7th year	212,900	1,444	6,500	147.45	32.75	"
8th year	239,200	1,444	6,500	165.65	36.80	Interest and amortization
9th year	314,300	1,444	6,500	217.66	48.35	"
10th to 37th year	362,000	1,444	6,500	250.69	55.69	"

5.4 Initial farm investments

At the commencement of irrigation farming, it is necessary to improve the existing farm by installing farm buildings and farm implements. In addition to them, the operation and maintenance cost of the farm in the first year of irrigation farming should be provided as no revenue can be collected from irrigated farmers at the beginning of irrigation farming. Therefore, the initial farm investments are required for the improvement of existing farms.

Assuming that these initial farm investments are similar to those required for the same upland area of the Upper Se San Irrigation Scheme, the detail of such investments is shown on Table 5.3.

Table 5.3 Initial farm investment

Item	Amount per farm (US$)	No. of farms (Farmstead)	Total amount (US$)
Cost for supplementary farm buildings	70.00	1,444	101,080
Cost for supplementary farm implements	150.00	1,444	216,600
Cost for farmland reformation for irrigation	130.00	1,444	187,720
Annual working capital of the farm in the first year of irrigation farming	130.00	1,444	187,720
Total	480.00		693,120 (say 700,000) (US$ 107.75/ha)

Providing that the initial farm investments are financed by a standard loan with terms of payment analogous to those granted in case of financing the investment for the above-mentioned construction cost of the irrigation system, the annual total repayment and the annual assessment on an irrigated farm are estimated as shown on Table 5.4.

Table 5.4 Annual repayment of initial farm investment and the assessment on an irrigation farm

Year in order after irrigation	Annual repayment (US$)	Under irrigation (Farm) (No.)	Under irrigation (Areas) (ha)	Annual assessment (per farm) (US$)	Annual assessment (per ha) (US$)	Remarks
1st to 5th year	-	1,444	6,500	-	-	Unredeemable
6th to 10th year	24,300	1,444	6,500	16.83	3.74	Interest payable
11th year to 40th year	41,800	1,444	6,500	24.95	6.45	Interest and amortization

5.5 Cost for invitation of foreign experts

As all the existing farmers have no experiences of improved irrigation farming, it is strongly required that they should be trained in improved irrigation farming practice under the guidance of well experienced experts to be invited from advanced foreign countries for several years at the initial stage of irrigation farming.

The total cost for the invitation of 5 foreign experts during 5 years (1 expert in each year) are estimated as shown Table 5.5.

Table 5.5 Total cost for inviting foreign experts

Item	Unit per year (US$)	No. of year (year)	Total (US$)
Consultant fee	12,500	5	62,500
Travelling expenses	1,500	5	7,500
Total	14,000	5	70,000 (US$ 10.77/ha)

Providing that the total cost for such invitation is financed by a standard loan with terms of payment similar to those granted in case of financing the investment for the construction cost of the irrigation system, the annual total repayment and its assessment on an irrigated farm are estimated as shown on Table 5.6.

Table 5.6 Annual repayment of cost for inviting foreign experts and its annual assessment on an irrigated farm

Year in order after irrigation	Annual repayment (US$)	Under irrigation (Farm) (No.)	Under irrigation (Area) (ha)	Annual assessment (per farm) (US$)	Annual assessment (per ha) (US$)	Remarks
1st to 5th year	-	1,444	6,500	-	-	Unredeemable
6th to 10th year	2,400	1,444	6,500	1.66	0.39	Interest payable
11th to 40th year	4,200	1,444	6,500	2.91	0.65	Interest and amortization

5.6 Annual operation and maintenance cost

The total annual working expenses of an administrative organization of irrigation to be established in the Krong Buk project area are estimated as shown on Table 5.7.

Table 5.7 Total annual working expenses of administrative organization of irrigation

Item	Annual pay per capita (US$)	Numbers of personnel	Total annual amount (US$)
Salaries			
Director	1,300	1	1,300
Water master	1,000	4	4,000
Civil engineer	900	1	900
Ditch rider	850	6	5,100
Repair man	800	5	4,000
Clerk	700	10	7,000
Laborer	50/month	298	14,900
Sub-total			37,200
Office expenses			
Head office	US$ 450 per month·12 month =		5,400
Branch office (1)	US$ 300 per month·12 month =		3,600
Branch office (2)	US$ 300 per month·12 month =		3,600
Branch office (3)	US$ 300 per month·12 month =		3,600
Sub-total			16,200
Repairing cost	1.5% of construction cost		91,800
Miscellaneous and contingency			17,300
Total			US$ 162,500

Then, the annual operation and maintenance cost of irrigation works, which corresponds to the annual working expenses of the above-mentioned administrative organization and which will be assessed uniformly on an irrigated farm for a period of 40 years from the beginning of irrigation, is estimated as shown on Table 5.8

Table 5.8 Annual assessment of operation and maintenance cost of irrigation works

Total annual cost (US$)	Under irrigation (Farms) (No.)	Under irrigation (Area) (ha)	Annual assessment (per farm) (US$)	Annual assessment (per ha) (US$)
162,500	1,444	6,500	112.50	25.00

CHAPTER VI

BENEFITS AND ECONOMIC EVALUATION

6.1 General

The benefits resulted from the irrigation project might be estimated as the total of direct or primary, indirect or secondary and intangible benefits. However, owing to lack of reliable data on the project area as described previously, they might be summarized as hereunder by taking into consideration those deriving from other similar developments, such as the upland area of the Upper Se San Irrigation Scheme.

6.1.1 Direct benefit of irrigation

As stated in the foregoing paragraph, the upland-livestock farming is utilized in the Upper Krong Buk Project area. In this area, it is estimated that the average annual net income will be about 1,594,200 U.S. dollars on the basis of the pattern of land use, crop yields, livestock production, type and size of farm. By the irrigation farming practice, double cropping of paddy rice will make possible and more than 4,700 tons of rice may be expected annually. Besides, maize, fruits, vegetables, etc. could be produced in this area. Then, the annual direct benefit due to increased net farm profit is estimated at about 960,300 U.S. dollars.

6.1.2 Benefit of flood control

During the high water season, the flow of the Krong Buk stagnates and spreads over the lowland area extending on both banks of the river, inundating a large tract of land.

By the creation of the Upper and Lower Krong Buk reservoirs, the flood of about 22 million cubic meters in volume could be regulated, and by such flood control more than 2,000 hectares of lowland will be protected from the flood damage and would become suitable for cultivation. But, some tracts of land within the lowland area will not be protected from the damage caused by the synchronization of floods of the Krong Buk and the Krong Pach. In order to insure the complete effect of flood control, the comprehensive development plan in the Upper Srepok Basin will be required. Under the circumstances in which no detailed data are available for assessing the flood losses, at the present stage, it is difficult to evaluate the flood control benefits on a firm basis. However, some extent of benefits to be derived from flood control, such as increasing use of land for extension in arable land, public services, etc. will be expected, but these benefits cannot be expressed in terms of monetary value.

6.1.3 Indirect benefit of irrigation

The increase of economic activities, such as increased employment of labor during the construction of the Project, and the saving in transportation cost of products, otherwise coming from distant place as from Saigon City, as well as sociological and political benefits such as greater social stability and welfare of community, better diet and health, new opportunity for employment can be surely resulted from the implementation of this Project.

6.2 Project feasibility

The Upper Krong Buk Project is of irrigation and flood control. Therefore, the economic feasibility of the Projects should be justified on the basis of the economic justification on two factors, i.e. irrigation and flood control. However, as afore-mentioned, the flood control benefits and indirect benefits of irrigation cannot be expressed in terms of monetary value at this time. Therefore, these benefits were left out of consideration in studying the Benefits-Costs Ratio for evaluating the Project feasibility from the viewpoint of national economy.

In this study, the economic analysis will be made for a period of 65 years after the completion of the Project. The rate of interest was assumed as 3 per cent per annum.

The Benefits-Costs Ratio is 1.72 : 1.00 for the Upper Krong Buk Project area as shown on Table 6.1.

Tablo - 6.1 Calculation of the Benefit-Costs Ratio

(A) Calculation of total annual cost

(a)	Total construction cost	US$ 6,476,000
(b)	Annual equivalent of capital cost	US$ 6,467,000 x 0.035146 /1 = US$227,289
(c)	Operation and maintenance cost	US$ 25/ha x 6,500 ha = US$ 162,500
	Total annual cost	US$ 389,789

(B) Calculation of annual benefit

(a)	Increase in net annual farm income in years 11 - 65	US$ 147.72 x 6,500 ha = US$ 960,180
(b)	Present worth at beginning of eleventh year	US$ 960,180 x 26.7744 /2 = US$ 25,708,243
(c)	Present worth of net benefits at end of construction (zero point)	US$ 25,708,243 x 0.7441 /3 = US$ 19,129,504
(d)	Annual equivalent value of (c) in 65 years	US$ 19,129,504 x 0.035146 /4 = US$ 672,326

(C) Calculation of Benefits-Costs Ratio

$$\frac{\text{benefits}}{\text{costs}} = \frac{672,326}{389,789} = 1.72$$

/1 Conversion factor is $\frac{i(1+i)^n}{(1+i)^n-1}$ Where, $i = 0.03$, $n = 65$

/2 Present worth at beginning of eleventh year = (Increase in net annual farm income in years 11 - 65)

$$\frac{(1+i)^n - 1}{i(1+i)^n} = (A)$$

Where $i = 0.03$, n = economic useful life (65) - 10

/3 Present worth of net benefits at end of construction (zero point) $= (A) \times \frac{1}{(1+i)^n} = (B)$

Where $i = 0.03$, $n = 10$

/4 Annual equivalent value of in 65 years $= (B) \times \frac{i(1+i)^n}{(1+i)^n - 1}$

Where $i = 0.03$, $n = 65$

CHAPTER VII

FINANCIAL ARRANGEMENT

7.1 Anticipated loan for initial investment

The initial investment needed for this irrigation development scheme is estimated at 6,890,000 U.S.dollars as itemized hereunder.

Initial investment

1) Construction cost of irrigation system	US$	6,120,000
2) Initial farm investment	US$	700,000
3) Cost for foreign expert service	US$	70,000
Total	US$	6,890,000

As it is difficult to expect big returns from the anticipated benefit of this scheme, the financing for this scheme from fund with low interest rate and long maturity period are desirable.

7.2 Financial feasibility

The financial feasibility of this scheme is examined by using a standard loan with the following terms.

Interest rate	3 percent per annum
Unredeemable period	first 5 years after obtained of loan
Interest payable period	second 5 years from 6th to 10th year after obtaining of loan
Interest and amortization period	from 11th to 40th year after obtaining of loan
Maturity period	40 years.

Providing that the afore-mentioned standard loan is obtainable, the Benefits-Costs Ratio is estimated from financial point of view.

Total investment	US$ 6,890,000
Annual equivalent of amount to pay (annual cost)	US$ 442,275
Annual equivalent of capacity to pay (annual benefits)......................	US$ 593,533
Benefits-Costs Ratio	593,533/442,275=1.34

As shown above, the Benefit-Costs Ratio evaluated from financial view point is 1.34 : 1.00.

CHAPTER VIII

RECOMMENDATIONS

For the successful accomplishment of this irrigation scheme, the following matters are recommended.

1) Further detailed investigations including especially an agricultural economic study of the project area should be conducted by competent consulting engineers for substantiating the feasibility of the project in detail.

2) Adapted pilot farms with well-installed irrigation facilities should be established at suitable sites and operated for the training of irrigated farmers and irrigation farming technicians together with for the extension and demonstration of improved irrigation farming practices.

   Therefore, the realization of the Eak Mat pilot farm is strongly recommended as a link in the chain of the Upper Srepok project.

3) Meteorologic and hydrologic observations at Key sites of the Basin should be continued systematically not only to confirm the feasibility of this scheme but also to provide sound data for coming development schemes and successful indication of irrigation farming in the Basin.

4) In advance of irrigation farming commencement, an adapted administrative organization of irrigating water whould be established and managed efficiently by irrigators cooperative association under the supervision of the Government and under the guidance of invited foreign experts.

PART II

SUMMARY OF OVERALL DEVELOPMENT OF THE BASIN

The preliminary studies of the Overall Development Scheme of the Upper Srepok have been made on the basis of the data obtained by our investigations of the Upper Krong Buk area and by utilizing every and all data obtained by various kinds of investigations of the Upper Srepok project area carried out by us before. Maps of the whole Srepok area on a scale of 1:50,000, which had recently been provided us for use, were also used.

1 Project

The Srepok River is one of the main tributaries of the Mekong. It rises in the Annamite Mountains and flows in the High Plateau Region of Viet-Nam. Then, it drains the vast Cambodian plain and finally joins the Mekong River near Stung-Treng in Cambodia.

It has an overall length of about 390 kilometers and a total drainage area of about 31,000 square kilometers.

The upper part of about 17,800 square kilometers lying in Viet-Nam territory is called the "Upper Srepok". This area is composed mainly of fertile land so that there is a possibility of agricultural development. The Government of Viet-Nam has been energetically promoting the policy to establish a large agricultural settlement in this area. Then, the agricultural development of the Upper Srepok is urgently required.

Ban Me Thuot is a chief city in the Upper Srepok Basin (administrative center of Darlac Province), having a population of more than 40,000. At present, the electricity is supplied from Drayling hydropower plant as well as from small diesel power units, but recently the shortage of electricity has become conspicuous due to the rapid growth of the city including military activities. The future power demand is also estimated to increase at a higher rate. To cope with this situation, the extension of Drayling power plant is now being planned by the Government of Viet-Nam.

Water supply of Ban Me Thuot is also insufficient. Then, the improvement and extension of the existing water supply system is needed.

In the Upper Srepok Basin, there is a large tract of lowlying flat land (called "Darlac Flats") which is annually subject to inundation during the rainy season. Most of this area is now left devastated with thick reed due to the lack of drainage facilities. The improvement of drainage together with adequate irrigation has been a long question for the Darlac Flats.

In the highland areas extending around Ban Me Thuot and to the east, there exist plantations for rubber, tea, coffee, etc. But the productivity is low due to the lack of irrigation water. Therefore, if lift irrigation can be used, it would be possible to bring a large area under cultivation and to expect a great increase in agricultural production.

The overall development of the Upper Srepok has thus become an utmost necessity in Viet-Nam and it involves a reclamation of the lowland areas by flood prevention, a supply of irrigation water by gravity or pump, a supply of domestic water and a hydropower generation to meet the increasing demand.

2. Flood control

The flood problem in this basin constitutes one of the chief obstacles to the development of the Project area, as the lowlying lands extending on both banks of the river are annually subject to flooding during the rainy season. Especially, the damage by flooding appears remarkably in the fertile lowlands in the Darlac Flats which extend immediately upstream of the Ban Dray Falls and in the lowland lying upstream of the Ea Krong Ana.

According to the past records of the Kana gauging station, the water level of the river rose up to an elevation of 431 meters in December 1962, and at the same time flooding spread over the vast area of about 100/1 square kilometers extending on both banks of the Ea Krong Ana.

In order to prevent or mitigate such periodic flood damage, the properly designed and operated flood control works should be accomplished.

/1: Flooding spread over the Ea Krong Ana banks inundating an extent of 74 square kilometers above the Kana station, and 26 square kilometers in the Darlac Flats.

For this purpose, two flood control plans are contemplated.

One is to control the flood by utilizing the vast area which extends in the downstream part of the Ea Krong Ana as a retention reservoir, but this is undesirable because it will result in a submergence of large fertile lands for a long period, owing to the narrow path at the outlet of the Darlac Flats.

Another is to control the flood by using many flood retention reservoirs to be created on most of the tributary rivers flowing into the upper basin as mentioned below. (See Plate No.1)

the Upper Krong Buk
the Lower Krong Buk
the Ea Krong Pach
the Ea Krong Boung
the Ea Krong Ana
the Upper Krong Kno
the Lower Krong Kno

Since the necessary flood retention capacity is estimated at 800 million cubic meters in total, the creation of the following series of reservoirs would be proposed: (See Plate No.1).

Reservoir	Retention capacity
the Upper Krong Buk	70 million m^3
the Lower Krong Buk	40 "
the Krong Pach	200 "
the Krong Boung	240 "
the Krong Ana	250 "

With the creation of the series of reservoirs, it would be possible to lower the water level at the Kana gauging station from 431 meters to 429.3 meters in elevation during a large flood as occurred in December 1962 and to keep down the submerged area from 74 square kilometers to 55 square kilometers. By the regulation of these reservoirs, the flood of the Darlac Flats can be reduced to a large extent.

The creation of the Krong Ana reservoir/1 will cause a large sub-

/1 From this reservoir, it would be possible to irrigate about 33,000 hectares of land extending from the reservoir site towards Ban Me Thuot by pumping up water at a low lift of 20 to 28 meters.

mergence of arable land but the period of submergence will not de dominant throughout the year. While the reservoir water level comes down, some 60%/1 of the total submerged area could be utilized for agricultural use during 9 to 10 months a year and even additional 20%/2 will be utilized for such purpose during the period of 8 to 9 months.

In this way, by controlling the flood and regulating the discharge, it will be possible to confine the extent of the submerged area as well as to reduce the period of submergence.

To eliminate the inundation of the Darlac Flats, it is necessary to control the discharge of the two small rivers, the Da P'Heui and the Ea Lien, flowing into the Darlac Flats. For this purpose, it is proposed to change the downstream courses so that these rivers discharge into the Darlac Lake without flooding the Darlac Flats.

In addition, the regulation of the flow of the Ea Krong Kno is also necessary for the complete elimination of inundation in the Darlac Flats. The Ea Krong Kno is one of the largest tributaries of the Upper Srepok flowing from the south into the Darlac Flats. The flood discharge of the Ea Krong Kno, the catchment area of which is about 3,860 square kilometers, spreads into the Darlac Flats which act as a regulation basin.

To alleviate the Darlac Flats from such flood damages, the regulation of the Ea Krong Kno is indispensable. To this effect, it is proposed to build a dam on the Lower Krong Kno at a site above the Darlac Flats, and to divert part of the water into the Dak Mam basin, by cutting

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/1 For instance, by releasing gradually after the flood period, the water level will be kept at El. 425 meters, in January when irrigation is mostly needed. Consequently, it will be possible to turn the submerged area of 33 square kilometers to an arable land. As a result, submerged area will be reduced to 55 km^2 - 33 km^2 = 22 square kilometers. The period of submergence is about 2 to 3 months.

/2 The water level can be further lowered to 421 meters in February when water requirement is smaller than in January.
Consequently, more 11.5 square kilometers of land will be utilized for agricultural purpose. Therefore, a submerged area can be further reduced to 22 km^2 - 11.5 km^2 = 10.5 square kilometers in 3 to 4 months counting from the end of the flood season.

a channel across the low-lying mountain located north of the Ea Krong Kno.

However, the large floods of this river could not be absorbed entirely by the Lower Krong Kno reservoir alone (storage capacity of 73 million cubic meters), a second reservoir with a storage capacity of about 500 million cubic meters will be needed on the Upper Krong Kno. The creation of the second reservoir (Upper Krong Kno reservoir) will also make it possible to irrigate about 3,000 hectares of land on the river banks and will help to increase the power at many power plants to be located downstream due to the increase of river flow in the dry season.

3. Irrigation

Drought is one of the important problems to be solved in the development of the Upper Srepok Basin, because the hilly lands in the upstream area of the Upper Srepok Basin cannot be used fully for agriculture due to the shortage of water during the dry season lasting from October to March.

The prospective reservoirs for flood protection as described above may solve this problem. In fact, the above-mentioned hilly lands could be irrigated from both the Upper and Lower Krong Buk reservoirs, i.e. the former will command 6,500 hectares of lands and the latter 4,900 hectares respectively. Another 5,300 hectares of lands including both lowland and upland could be irrigated from the Krong Pach reservoir. 8,000 hectares of Darlac Flats, after being prevented from flood damages, are expected to be irrigated by gravity and/or pumping, including 2,100 hectares of lands along the Ea Krong Kno which could be irrigated by gravity from the Lower Krong Kno reservoir.

A large arable lands of about 33,000 hectares extending to the west and southeast of Ban Me Thuot could be irrigated by low lift pumping from the aforementioned Krong Ana reservoir, and 4,500 hectares of land in the valley north of Darlac could also be irrigated by pumping from the same reservoir.

The land of about 3,000 hectares and 1,700 hectares located on the left and right banks of the Ea Krong Ána near Ban Don could be irrigated by pumping directly from the Ea Krong Ana.

On the other hand, the Upper Krong Kno reservoir, which will be proposed for flood control, could also irrigate about 3,000 hectares of downstream lands along the Ea Krong Kno and generate hydropower as described later.

With the construction of reservoir on the middle course of the Ea Gan, which comes from the west and joins the Ea Krong Ana at a point downstream of the Ban Dray Falls, the irrigation of about 4,000 hectares of downstream lands will become possible.

Although it is necessary to study the suitability of soil for agriculture collectively on the whole area, it is expected that a total of 74,500 hectares will have to be brought under irrigation in the entire Upper Srepok Basin.

For the successful development of the above-mentioned irrigation projects, it is necessary to establish a pilot farm where irrigated farmers and irrigation farming technicians can be trained. The pilot farm should also include the extension and demonstration of improved irrigation farming practices and examination of the adaptability and profitability of irrigation method, farm implements, machinery, agricultural chemicals, fertilizers, species and varieties of crops for the evaluation of basic factors.

Fortunately, under the U.N.aid, the Government of Viet-Nam contemplates a pilot farm project in Eak Mat located in the center of the Upper Srepok project area. It is desirable that this pilot farm should be built as one of the frameworks of the Overall Development Project of the Upper Srepok Basin. And it should be realized in advance of construction of the above-mentioned irrigation projects.

4. Power

Although the main elements in the Overall Development of the Upper Srepok Basin are flood control and irrigation, the development of hydropower is another important element. The hydropower to be developed in the Upper Srepok will meet the growing demand in Ban Me Thuot as already stated. The hydropower is also used for irrigation pumps as well. (See Plate No. 1)

The annual energy output of the Upper Krong Kno power scheme will be about 212 million kilowatt-hours with an installed capacity of 40,000 kilowatts.

The annual energy output of the Lower Krong Kno power scheme will be about 100 million kilowatt-hours with its installed capacity of 20,000 kilowatts.

By creating the Dak Mam reservoir which will have a retention capacity of about 20 million cubic meters and receive water diverted from the Ea Krong Kno together with the additional discharges of about 18 cubic meters per second from the regulation of the Ea Krong Ana, it will be possible to generate about 113 million kilowatt-hours of annual energy with an installed capacity of 20,000 kilowatts. Moreover, with the realization of the Upper Krong Kno power scheme, the installation will be increased upto 33,000 kilowatts to generate an annual energy of 166 million kilowatt-hours.

On the other hand, on the main stem of the Upper Srepok, there is a possibility of building a dam at the Buon Kuop site to receive the discharge from the Dak Mam. By this dam, an annual energy of 149 million kilowatt-hours could be generated with an installed capacity of 28,000 kilowatts.

Furthermore, by constructing a dam at a site where the National Road No.14 crosses the Upper Srepok, it will be possible to generate an annual energy of 102 million kilowatt-hours with an installed capacity of 20,000 kilowatts.

With the creation of many upstream reservoirs, the flow regime at the existing Drayling power station will be improved. This will make it possible to increase its capacity more than 8,000 kilowatts which is now contemplated for extension work. After the completion of the Upper Krong Kno reservoir it is expected that the capacity may be increased by another 12,000 kilowatts.

In the lower reaches of the Upper Srepok, there are 3 power sites, i.e. C, B and A (see General Plan), where the installed capacity will be 39,000 kilowatts (annual energy output $203x10^6$kwh), 37,000 kilowatts (192×10^6kwh) and 26,000 kilowatts (134×10^6kwh) respectively.

Conclusion and Recommendation

The Overall Development Scheme of the Upper Srepok, as explained hitherto, may be divided into the following two development project groups:

(1) Project in which irrigation is a primary purpose without significant reservoir capacity for flood control, such as the Upper Krong Buk Project and Lower Krong Buk Project.

(2) Combination projects of flood control, agricultural development, land reclamation and power development.

In the first projects group, the Upper Krong Buk Project, which has been investigated this year, should be given higher priority than the Lower Krong Buk Project, because of the progress in investigations so far accomplished and of its economic feasibility. Moreover, there exists a number of settlers in the Upper Krong Buk area.

The Lower Krong Buk Project, aiming at the irrigation of about 4,900 hectares of land should be considered as the second priority scheme in the Overall Scheme of the Upper Srepok Basin.

Although a part of the Darlac Flats/1 covering about 1,000 hectares (Section C in the general plan) was included in the initial irrigation project, this scheme has been switched to the above-mentioned second development projects group, because the farmers in this area were resettled in other zones and accordingly its development can be envisaged at a later stage.

In the second projects group, priority should be given to the flood control schemes. In view of preventing the Darlac Flats from flood, the coordinated plan of the Krong Ana reservoir scheme and the Lower Krong Kno scheme should first be taken up.

Regarding the power scheme, the first step should be taken to increase the capacity of the existing Drayling hydropower station to meet the immediate demand of Ban Me Thuot. Since the Drayling capacity is insufficient to meet the long range power demand in this area including domestic and irrigation uses, the Dak Mam hydropower project should be considered as the successive step.

/1 The Feasibility report on the Darlac Irrigation Project was submitted to the Mekong Committee in December 1963.

In the Upper Srepok Basin, more than 20 individual projects are now contemplated for its final stage. From the viewpoint of coordinated development of these projects, it has been considered essential to establish an overall basin plan first, so that the individual project can be pursued according to their priority.

The Japanese Government has undertaken the investigations of the Upper Srepok for last 3 years, but there still remain some more works for the completion of the abovementioned overall basin plan.

It is therefore required to complete the said overall basin plan for the entire Upper Srepok Basin by continued studies and investigations. At the same time it is also recommended to prepare a feasibility report on two or three selected priority projects for their early realization.

In order to complete these future works, the following investigations will be needed:

1.	Hydrologic investigation	for 3 years
2.	Soil survey	for 50,000 ha.
3.	Preparation of topographic map including ground control	for irrigable area 150,000 ha.
		for power site 500 km^2
4.	Geological drilling for 11 sites	Total depth 1,100 m
5.	Investigations for embankment materials	for 11 sites
6.	Agricultural market survey	

The costs for these works are estimated at about 300,000 US dollars plus some local cost 60,000 US dollars equivalent which will be provided in cash or in kind.

APPENDIX

APPENDIXES

I. INVESTIGATION

II. METEOROLOGY

III. HYDROLOGY

IV. GEOLOGY

V. AGRICULTURE

VI. IRRIGATION PROJECT

VII. HYDROELECTRIC DEVELOPMENT PLAN

APPENDIX I

INVESTIGATION

APPENDIX I

INVESTIGATION

Section 1. General

In accordance with the "Plan of Operation" for the Investigation of the Irrigation Scheme of the Upper Krong Buk Area in the Upper Srepok Basin to be undertaken by the Government of Japan in cooperation with the Government of Viet-Nam and the Committee for Coordination of Investigations of the Lower Mekong Basin, the field works were carried out for about a month and half from March 22, 1965 to the end of April, 1965 in the Upper Srepok Basin covering the Ea Krong Buk and its tributaries. The survey team, which consists of one agronomist, one geologist, one irrigation engineer, two civil engineers and one boring expert executed the agricultural researches, soil and water studies, hydrologic and geological investigations and topographic survey as described in the following :

Description	Works performed
(1) Agricultural investigations	Detailed reconnaissance soil survey and agronomic investigations were done over the whole irrigable land within the Upper Krong Buk Project Area.
(2) Hydrological investigations	At Kana station, Ban Bur station and Krong Buk station, the observation of river water stage were conducted daily, and the measurement of stream discharge by current-meter was carried out periodically at each gauging station during the survey period. The observation of river water stage is being continued by the local personnel.
(3) Geological Investigations	Test pitting of 18 meters in total depth along the proposed dam axis was performed at four spots. Test pitting for investigating the dam embankment materials was executed where it was necessary.
(4) Spot leveling for mapping from aerial photo	Ground control survey, including spot leveling, was executed for an area of about 460 square kilometers in total.

Section 2. Agricultural investigations

The detailed reconnaissance soil survey was carried out over the whole irrigable land in the Project Area. In the course of field works, several principal soil characteristics such as specific gravity, moisture contents,field capacity, etc., were disclosed in view of permitting the determination of the design criteria of irrigation system in the Project Area. At the same time, for the detailed soil analysis, soil sampling was made at fourteen points which may be considered as representative places of the investigation area.

The current stage of crop production and farm management were also investigated during the soil survey period.

Based upon these data, the most adapted farm unit was also illustrated for the type and pattern of crops suitable to the natural and economical conditions of the Project Area.

Section 3. Meteorological and hydrological investigations

In addition to two gauging stations already established in Kana and Ban Bur by the contribution of the Government of Japan in 1961, two more gauging stations were established near the proposed dam sites of the Krong Buk and the Krong Pach. The observation of river water stage were conducted daily at these four stations, and the measurement of stream discharge by current-meter was carried out periodically at each station during the survey period. The observation of river water stage is being continued by the local personnel.

The meteorological data such as rainfall, temperature, relative humidity and evaporation were collected from the Service Meteorologique in Saigon.

Section 4. Geological investigations

Before planning the Upper Krong Buk dam, test drilling was at first prearranged, and the necessary equipment was brought to Ban Me Thuot to find out the thickness of earth covering. But, because the public peace was threatening and admitted no anticipation, it was judged as too dangerous to carry in a drilling machine, the test drilling was finally given up. As an alternative, 6 test pittings in total were adopted to dig along dam axis. However, when test pitting was started from the most important spots of river-bed and two-thirds of them were finished, that unfortunate incident happened, and the operation had to be discontinued.

Section 5. Survey

5.1 Basic leveling

Basic leveling was done by two engineers for eleven days from March 26, 1965 to April 5, 1965.

The existing bench-marks at Ban Me Thuot or along the National Road No. 21 were utilized as the datum-points for basic leveling, which was extended over about 40 kilometers from Ban Me Thuot to Buon Ho village along the National Road No.14 and another basic leveling was carried out for about 15 kilometers from Buon Ho village to the Upper Krong Buk dam site.

The off-set leveling was extended over 10 kilometers from the National Road No. 14 in the vicinity of B. Quang village to the National Road No. 21 in the vicinity of B. Rok Kenn village.

All the bench-marks were set on the survey lines. The details of the bench-marks are shown in the Attached Data Books.

In leveling, the precise Japanese tilting levels were used. The maximum length of sight was kept at 100 meters by stadia and the difference in length between the foresight distance and the backsight distance were kept within 20 meters in the interval of temporary bench-marks.

On the main route, double-run leveling was undertaken on all temporary bench-marks in order to check the discrepancies. The allowable error was 10 millimeters times the square root of the length of the running distances in kilometers, and whenever these discrepancies were noted, third-run leveling was undertaken.

5.2 Ground control surveys

Ground control survey, including spot leveling for mapping from aerial photo, was done by one engineer for 25 days from April 6 to the end of the Month, 1965.

By using the results of the basic and off-set leveling, spot leveling was executed, extending over 75 kilometers in total length for aerial mapping of the Project Area.

Section 6. Aerial mapping

By the use of the ground control survey results and the aerial photograph on a scale of 1 to 40,000 of U.S. Army Map Service, the topographic maps of the Project Area on a scale of 1 to 20,000 with contour intervals of 1 meter for plain area and of 5 to 10 meters for steep sloping area were prepared in Tokyo. This time, the extent of aerial mapping is 460 square kilometers of the Upper Krong Buk Project area.

APPENDIX II

METEOROLOGY

APPENDIX II.

METEOROLOGY

Section 1 General

In this area, as in the whole of the extensive Mekong basin, the climate may be divided into two seasons on the basis of the regular monsoons. Especially as the Annamite Mountains lying east of the Srepok basin runs approximately from north to south and forms a shield, the southwest monsoon, which begins in May and ends in October, causes a large quantity of rainfall in front of the Mountains. On the contrary, for the remaining half of the year from November to April prevails the dry season because the northeastern monsoon is dehydrated while passing over the Annamite Mountains.

In the Upper Srepok basin, there is only one meteorological station which is situated at Ban Me Thuot. The results of the analysis of the records concerning precipitation, temperature, evaporation and relative humidity are shown in the attached Data Books.

Section 2 Precipitation

The monthly rainfall records at Ban Me Thuot, situated about 65 kilometers from the Upper Krong Buk dam site, is shown below:

Table - 2.1 Monthly mean precipitation (Unit: mm)

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1.7	2.9	25.0	98.9	213.3	229.8	272.0	293.2	307.7	211.0	93.3	22.7	1,771.5

(Source: Engineers in charge of hydrologic investigation on the Upper Srepok, the Government of Japan)

According to the above table, the monthly maximum amount of rainfall in the Ban Me Thuot district occurs in September, and 85 to 90 percent of the total annual rainfall come during the rainy season. On the other hand, the mean precipitation in the six months of the dry season (November to April next year) is 244.5 millimeters in total. or

40.8 millimeters per month; consequently water is not sufficient for cropping, unless supplied from other sources.

Section 3. Evaporation

According to the observation records, evaporation in each month is as shown in the following table.

Table - 2.2 Monthly mean evaporation (Unit: mm/day)

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
4.16	5.24	6.18	6.27	3.53	2.64	2.25	1.99	1.74	2.20	2.77	3.35	42.32

As shown in the above table, the evaporation value in the dry season is larger than that in the rainy season. The maximum monthly mean value appears in April, the minimum in September, and these values are 6.27 millimeters and 1.74 millimeters per day, respectively.

The mean valve in the dry season is 4.66 millimeters, 2.39 millimeters per day in the rainy season. The former is about 1.9 times the latter.

Studying the relation between the temperature and evaporation, it becomes clear that the evaporation has little to do with the temperature. On the other hand, there is a closed relation between the evaporation and the relative humidity.

Section 4. Temperature

The Upper Srepok basin, because of its inland nature and tropical latitude, experiences a long period of hot weather.

The annual mean temperature is 24.24°C and the highest monthly mean temperature is 26.5°C in May, while the lowest is 21.7°C in January.

The maximum daily temperature is 39.4°C (April 1937) and the minimum daily temperature is 7.4°C (December 1955)

Table - 2.3 Monthly mean temperature (Unit: degree in Centigrade)

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
21.67	23.51	24.26	26.45	26.48	25.22	24.81	24.82	24.43	24.43	22.94	21.89	24.24

(Source: Meteorological Bureau's data 1937 - '39, 1955 - '64)

During the rainy season, the temperature is high, but evaporation is small; on the contrary, in the dry season, the temperature is low, but evaporation is large. It may be considered that the above mentioned fact is one of the special features observed in the monsoon zone.

Section 5. Monthly mean relative humidity

The annual mean relative humidity at Ban Me Thuot lies between 65 percent and 80 percent. During the southwest monsoon season or rainy season, the monthly mean relative humidity becomes higher to about 75 percent to 80 percent. During the northeast monsoon season or dry season, it falls to about 65 percent.

The monthly mean relative humidity in Ban Me Thuot area is as shown in the following table.

Table - 2.4 Monthly mean relative humidity (Unit: %)

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
72.85	70.36	65.55	67.49	74.72	77.18	81.98	82.31	80.55	80.97	81.16	78.73	76.15

Fig. 2 1 Monthly mean precipitation
PRECIPITATIONS MOYENNES MENSUELLES

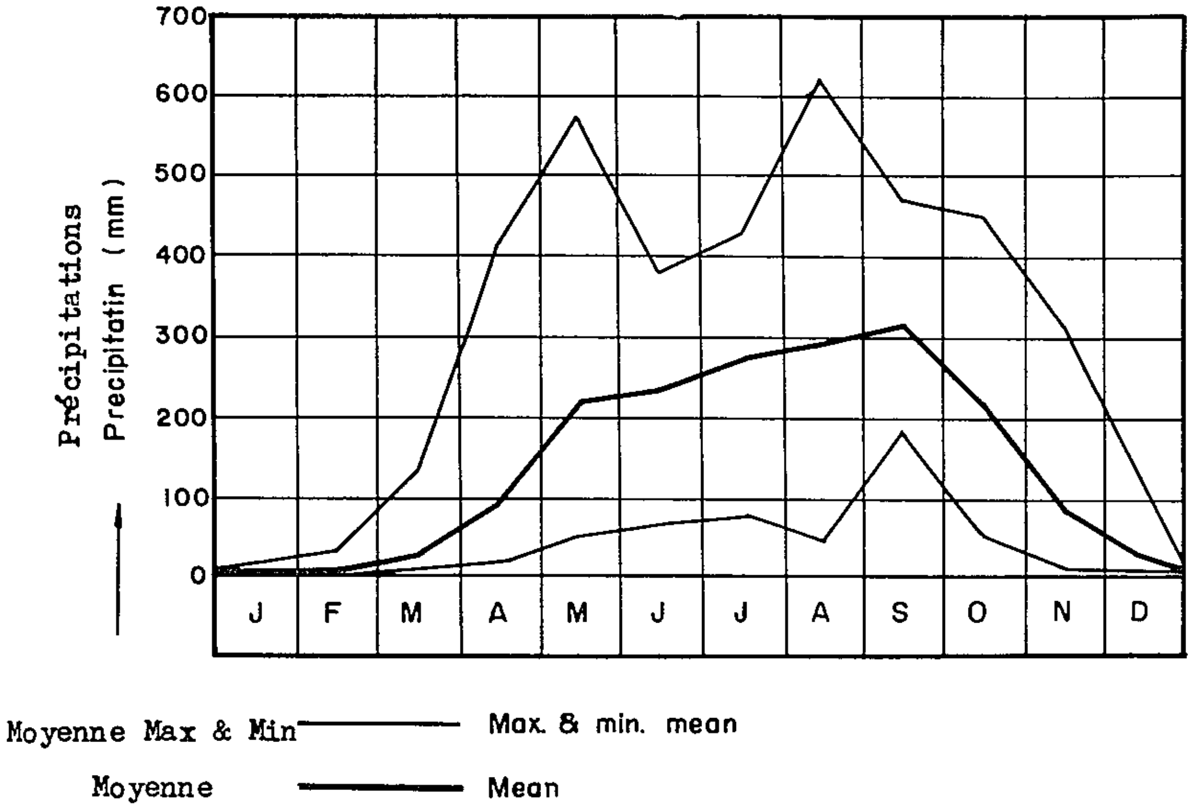
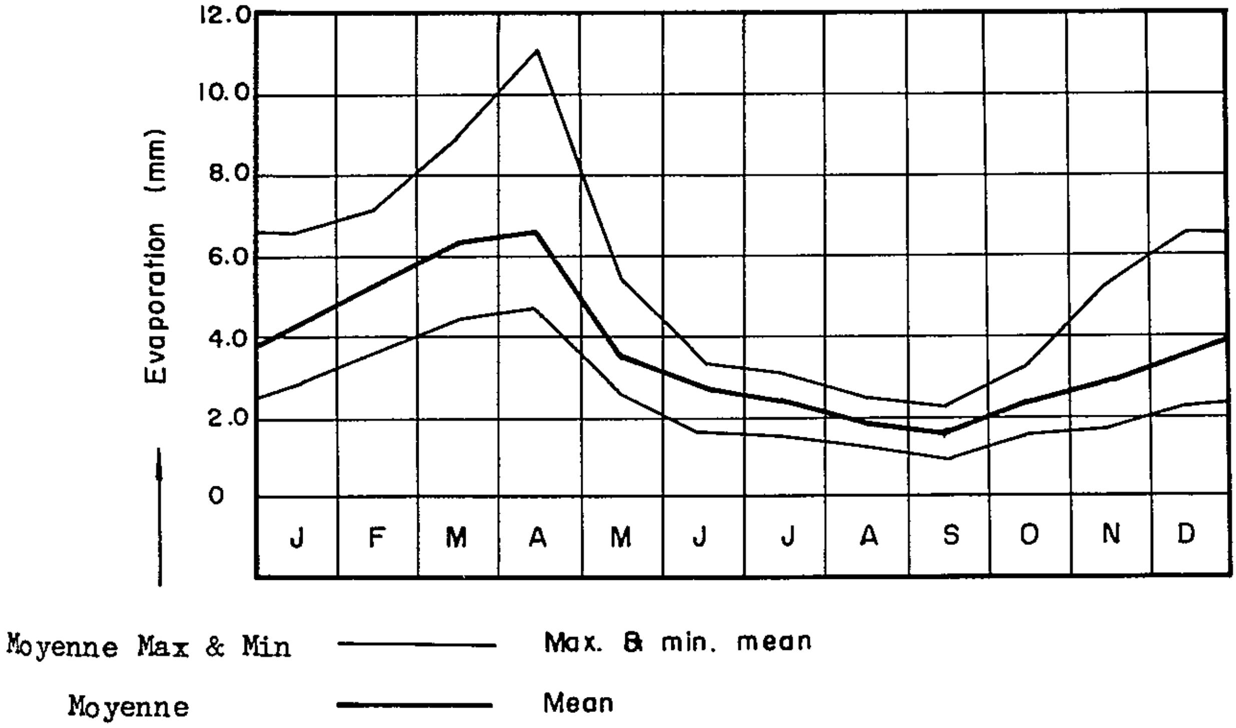
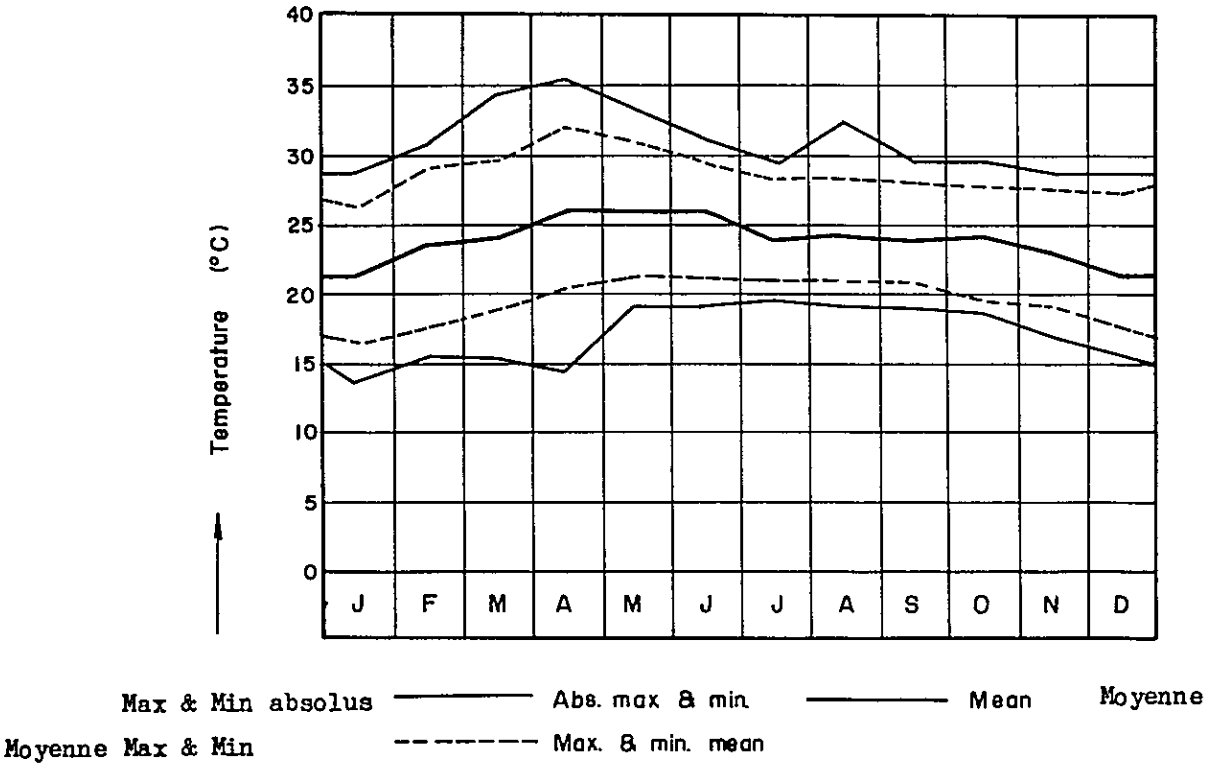


Fig. 2.2 Monthly mean evaporation
EVAPORATION MOYENNE MENSUELLE



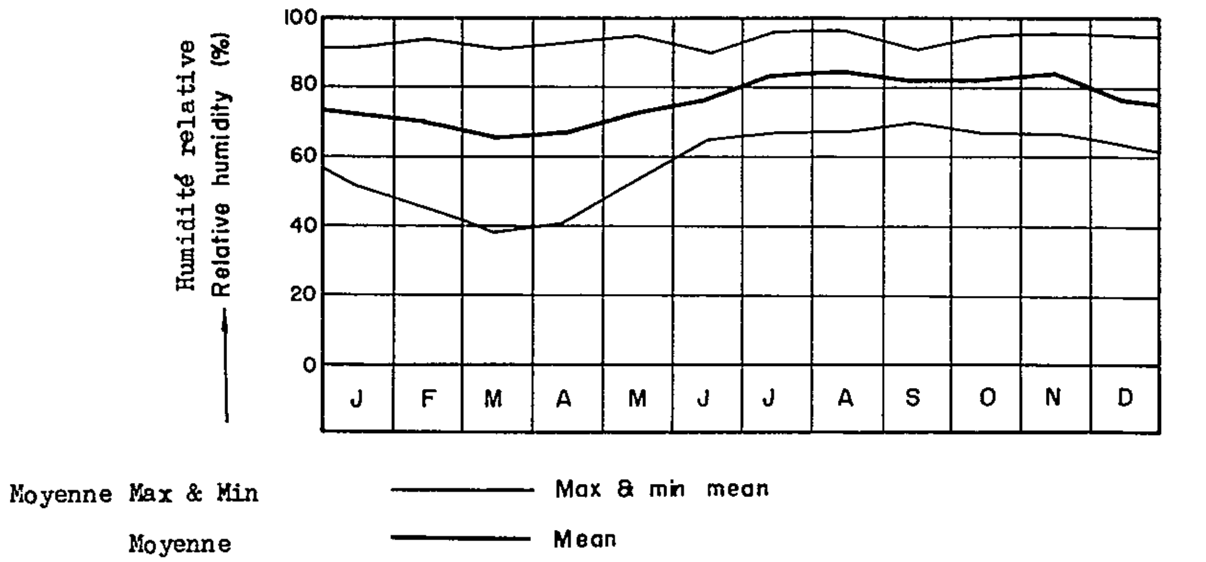
TEMPERATURE MOYENNE PAR MOIS

Fig. 2.3 Mean temperature by month



HUMIDITE RELATIVE MOYENNE MENSUELLE

Fig. 2.4 Monthly mean relative humidity



APPENDIX III

HYDROLOGY

APPENDIX III

HYDROLOGY

Section 1. Available data

1.1. Precipitation

The most important factor which influences the river discharge is precipitation. In the Upper Srepok Project Area, there is one meteorological station which is located at Ban Me Thuot. Precipitation records at Ban Me Thuot covering 22 years from 1928 to 1939 and from 1955 up to now should be used for estimating the river discharge, and listed attached Data Books.

1.2. Discharge record

The daily recording of water stage and periodical measurement of stream discharge have been carried out at the following four gauging stations established by the contribution of the Government of Japan.

Station	Discharge records available
Kana	Oct. 1961 - Mar. 1965
Ban Bur	Oct. 1961 - Mar. 1965
Krong Buk	Sep. 1963 - Mar. 1965
Krong Pach	Dec. 1963 - Oct. 1964

These discharge records are derived from the water stage data which were read every day during the observation period. The average monthly discharge and daily records at each station are given in Table - 3.1 and in the attached Data Books respectively.

Section 2. Characteristics of the Upper Krong Buk drainage area

The upper part of the Ea Krong Buk with rather steep slope of 1 : 150 runs southward through the central part of the highland lying northeast of Ban Me Thuot. The catchment area above the proposed Upper Krong Buk dam site is about 149 square kilometers.

The characteristics of the area can be explained under four categories:

Table 3.1 Monthly discharge at each gauging station (measured)

(discharge in m^3/sec)

Year		Kana gauging station (3,210 km2)						Dan Bur gauging station (8,650 km2)						Krong Pach gauging station (490 km2)						Krong Buk gauging station (460 km2)					
		Mean discharge		Maximum discharge		Minimum discharge		Mean discharge		Maximum discharge		Minimum discharge		Mean discharge		Maximum discharge		Minimum discharge		Mean discharge		Maximum discharge		Minimum discharge	
		(m3/sec)	(m3/sec/100km2)	(m3/sec)	(m3/sec/100km2)	(m3/sec	m3/sec/100km2)	(m3/sec)	(m3/sec/100km2)	(m3/sec)	(m3/sec/100km2)	(m3/sec)	(m3/sec/100km2)	(m3/sec)	(m3/sec/100km2)	(m3/sec)	(m3/sec/100km2)	(m3/sec)	(m3/sec/100km2)	(m3/sec)	(m3/sec/100km2)	(m3/sec)	(m3/sec/100km2)	(m3/sec)	(m3/sec/100km2)
1961	O	85.6	2.7	139.0	4.3	30.5	0.9	487.4	5.6	822.0	9.5	266.0	3.1												
	N	59.4	1.9	72.5	2.3	43.0	1.3	199.3	2.3	296.0	3.4	160.0	1.8												
	D	31.8	1.0	45.5	1.4	25.0	0.8	120.0	1.4	160.0	1.8	90.0	1.0												
1962	J	25.5	0.8	36.5	1.1	20.0	0.6	64.2	0.7	103.0	1.2	41.5	0.5												
	F	18.1	0.6	21.5	0.7	15.0	0.5	50.1	0.6	61.0	0.7	38.0	0.4												
	M	12.9	0.4	16.5	0.5	10.5	0.3	45.0	0.5	57.0	0.7	41.5	0.5												
	A	9.8	0.3	11.5	0.4	8.5	0.3	42.3	0.5	50.0	0.6	39.0	0.5												
	M	13.0	0.4	24.5	0.8	8.0	0.2	62.0	0.7	100.0	1.2	41.0	0.5												
	J	14.4	0.4	35.5	1.1	9.5	0.3	83.6	1.0	123.0	1.4	63.0	0.7												
	J	37.8	1.2	91.0	2.8	12.0	0.4	211.6	2.4	416.0	4.8	59.0	0.7												
	A	88.7	2.8	158.0	4.9	41.0	1.3	259.3	3.0	403.0	4.7	57.0	0.7												
	S	94.8	3.0	185.0	5.8	35.0	1.1	280 *	3.2*	555 *	6.4*	66 *	0.8*												
	O	110.0*	3.4*	71.0*	2.2*	71.0*	2.2*	336.5	3.9	1,040.0	12.0	121.0	1.4												
	N	286.4	8.9	400.0	12.5	133.0	4.1	627.1	7.2	1,000.0	11.6	305.0	3.5												
	D	172.9	5.4	395.0	12.3	51.0	1.6	283.3	3.3	482.0	5.6	114.0	1.3												
1963	J	35.0	1.1	54.0	1.7	24.5	0.8	88.5	1.0	111.0	1.3	73.0	0.8												
	F	19.9	0.6	24.0	0.7	16.0	0.5	60.8	0.9	73.0	0.8	51.0	0.6												
	M	13.1 (74.7)	0.4(2.77)	15.0(122.0)	0.5(3.81)	12.0(35.1)	0.4 (1.10	44.2(198.3)	0.5(2.30)	49.0(366.8)	0.6(4.25)	41.0(85.8)	0.5(1.00)												
	A	11.1	0.3	12.0	0.4	10.0	0.3	35.6	0.4	40.0	0.5	31.0	0.4												
	M	11.0	0.3	15.0	0.5	10.0	0.3	36.7	0.4	61.7	0.7	28.7	0.3												
	J	11.6	0.4	16.9	0.5	10.0	0.3	48.4	0.6	98.1	1.1	31.0	0.4												
	J	33.6	1.1	39.2	1.2	29.2	0.9	59.4	0.7	78.3	0.9	43.8	0.5												
	A	72.0	2.2	104.0	3.2	34.1	1.1	158.0	1.8	260.2	3.1	61.7	0.7							10.85	2.36	31.49	6.85	3.57	0.78
	S	120.2	3.7	240.0	7.5	34.1	1.1	334.8	3.9	555.1	6.4	176.6	2.0							11.69	2.54	42.06	9.14	4.59	1.00
	O	214.7	6.7	355.9	11.1	39.3	1.2	466.7	5.4	764.2	8.8	271.9	3.1							24.54	5.33	79.63	17.31	5.89	1.28
	N	57.0	1.8	116.4	3.6	32.3	1.0	161.5	1.9	260.2	3.0	96.0	1.1							11.01	2.39	31.09	6.76	5.21	1.13
	D	31.3*	1.0*	95.0*	3.0*	22.0*	0.7*	84.6	1.0	118.6	1.4	58.7	0.7	11.68	2.38	27.53	5.62	5.58	1.14	4.68	1.02	6.64	1.44	4.15	0.90
1964	J	17.9*	0.6*	48.0*	1.5*	15.0*	0.5*	46.4	0.5	60.2	0.7	38.0	0.4	4.99	1.02	5.58	1.14	4.46	0.91	3.63	0.79	4.15	0.90	2.84	0.62
	F	15.6	0.5	19.8	0.6	12.7	0.4	38.9	0.4	42.7	0.5	35.6	0.4	4.42	0.90	5.15	1.05	9.09	1.86	2.43	0.53	3.06	0.67	2.25	0.49
	M	12.5(50.7)	0.4(1.66)	14.2(89.7)	0.4(2.79)	11.8(21.7)	0.4(0.68)	32.4(125.3)	0.4(1.45)	34.6(197.8)	0.4(2.29)	28.3(75.1)	0.3(0.86)	4.36	0.89	4.63	0.94	4.21	0.86	2.44(7.95)*	0.53(1.73)*	3.06(41.00)*	0.67(8.92)*	2.25(2.94)*	0.49(0.65)*
	A	11.3	0.4	11.9	0.4	10.9	0.3	28.5	0.3	31.5	0.4	26.4	0.3	3.44	0.70	4.21	0.86	2.86	0.58	2.59	0.56	3.21	0.70	2.25	0.49
	M	13.2	0.4	15.9	0.5	10.9	0.3	49.3	0.6	84.0	1.0	26.4	0.3	4.29	0.88	6.12	1.25	3.12	0.64	3.45	0.75	5.21	1.13	2.25	0.49
	J	16.5	0.5	20.3	0.6	12.7	0.4	60.5	0.7	87.8	1.0	41.7	0.5	4.60	0.94	6.35	1.30	3.54	0.72	3.12	0.68	3.57	0.78	2.48	0.54
	J	15.9	0.5	26.0	0.8	12.8	0.4	79.1	0.9	92.9	1.1	64.7	0.7	4.86	0.99	13.38	2.73	3.28	0.67	3.68	0.80	6.48	1.41	2.77	0.60
	A	30.7	1.0	54.4	1.7	14.2	0.4	141.5	1.6	209.2	2.4	91.8	1.1	4.10	0.84	5.03	1.03	3.12	0.64	5.27	1.15	16.24	3.53	2.77	0.60
	S	32.9	1.0	46.7	1.5	17.4	0.5	135.1	1.6	264.0	3.1	89.8	1.0	8.36	1.71	19.96	4.07	4.13	0.84	10.63	2.31	37.20	8.09	3.57	0.78
	O	44.6	1.4	75.1	2.3	23.7	0.7	93.4	1.1	233.9	2.7	152.9	1.8	8.54	1.74	41.08	8.38	4.04	0.82	12.21	2.65	29.18	6.34	5.21	1.13
	N	222.7*	6.9*	324.0*	10.1*	89.3*	2.8*	600.0*	6.9*	873.0*	10.1*	155.7*	1.8*							41.18	8.95	235.61	51.22	7.43	1.62
	D	131.1*	4.1*	187.0*	5.8*	75.6*	2.4*	421.5	4.9	592.7	6.9	317.4	3.7							19.44	4.23	224.70	48.85	4.04	0.88
1965	J	59.6	1.9	115.7	3.6	36.3	1.1	144.5	1.7	352.9	4.1	60.2	0.7							3.99	0.87	4.59	1.00	3.57	0.78
	F	29.2	0.9	38.0	1.2	23.2	0.7	54.1	6.3	60.2	0.7	48.2	0.6							3.45	0.75	4.47	0.97	2.84	0.62
	M	19.9(52.3)	0.6(1.84)	27.9(78.6)	0.9(2.45)	15.6(28.6)	0.5(0.88)	46.0(154.5)	0.5(2.26)	48.2(244.2)	0.6(2.84)	42.7(93.2)	0.5(1.08)							2.46(9.29)	0.53(2.02)	3.46(47.83)	0.75(10.40)	2.02 (3.43)	0.44 (0.75)

* : Estimated discharge

( ) : Annual mean discharge of hydrologic year

1. Relief : rolling, with average slopes of 5 to 10%
2. Soil infiltration : rather low infiltration capacity.
3. Vegetable cover : about 80 - 90 percent of drainage area in grassland and woodland.
4. Surface storage : surface depressions few and shallow ; drainage-ways steep and small; no ponds or marshes.

Section 3. Hydrologic year

According to the hydrograph observed, the stream flow continues to increase during the rainy season and the peak of stream flow occurs generally in September or October, and after that it decreases gradually till the end of the dry season. Such characteristics of hydrograph also appear at each gauging station. Therefore, we have determined that the hydrologic year should be from April to March next year.

Section 4. Available Discharge

As no gauging station has been set up at the Upper Krong Buk dam site, the rate of run-off is assumed with the aid of discharge data collected at the Krong Buk gauging station, about 45 kilometers downstream from it. Moreover, since even this discharge record is kept for no more than 20 months, the following attempts are made to find out the relation between discharge and rainfall, in order to assume the rate of discharge retroactive to the further past.

4.1 Run-off

First, the surveyed value is amended as below, in order to find out the relation between run-off and rainfall. In other words, when there is excessive daily rainfall during the flood season, the rate of run-off rises, and the relation between run-off and rainfall is complicated. In order to simplify it, assuming that 70 per cent/1 of daily rainfall flow out in case daily rainfall is more than 80 millimeters, the discharge influence of typhoons during a 10-year period from 1955 to 1964 can be computed as follows:

/1 : "Soil and Water Conservation Engineering" Richard K. Frevert, Glenn O. Schwab, Talcott W. Edminster, Kenneth K. Barnes: (1955) According to Cook's method.

1957 October	110.0 mm x 0.70 = 77.0 mm
1960 October	103.9 mm x 0.70 = 72.7 mm
1964 November	143.0 mm x 0.70 = 100.1 mm

Then, the discharge observed in November 1964 is amended as follows, by deducting the increase by the storm from the actual flow.

Table 3.2 Discharge at Krong Buk Station (unit : mm)

	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1963				45.0	63.2	65.9	142.9	62.0	27.2	21.1	13.2	14.2
1964	14.6	20.1	17.6	21.4	30.7	59.9	71.1	232.0	80.6	23.2	18.1	14.3
								(131.9)				

N.B. The figure enclosed with brackets for November 1964 shows a normal numerical value not influenced by flood.

Also, modifications of rainfall can be made as shown in the following table.

Table 3.3 Rainfall at Ban Me Thuot (unit : mm)

	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1963	17.7	116.4	146.3	232.2	184.1	456.1	176.6	19.7	1.6	6.8	2.3	29.7
1964	15.1	219.9	134.0	76.6	336.0	209.7	85.2	304.0	130.0	0.2	5.3	0.8
								(161.0)				

N.B. The figure enclosed with brackets for November 1964 shows the rainfall from which 143.0 mm of daily rainfall were deducted.

4.2 Relation between run-off and precipitation

Since a large percentage of precipitation flows out, some correlation is likely to exist between precipitation and discharge. So, the correlation between them is assumed by the following process. First, one water year is divided into 4 periods.

i) April to June
ii) July to September
iii) October to December
iv) January to March

Then, by using the amended discharge and rainfall calculated in Table 3.2 and 3.3 respectively, the ratios of the runoff in a trimester to a total precipitation for the period up to the trimeter are calculated as shown in the following Table 3.4.

Table 3.4 Relation between run-off and accumulated rainfall

Year	Item	(i) Apr. - June	(ii) July - Sept	(iii) Oct. - Dec.	(iv) Jan. - Mar.
1963	Run-off (mm)		174.1	232.1	48.5
	Accumulated rainfall (mm)		1,352.8	1,550.7	1,589.5
	Ratio		0.129	0.150	0.031
1964	Run-off (mm)	52.3	112.0	283.6	55.6
	Accumulated rainfall (mm)	369.0	991.3	1,367.5	1,373.8
	Ratio	0.142	0.113	0.207	0.040

From the above table, it is obvious that there are not wide differences among the ratios of run-off and accumulated rainfall in each year, according to the past 2 years' survey. Though it is very selfrighteous, the following numerical values are employed in order to imagine the run-off in a trimeter from the rainfall in the past.

Trimester	(i)	(ii)	(iii)	(iv)
Ratio	0.142	0.121	0.179	0.036

Table 3.5 is the run-off in each trimester computed by the numerical values of the above table.

4.3 Presumption of monthly mean discharge in the past years

From the discharge and accumulated rainfall obtained in the above paragraph, it is possible to presume the rate of discharge at the Upper Krong Buk dam site in a trimeter at a given year from the rainfall record in the past.

In order to presume monthly mean discharge from the presumed discharge in a trimeter, the ratios of each monthly mean discharge to the total discharge in a trimeter which was observed at the Krong Buk gauging station is shown in the following table.

Table 3.6 Monthly discharge ratio

Trimester	(i)			(ii)			(iii)			(iv)		
Month	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Ratio	0.28	0.34	0.38	0.23	0.33	0.44	0.41	0.38	0.21	0.43	0.30	0.27

Table - 3.5 Estimated runoff of trimester at Krong Buk and accumulated precipitation at Ban Me Thuot

Year	Apr. - Jun. Precipitation (mm)	Apr. - Jun. Runoff (mm)	Jul. - Sept. Precipitation (mm)	Jul. - Sept. Runoff (mm)	Oct. - Dec. Precipitation (mm)	Oct. - Dec. Runoff (mm)	Jan. - Mar. Precipitation (mm)	Jan. - Mar. Runoff (mm)
1955	466.9	66.3	1,358.6	164.4	1,688.3	302.2	1,691.3	60.9
1956	644.2	91.5	1,376.4	166.5	1,544.6	276.5	1,697.6	61.1
1957	557.2	79.1	1,391.5	168.4	1,627.8 /1 (110.0)	291.4 /2 (77.0)	1,636.9	58.9
1958	467.6	66.4	1,278.3	154.7	1,635.0	292.7	1,662.0	59.8
1959	551.1	78.3	1,318.6	159.6	1,622.8	290.5	1,628.6	58.6
1960	605.2	85.9	1,539.3	186.3	1,756.7 /1 (103.9)	314.4 /2 (72.7)	1,827.4	65.8
1961	743.7	105.6	1,656.3	200.4	1,944.1	348.0	1,950.0	70.2
1962	322.6	45.8	1,241.5	150.2	1,611.9	288.5	1,613.1	58.1
1963	280.4	39.8	1,352.8	163.7 166.8*	1,550.1	277.5 232.1*	1,589.5	57.2 48.5*
1964	369.0	52.4 52.3*	991.3	119.9 112.0*	1,367.5 /1 (143.0)	244.8 /2 (100.1) 416.3*	1,373.8	49.5 55.6*

/1 The figures are obtained by deducting the daily rainfall by storm from the accumulated precipitation.

( ): Daily rainfall by storm which is observed more than 80 millimeters.

/2 The normal discharge not affected by flood

( ): The increases in runoff affected by storm

* : The actual discharge recorded

Consequently, the monthly mean discharge at the Krong Buk gauging station can be presumed by multiplying the abovementioned monthly discharge ratio to the run-off in a trimester. From this datum, the monthly mean discharge at the Upper Krong Buk dam site can be obtained by the ratio of catchment area of the Upper Krong Buk dam site to the catchment area of the Krong Buk gauging station. The monthly mean discharge at the Lower Krong Buk dam site is obtained in the same manner. They are shown in Table 3.7 and 3.8 respectively.

Section 5. Review on Section 4

Annual specific discharge at Kana gauging station during three hydrologic years of 1962 - 63, 1963 - 64 and 1964 - 65 is 2.77, 1.66, 1.84 cubic meters per second per 100 square kilometers. This value is applicable to the Ea Krong Buk. As stated in the previous report, the Krong Buk is a more swiftly flowing stream as compared with the Ea Krong Ana basin, because there is no surface depression in its catchment basin.

Based upon these specific discharge and granted that confidence limits are 5%, population mean (m) is obtained as follows:

$$m = \bar{X} \pm \frac{t}{\sqrt{n}} s$$

where $\bar{x}$: Mean value of specific discharge

t : "t" of Student, 4.303 in this case.

n : Number of observed years.

s : Standard deviation $= \sqrt{\frac{1}{n} \sum (\bar{X}_i - \bar{X})} = 0.188$

$$m = 2.088 \pm \frac{4.303}{\sqrt{3}} (0.188)$$

$$= 2.088 \pm 0.466$$

$$= 2.554 \text{ or } 1.622 \text{ m}^3\text{/sec/100 km}^2$$

Therefore, the specific discharge that occurs once in 20 years is considered to be within the limits of 2.554 m^3/sec/100 km^2, 1.622 m^3/sec/100 km^2.

Now, annual run-off is calculated by the lowest value, at a moderate estimate,

$$\frac{460}{100} \times 1622 \times 365 \times 86,400 \doteqdot 230,000,000 \ m^3$$

This run-off is sufficient enough, as compared with the storage capacity of both the Upper Krong Buk and the Lower Krong Buk reservoirs.

Table 3. 7 Estimated mean monthly discharge at the Upper Krong Buk dam site (unit: m^3/s)

(catchment area 149 Km^2)

Year	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	(Next year) Jan.	Feb.	Mar.	Mean
1955	1.07	1.25	1.45	2.10	3.02	4.16	6.89	6.60	3.53	1.46	1.09	0.91	2.79
1956	1.47	1.73	2.00	2.13	3.05	4.21	6.31	6.04	3.22	1.46	1.13	0.92	2.81
1957	1.27	1.50	1.73	2.15	3.09	4.26	10.93	6.37	3.40	1.41	1.09	0.88	3.17
1958	1.07	1.26	1.46	1.98	2.84	3.91	6.67	6.39	3.42	1.43	1.10	0.90	2.70
1959	1.26	1.48	1.71	2.04	2.93	4.04	6.62	6.35	3.39	1.40	1.05	0.88	2.76
1960	1.39	1.62	1.87	2.38	3.42	4.72	11.21	6.87	3.67	1.57	1.21	0.99	3.41
1961	1.70	2.00	2.31	2.56	3.68	5.07	7.93	7.60	4.06	1.68	1.30	1.05	3.41
1962	0.74	0.87	1.00	1.92	2.76	3.80	6.58	6.30	3.37	1.39	1.07	0.87	2.56
1963	0.64	0.75	0.87	2.10	3.51	3.79	7.95	3.57	1.51	1.17	0.79	0.79	2.58
1964	0.84	1.12	1.01	1.19	1.71	3.44	3.95	13.34	6.29	1.29	1.12	0.80	3.01
Mean	1.15	1.36	1.54	2.06	3.00	4.14	7.50	6.94	3.59	1.43	1.10	0.90	2.92

Table 3. 8 Estimated mean monthly discharge at the Lower Krong Buk dam site (unit: m^3/s)

(Remaining catchment area 311 Km^2)

Year	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	(Next year) Jan.	Feb.	Mar.	Mean
1955	2.23	2.61	3.02	4.39	6.30	8.68	14.38	13.78	7.37	3.04	2.27	1.90	5.83
1956	3.07	3.61	4.18	4.45	6.37	8.80	13.17	12.61	6.73	3.05	2.35	1.92	5.86
1957	2.65	3.12	3.61	4.49	6.46	8.89	22.81	13.28	7.11	2.94	2.28	1.89	6.62
1958	2.23	2.61	3.02	4.13	5.93	8.16	13.93	13.34	7.14	2.98	2.30	1.88	5.64
1959	2.63	3.09	3.58	4.26	6.12	8.42	13.83	13.25	7.08	2.93	2.18	1.83	5.77
1960	2.89	3.39	3.91	4.97	7.14	9.84	23.41	14.34	7.66	3.29	2.53	2.07	7.12
1961	3.55	4.17	4.81	5.35	7.67	10.58	16.57	15.86	8.49	3.51	2.71	2.19	7.12
1962	1.54	1.81	2.09	4.01	5.76	7.93	13.73	13.15	7.04	2.90	2.24	1.82	5.34
1963	1.34	1.57	1.81	4.38	7.33	7.91	16.59	7.44	3.16	2.45	1.64	1.65	4.77
1964	1.75	2.33	2.11	2.48	3.56	7.19	8.25	27.84	13.14	2.69	2.33	1.66	6.28
Mean	2.39	2.83	3.21	4.29	6.26	8.64	15.67	14.49	7.49	2.58	2.28	1.88	6.04

APPENDIX IV

GEOLOGY

APPENDIX IV

GEOLOGY

Section I. General

The geological reconnaissance survey was carried out two times in the Krong Ana basin by our chief geologist: from November 5 to November 30, 1963 and from February 1 to February 12, 1964. Especially in the upper reaches of the Krong Buk, a detailed geological survey was carried out by the same engineer from mid-April 1965 to the end of the month.

Besides, test boring was made at the following two dam sites for 3 months from the end of November to mid-February 1964.

i) Lower Krong Buk site, 3 holes, total depth: 16 m
ii) Krong Pach site, 2 holes, total depth: 29 m

Test pitting was carried out at the following dam site from mid-April 1965 to the end of the month.

iii) Upper Krong Buk site, 4 holes, total depth: 18 m

Section 2. Geology of the basin

The basin of the Ea Krong Ana located at elevations of 750 to 430 meters above the sea level occupies approximately a southern part of the Central Highland in Viet-Nam, and most part of the basin belongs to the highland area with a gentle slope on which exist several hilly spots with a height of 50 to 100 meters.

Basal formations of the highland is of Paleozoic. The Paleozoic formation had been intruded by granitic rocks probably in the Tertiary period.

Subsequently it was extruded by volcanic rocks in the late Tertiary or early Quaternary period. The hilly spots dotted within the Highland consist of the Paleozoic rocks.

The volcanic rocks are mainly composed of basalt. In many of the rivers within the basin, there exist numerous small waterfalls and rapids caused by the basaltic lava interrupting the flow of the river. These volcanic activities developed the typical topography of rolling plain. The basaltic lava erupted over the area by volcanic activities is decomposed under the tropical monsoon climate: in consequence, it forms the thick residuals of brick-red, clayey soils which are called "terre rouge". It is generally told that the terre rouge is a good soil for plantation farming especially for rubber plantation. But, analysis of its chemical composition does not always show special fertility.

The mountain ranges with an elevation of 1,000 to 2,000 meters about the sea level mainly consist of granitic rocks of the Tertiary period, and they have a steep slope topography. The rivers with their origins in the mountain ranges have a steep slope, and the river water is relatively clear and not so muddy even in the flood season.

Section 3. Geology of dam sites

3.1 Upper Krong Buk dam site: The whole catchment basin of the Krong Buk is covered with vast basaltic lava flow. Especially, the Upper Krong Buk area presents undulating topography on account of lava flow, covered with its weathered decomposition "terre rouge", presenting a few outcrops. However, on the river-bed of rivulet which develops in branch-like shape on the Plateau, lots of hard basalt are exposed.

Basalt is clearly exposed on the upstream and partially on the downstream of the proposed dam site where the current is slightly swift. But at the dam center, the river-slope is extremely gentle and meandering, and consequently, the river-bed is not exposed, being covered with silty and muddy deposit. Before planning a dam, test drilling was at first prearranged, and the necessary equipment was brought to Ban Me Thuot to find out the thickness of earth covering. But, because the public peace was threatening and admitted of no presupposition, it was judged as too dangerous to carry in a drilling machine, the test drilling was finally given up. As an alternative, 6 test pittings in total were adopted for digging along the dam axis. However, when test pitting was started beginning with the most important spots of river-bed and two-thirds of them were finished, that unfortunate incident happended, and the operation had to be discontinued. Nevertheless, it was roughly confirmed by four test pits that basalt rockbed could be reached at 4 to 6 meters below the surface of the earth. The result of test pitting are shown in the appended Plate No.6.

The basaltic lava in this region is supposed to have flowed out at several times. Sometimes, sand and gravel formed a permeable layer in the major flow planes between old and new lava flows. Therefore, it was necessary to observe the bedding condition of lava by test drilling. It is sincerely regretted that test drilling was unable to do on account of guerilla warfare. However, granted that such a permeable layer is latent underground (almost horizontally), it is possible,by advanced modern grouting technique, to prevent water leakage by forming a grout curtain.

Samples collected at various depths at the time of pitting were sent to the Soil Laboratory of the Government of Viet-Nam for soil analysis. According to it, the samples abound with 30 to 40 percent clay component. As the fill material for earth dam, it is suitable although clay component is somewhat much more than the degree desirable from the point of view of execution.

3.2 Lower Krong Buk dam site: As stated in the report submitted in December 1964, the outline of the geological study is as follows:

According to our boring test, the sound bed-rock of basalt lies beneath alluvial deposits of about 3 meters in thickness at the dam site, while the fresh basalt crops out in part of the river bed of the lower site (about 500 meters downstream from the confluence).

In view of the topographical features of the site, it is possible to construct a dam of more than 20 meters in height and with a crest length of about 1,400 meters, crossing two rivers of the Krong Buk and Ea Drang. Such being the case, if the concrete gravity type is undertaken, considerable excavation would be required for constructing a dam foundation on the fresh bed-rock, because alluvial deposits must be removed completely. This requires a large investment for treatment of the dam foundation.

Therefore, a fill type will be selected as a type of dam, taking into consideration such factors as the construction cost, foundation treatment and embankment materials.

3.3 Krong Pach dam site: According to our investigations, there is a suitable dam site at a point about two kilometers east of B. Rok. From the results of test boring of the proposed dam site, it became clearly that bed-rock of sandstone lies beneath the silt deposits of about 11 to 13 meters in thickness, and under such circumstances it is desirable to construct a fill type dam at this site mainly from the economic consideration.

3.4 Krong Ana dam site: The Krong Ana in its upper reaches drains through an intermountain area comprising Paleozoic strata and granite, and the Plateau comprising basalt lava. In its middle courses, the river devouches into the Darlac Lowland through a hilly district about 8 kilometers downstream from Kana bridge. As a matter of course, on the Plateau upstream and the Darlac Lowland downstream, the river has gentle slope and shows discharge duration of sedimentation type. But, in the 13-kilometer gorge section in the middle courses, the river has slightly steep slope and shows discharge duration of erosion type.

Such a type of the river influences discharge duration in case of flood, and forms a bottle neck at gorges of the middle courses, which checks the flood flow at Kana bridge and causes inundation on the upper reaches. During and after the flooding, large silting develops on the Darlac Lowland downstream.

The proposed dam site, located on this gorge, has been selected for its favorable topography. The public peace had been so threatening in this region that a boring machine could not be brought in. But, one day a reconnaissance survey of geological conditions was carried out using a small boat. The result is described below.

The Krong Ana river at this gorge section flows down between both banks in hilly districts of 100 to 200 meters in relative height, and meanders to the right and left, at a pitch of several hundred to a thousand meters. Both banks comprise hillsides of 25° to 40° gradient. At the elbow of meandering, always exposes bed-rock of Paleozoic strata; and on the opposite bank gravel deposit. The rock is composed of slate, shale and sandstone, the first two dominating in quantity. The strike runs east-west to some degree and inclines 40° to 70° toward upstream or downstream reaches. Around the dam axis, the rock is mainly formed of alternate strata of black shale and slate mixed with sandy slate or sandstone.

The left bank lies in the direction of the elbow of bent flow, and black slate is exposed at the water's edge. On the right bank, there is a sand deposition. The rock formation has sufficient bearing strength for a fill-type dam of less than 30 meters in height.

Fill material could be supplied by establishing a quarry on the hill on the left bank side. Since the rock consisted of an alternate strata of slate, shale and sandstone as mentioned above, great lumps could not be quarried, but, on the other hand, it would not necessitate the transportation and use of large-sized machines and equipment for handling these medium-sized materials.

The flood spillway projected on the right bank side would be constructed by cutting off a relatively low section of the hill; therefore the excavation of a section of alternate strata of slate and shale would be comparatively easy. However, as the lower part of spillway is apt to be scoured by the energy of falling water, sufficient countermeasure against scouring would be required.

APPENDIX V

AGRICULTURE

APPENDIX V

AGRICULTURE

Section 1. Proposed Agricultural Development Schedule

Adapted Type of Standard Farm

The essentials of the proposed standard farms are outlined hereunder:

The standard acreage of farming units are determined at 2 hectares for paddy-livestock mixed farming in lowland area and at 4.5 hectares for upland-livestock mixed farming in upland area. Such a small-scale farm units will be most adaptable for Asian farmers who have long experienced in a small-scale farming on narrow strip of land.

1.1 Standard farm on lowland with a paddy-livestock mixed farming unit

(1) Use of land

Among 2.0 hectares in total, 1.8 hectares will be used for cropping, 0.1 hectare for homestead and the remaining 0.1 hectare for grassland with forest around the premises.

(2) Adapted crops and cropping pattern

The adapted crops are selected out of the various tropical and subtropical crops and are cultivated as shown below.

Kind of crop	Cultivated area (ha)
1st paddy rice (in rainy season)	0.50
2nd paddy rice (in dry season)	0.50
Maize	0.30
Beans	0.30
Peanut	0.40
Pasture grass	0.50

Kind of crop	Cultivated area (ha)
Green manure	0.40
Kenaf	0.40
Tobacco	0.30
Fruits	0.10
Vegetables	0.10
Total (Accumulated area)	3.80
(Multi-cropping index)	2.10

The adequate cropping schedule is framed so as to harvest rice plant twice a year, common dry field crops once a year as the third crop after the harvest of rice plant, and most vegetables are yielded two or three times a year. Fruit trees are planted throughout the year as perennial crops.

(3) Livestock

The most fundamental object of livestock raising in this farming unit is the production of stable manure necessary for the maintenance and increase of the productivity of farmland as well as the production of livestock products for the increase of farming profit.

For such purpose, 2 milk cows, 1 swine, 11 fowls should be raised to get about 20 tons of stable manure which nearly correspond to the annual organic manure requirement of cropping field with area of 1.8 hectares per annum.

(4) Fertilization

According to the results of our soil survey, the lowland soils have rather high natural fertility in comparison with the soils in the basin. Even so, the application of proper quantity of chemical fertilizer is necessary in order to have the satisfactory returns by irrigation farming. In this case, the design value of chemical fertilizer requirement on lowland farm is estimated at about 30 kilograms per hectare of ammonium sulphate, and about 30 kilograms per hectare of calcium superphosphate.

1.2 Standard farm on upland with an upland-livestock mixed farming unit

(1) Use of land

Among 4.50 hectares in total, 4.20 hectares are used for cropping, including 1.50 hectares for rubber plant, while 0.15 hectare is used for homestead and the remaining 0.15 hectare is used for grassland with forest around the premises.

(2) Adapted crops and cropping pattern

Out of various tropical and sub-tropical crops, the adapted crops are selected out for the sustainable and profitable irrigation farming on the standard farm with an upland-livestock mixed farming system as follows.

Kind of crop	Cultivated area (ha)
1st paddy rice(in rainy season)	0.75
2nd paddy rice(in dry season)	0.75
Maize	0.40
Beans	0.65
Peanut	0.40
Pasture grass	0.75
Green manure	0.40
Kénaf	0.50
Tobacco	0.30
Sugar cane	0.10
Fruits	0.10
Vegetables	0.20
Rubber plant	1.50
Total	6.80
(Multi-cropping index)	(1.62)

As shown above, most crops selected for the upland farming unit are similar to those adopted for the lowland farming unit. In addition, sugar cane and rubber trees will be cultivated on upland.

Economic profit of rubber planting as compared with rice plant

The essential measures for the promotion of latex production are itemized as follows.

All the rubber budlings to be planted on farmer's field are given without cost from the Governmental nursery established in the experimental field of the Central Highland Agricultural Experiment Station at Eakmat in the vicinity of Ban Me Thuot.

Along with budlings, proper amount of chemical fertilizers needed for the settling up of budlings are also given to farmers free of charge by the Government.

Some special implements for tapping such as tapping knives, flat-bottomed buckets, cups, and spouts together with sufficient amount of anticoagulant are supplied also by the Government without compensation.

All latex products tapped by farmers are collected and transported by tank trucks to the Governmental rubber processing plant established at Ban Me Thuot.

The purchasing price of latex on farm is set at 100 US dollars per ton in reference to the lowest market price of raw rubber to be produced out of latex three times the weight of raw rubber. The lowest market price of raw rubber in Singapore is 400 US dollars per ton during these 10 years.

Under such a special patronage of the Government, the profit derived from the plantings of rubber trees is comparable with that of other crops for upland farmers in the project area as shown in the following table illustrating the net farm profit of rubber planting as compared with that of rice cropping.

As shown in the following table, the annual net profit derived from rubber planting is estimated at about 48 US dollars per hectare and is nearly comparable with the annual net profit derived from two crops of rice culture with estimated amount of about 43 US dollars per hectare.

Comparative estimation of net farm profits derived from rubber planting and rice culture on upland farm of 1 hectare under irrigation

Item	Yield (Ton/ha)	Unit price (US$/T)	Paddy rice (US$/ha)	Rubber tree (US$/ha)
Gross income				
Paddy (2 crops)	2.50 x 2	50.00	250.00	-
By-product (2 crops)	0.525 x 2	1.00	10.50	-
Latex	3.60	100.00	-	360.00
Total (gross income)			260.50	360.00
Gross outgo				
Cost for land preparation			-	-
Cost for seed			2.89	-
Cost for budling			-	-
Cost for fertilizer			20.00	(10.00)/1
Cost for agricultural chemicals			3.00	(2.00)/1
Cost for common farm implements			-	-
Cost for tapping implements			-	(10.00)/1
Cost for employed labor for weeding			-	20.00
Depreciation of farm implements			3.33	2.00
Depreciation of tapping implements			-	20.00
Depreciation of buildings			1.55	1.50
Cost for land improvement			0.25	0.30
Tax and public impost			2.22	1.50
Insurance			2.38	2.40
Farmer's living cost per hectare (cost for self-supplied labor)			94.95	52.50
Amortization of debt during period until completion of rubber farms			-	65.11/2
Annual depreciation of rubber trees			-	31.93/3
Water charge for irrigation			92.40	92.40
Total (gross outgo)			223.01	311.64
Balance (net profit per hectare)			+42.49	+48.36

/1, /2, /3: Refer to foot note on page A V-6.

Of the items of expenditure in the above table, cost for depreciation of tapping implements and for the amortization of initial investments for rubber planting can be eliminated from the balance sheet of rubber planting, because the land for planting and tapping and planting implements are given to farmers by the Government without cost and the land preparation are done by farmers self-supplied labors at the early stage of irrigation farming when the farmers have sufficient time to be used for this purpose.

Then the annual net profit derived from rubber planting is estimated at about 70 US dollars per hectare and is as large as about 1.7 times of the annual net profit per hectare derived from two crops of paddy rice.

As for the economic effect of irrigation on rubber planting, the latex yield of 2.40 tons per hectare (equivalent to about 0.8 ton of raw rubber) tapped from unirrigated rubber plant can be increased to 3.60 tons per hectare (equivalent to about 1.20 tons of raw rubber) by irrigation. The increase of annual net income due to irrigation is estimated at about 120 US dollars per hectare and is greater than the water charge of about 93 US dollars for irrigation.

Moreover, the growth of rubber budlings are considerably accelerated by irrigation so that the farmers are able to commence their tapping works in and after the 5th year of planting with irrigation while the commencement of tapping is expected in and after the 8th year of new planting without irrigation.

/1 Figure in parenthesis shows the cost subsidized by the Government.

/2 Total sum of annual debt from 1st to 6th year amounts to about 800 US dollars which is amortized during 20 years from 7th to 26th year at annual interest rate of 5%.

/3 Accumulated cost for land preparation, seed, budling, fertilizer, agricultural chemicals, farm implements, tapping implements, labor for weeding, depreciation of implements and buildings amounts to about 400 US dollars (including interest by annual rate of 5%) which is depreciated for 20 years of useful life of rubber trees from 7th to 26th year.

(3) Livestock

Livestock raising is an essential work on an improved irrigation farm not only to increase the farm income derived from stock products but also to elevate land productivity by applying sufficient stable manure on upland farm soils including very few humus less than 2 percent by weight in general.

Then, on an adapted standard farm on upland,3.0 cows,2.0 calves, 2.4 swine, 20.0 shoats, 21.0 fowls, 21.0 chickens are raised to get about 30 tons of stable manure which nearly correspond to annual organic manure requirement of cropping field.

(4) Fertilization

The propoper amount and adapted kind of fertilizers needed for harvesting the optimum amount of crop product is one of the most important matter to be clarified for profitable irrigation farm management in tropical region whore reliable data concerning this topic is scarcely obtainable except on some estate crops such as coffee, tea plant, sugar cane and some others.

Based upon our field experimental results on the pilot farm at Pleiku carried out in 1963, we estimated the design value of chemical fertilizer requirement on upland farm at about 50 kilograms per hectare of ammonium sulphate, and 30 kilograms per hectare of calcium superphosphate.

Section 2. Design Criteria for Fertilization

2.1 Design Criteria for Fertilization on Lowland soil

In the light of the experimental results on the pilot farm the naturally supplied amount of essential plant nutrients are measured as follows:

Natural supply of nutrients for optimum growth of rice plant with paddy yield of 3.5 tons per hectare

Kind of nutrient	Natural supplied amount(A) (kg/ha)
N	58
P_2O_5	16
K_2O	47

The total amount of nutrients included in rice plant with yield of 3.5 tons per hectare of unhulled rice is measured as follows:

Total essential nutrients included in rice plant with paddy yield of 3.5 tons per hectare

Kind of nutrient	Total amount included rice plant (B) (kg/ha)
N	71
P_2O_5	19
K_2O	48

Then, the amount of essential nutrients to be applied by fertilization for the production of 3.5 tons per hectare of unhulled rice is computed as follows:

Nutrients to be supplied by fertilization for optimum growth of paddy with yield of 3.5 tons per hectare

Kind of nutrient	Nutrient to be supplied (B-A = C) (kg/ha)
N	13
P_2O_5	3
K_2O	1

According to our study on soil humus in the project area, annual amount of organic manure to be supplied on irrigated cropping field soil is estimated at 10 tons per hectare for maintaining the humus content level at optimum.

Assuming the 10 tons of stable manure are applied on farmland, the nutrients included in the manure are estimated as follows:

Nutrients included in 10 tons of stable manure

Kind of nutrient	Content in stable manure(D) (%)	Amount of nutrients in 10 tons of stable manure (10,000 x D/100 = E) (kg)
N	0.4	40
P_2O_5	0.2	20
K_2O	0.3	30

As the rate of availability of nutrients in manure is relatively low, the amount of nutrients absorbed by crop is measured as follows:

Nutrients absorbed by crop from stable manure

Kind of nutrient	Rate of availability of nutrients by crop(F) (%)	Amount of nutrients absorbed by crop (ExF/100=G) (kg/ha)
N	25	10
P_2O_5	10	2
K_2O	30	9

Then, the amount of nutrients to be supplied by chemical fertilizers is as follows:

Kind of nutrient	Nutrients to be supplied by chemical fertilizer(C-G=H) (kg/ha)
N	3
P_2O_5	1
K_2O	-

Assuming that the above necessary nutrients are supplied by using ammonium sulphate including 20 per cent of nitrogen, and calcium superphosphate including 16 per cent of phosphoric anhydride, the chemical fertilizer requirement is estimated as follows:

Necessary amount of chemical fertilizer for the production of 3.5 tons per hectare of unhulled rice

Kind of nutrient	Amount of nutrient required(H) (kg/ha)	Rate of availability of chemical fertilizer(I) (%)	Content of nutrient in chemical fertilizer(J) (%)	Amount of chemical fertilizer required (H x 100/Ix100/J) $(NH_4)_2SO_4$ (kg/ha)	$CaH_4(PO_4)_2$ (kg/ha)	KCl (kg/ha)
N	3	50	20	30	0	0
P_2O_5	1	20	16	-	30	-
K_2O	-	60	48	-	-	-

Then, the proper fertilizer requirement for the production of 3.5 tons per hectare of unhulled rice on lowland soil is estimated at 30 kilograms of ammonium sulphate, 30 kilograms of calcium superphosphate per hectare per crop together with 10 tons of stable manure per hectare per annum, and these are able to be used as the design value of fertilizer requirement on lowland soil until more reliable data become available.

2.2. Design Criteria for Fertilization on upland Soil

Based upon our field experimental results on the pilot farm at Pleiku carried out in 1963, the proper amount of chemical fertilizers to be applied together with stable manures on upland field for the production of an expected amount of crop is estimated by means of the computation procedure similar to the method used for the estimation of fertilizer requirement on lowland field as summarized hereunder.

Natural supply of nutrients on upland for optimum growth of rice plant with paddy yield of 3.5 tons per hectare

Kind of nutrient	Naturally supplied amount(A) (kg/ha)
N	56
P_2O_5	16
K_2O	45

Total essential nutrients included in rice plant with paddy yield of 3.5 tons per hectare

Kind of nutrient	Total amount included rice plant (B)
N	71
P_2O_5	19
K_2O	48

Nutrients to be supplied by fertilization for optimum growth of paddy with yield of 3.5 tons per hectare

Kind of nutrient	Nutrient to be supplied(B-A=C) (kg/ha)
N	15 (71 - 56)
P_2O_5	3 (19 - 16)
K_2O	3 (48 - 45)

Nutrients included in 10 tons of stable manure to be used for base manure

Kind of nutrient	Rate of nutrient content in stable manure (D) (%)	Amount of nutrients in 10 tons of stable manure (10,000 x D/100 = E) (kg)
N	0.4	40
P_2O_5	0.2	20
K_2O	0.3	30

Nutrients absorbed by crop from stable manure

Kind of nutrient	Rate of availability of nutrients by crop (F) (%)	Amount of nutrients absorbed by crop (Ex F/100=G) (kg/ha)
N	25	10
P_2O_5	10	2
K_2O	30	9

Chemical fertilizer requirement for producing 3.5 tons per hectare of unhulled rice on upland

Kind of nutrient	Amount of nutrient required(H) (kg/ha)	Rate of availability of chemical fertilizer(I) (%)	Content rate of nutrient in chemical fertilizer(J) (%)	Amount of chemical fertilizer required(Hx100/Ix100/J)		
				$(NH_4)_2SO_4$ (kg/ha)	$CaH_4(PO_4)_2$ (kg/ha)	KCl (kg/ha)
N	5	50	20	50	-	-
P_2O_5	1	20	16	-	30	-
K_2O	-	60	48	-	-	-

Then, the proper fertilizer requirement for the production of 3.5 tons per hectare of unhulled rice on upland soil is estimated at 50 kilograms of ammonium sulphate, 30 kilograms of calcium superphosphate per hectare per crop together with 10 tons of stable manure per hectare per annum as base manure, and these figures can be used as the design value of fertilizer requirement on upland latosols until more reliable data become available.

Section 3. Water requirements

The water requirements are needed for determination of the adequate water supplies and for proper design of the canals and structures in planning the new irrigation projects.

Estimation of the water requirements can be made by the following procedures.

a) Computing the average consumptive use for each crop.

b) Adding the loss and waste of irrigation water during delivery and conveyance to the consumptive use of water.

The consumptive use of each crop varies mainly with influence of weather conditions. Based on the results of analysis of consumptive use and weather data for various kinds of crops grown in many countries of the world, the empirical curve is drawn as shown in Fig. 5.1. /1 This figure shows in the relation of the consumptive-use evaporation ratio to relative growth of crop and the stage of growth.

In general, the consumptive use of water is high as for rice-plant, so that we have determined the values of the normal consumptive use coeffici-

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/1 This figure is given at p. 257 in "Irrigation Principles and Practices" by Orson W. Israelsen and Vaughn E. Hansen.

ents for several crops to rice plant as shown in the following Table - 5.1.

Table - 5.1. Normal seasonal consumptive use coefficient for several irrigated crops in the Project area

Crops	Length of growing (average)	Consumptive use Coefficient K
Paddy rice	120 days	1.0
Sugar cane	360 days	1.0
Tobacco	150 days	0.7
Green manure	150 days	0.6
Kenaf	150 days	0.75
Maize	120 days	0.7
Beans	120 days	0.65
Pasture grass	Frost free	0.55
Peanut	120 days	0.7
Fruit	Perennial	0.55
Vegetable	Variable	0.55
Sweet potato	120 days	0.65
Rubber	Perennial	0.5

An adequate irrigation period for a given crop should be determined in consideration of the stage of crop growth, especially the harvest stage.

The growth of all plants can be divided into three stages, vegetative, flowering and fruiting. The relation of these stages of growth of the consumptive use of water is shown in Fig. -5.1. From this figure, it is easy to understand that the consumptive use during the vegetative stage continues to increase and the flowering occurs at around the peak of the consumptive use. The fruiting stage is accompanied by a decrease in the consumptive use, untill the transpiration ceases during the latter part of the formation of fruit.

Making reference to such relations of each stage of growth to the consumptive use and the concept embodied in Fig. -5.1, we have determined the adequacy of water irrigation period and the ratio of the seasonal consumptive use for several crops to evaporation as shown in Fig. -5.2.

Thus, the calculation process of the consumptive use of water in the

Fig. 5. 1 Courbe généralisée du rapport Quantités d'eau effectivement consommées-Evaporation à la croissance des plantes.
Generalized curve consumptive use-evaporation ratio to relative growth of crop

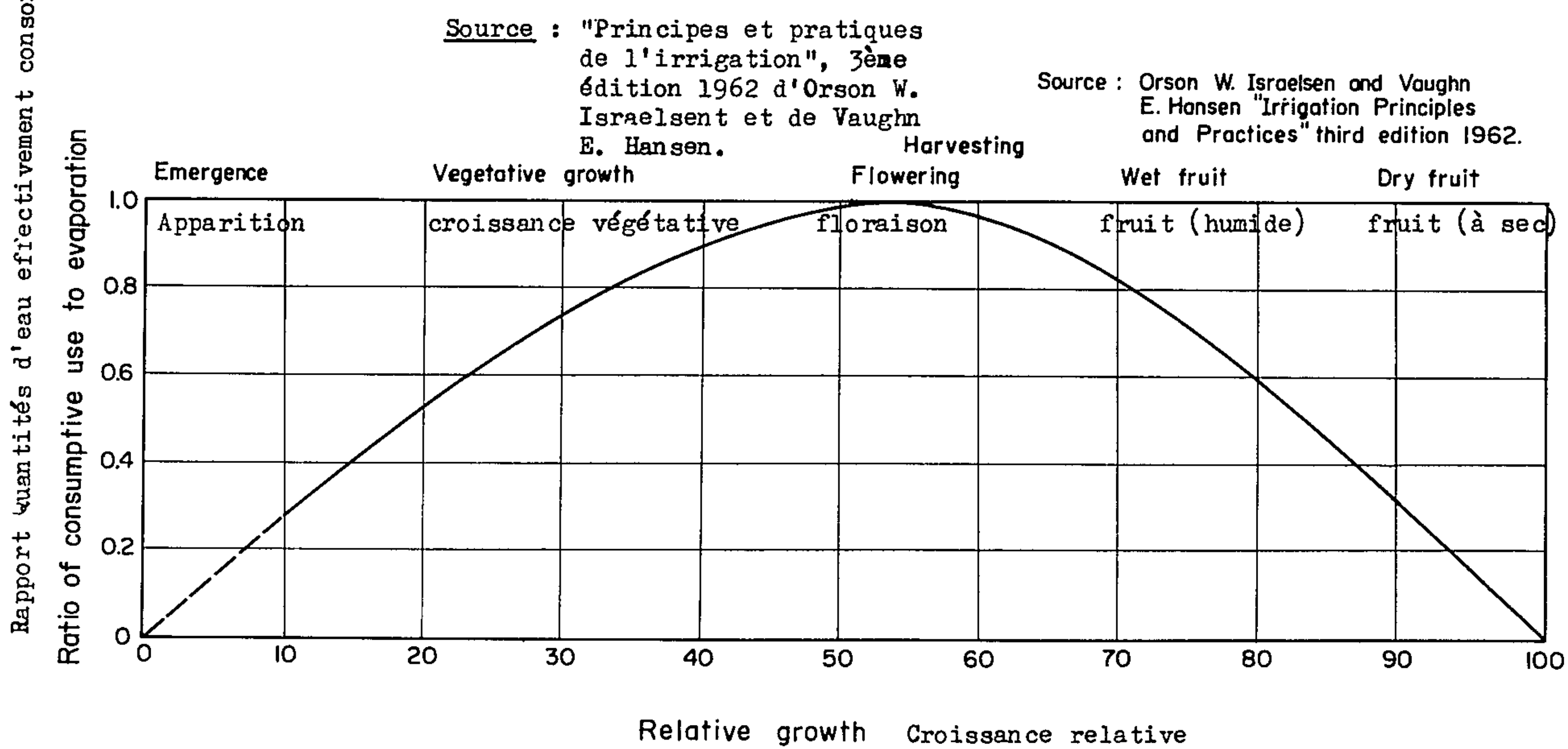

Fig. 5. 2

Seasonal variation of the ratio of consumptive use to evaporation

Crops harvested during the different stage of growth.

① Vegetative ; Vegetables, Pasture grass, Green manure

② Flowering ; Kenaf, Tobacco

③ Fruiting (Wet) ; Beans, Fruits,

④ Fruiting (Dry) ; Rice, Peanut, Maize

stage	Growning period						
	180	165	150	135	120	105	90
1	0.24	0.25	0.25	0.27	0.26	0.28	0.29
2	0.41	0.45	047	0.54	0.56	0.65	0.69
3	0.61	0.67	0.73	0.82	0.88	1.01	1.09
4	0.77	0.90	097	1.11	1.20	1.31	1.39
5	1.05	116	1.21	1.35	1.45	154	1.59
6	121	1.33	1.40	1.53	159	1.67	1.68 ①
7	1.40	1.50	1.55	163	1.68	169	160 ②
8	152	159	164	168	1.68	160	1.33 ③
9	1.62	1.66	1.69	1.69	1.59	1.30	0.96 ④
10	168	168	168	1.55	140	100	0.51
11	169	168	163	139	1.15	072	0.14
12	1.68	164	148	1.19	0.85	0.35	
13	1.62	1.47	1.30	1.03	0.48		
14	1.52	1.30	106	065	0.21		
15	1.38	1.21	0.79	039	0.02		
16	121	090	0.53	0.16			
17	099	0.67	0.27				
18	077	0.45	010				
19	053	0.20					
20	034	0.03					
21	0.16						
22	0.02						

①–④ Last season of irrigation

Table - 5.2 Calculation sheet of consumptive use of water

Farm Unit Upland livestock farming unit

Crop	Length of Growing	K	Irrigation Area (ha)	Irrigation Period																																			
				JAN			FEB.			MAR.			APR.			MAY			JUNE			JUL			AUG			SEP			OCT.			NOV.			DEC.		
Rice	120	1.00	0.75	1.260	1.260	1.192	1.050	0.863	0.638		0.195	0.420	0.660	0.900	1.087	1.192	1.260	1.260	1.192	1.050	0.863	0.638												0.195	0.420	0.660	0.900	1.087	1.192
Kenaf	150	0.75	0.50																	0.094	0.176	0.274	0.364	0.454	0.525	0.581	0.615	0.634	0.630	0.611									
Vegetables	90	0.55	0.10							0.016	0.038	0.060	0.076	0.087	0.092				0.016	0.036	0.060	0.076	0.087	0.092				0.016	0.038	0.060	0.076	0.087	0.092					0.016	0.038
Beans	120	0.65	0.65	0.710	0.710	0.672	0.592																														0.110	0.237	0.372
Peanut	120	0.70	0.40	0.470	0.470	0.445	0.392	0.322	0.238																						0.073	0.157	0.246	0.336	0.406	0.445	0.470	0.470	0.445
Maize	120	0.70	0.40	0.445	0.470	0.470	0.445	0.392	0.322	0.238			0.045	0.085	0.131	0.175	0.218	0.252	0.279	0.295	0.304																		
Tobacco	150	0.70	0.30																				0.063	0.099	0.153	0.204	0.254	0.294	0.326	0.344	0.355	0.353	0.342						0.015
Green manure	150	0.60	0.10	0.039	0.098	0.101				0.015	0.028	0.044	0.058	0.073	0.084	0.093	0.098	0.101																					
Pasture	120	0.55	0.75																0.107	0.231	0.363	0.494	0.597	0.655	0.692	0.692													
Furuit	360	0.55	0.10	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055
Sugar cane	360	1.00	0.10	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
Rubber plant	360	0.50	1.50	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
Total				3.883	3.913	3.785	3.384	2.482	2.103	1.174	1.166	1.429	1.744	1.050	2.299	2.365	2.481	2.518	2.499	2.613	2.671	2.387	2.006	2.205	2.275	2.382	1.774	1.849	1.899	1.920	1.409	1.502	1.585	1.436	1.731	2.010	2.385	2.715	2.967
f					0.919		0.632				0.299			0.404			0.584			0.406			0.524			0.510			0.450			0.357			0.411			0.640	
E					132		140				182			168			107			77			57			60			52			67			84			102	
U = Exf					121		88				54			68			62			31			30			31			23			24			35			65	

K Normal seasonal consumptive use coefficient

E Average monthly evaporation (mm)

f Ratio of consumptive use to evaporation

U Average monthly consumptive use of water per hectare proposed farm units of upland is shown in Table 5.2.

The over-all efficiency in irrigation combining the conveyance and irrigation efficiencies has been determined as follows after careful consideration of soil, climatic, hydrological and agricultural conditions.

	Upland
Conveyance efficiency	70%
Irrigation efficiency	55%
Over-all efficiency	38.5%

From Table 5.2, the maximum monthly water requirement will occur in January in upland. The detailes are as follows:

	Upland
Net water requirements	121mm
Effective rainfall	0mm
Over-all efficiency in irrigation	38.5%
Maximum monthly water requirement	341mm $1.17m^3$/sec/1,000 ha.

The maximum diversion requirement is calculated on the basis of the maximum monthly water requirement.

Section 4. Soils

Nearly all the area of the Darlac Plateau is covered with reddish brown latosols of basaltic origin, forming mostly level or undulating relief. Rather steep sloping areas are partially found only on the flanks and their transitional parts of V-shaped section where several streams flow at the bottom through this flat plateau.

In proportion to the degree of erosion and leaching, some soil varieties with different physical properties are found in the same soil series and classified into several soil types, namely the Eakmat soil types and Kotam soil type in the main, owing to the phases of land inclination and drainage condition. The Eakmat soil types occupy more than 90 per cent of the total proposed area and are regarded as the most important soil in this agricultural development project area. These soils may be further divided into several subdivisions in accordance with the land slope, but the soil of flat phase has superior properties as compared to others, especially on the physical viewpoint, and nearly all existing rubber and coffee plantations have been developed on these soils.

The steeper the slope of the soil surface is, the more accelerated the degree of eluviation of the sandy fraction of the surface soil is, and the worse the physical properties of the soil become. (Refer to the results of soil analyses given at the end of this section.)

Exploiting the area with the topography of a slope exceeding 10 per cent, careful management for soil improvement and run-off water disposal is a matter of paramount importance. Reddish brown latosol soils contain rather small quantity of plant nutrients as shown in the above-mentioned table; nevertheless their optimum physical properties and fairly high base exchange capacities are showing that these soils still have potentials of turning into rich agricultural soils by means of proper management.

In the reddish brown latosol soil zone, there exist locally some low concave areas into which run-off water from the surroundings habitually flows. The reddish brown latosol soils in these ill-drained areas are called Kotam soil. Some of these soils contain regurs in some degree. These soils may be utilized as good farming soils by means of providing appropriate drainage facilities.

At the skirts of slope, shallow latosol soils sometimes overlie the tuff base and the thickness of latosol is usually less than several decimeters. These soils are not suitable for crop cultivation, but may be utilized as agricultural forest soils or as grassland for the purpose of grazing.

Running parallel with National Road No. 14, there lies on the plateau a long and narrow strip of marshy depression on which hydromorphic gley alluvial soils are deposited, and very extensive paddy cultivation is now practiced on it.

Alluvial soils are deposited in the proximity of the confluence of streams, forming small-scaled damp area and being always subjected to the fear of inundation; they are called Anh soils and cannot be used for other than paddy cultivation.

Along the river courses of the southeastern part of the plateau, latosol soils with regurs are distributed over fairly large extent of the area; however, these soils have scarcely any agricultural value because of their unfavourable topography.

As mentioned above, of all kinds of soils on the proposed area, the one which becomes the object of agricultural development is mainly the reddish brown latosols of the level or undulating phase. The results of soil analyses are shown on the following tables, and the soil map of the proposed irrigation area is cited as in the Plate No.4.

Table- 5.3 Results of Soil Analysis [Reddish brown latosols]

	Relief	Level or undulating				Undulating				Rolling			
	Depth (cm)	0 - 8	8 - 20	20 - 40	40 - 60	0 - 5	5 - 15	15 - 50	50 - 100	0 - 12	12 - 30	30 - 60	60 - 100
	Colour	Very dusky red (2.5YR2/2)	Dark reddish brown (5YR3/3)	Dark reddish brown (5YR3/3)	Dark reddish brown (5YR3/4)	Dark reddish brown (2.5YR3/4)	Dark reddish brown (5YR3/4)	Dark reddish brown (5YR3/4)	Dark reddish brown (5YR 3/4)	Dark reddish brown (5YR3/3)	Dark reddish brown (2.5YR3/3)	Dark reddish brown (2.5YR 3/4)	Dark red (2.5YR 3/6)
	Texture	Light clay loam	Clay loam	Clay	Clay	Clay	Clay	Clay	Clay	Clay	Clay	Clay	Clay
	Structure	Weak medium granular	Weak coarse granular	Weak coarse subangular blocky	Weak coarse granular	Moderate medium granular	Moderate fine subangular blocky	Moderate fine subangular blocky	Moderate fine subangular blocky	Weak fine granular	Weak fine subangular blocky	Weak fine subangular blocky	Weak fine subangular blocky
Components	Sand (%)	43.5	33.5	21.5	7.5	17.5	15.5	13.5	9.5	9.5	7.5	7.5	7.5
	Silt (%)	26.0	28.0	30.0	28.0	32.0	26.0	26.0	22.0	32.0	14.0	18.0	20.0
	Clay (%)	30.5	38.5	48.5	64.5	50.5	58.5	60.5	68.5	58.5	78.5	74.5	72.5
	pH	5.0	4.9	5.5	5.0	4.8	4.8	4.5	4.8	5.3	4.7	4.9	5.0
	pC (milli mho)	52.0	40.0	31.0	21.0	85.0	32.0	44.0	21.0	56.0	32.0	20.0	23.0
	C (%)	4.32	3.36	3.24	1.56	3.72	3.24	2.24	1.44	4.04	1.72	1.44	1.20
	N (%)	0.20	0.20	0.13	0.08	0.21	0.15	0.09	0.07	0.22	0.08	0.08	0.08
	C/N	21	16	24	19	17	21	24	20	18	21	18	15
	P (%)	0.0014	0.0003	0.0003	0.0001	0.0018	0.0006	0.0006	0.0005	—	0.0002	0.0005	0.0005
	Cation exchange capacity (me/100g of soil)	14.9	12.8	11.60	6.50	15.00	14.50	12.50	8.80	16.0	10.4	8.5	7.4
	Exchangeable Ca (")	3.00	1.50	0.50	0.60	4.60	2.60	1.20	0.60	8.20	1.60	1.00	1.10
	" Mg (")	0.80	0.30	0.70	1.20	0.70	0.50	0.80	1.00	1.50	0.60	1.40	2.60
	" K (")	0.21	0.13	0.10	0.06	0.46	0.13	0.10	0.11	0.21	0.09	0.08	0.06
	" Na (")	0.10	0.10	0.10	0.10	—	—	—	—	0.14	0.10	0.10	0.10
	Total bases (")	4.11	2.03	1.40	1.96	5.90	3.36	2.18	1.77	10.05	2.39	2.58	3.86
	Base saturation (%)	27	15	12	30	39	23	17	20	63	23	30	52

Table – 5.4 Results of Soil Analysis for the Northeastern area of Ban Me Thuot

Sample No	Location	Layer	Depth in cm	Color	PH		y_1	Humus %	Exchangeable base						Soluble substances			Phosphate absorption	Specific gravity		Nitrogen mg/100g			Granulometric composition in percent					Remarks
					KCl	H_2O			CaO	MgO	K_2O	Na_2O	Capacity	Saturation degree	Available P_2O_5	MnO	Cl		Apparent	True	Total	NH_3	NO_3	Coarse sand	Fine sand	Silt	Clay	Textural class	
									mg/100g	mg/100g	mg/100g	mg/100g	m.e	%							N %								
1		I	10		43	53	50	38	7	10	4	2	84	12	0	650	00	1.300		2889	0.16	10	04	057	269	933	8742	HC	
2		I	20~30		44	49	25	44	7	5	5	3	91	10	1	67.5	00	1450		2965	0.17	0.8	2.3	0.97	14.99	4048	4356	LiC	
3		I	10~20		42	46	63	34	7	3	6	3	88	8	2	5.0	23	1.300		2.828	013	22	1.3	2.05	1066	2180	6549	HC	
4		I			4.9	53	1.0	37	98	45	28	3	101	64	1	1125	00	1210		2.754	018	03	26.9	2.84	1407	2122	6187	HC	
		II	20~30		36	46	138	39	98	45	4	3	132	46	14	12.5	00	970		2680	017	17	7.8	0.40	7.31	17.72	7457	HC	
5		I	10		44	54	25	1.0	98	65	52	1	128	62	2	181.3	00	1120		2.944	0.15	1.1	45	2004	754	14.15	5827	HC	
		II	35~45		40	52	13.8	15	28	50	9	1	122	30	1	1050	0.0	1210		3019	011	12	03	2403	411	6.85	6501	HC	
6		I	10		5.0	66	10	1.1	490	255	3	7	280	113	1	800	0.0	910		2.987	006	0.8	05	1991	27.96	1585	3628	LiC	
7		I	5~15		40	54	3.8	32	98	70	5	2	145	50	27	6.0	0.0	810		2823	015	2.4	3.5	488	1342	30.18	5152	HC	
		II	30~40		39	5.5	75	16	70	60	4	3	13.8	41	1	15	00	870		2.784	0.08	1.1	00	1.09	6.96	1756	7439	HC	
		III	50~60		45	58	10	10	119	90	4	4	135	67	3	1.0	0.0	1.090		3057	0.06	07	21	3319	1406	1003	4272	LiC	
8		I	10~20		48	49	10	23	7	5	3	1	54	13	0	148.5	00	1470		2.958	0.11	11	8.0	1.56	5695	2605	15.44	CL	
9		I	30~40		44	5.1	2.5	15	49	15	19	1	81	37	0	187.5	0.0	1.270		2.905	004	11	1.4	269	5.58	1064	8109	HC	
10		I	20~30		43	49	3.8	18	14	15	3	0	64	22	2	65.0	00	1120		2.858	013	0.7	18	0.13	567	1312	8108	HC	
11		I	20		42	47	75	65	21	5	5	0	128	9	3	1810	0.0	1.450		2.765	027	39	100	2.74	3476	38.89	2361	CL	
		II	30~40		46	49	10	25	7	5	2	0	68	10	1	900	0.0	1.370		2872	0.11	0.5	36	056	4966	3427	15.51	CL	
12		I	20~30		43	52	38	17	14	15	3	0	81	17	0	240	0.0	870		3016	0.09	04	10	2.47	446	11.18	8189	HC	
13		I	30~40		42	48	5.0	3.7	7	5	3	0	122	6	7	115.0	0.0	1.590		3.052	014	0.5	10	1.28	4120	3444	23.00	CL	
14		I	20		41	49	63	99	42	20	8	0	12.5	22	1	57.5	0.0	1.250		2.845	0.19	1.8	5.1	1.81	807	15.27	7485	HC	
		II			43	46	3.8	1.9	21	10	4	0	7.4	19	0	52.5	0.0	1150		2919	0.08	0.7	18.5	0.05	5.00	1318	81.77	HC	

Note LiC Light clay
HC . Heavy clay

APPENDIX VI

IRRIGATION PROJECT

APPENDIX VI

IRRIGATION PROJECT

Flood control and irrigation are important problems in the land where water resources are left undeveloped. If these problems are solved, diversified farming would become possible, and coupled with the introduction of techniques, crop production would increase. Furthermore, the seasonal inclination of crop production could be avoided, the possibility of two-crop a year would be realized by the implementation of irrigation projects, and natural impediments such as drought and floods could be eliminated.

Irrigation in the Upper Srepok basin has a close relation with flood control. This irrigation project area may be divided into two classes.

Class one enables irrigation farming during the dry season by reserving water during the wet season. In this case, it is necessary to be free from the danger of flooding.

The other class is one that will not only require storing of water for the dry season, but also necessitate large-scale flood control for the purpose of preventing inundation. The following projects in the Upper Srepok basin belongs to either one of these 2 classes.

Section 1. Upper Krong Buk

There is a suitable dam site at the confluence of the Ea Krong Buk with the Ea Aunchi, about 4.5 kilometers east of the point where the National Road No. 14 crosses Chu Leo Village. A 25-meter high dam will be built here with 70 million cubic meters of effective storage capacity. It would be possible to irrigate 6,500[/1] hectares of land throught 3 Main Canals.

/1 This project was originally contemplated to provide irrigation to 9,000 hectares by creating one each reservoir on the Ea Krong Buk and Ea Jung. But, for economical reasons, the Ea Jung reservoir was abandoned, and the irrigable area was lessened to 6,500 hectares. As a result, the catchment basin of the Lower Krong Buk would increase, and the irrigable area would increase from 3,500 hectares to 4,900 hectares.

The construction cost will be about 6,890,000 US dollars which correspond to 1,060 US dollars per hectare and benefit-cost ratio 1.72.

Section 2. Lower Krong Buk

Immediately upstream from the point where the Ea Krong Buk crosses the National Road No. 21, a 21-meter high dam is to be built with 46 million cubic meters of effective storage capacity to provide irrigation to 4,900/1 hectares of land. This region consists of rubber plantations, coffee plantations and a number of hamlets; therefore, if irrigation is provided, this region would share in various benefits. And the reservoir with a large storage capacity will also contribute much to the flood control for the downstream areas.

The construction cost is estimated at 5,500,000 US dollars which correspond to 1,123 US dollars per hectare. This is a little high, as no allocation of cost on the downstream projects was considered in the estimation. However, benefit-cost ratio will be 1.61/2 which makes the project economically justified.

Section 3. Krong Pach

The Ea Krong Pach is a tributary that originates in the part of the Annamite Mountains located in the upstream reaches of the Ea Krong Ana. It flows westward, turns southward, and joins the Ea Krong Ana. There is a suitable dam site, about 2 kilometers east of B. Rok Village where the catchment basin is estimated at about 490 square kilometers (River-bed El. 440 meters). If an earth dam (about 600,000 cubic meters in volume) is built here with 140 million cubic meters of effective storage capacity in-

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/1 Refer to /1 on page A VI - 1.

/2 Benefit-cost ratio was calculated on the assumption that annual maintenance and operation cost is 3 percent of the construction cost. The benefits were calculated at 122 US dollars per hectare at a moderate estimate. Hereinafter, benefit-cost ratios are calculated in the same manner.

cluding flood control space, irrigation may be effected to 5,300 hectares of highland and lowland below El 445 meters in the downstream reaches of the Ea Krong Pach.

The principal purpose of this reservoir is irrigation. But, at the same time, its large storage capacity could be serviceable for flood control in lessening the flood peak discharge for the downstream reaches.

The construction cost is estimated at 6,440,000 US dollars which correspond to 1,215 US dollars per hectare. This is rather a high figure, as no allocation of cost on the downstream projects was considered in the estimation. However, the benefit-cost ratio of 1.48 is sufficient to make this project feasible.

Section 4. Krong Ana Project

There is a suitable dam site on the Ea Krong Ana 4 kilometers downstream from the Kana gauging station. At this site, the reservoir with an effective storage capacity of about 250 million cubic meters will be created by constructing a rock-fill type dam.

By pumping up the reservoir water, about 33,000 hectares of land extending from the Krong Ana reservoir site towards Ban Me Thuot could be irrigated as explained below.

The storage area curve is as shown in Fig. 6.1.

4.1 West Ban Me Thuot and Southeast Valley

Pumping equipment shall be installed on a hill about 3 kilometers north of B. Ea Khit. The water shall be pumped up to El 451 meters, and led into a reservoir of 30 million cubic meters effective capacity at Ea Puor after being conducted for about 4 kilometers. The Ea Puor reservoir will be able to utilize the above mentioned water collectively together with its own runoff which flows in from the catchment basin amounting to 100 square kilometers. This water will bring under irrigation about 2,000 hectares of land, east of the reservoir (South-east Valley).

And, the reservoir water is led through a long tunnel of about 7 kilometers to the neighborhood of B. Tieu and irrigates about 25,400 hectares of gentle slope (West Ban Me Thuot area) by 2 trunk lines of canals, south and north, which spread up between there (less than El. 445 meters) and the Ea Krong.

Furthermore, by pumping up water through an inclined tunnel shaft, it is possible to irrigate about 6,600 hectares of highland below El. 490 meters (Ban Me Thuot Highland area).

The construction cost of the above 3 schemes is 37,016,000 US dollars which correspond to 1,089 US dollars per hectare, and benefit-cost ratio 1.42. A series of these schemes are considered to be economically feasible.

4.2 North Darlac Valley

There are two mountain ranges between the Darlac flats and the mountain mass south of Ban Me Thuot. Between these ranges, there are 2 valleys. One is West Ban Me Thuot area and the other (near Darlac) is North Darlac Valley.

The soil is relatively fertile. The water shall be pumped up immediately upstream from the Krong Ana dam to El 475 meters and by means of a canal about 9 kilometers long conducted through south of B. Krong into a farm pond, which is created at B. Kmarmu. The water then shall be conducted about 20 kilometers farther to irrigate about 4,500 hectares of elevated ground extending to the Ea Krong Ana.

The construction cost is roughly estimated at 5,585,000 US dollars, which correspond to 1,241 US dollars per hectare. Benefit-cost ratio is 1.27.

4.3 Municipal water supply

As Ban Me Thuot is located on an elevated ground, water supply is indispensable for its future expansion. This problem may be solved, if the water is pumped up from the irrigation canal to a height required for sufficient water pressure. The quantity of city water required for 50,000 city-dwellers is estimated to be approximately 4 million cubic meters per year, on the assumption that a dweller consumes 200 liters per day. The cost of water is estimated at about 2.5 US cents per cubic meter.

Section 5. Darlac

The irrigation area may be divided into 6 sub-areas according to terrain and location. For 3 sub-areas out of 6, pumping irrigation is deemed suitable in view of their terrain.

In the report/1 compiled in 1963, it was stated that the sections suitable for pumping irrigation were 5 out of 6. However, 2 sub-areas near the Ea Krong Kno can get irrigation water by gravity flow from the Lower Krong Kno reservoir; consequently, the number of sub-areas which require pumping irrigation turns out to be 3.

While supply of cheap power is desirable for pumping irrigation, the Lower Krong Kno project could be depended for supply of power.

6 sub-areas are divided as follows.

A - sub-area: 1,500 hectares. The area includes existing paddy fields around the Darlac Lake. (pumping)

B - sub-area: 1,000 hectares. The elevated flat land where gravity flow intake is possible from the Da P'Heui and the Ea Lien, the tributaries of the Ea Krong Ana.

C - sub-area: 2,400 hectares. The area in the middle part of the Darlac Basin (pumping)

D - sub-area: 1,600 hectares. The area located in the middle part of the Darlac Basin on the left bank near the downstream reaches. (gravity flow intake)/2

E - sub-area: 1,000 hectares. The area located in the middle part of the Darlac Basin on the right bank of the Ea Krong Ana near the downstream reaches. (pumping)

/1 The Feasibility report on the Darlac Irrigation Project was submitted to the Mekong Committee in December 1963.

/2 Refer to foot note on page A VI - 6.

r - sub-area: 500 hectares. The area located on the left bank of the Ea Krong Kno (gravity flow intake)/1

Total 8,000 hectares

The abovementioned C-sub-area which is easy to be brought under reclamation is located in the middle part of the Darlac Basin and the soil is fertile.

Previously, about 500 farming households were engaged there in rain-fed culture of paddy etc., and suffered from flood damage in the rainy season.

In order to relieve them from the difficult position, we recommended to reclaim 1,000 hectares of the relatively elevated ground. But, the greater part of the 500 farming households moved away. So, a great portion of our purpose has now become extinct automatically.

Therefore, we think it advisable to execute the irrigation scheme for this area as a part of the whole Darlac project after creation of flood control reservoirs.

The construction cost for the whole area is roughly estimated at 7,800,000 US dollars which correspond to 975 US dollars per hectare.

Section 6. Krong Kno

If a reservoir of 500 million cubic meters storage capacity is created on the Upper Krong Kno for the purpose of power generating and flood control, inundation over the banks would be thoroughly controlled, and about 3,000 hectares of farmland would be brought under irrigation.

The construction cost will be 3,410,000 US dollars which correspond to 1,136 US dollars per hectare.

/1 D-sub-area and F-sub-area will be irrigated by gravity flow intake from the Lower Krong Kno reservoir.

As the great part of the construction cost of the related reservoir is to be allocated on power generation, the construction cost for irrigation will prove to be comparatively low. Benefit-cost ratio is approximately 1.59.

Section 7. Ea Gan

The Ea Gan flows in parallel to the National Road No. 14 on the left bank of the Ea Krong, at a distance of 4 kilometers from the National Road No. 14. There is a suitable dam site in the middle course of the Ea Gan. Basin area covers about 190 square kilometers. A reservoir will be created here with 45 million cubic meters of storage capacity. With this, about 4,000 hectares of gentle slope (below El. 337 meters) could be brought under irrigation.

The construction cost is estimated at about 3,900,000 US dollars which correspond to 975 US dollars per hectare. Benefit-cost ratio is 1.85. This is, however, no more than a rough estimate, because thorough-goint investigations have not been conducted. Conclusion should be derived after detailed investigations were conducted.

Section 8. Ban Don 1,2

8.1 Ban Don 1

Water will be pumped up by about 15 meters in height in the vicinity of Buon N'Dreck located 10 kilometers upstream from Ban Don. In this way, about 3,600 hectares of land (below El 180 meters), along the left bank of the Ea Krong could be brought under irrigation.

8.2 Ban Don 2

Water will be pumped up by about 15 meters in height in the vicinity of Ban Drang Phok located about 10 kilometers downstream from Ban Don. Thus, about 1,700 hectares of relatively gentle slope along the right bank could be brought under irrigation.

The construction cost is roughly estimated at 3,823,000 US dollars which correspond to 1,062 US dollars per hectare for the former, at 1,947,000 US dollars which correspond to 1,145 US dollars for the latter.

Concerning this region, investigation is not complete. It requires further, detailed investigations.

Section 9. Eak Mat pilot farm

In April 1966 a design report entitled 'Eak Mat irrigation project' is to be submitted to the Government of Viet-Nam from Nippon Koei Co., Ltd. As will be stated in this report too, this scheme of building a pilot farm must be conceived as a link in the chain of the Upper Srepok Irrigation Project with a view to bringing about successful realization of irrigation projects as mentioned above.

The objectives of this scheme are as follows:

1) To demonstrate the practical management of the most adapted irrigation farm as the model necessary for the rapid improvement of customary farming system and practice.
2) To examine the adaptability and profitability of irrigation method, farm implements, machinery, agricultural chemicals, fertilizers, species and varieties of crops for the evaluation of basic factors indispensable for the satisfactory design and planning of the Upper Srepok irrigation project.
3) To train technicians and leading farmers needed for the successful management of the pilot farm and extension of the latest scientific irrigation farming methods and to furnish technics to all the farmers in the Upper Srepok Project area.

The Eak Mat pilot irrigation project consists of establishing an experimental farm of about 16.4 hectares within the existing Eak Mat Agricultural Experiment Station, located between the Ea Pak stream in the north and the Ea Chur Kap stream in the east, for determining the crop and cropping patterns best suited to the soil and climatic conditions, as well as the water application method best adapted to the region; and a demonstration farm of about 195 hectares, located east of the western part of the

Ea Chur Kap stream and along the same stream for demonstrating the technics thus clarified.

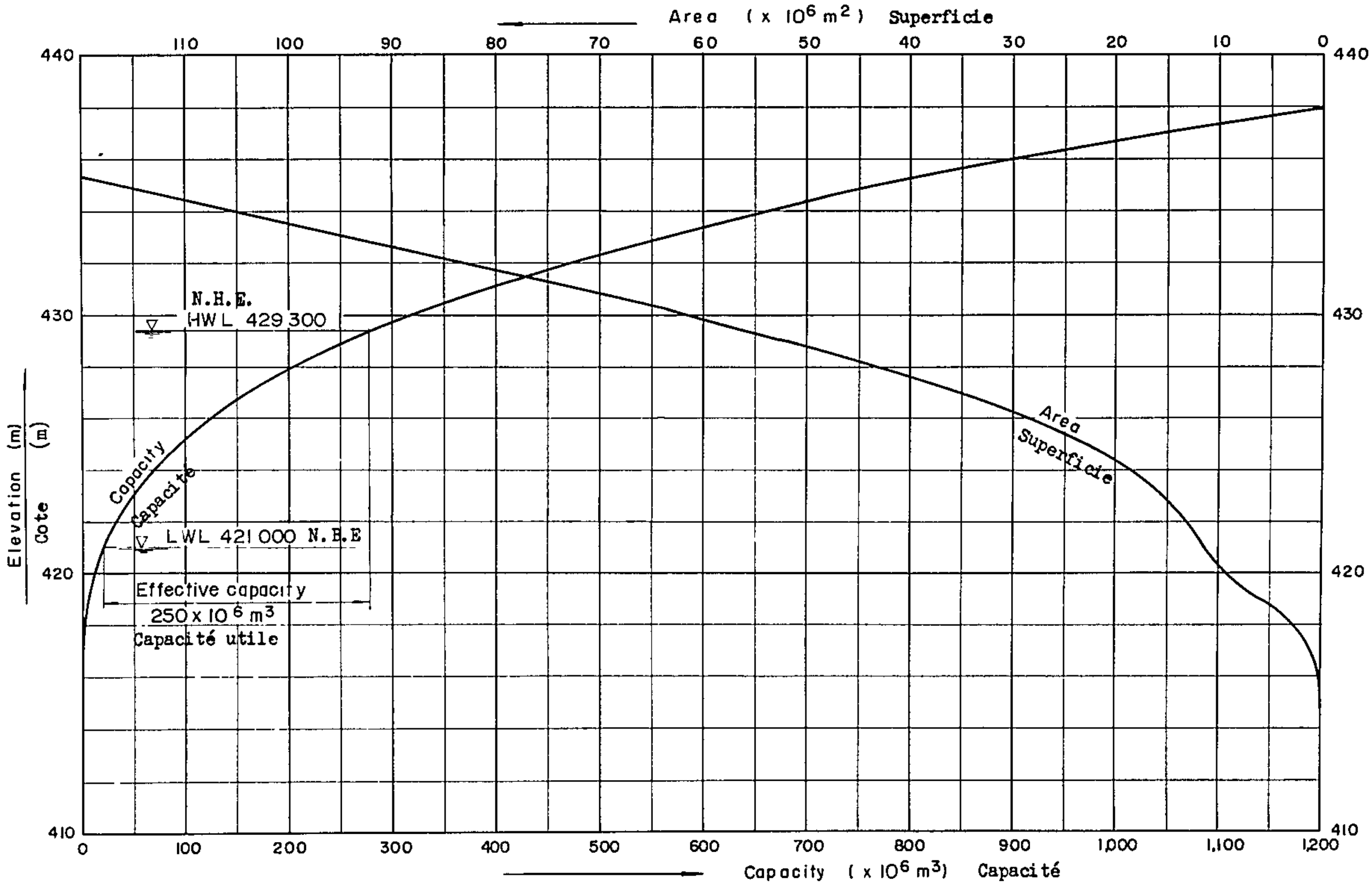
In this pilot irrigation project, a reservoir with an effective storage capacity of 1,000,000 cubic meters will be created by constructing one earth dam on the Ea Chur Kap stream with a drainage area of 11 square kilometers at the proposed dam site.

In the demonstration farm scheme, the irrigation water with a maximum discharge of 400 liters per second will be diverted into the farmland through the outlet structure. The main canal of about 3.6 kilometers in length consisting of two concrete pipe culverts with corrugated steel lining, one regulating pond, one farm pond, one block lined open canal and one rigid polyvinyl chloride pipe will lead the water into the main lateral concrete pipelines of about 25 kilometers long and the rigid polyvinyl chloride pipeline of about 6.3 kilometers long in total.

The maximum amount of about 60 liters of water per second will be diverted into the farmland of the experimental farm scheme from the main canal discharging into the demonstration farm by installing a turnout at a point about 1,550 meters downstream from the outlet structure. For conveyance of irrigation water through the polyvinyl chloride pipe of about 3.8 kilometers to the irrigation field, the water will be led to the farm pond with a capacity of 50 cubic meters, then, it will be delivered to each plot through concrete pipe laterals and risers.

The construction cost is estimated at 1,283,000 US dollars of which 800,000 US dollars is required in foreign exchange and the remaining 483,000 US dollars in local currency.

Fig. 6.1 RESERVOIR DU KRONG ANA
KRONG ANA RESERVOIR



APPENDIX VII

HYDROELECTRIC DEVELOPMENT PLAN

APPENDIX VII

HYDROELECTRIC DEVELOPMENT PLAN

Section 1. Outline of Hydroelectric Development Plan

The Upper Srepok is one of the tributaries of the Mekong and originates in the Annamite mountains at an elevation of about 1,500 meters. The lower reaches are called as Ea Krong and its upper reaches are consisted of two main tributaries called as Ea Krong Ana and Ea Krong Kno. The Ea Krong Ana and Ea Krong Kno join at the opening of Darlac marshy area forming the Ea Krong, which flows through Ban Dray Falls and Drayling Falls before joining with the Mekong.

The Upper Srepok in the territory of Viet-Nam covers a drainage area of about 17,800 square kilometers with the total length of approximately 250 kilometers.

The water resources development plan of the Upper Srepok may be divided broadly into two categories, one for water utilization of the Ea Krong Ana for irrigation use, and the other for water utilization of the Ea Krong Kno and the Ea Krong for hydroelectric power generation. As for hydroelectric project, it is purely in the stage of an on-the-chart project, outline of which is described below.

There is neither a stream-flow gauging station nor a meteorological station along the Ea Krong Kno. But, assuming the rate of discharge for that of the Ea Krong Ana and the Ea Krong, the annual mean discharge of the Ea Krong Kno in the droughtiest year during the last 10 years in approximately 55 cubic meters per second. And the annual mean discharge of the Ea Krong Ana measured in three years is approximately 62 cubic meters per second, which, however, should be estimated to be 42 cubic meters per second in reality, because 20 cubic meters per second will be deducted for irrigation water in future.

The Ea Krong Kno river basin is still left undeveloped. However, there is a favorable dam site along the Upper Krong Kno, 2 kilometers above Ban Ton Srah. The basin area at this site is 2,965 square kilometers, and the annual mean discharge is estimated to be approximately 60 cubic meters per second in the droughtiest year during the last 10 years. By regulating this flow of water 40,000 kilowatts of electric power may be generated.

A dam called Lower Krong Kno dam will be constructed at the narrow gorge just upstream from the Darlac marshy area. The water regulated by the Upper Krong Kno reservoir can be intaken at the Lower Krong Kno dam for the irrigation of about 2,000 hectares of the Darlac area. At the same time, the river flow of the Ea Krong Kno can be diverted toward Dak Mam river. By this diversion, two power stations may be built with a head of 70 meters obtainable between Dak Mam and the downstream reaches of Ban Dray falls; whereby to generate 73,000 kilowatts of electric power in total.

It may be also feasible to construct six power stations in the downstream reaches of the Ea Krong down to Ban Don, harnessing the total head of 150 meters, whereby to generate total 283,000 kilowatts of power and 1,473 million kilowatt-hours of energy per year.

The construction cost required for the above whole development plan is roughly estimated at 145,200,000 US dollars including power transmission line and substation facilities. The construction cost per kilowatt-hour will be 10 US cents, power rate will be around 8 mill per kilowatt-hour.

Power on the Darlac Plateau is demanded for general consumption in and around Ban Me Thuot city and pumping stations for irrigating purposes. Ban Me Thuot, populated of 40,000 is the center of highland agricultural development. At present, there are a diesel power station of 480 kilowatt output capacity in the city and two hydro-power stations of a total 590 kilowatt capacity at Drayling and Eanao. But this power supply is so extremely short that the Government of Viet-Nam has planned to increase the generating capacity of the Drayling power station to 4,000 kilowatts by 1967. Although there is no record of power demand in the past on the Darlac plateau, the Bureau of Electricity Supply of the Government of Viet-Nam estimates in its report the general demand to increase to 2,500 kilowatt by 1967, and the increasing rate after 1968 to be 12% a year. According to the agricultural development plan disclosed in this report, the total power demand will reach to about 10,000 kilowatts by 1975, about

20,000 kilowatts by 1980, and 50,000 kilowatts by 1988 which is the year of final completion of the agricultural development plan.

Power demands in Ban Me Thuot area are shown in detail in Table 7.1.

As to the hydroelectric development of the Upper Srepok, it is desirable, in view of its development scale, that the first stage development at Drayling be 8,000 kilowatts and that the second stage development at Dak Mam be 20,000 kilowatts at its initial stage. The third stage development will be consisted of the Lower Krong Kno, the Upper Krong Kno, the Dak Mam (second stage) and Drayling Falls (second stage), the total installed capacity of which will be 105,000 kilowatts.

And the development of the remaining hydro-electric potential of 150,000 kilowatts may belong to the fourth stage. It is, however, desirable, that the third and fourth stage development shall be left as the far future problem when they are needed, because the large scale project of Sambor would be realized by the time and power in low cost might be supplied by the Sambor project.

1.1 Upper Krong Kno Project

There is a favorable dam site about 2 kilometers upstream from Ban Ton Srah, at El 425 meters. This dam site has 2,965 square kilometers of catchment area and the mean run-off of 15.4 cubic meters per second during the dry season from January to June. By building here 75 meters high rock-fill dam with about 4,500,000 cubic meters in dam volume and creating a reservoir of 1,200 million cubic meters in gross storage capacity and 900 million cubic meters in effective storage capacity, it is possible to regulate flood flow and generate the power of 40,000 kilowatts. The annual energy output will amount to 212 million kilowatt-hours. The construction cost would be 32,100,000 US dollars including the allocated cost of transmission line and substation and then the construction cost per kilowatt-hour will be 15.1 U.S. cents.

Although this cost is not so cheap, this reservoir will play an important role for increasing the energy output of the down-stream power stations by regulating the flood flow and increasing the river discharge in the dry season covering from January to July.

The energy output of the down-stream power stations to be increased by the Upper Krong Kno reservoir will be 274 million kilowatt-hour per year as shown below:

Effective head available between Dak Mam and the dam site is 203.0 meters.

Annual mean discharge during dry-season (Jan. to July) is 27.0 m^3/sec.

Increased droughty water-discharge 60.0 m^3/sec - 27.0 m^3/sec = 33.0 m^3/sec

Generated energy

$$9.8 \times 33.0 \times 203.0 \times 0.82 = 53{,}800 \text{ kw}$$

$$53{,}800 \text{ kw} \times 8{,}760 \text{ h} \times \frac{7}{12} = 274{,}000{,}000 \text{ kwh}$$

As shown in Table 7.2, the average construction cost per kilowatt-hour including the increased energy output of the downstream power stations will become about 10 US cents, power rate around 8 mill which is quite reasonable.

1.2 Lower Krong Kno Project

The proposed dam site of Lower Krong Kno locates about 11 kilometers upstream from the confluence of the Ea Krong Kno and Ea Krong Ana and has an elevation of 412 meters from the sea level. The catchment area of this dam site is 3,858 square kilometers which drains about 72 cubic meters per second of annual mean run-off.

When a 15 meters high rockfill dam is constructed here and an open diversion channel is constructed by cutting the saddle of low ridges on the left bank of Dak Dro stream, the river flow of Krong Kno can be diverted to Dak Mam river. Thus, about 2,000 hectares of arable land can be prevented from flooding out of 7,500 hectares of Darlac marshy area.

Also a head of about 25 meters thus created between this reservoir and Dak Mam reservoir can be harnessed into power generation of 20,000 kilowatts. This Lower Krong Kno power station will be able to generate about 100 million kilowatt-hours of annual energy under the total construction cost of 7,400,000/1 U.S.dollars excluding the construction cost of the flood diversion channel which shall be estimated in the Darlác project.

/1 The cost includes the allocated cost of transmission line and substations.

The construction cost per kilowatt-hour, therefore, will be 7.4 U.S. cents, which is deemed to be cheap cost.

The total dam volume is estimated to be only 24,000 cubic meters in a rockfill type.

1.3 Dak Mam project

By diversion of the river water of Krong Kno, 72.0 cubic meters per second of annual mean discharge flows into the Dak Mam river. The residual of irrigation water in the Ea Krong Ana, 30 cubic meters per second at maximum (annual mean discharge being 25.0 cubic meters per second), is intaken from above Ban Dray falls through a circular, non-pressure concrete pipe about 7.5 kilometers in its length. Therefore, 36 cubic meters per second (at the first stage) and 89 cubic meters per second (at the second stage) of inflow discharge can be utilized for firm power generation at this site.

There is a favorable reservoir site on the Dak Mam at about 390 meters above sea level. By constructing an earth dam, about 20 meters high and about 310,000 cubic meters in dam volume, and a concrete overflow weir on the tributary Dak Gong, about 20 meters high and about 30,000 cubic meters in volume, 20,000 kilowatts of power and 113 million kilowatt-hours of annual energy (at first stage) and 33,000 kilowatts of output and 166 million kilowatt-hours of annual energy (at second stage), can be generated harnessing about 47 meters of the maximum head between this reservoir and Buon Kuop reservoir. The saddle of about 390 meters in elevation of the mountain mass of the left bank of the Dak Louk may provide the best site for intake structure. The tail water will be drained into the Buon Kuop reservoir, downstream through the tail race 1.2 kilometers long. The construction cost required for this project is 11,000,000 U.S. dollars at the first stage and 7,300,000 U.S. dollars at the second stage. Power construction cost is calculated at the rate of 9.8 U.S. cents per kilowatt-hour at the first stage, and 4.4 cents at the second stage, making an average of 6.6 cents. In view of the scale of power demand on the Darlac Plateau, this project has the possibility of early development.

1.4 Buon Kuop project

It is a thinkable project to build a concrete dam 39 meters high and about 120,000 cubic meters in concrete volume, on the Ea Krong about 6 kilometers upstream from the National Road No.14 bridge which connects Saigon with Ban Me Thuot. This project site covers 8,520 square kilometers of catchment area, and can utilize 90.8 cubic meters of firm discharge after deducting the required irrigation water. By harnessing a water head of 23.5 meters, a dam-type power house could generate 28,000 kilowatts of maximum output and 149 million kilowatt-hours of annual energy. The tale water is drained into the "D" reservoir. The construction cost required for this development is 12,200,000 US dollars and power cost is calculated at the rate of 8.2 US cents per kilowatt-hour.

1.5 Dam Site "D" project

This project is to build an approximately 31 meter high concrete dam (130,000 cubic meters in volume) in the vicinity of National Road No.14 and to generate by a dam-type power station 20,000 kilowatts of output and 102 million kilowatt-hours of annual energy. The construction cost at the power house is 11,200,000 US dollars, and power cost is calculated at the rate of 11.0 US cents per kilowatt-hour.

1-6 Drayling project

About 9.5 kilometers downstream from Dam Site "D", there are 13 meter high Drayling Falls. At present, below these falls, a hydroelectric power station of 500 kilowatts in installed capacity is being operated. But, owing to power shortage in Ban Me Thuot City, the Government of Viet-Nam is planning a reinforcement of 8,000 kilowatts in installed capacity at the first stage. This project site has 8,800 square kilometers of catchment area and could utilize 38 cubic meters per second of firm discharge at the first stage.

The Drayling project contemplated is to build a 3.5 meter high overflow weir in the upstream reaches of Drayling Falls at the first stage and widen the existing head race channel on the right bank. New power house, equipped with a 8,000 kilowatt generator, will be constructed just adjacent with the existing one and will generate 43 million kilowatt-hours of annual energy.

In the second stage when the run-off in the dry season is much increased by the water regulation of the Upper Krong Kno reservoir, another generator of 12,000 kilowatts shall be installed in the additional power house to be newly built on the left bank. Thus a total of 20,000 kilowatts of output and 102 million kilowatt-hours of annual generated energy can be obtained. Construction cost at the first stage is 4,500,000 US dollars and 5,000,000 US dollars at the second stage. Construction cost will be 10.5 US cents per kilowatt-hour at the first stage, and 8.5 cents at the second stage, making an average of 9.3 cents per kilowatt-hour.

1.7 Dam Site "C" project

There is a suitable dam site named "C" site about 9 kilometers downstream from Drayling falls. A concrete gravity dam may be constructed about 42 meters in its height and about 300,000 cubic meters in dam volume so as to generate 39,000 kilowatts of output and 203 million kilowatt-hours of annual energy. Construction cost is estimated at 20,300,000 US dollars which corresponds to 10.0 US cents per kilowatt-hour.

1.8 Dam Site "B" project

It is possible to build an approximately 40 meter high concrete dam (270,000 cubic meters in body volume), about 6 kilometers downstream from Dam Site "C", so as to generate 37,000 kilowatts of output and 192 million kilowatt-hours of annual energy. Construction cost may be 18,900,000 US dollars which is equal to 9.9 US cents per kilowatt-hour.

1.9 Dam Site "A" project

It is possible to build an approximately 32 meter high earth dam (2 million cubic meters in its volume), about 5 kilometers downstream from Dam Site "B", so as to generate under dam type 26,000 kilowatts of output and 134 million kilowatt-hours of annual energy. Construction cost is estimated to be about 15,300,000 US dollars which corresponds to 11.4 US cents per kilowatt-hour.

Section 2. Order of Development

Field investigation has not been conducted about hydroelectric projects, and it requires detailed investigations in the future. But as the first stage development, 8,000-kilowatt development of Drayling project is proposed as the first priority, in view of the estimates of power demand and the scale of development. As there is an existing power station already, the development of the Drayling project is very easy. As the second priority, the first stage development of 20,000 kilowatts of the Dak Mam project is desirable.

As the third stage development, the development of the Upper Krong Kno, the Lower Krong Kno, the Dak Mam and the second stage of the Drayling project are recommended. However, anticipating that the time of this third stage development falls on 1980's when the Sambor project on the main Mekong might be realized, the order of development of final stage hydroelectric projects including the Lower Ea Krong shall be duely reviewed again based on more detailed investigation and study.

Power demand of Banmethuot area

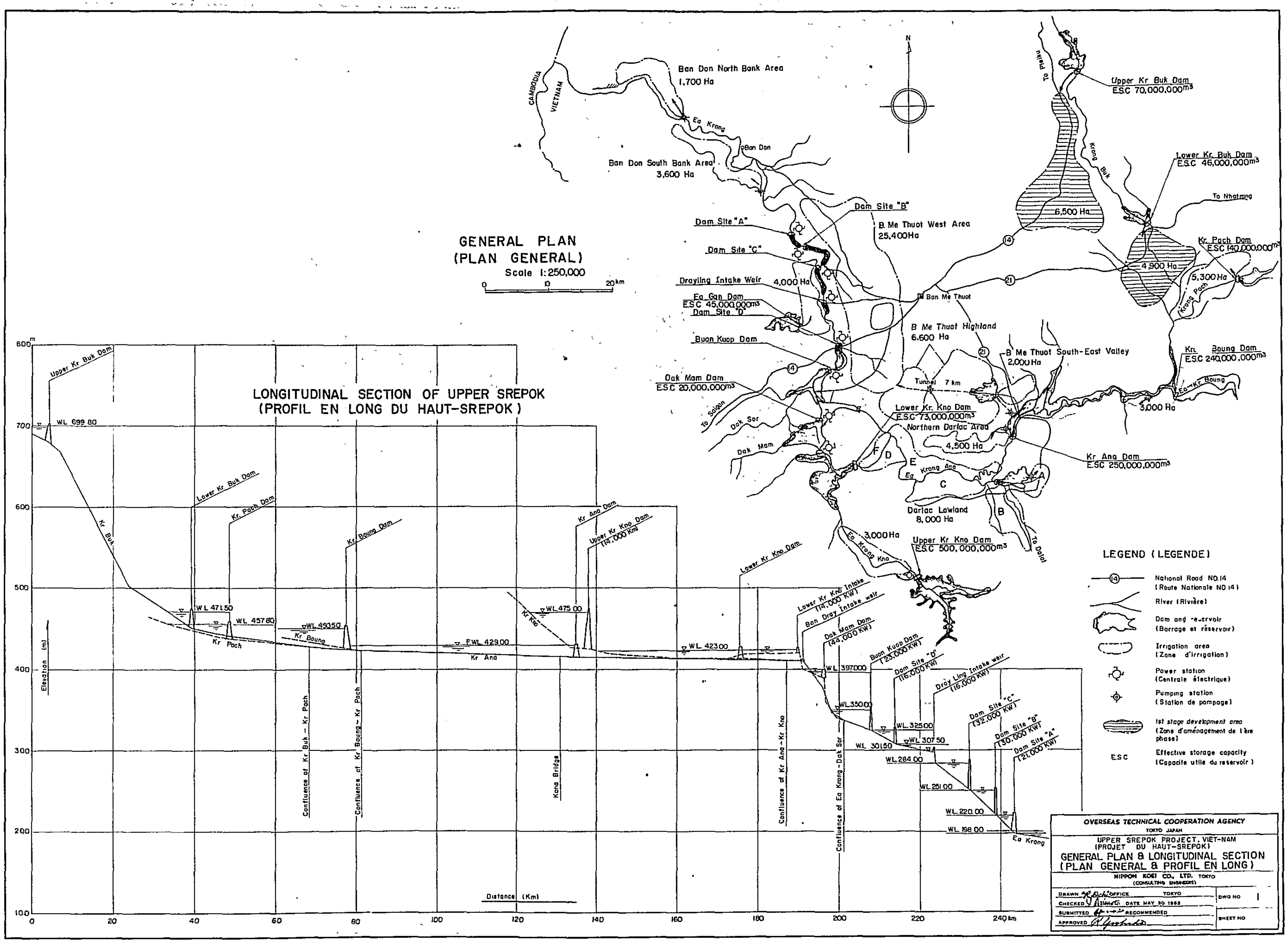
Table 7.1

	Year	General demand Energy (Mwh)	General demand Peak power (kW)	Rate of increase	Irrigation demand Energy (Mwh)	Irrigation demand Peak power (kW)	Total demand Energy (Mwh)	Total demand Peak power (kW)	Schedule installation
1	1967	10,500	2,500	28 %			10,500	2,500	4,000KW Dray Ling PS 1st Unit
2	1968	14,800	2,800	12			14,800	2,800	
3	1969	16,500	3,140	12			16,500	3,140	
4	1970	18,400	3,510	12			18,400	3,510	
5	1971	20,600	3,930	12			20,600	3,930	4,000KW Dray Link PS 2nd Unit
6	1972	23,100	4,400	12	1,700	1,053	24,800	5,453	
7	1973	25,900	4,930	12	3,400	2,106	29,300	7,036	
8	1974	29,000	5,520	12	5,100	3,159	34,100	8,679	10,000KW Dak Mam PS. 1st Unit
9	1975	32,500	6,190	12	6,800	4,212	39,300	10,402	
10	1976	36,300	6,930	12	8,500	5,265	44,800	12,195	
11	1977	40,900	7,780	12	10,200	6,318	51,100	14,098	
12	1978	45,700	8,700	12	11,900	7,371	57,600	16,071	10,000KW Dak Mam PS. 2nd Unit
13	1979	51,200	9,750	12	13,600	8,424	64,800	18,174	
14	1980	57,200	10,900	12	15,300	9,477	72,500	20,377	
15	1981	64,000	12,200	12	17,000	10,533	81,000	22,733	
16	1982	72,000	13,700	12	23,370	13,108	95,370	26,808	20,000KW Upper Kr. Kno PS. 1st Unit
17	1983	80,600	15,350	12	29,750	15,673	110,350	31,023	
18	1984	90,300	17,200	12	35,750	18,010	126,050	35,210	
19	1985	101,000	19,250	12	37,640	19,304	138,640	38,554	
20	1986	113,000	21,600	12	39,530	20,597	152,530	42,197	
21	1987	127,000	24,200	12	41,420	21,891	168,420	46,091	20,000KW Upper Kr. Kno PS.
22	1988	139,000	26,600	10	43,350	23,185	182,350	49,785	
23	1989	153,000	29,200	10	43,350	23,185	196,350	52,385	
24	1990	169,000	32,200	10	43,350	23,185	212,350	55,385	
25	1991	186,000	35,400	10	43,350	23,185	229,350	58,585	
26	1992	204,000	38,900	10	43,350	23,185	247,350	62,085	
27	1993	224,000	42,800	10	43,350	23,185	267,350	65,985	
28	1994	247,000	47,000	10	43,350	23,185	290,350	70,185	
29	1995	271,000	51,700	10	43,350	23,185	314,350	74,885	20,000KW Lower Kr. Kno PS.
30	1996	300,000	57,000	10	43,350	23,185	343,350	80,185	

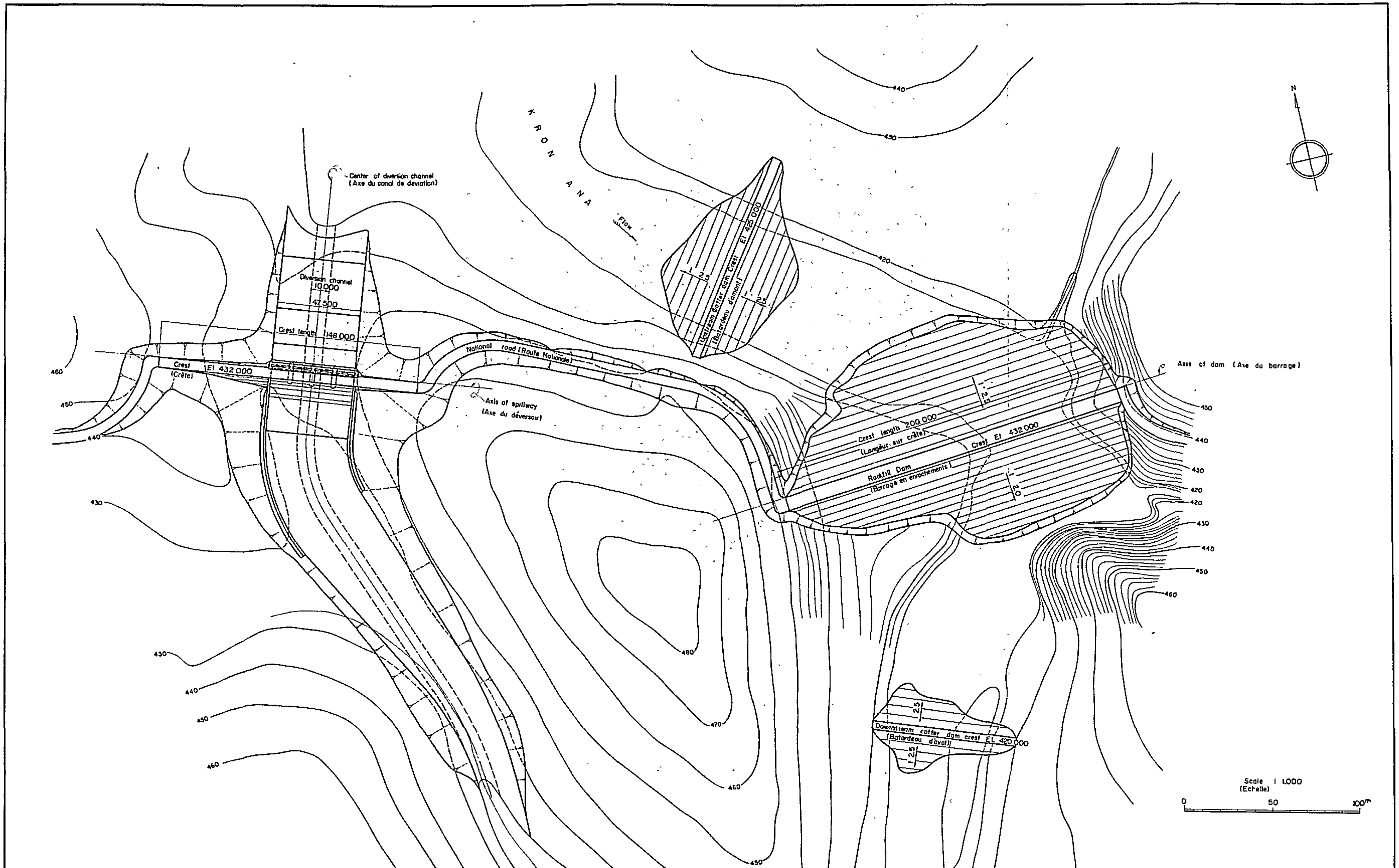
SUMMARY OF HYDROELECTRIC DEVELOPMENT IN UPPER SREPOK BASIN

Table 7-2

Order development		1st development	2nd development			Total up to 2nd development	3rd development				Total up to 3rd development	Final development					Total up to Final development
Description	Unit	Dray Ling 1st Stage	Dak Mam 1st Stage				Upper Kr. Kno	Lower Kr. Kno	Dak Mam 2nd Stage	Dry Ling 2nd Stage		B.Kuop	Dam "D"	Dam "C"	Dam "B"	Dam "A"	
I. Catchment area	Km^2	8,880	8,085				2,965	3,858	-	-		8,520	8,643	9,193	9,353	9,411	
II. Reservoir																	
High water level	m	301.5	397.0				490.0	423.0	-	-		350.0	325.0	284.0	251.0	220.0	
Low water level	m		396.0				460.0	420.0	-								
Surface area	Km^2		14.5				45.0	30.0	-								
Gross storage capacity	$x10^6\ m^3$		105				1,200	73	-								
Net storage capacity	$x10^6\ m^3$		20				900	73	-								
III. Dam																	
Type		Concrete	Concrete				Rockfill	Concrete	-	-		Concrete	Concrete	Concrete	Concrete	Earth	
Height	m	7.5	20.0				75.0	14.0	-	-		39.0	31.0	42.0	40.0	32.0	
Crest length	m	748.0	160.0				780.0	260.0	-	-		240.0	460.0	480.0	430.0	1,240.0	
Volume	m^3	11,000	30,000				4,500,000	24,000	-	-		120,000	130,000	300,000	270,000	2,000,000	
IV. Sub dam			Lower Kr. Kno	No.1	No.2												
Type			Rockfill	Earth	Earth												
Height	m		18.0	15.0	20.0												
Crest length	m		190.0	80.0	330.0												
Volume	m^3		124,000	35,000	310,000												
V. Head																	
Max. effective head	m		45.5				65.0	24.5	-								
Min. effective head	m	16.0	44.5				35.0	21.5	-			23.5	16.0	31.5	29.5	20.5	
Average effective head	m		45.0				50.0	23.0	-								
VI. Discharge																	
Firm	m^3/sec	38.0	36.0				60.0	66.9	53.3	52.8		90.8	90.8	91.8	92.8	92.8	
Maximum	m^3/sec	78.0	56.0				100.0	115.0	92.0	67.0		149.0	156.0	156.0	156.0	157.0	
VII. Power generation																	
Firm at min. head	KW	4,900	12,900			17,800	17,000	11,500	19,000	6,800	72,100	17,000	11,700	23,200	22,000	15,300	161,300
Firm at average head	KW		13,000				24,000	12,300	19,200								
Installed capacity	KW	8,000	20,000			28,000	40,000	20,000	33,000	12,000	133,000	28,000	20,000	39,000	37,000	26,000	283,000
Annual energy output	$x10^6$ KWH	43	113			156	212	100	166	59	693	149	102	203	192	134	1,473
VIII. Construction cost	$x10^6$ US$	4.5	11.0			15.5	32.1	7.4	7.3	5.0	67.3	12.2	11.2	20.3	18.9	15.3	145.2
Dam and power plant	$x10^6$ US$	3.7	8.8			12.5	31.0	6.3	6.2	4.2	60.2	11.0	10.0	19.0	17.6	14.0	131.8
Transmission line and substation	$x10^6$ US$	0.8	2.2			3.0	1.1	1.1	1.1	0.8	7.1	1.2	1.2	1.3	1.3	1.3	13.4
IX. Construction cost per KWh	US.cent/KWH	10.5	9.8			9.9	15.1	7.4	4.4	8.5	9.7	8.2	11.0	10.0	9.9	11.4	9.9
X. Power cost per KWh	US.cent/KWh	0.84	0.78			0.79	1.21	0.59	0.35	0.68	0.78	0.66	0.89	0.80	0.79	0.92	0.79



GENERAL PLAN
(PLAN GENERAL)
Scale 1:250,000
LONGITUDINAL SECTION OF UPPER SREPOK
(PROFIL EN LONG DU HAUT-SREPOK)
Ban Don North Bank Area
1,700 Ha
Ban Don South Bank Area
3,600 Ha
Ban Don
Ea Krong
CAMBODIA
VIETNAM
Upper Kr. Buk Dam
E.S.C 70,000,000m3
Lower Kr. Buk Dam
E.S.C 46,000,000m3
Kr. Pach Dam
E.S.C 140,000,000m3
Kr. Boung Dam
E.S.C 240,000,000m3
Kr. Ana Dam
E.S.C 250,000,000m3
Lower Kr. Kno Dam
E.S.C 73,000,000m3
Upper Kr. Kno Dam
E.S.C 500,000,000m3
Ea Gan Dam
E.S.C 45,000,000m3
Dak Mam Dam
E.S.C 20,000,000m3
Dam Site "A"
Dam Site "B"
Dam Site "C"
Dam Site "D"
Drayling Intake Weir
Buon Kuop Dam
B. Me Thuot West Area
25,400 Ha
B. Me Thuot Highland
6,600 Ha
B. Me Thuot South-East Valley
2,000 Ha
Northern Darlac Area
4,500 Ha
Darlac Lowland
8,000 Ha
6,500 Ha
4,900 Ha
5,300 Ha
3,000 Ha
4,000 Ha
Ban Me Thuot
Tunnel 7 km
To Nhatrang
To Pleiku
To Saigon
To Dalat
LEGEND (LEGENDE)
National Road NO.14 (Route Nationale NO.14)
River (Rivière)
Dam and reservoir (Barrage et réservoir)
Irrigation area (Zone d'irrigation)
Power station (Centrale électrique)
Pumping station (Station de pompage)
1st stage development area (Zone d'aménagement de 1ère phase)
E.S.C Effective storage capacity (Capacite utile du reservoir)
Elevation (m)
Distance (Km)
WL 699.80
WL 471.50
WL 457.60
WL 450.50
WL 475.00
EWL 429.00
WL 423.00
WL 397.000
WL 350.00
WL 325.00
WL 307.50
WL 301.50
WL 284.00
WL 251.00
WL 220.00
WL 198.00
Lower Kr. Kno Intake (14,000 KW)
Ban Dray Intake weir
Dak Mam Dam (44,000 KW)
Buon Kuop Dam (23,000 KW)
Dam Site "D" (16,000 KW)
Dray Ling Intake weir (16,000 KW)
Dam Site "C" (32,000 KW)
Dam Site "B" (30,000 KW)
Dam Site "A" (21,000 KW)
Upper Kr. Kno Dam (14,000 KW)
Confluence of Kr. Buk – Kr. Pach
Confluence of Kr. Boung – Kr. Pach
Kana Bridge
Confluence of Kr. Ana – Kr. Kno
Confluence of Ea Krong – Dak Sor
OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN
UPPER SREPOK PROJECT, VIET-NAM
(PROJET DU HAUT-SREPOK)
GENERAL PLAN & LONGITUDINAL SECTION
(PLAN GENERAL & PROFIL EN LONG)
NIPPON KOEI CO., LTD. TOKYO
(CONSULTING ENGINEERS)
DRAWN OFFICE TOKYO
CHECKED DATE MAY 30 1962
SUBMITTED RECOMMENDED
APPROVED
DWG NO 1
SHEET NO

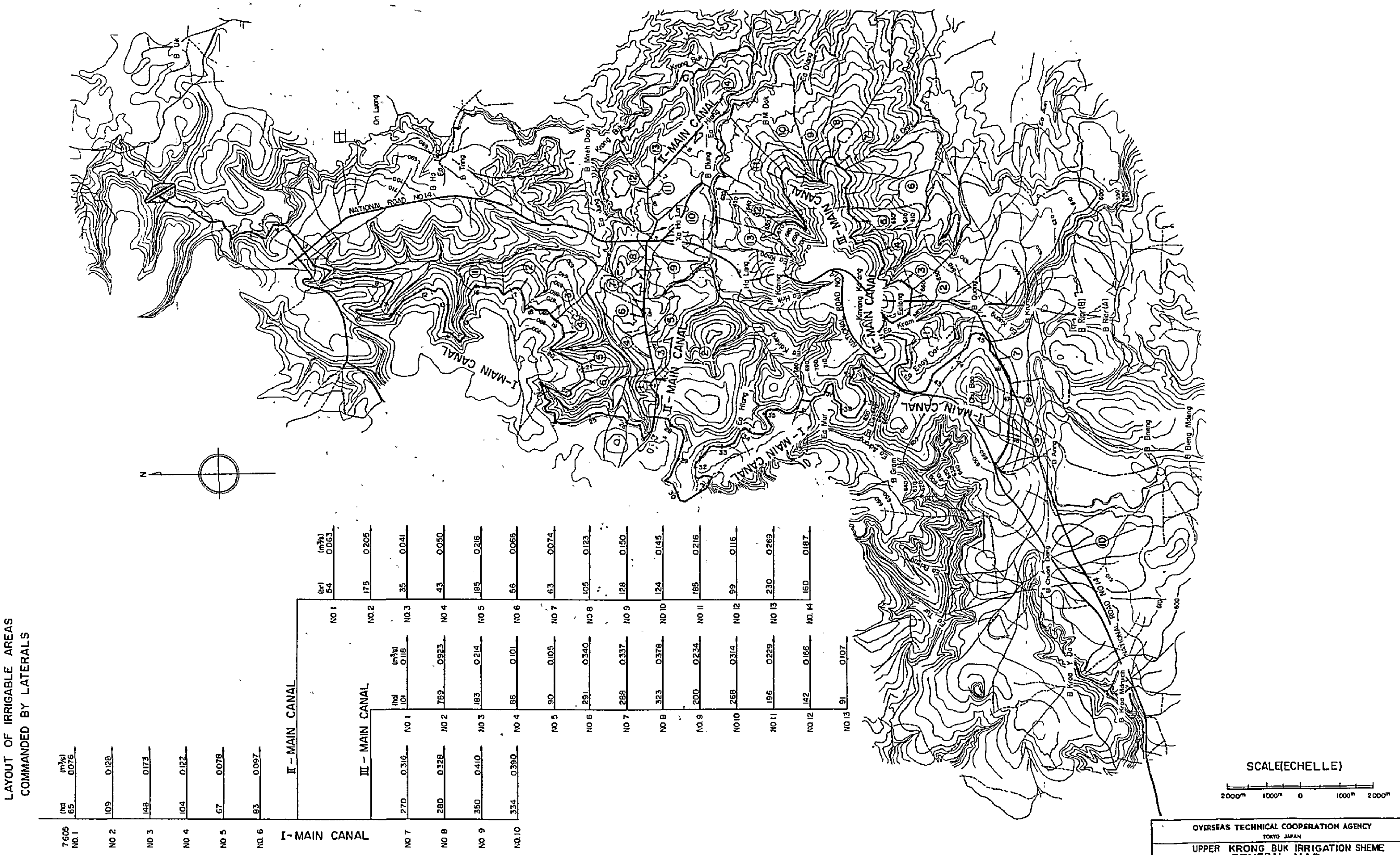


OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN

KRONG ANA DAM EMBANKMENT, PLAN
(PLAN DU BARRAGE DU KRONG ANA)

NIPPON KOEI CO., LTD. TOKYO
(CONSULTING ENGINEERS)

DRAWN OFFICE TOKYO	DWG NO 2
CHECKED DATE MAY 30 1963	
SUBMITTED RECOMMENDED	SHEET NO
APPROVED	

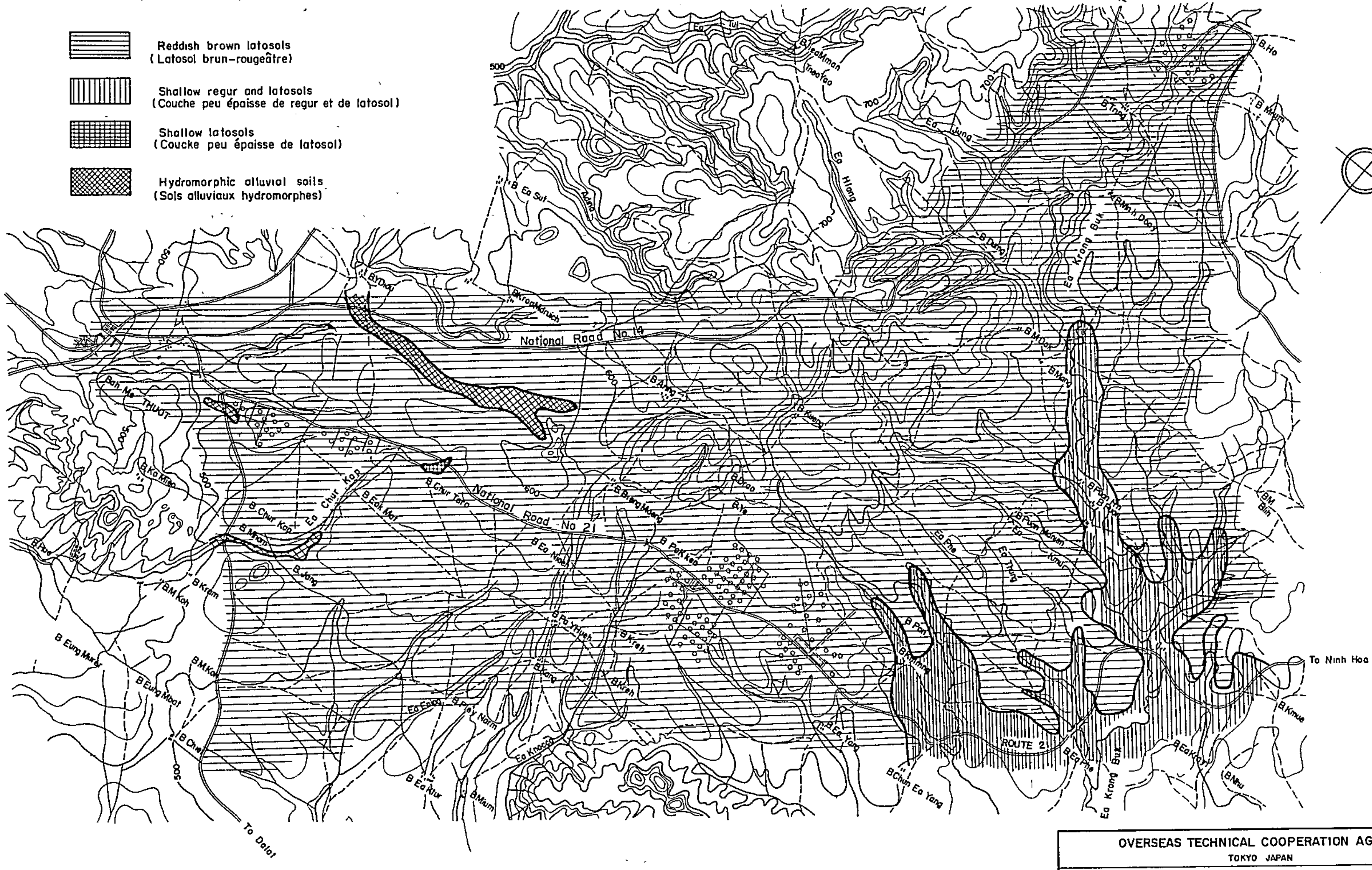


OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN

UPPER KRONG BUK IRRIGATION SHEME
GENERAL MAP
(CARTE GENERALE
DU PLAN D'IRRIGATION DU KRONG BUK SUPERIEUR)

NIPPON KOEI CO., LTD. TOKYO
(CONSULTING ENGINEERS)

DRAWN — OFFICE TOKYO		DWG NO. 3
CHECKED — DATE MAY 30 1963		
SUBMITTED — RECOMMENDED		SHEET NO
APPROVED		



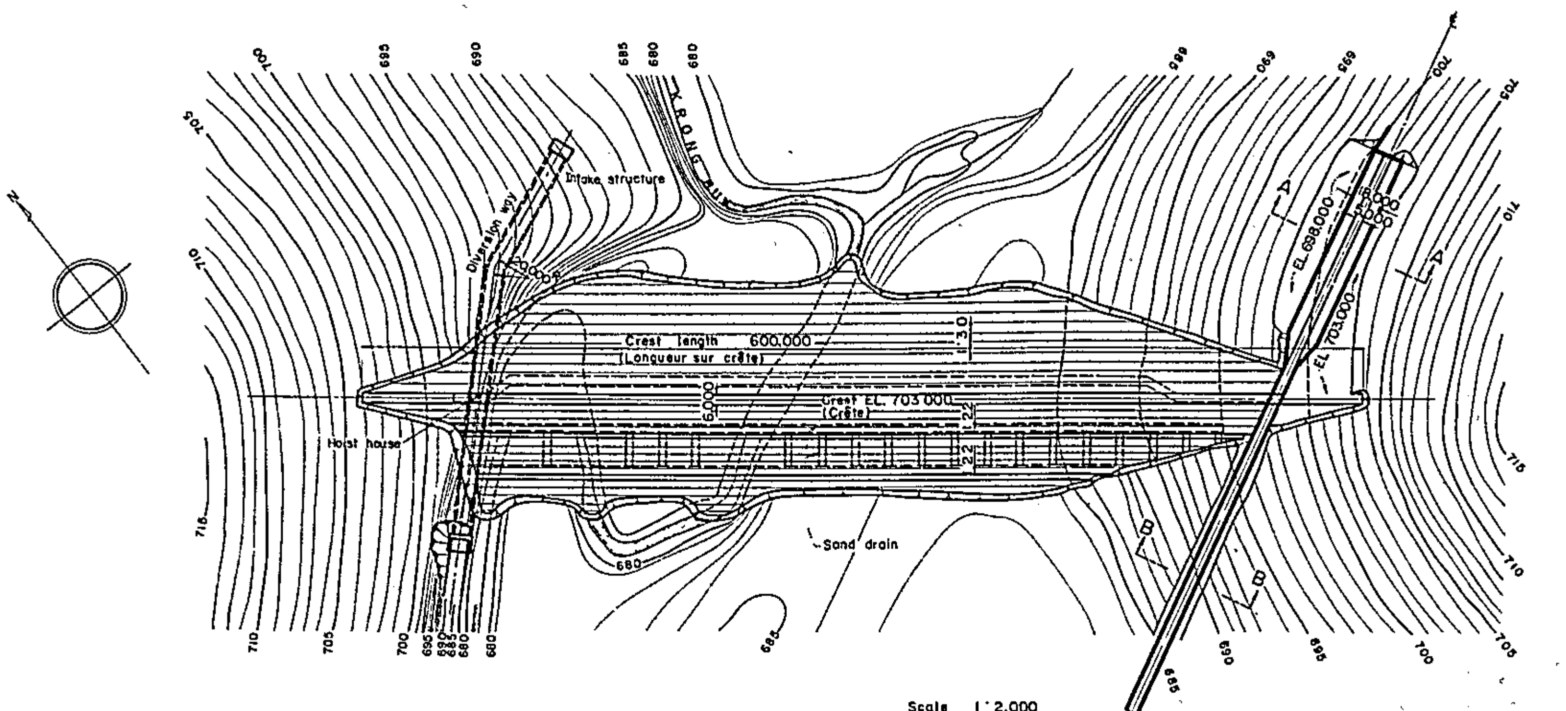
LEGEND
(LEGENDE)

- Reddish brown latosols (Latosol brun-rougeâtre)
- Shallow regur and latosols (Couche peu épaisse de regur et de latosol)
- Shallow latosols (Coucke peu épaisse de latosol)
- Hydromorphic alluvial soils (Sols alluviaux hydromorphes)

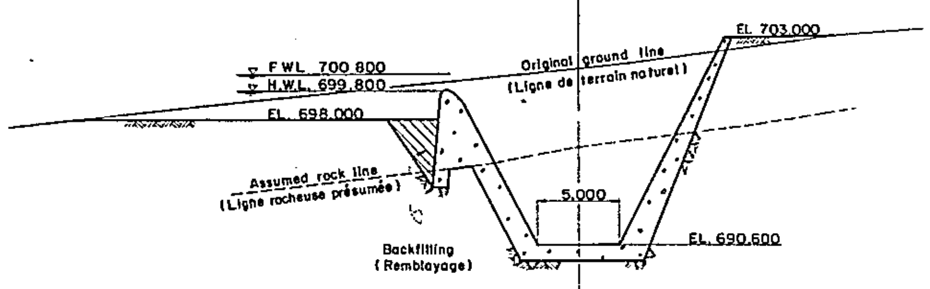
SCALE
(ECHELLE)

METERS 0 — 5000 — 10,000 METERS

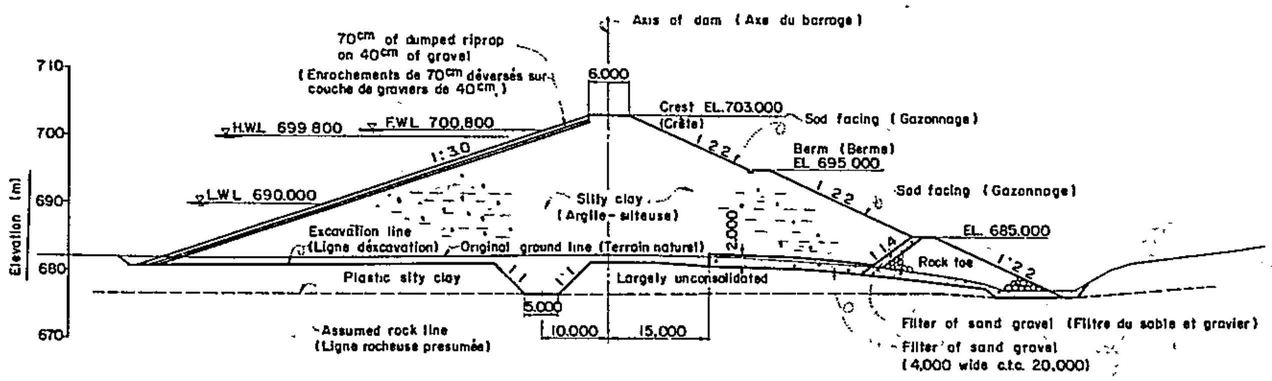
OVERSEAS TECHNICAL COOPERATION AGENCY TOKYO JAPAN	
SOIL MAP UPPER KRONG BUK PROJECT AREA (CARTE DE SOL DE LA ZONE DU PROJECT DU KRONG BUK SUPERIEUR)	
NIPPON KOEI CO. LTD. TOKYO (CONSULTING ENGINEERS)	
DRAWN K. Yatabe TOKYO	DWG NO 4
CHECKED DATE MAY 30 1963	
SUBMITTED RECOMMENDED	
APPROVED	SHEET NO



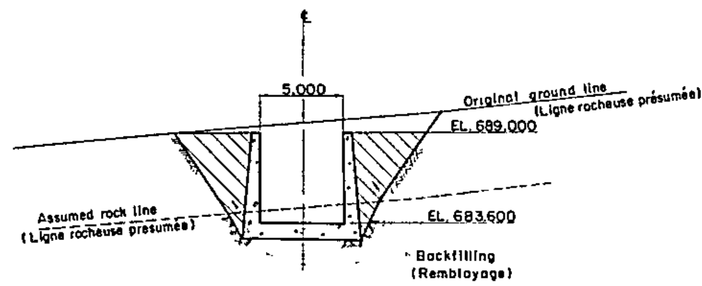
PLAN



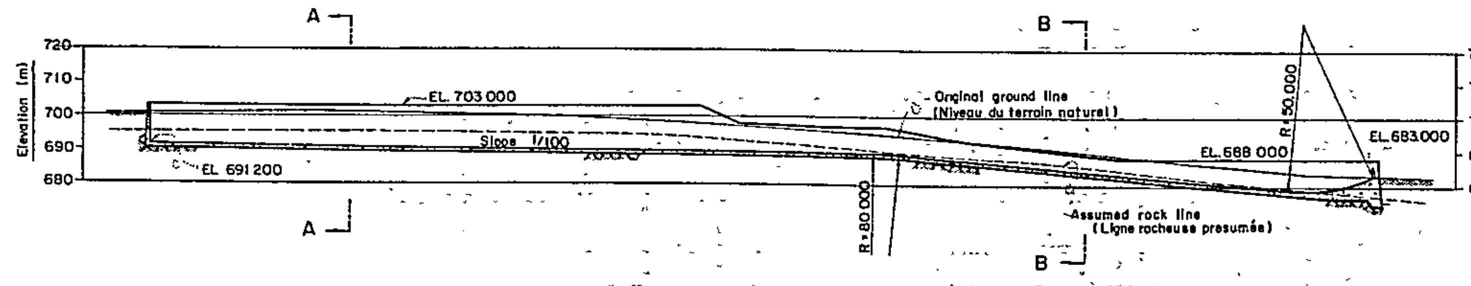
SECTION A–A
(COUPE A–A)



TYPICAL SECTION
(COUPE-TYPE)

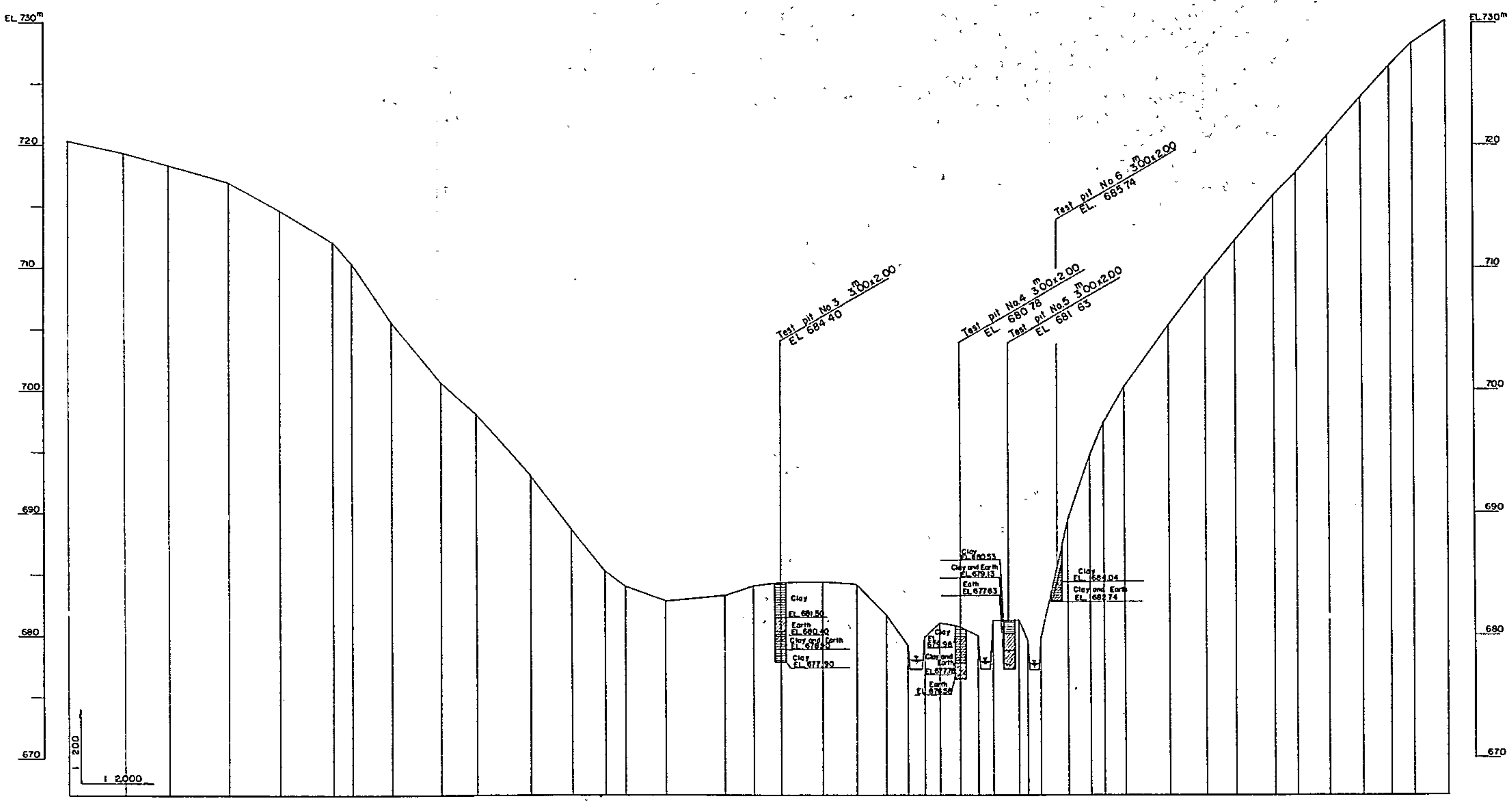


SECTION B–B
(COUPE B–B)



LONGITUDINAL SECTION OF SPILLWAY
(COUPE LONGITUDINALE DU DEVERSOIR)

OVERSEAS TECHNICAL COOPERATION AGENCY TOKYO JAPAN	
UPPER KRONG BUK DAM EMBANKMENT (BARRAGE DU KRONG BUK SUPERIEUR)	
NIPPON KOEI CO., LTD. TOKYO (CONSULTING ENGINEERS)	
DRAWN ... OFFICE TOKYO	DWG NO 5
CHECKED ... DATE MAY 30 1963	
SUBMITTED ... RECOMMENDED	SHEET NO
APPROVED ...	



No	Dis	Accum Dis.	G H	F H
No 0	0	0	720.276	
1	46.434	46.434	719.281	
2	35.579	82.013	718.278	
3	48.395	130.408	716.805	
4	41.915	172.323	714.781	
5	42.725	215.048	712.010	
6	15.306	230.354	710.259	
7	31.380	261.734	705.608	
8	40.262	301.996	700.720	
9	29.131	331.127	698.081	
10	43.348	374.475	693.170	
11	34.000	408.475	688.674	
12	27.836	436.311	685.348	
13	16.441	452.752	684.111	
14	33.718	486.470	682.900	
15	48.649	535.119	683.267	
16	24.316	559.435	684.099	
17	22.438	581.873	684.408	
17+34.460	34.460	616.333	684.377	
18	27.934	644.267	684.187	
18+24.053	24.053	668.320	681.794	
40.868	16.816	685.136	679.231	
54.945	14.076	699.212	678.919	
19	13.500	712.712	681.053	
19+15.238	15.238	727.950	680.792	
30.447	15.209	743.159	680.024	
42.561	12.114	755.273	681.300	
20	20.810	776.083	681.314	
20+7.324	7.324	783.407	679.644	
18.224	10.900	794.307	679.754	
41.044	22.820	817.127	689.490	
21	17.539	834.666	694.742	
21+11.144	11.144	845.810	697.282	
22	16.801	862.611	700.405	
22+37.685	37.685	900.296	705.610	
23	30.142	930.438	709.346	
24	23.798	954.236	712.155	
25	31.436	985.672	715.913	
26	18.063	1003.735	717.607	
27	26.338	1030.073	720.807	
28	27.448	1057.521	724.040	
29	23.353	1080.874	726.475	
30	19.498	1100.372	728.275	
31	27.694	1128.066	730.178	

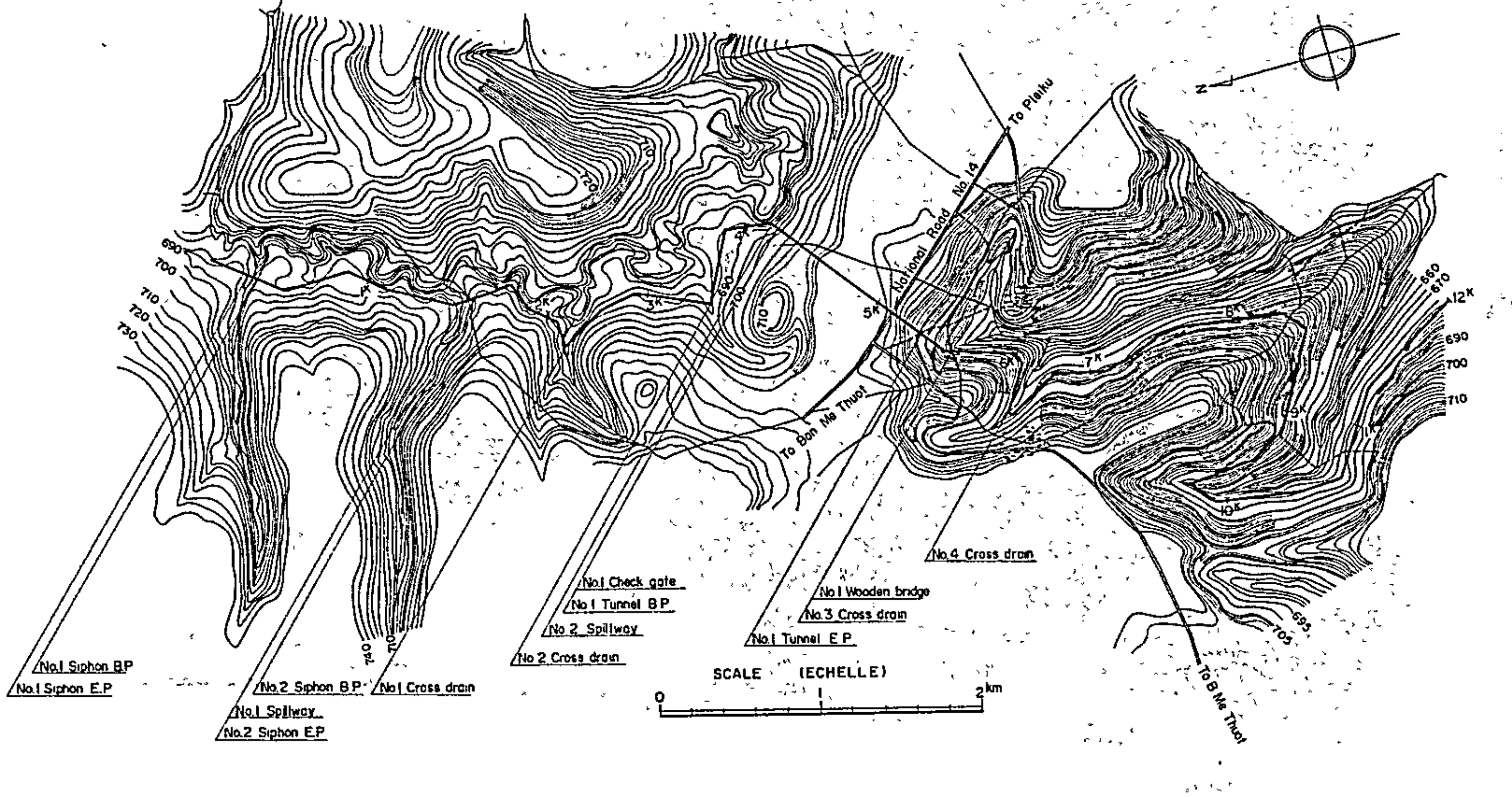
OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN

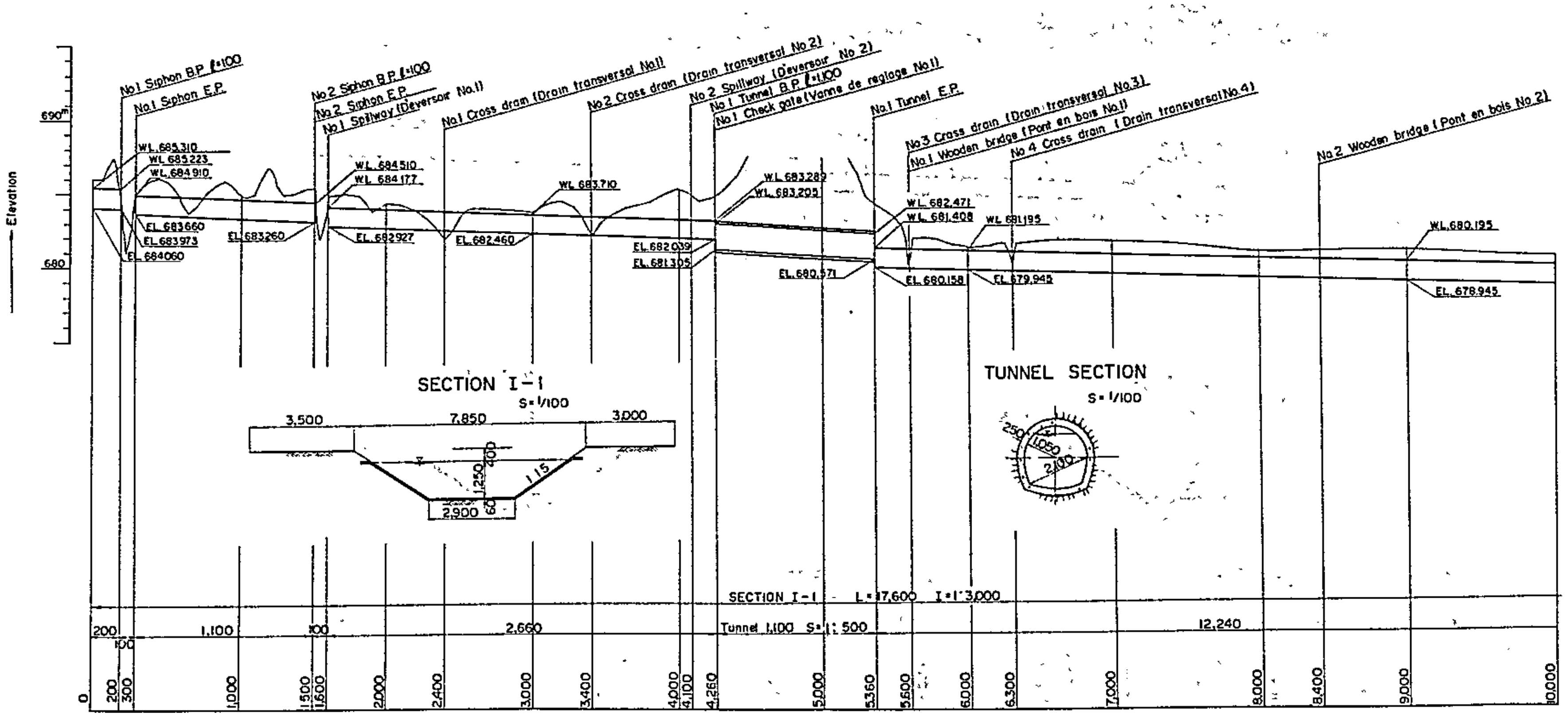
KRONG-BUK PROJECT, UPPER SREPOK VIET-NAM

GEOLOGICAL SECTION OF UPPER KRONG BUK DAM SITE

NIPPON KOEI CO., LTD. TOKYO
(CONSULTING ENGINEERS)

DRAWN K. Uetake	OFFICE TOKYO	DWG NO. 6
CHECKED	DATE MAY 30 1963	
SUBMITTED	RECOMMENDED	SHEET NO
APPROVED		



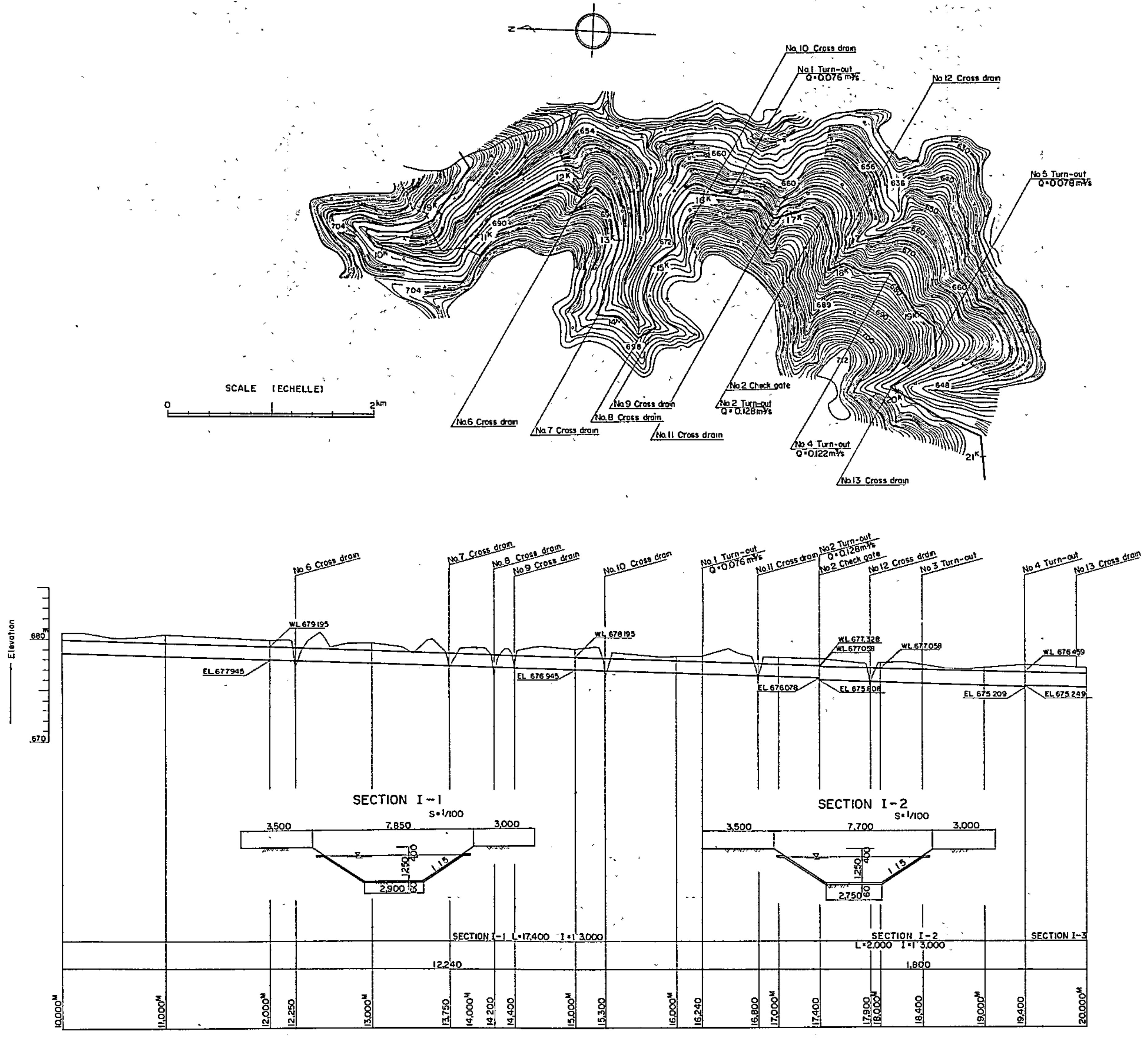


OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN

UPPER KRONG BUK SUB AREA I-MAIN CANAL PLAN AND PROFILE
(PLAN ET PROFIL DE CANAL PRINCIPAL NO I DE LA SUB DIVISION DU KRONG BUK SUPERIEUR)

NIPPON KOEI CO., LTD. TOKYO
(CONSULTING ENGINEERS)

DRAWN K. Yatabe	TOKYO	DWG NO. 7
CHECKED	DATE MAY 30 1963	
SUBMITTED	RECOMMENDED	
APPROVED		SHEET NO

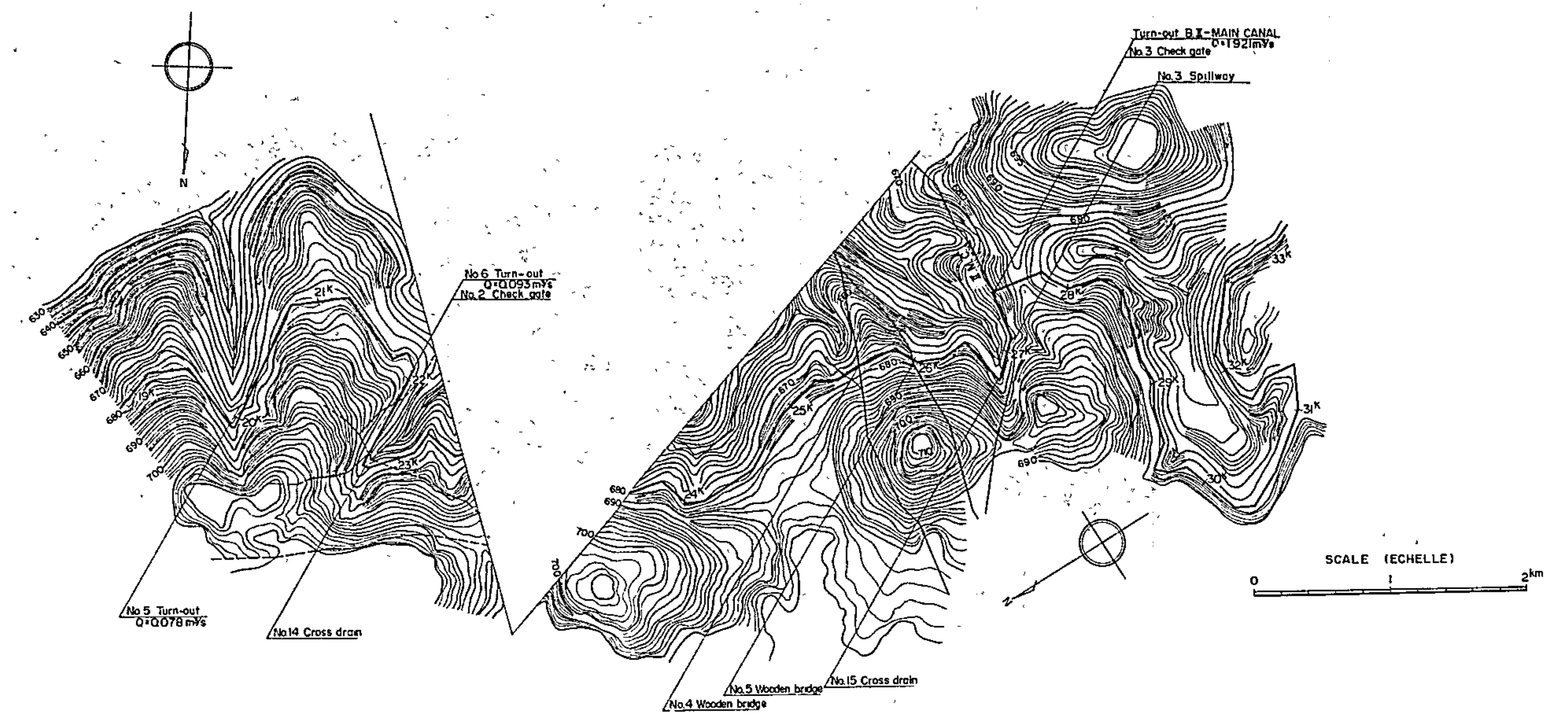


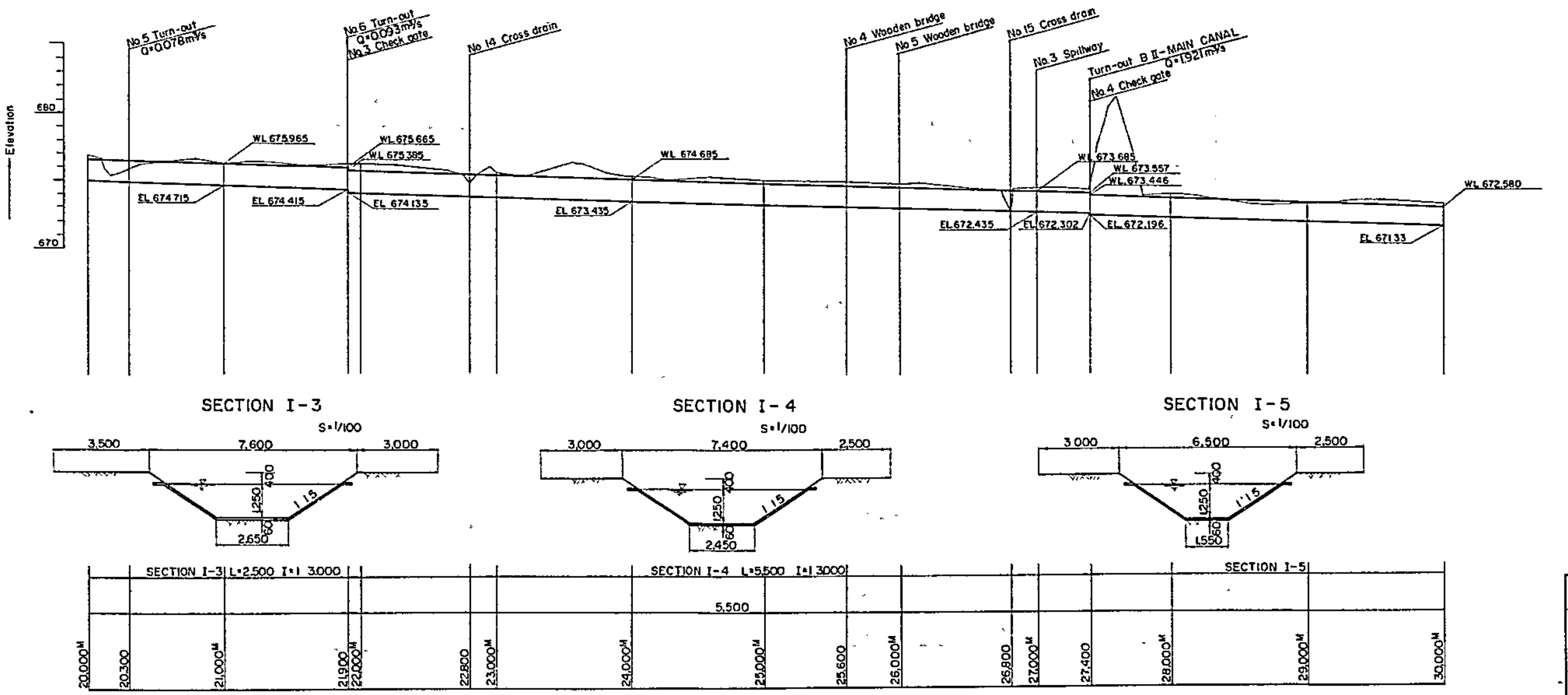
OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN

UPPER KRONG BUK SUB AREA I-MAIN CANAL
PLAN AND PROFILE
(PLAN ET PROFIL DE CANAL PRINCIPAL NO I DE LA SUB DIVISION DU KRONG BUK SUPERIEUR)

NIPPON KOEI CO., LTD. TOKYO
(CONSULTING ENGINEERS)

DRAWN K. Yotsuba	TOKYO	DWG NO	8
CHECKED	DATE MAY 30 1963		
SUBMITTED	RECOMMENDED		
APPROVED		SHEET NO	



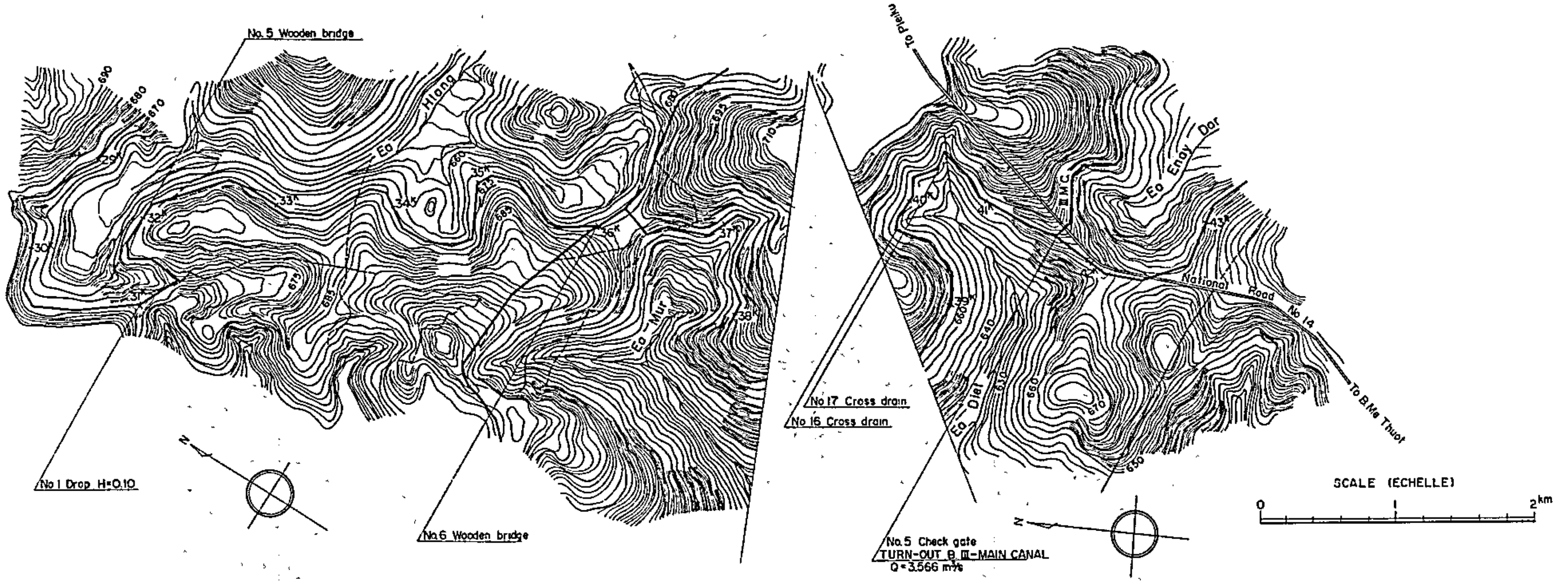


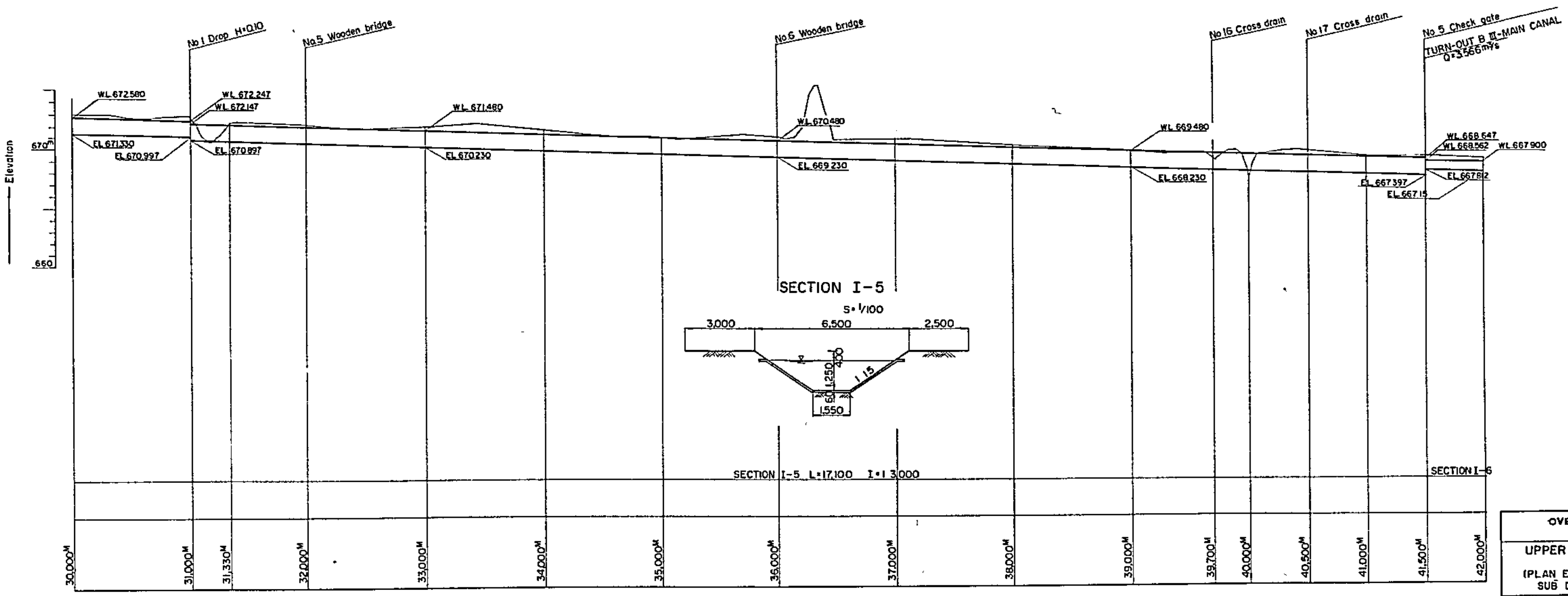
OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN

UPPER KRONG BUK SUB AREA I-MAIN CANAL
PLAN AND PROFILE
(PLAN ET PROFIL DE CANAL PRINCIPAL NO I DE LA SUB DIVISION DU KRONG BUK SUPERIEUR)

NIPPON KOEI CO., LTD. TOKYO
(CONSULTING ENGINEERS)

DRAWN K. Yatabe	OFFICE TOKYO	DWG NO	9
CHECKED	DATE MAY 30 1963		
SUBMITTED	RECOMMENDED	SHEET NO	
APPROVED			



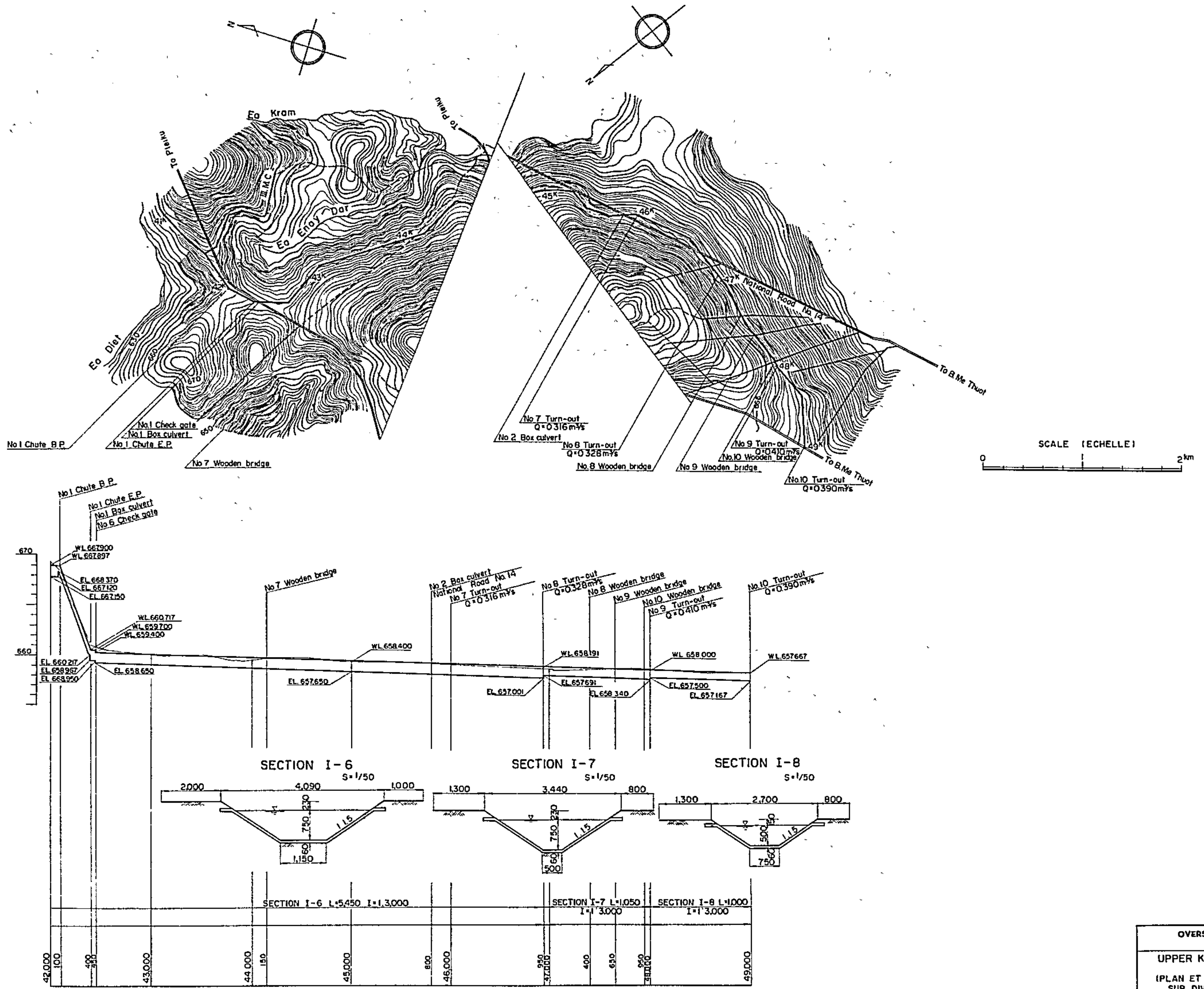


OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN

UPPER KRONG BUK SUB AREA I-MAIN CANAL
PLAN AND PROFILE
(PLAN ET PROFIL DE CANAL PRINCIPAL NO I DE LA SUB DIVISION DU KRONG BUK SUPERIEUR)

NIPPON KOEI CO., LTD TOKYO
(CONSULTING ENGINEERS)

DRAWN Kobayashi	OFFICE TOKYO	DWG NO 10
CHECKED K. Ito	DATE MAY 30 1963	
SUBMITTED [illegible]	RECOMMENDED	SHEET NO
APPROVED R. Yoshida		

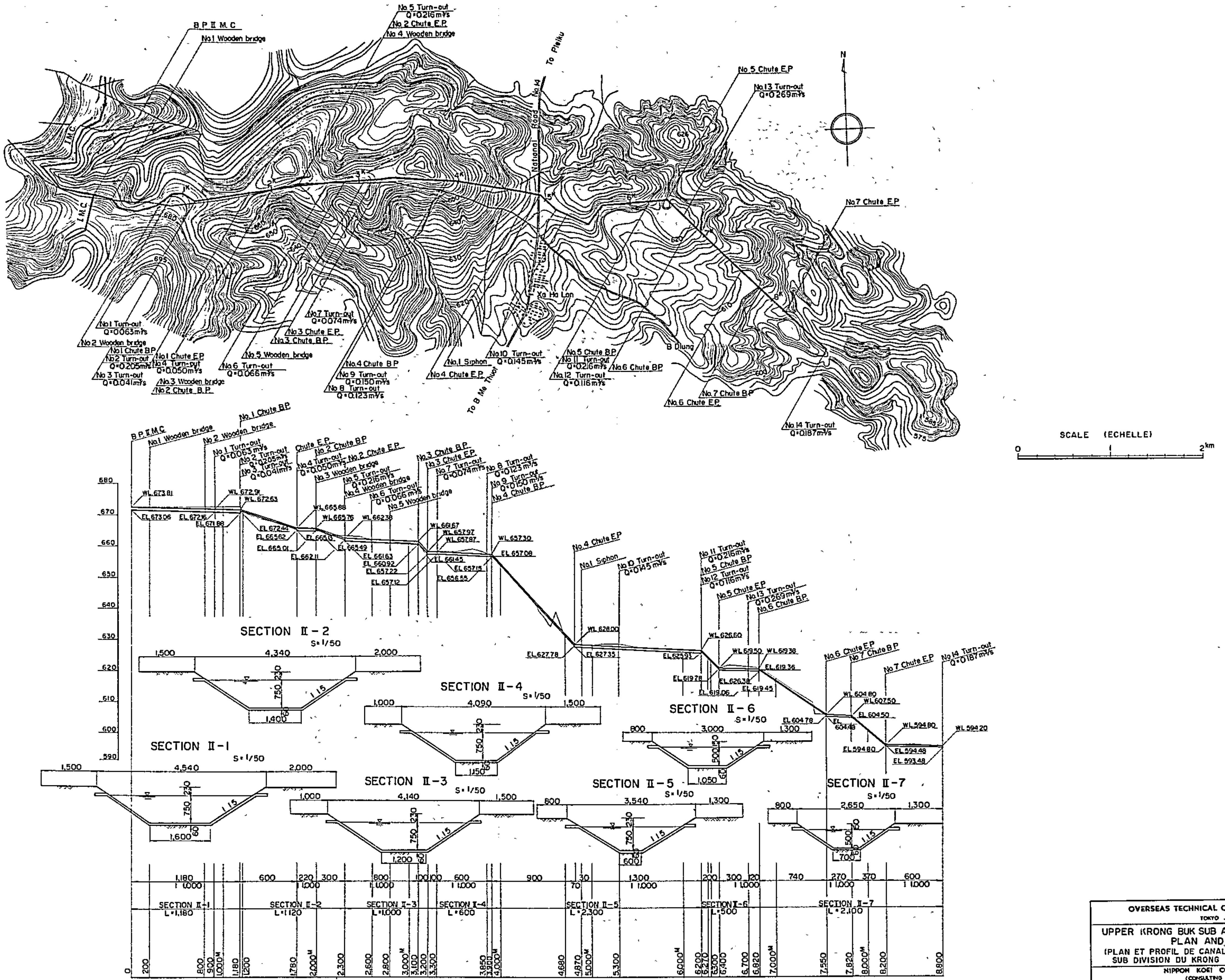


OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN

UPPER KRONG BUK SUB AREA I-MAIN CANAL
PLAN AND PROFILE
(PLAN ET PROFIL DE CANAL PRINCIPAL NO I DE LA SUB DIVISION DU KRONG BUK SUPERIEUR)

NIPPON KOEI CO., LTD. TOKYO
(CONSULTING ENGINEERS)

DRAWN K. Yatabe	OFFICE TOKYO	DWG NO 11
CHECKED K. Sato	DATE MAY 30 1963	
SUBMITTED & RECOMMENDED		SHEET NO
APPROVED R. Yoshida		



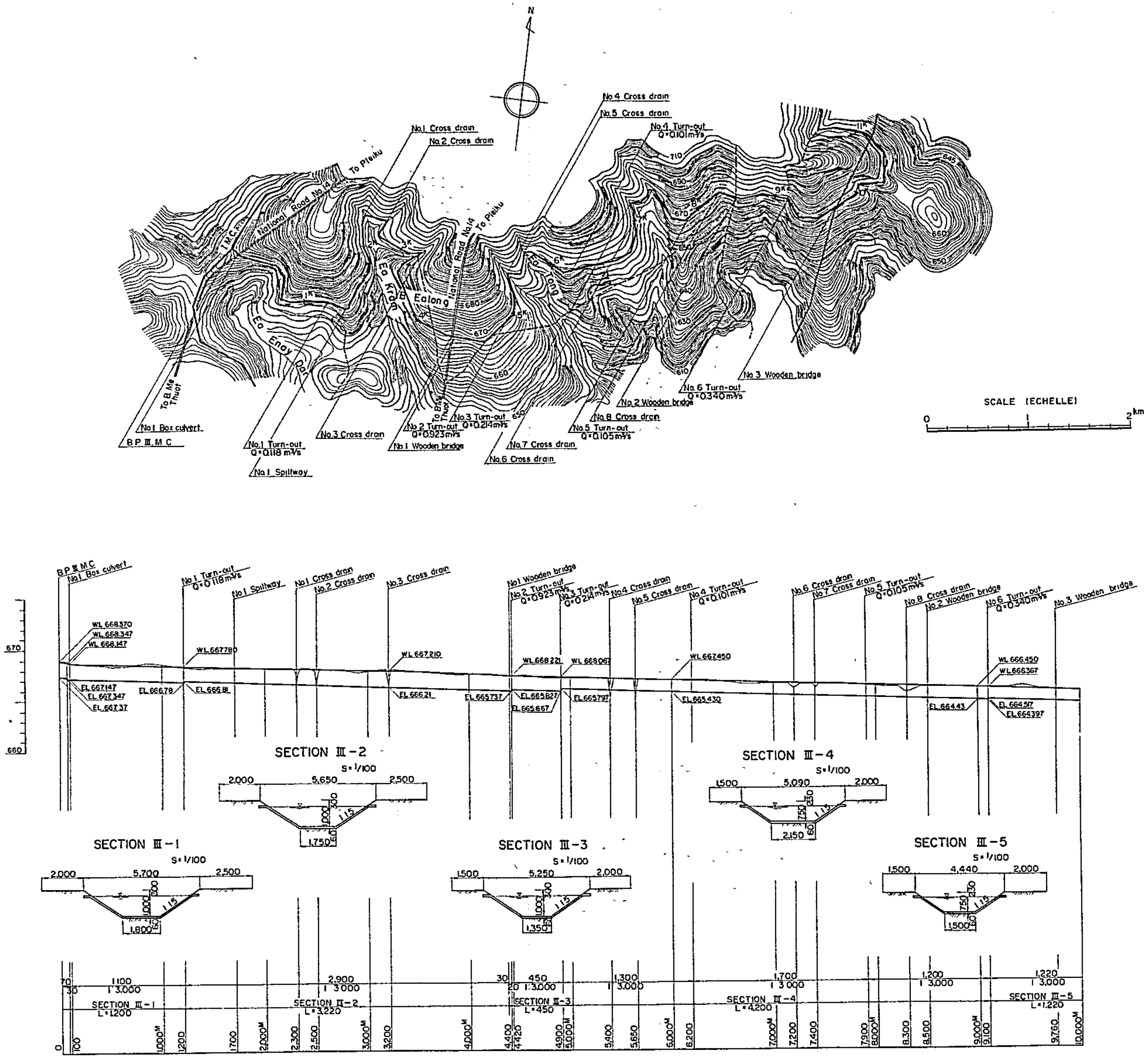
OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN

UPPER KRONG BUK SUB AREA II-MAIN CANAL PLAN AND PROFILE

(PLAN ET PROFIL DE CANAL PRINCIPAL NO 2 DE LA SUB DIVISION DU KRONG BUK SUPERIEUR)

NIPPON KOEI CO., LTD. TOKYO
(CONSULTING ENGINEERS)

DRAWN K. Yatal OFFICE TOKYO		DWG NO 12
CHECKED K. Goto DATE MAY 30 1963		
SUBMITTED	RECOMMENDED	SHEET NO
APPROVED K. Yoshida		

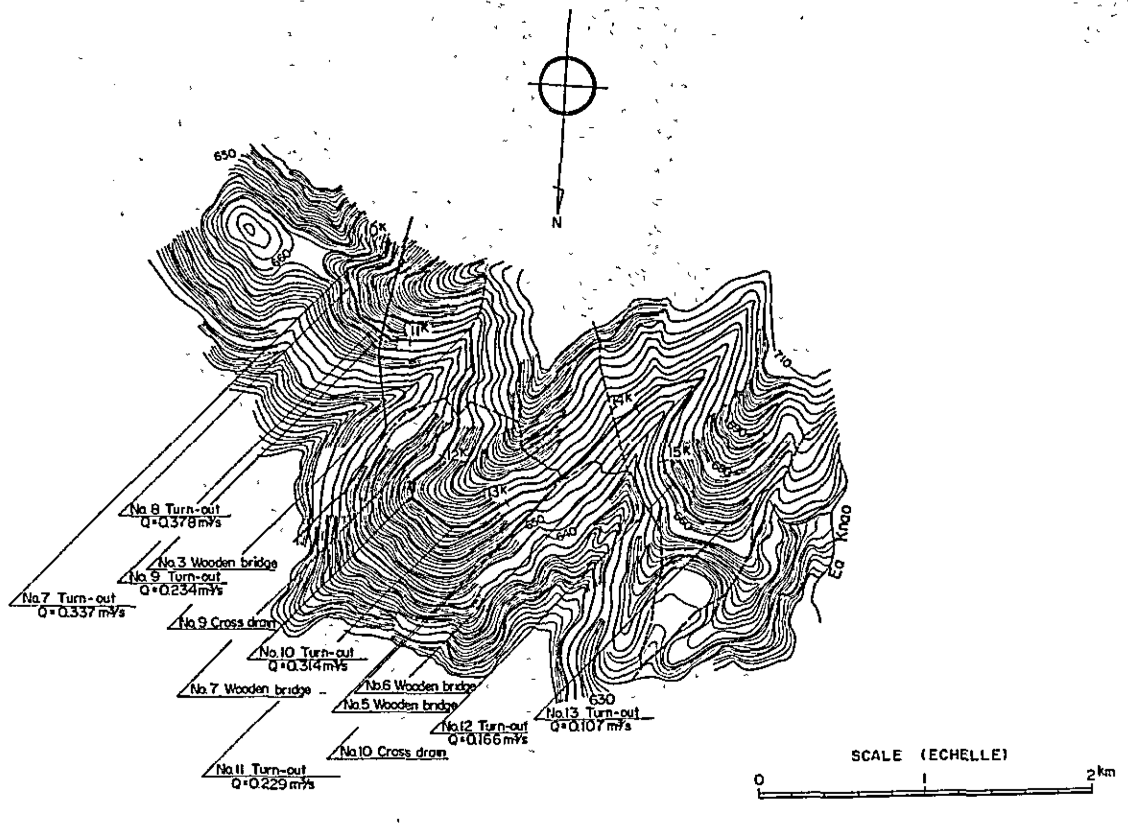


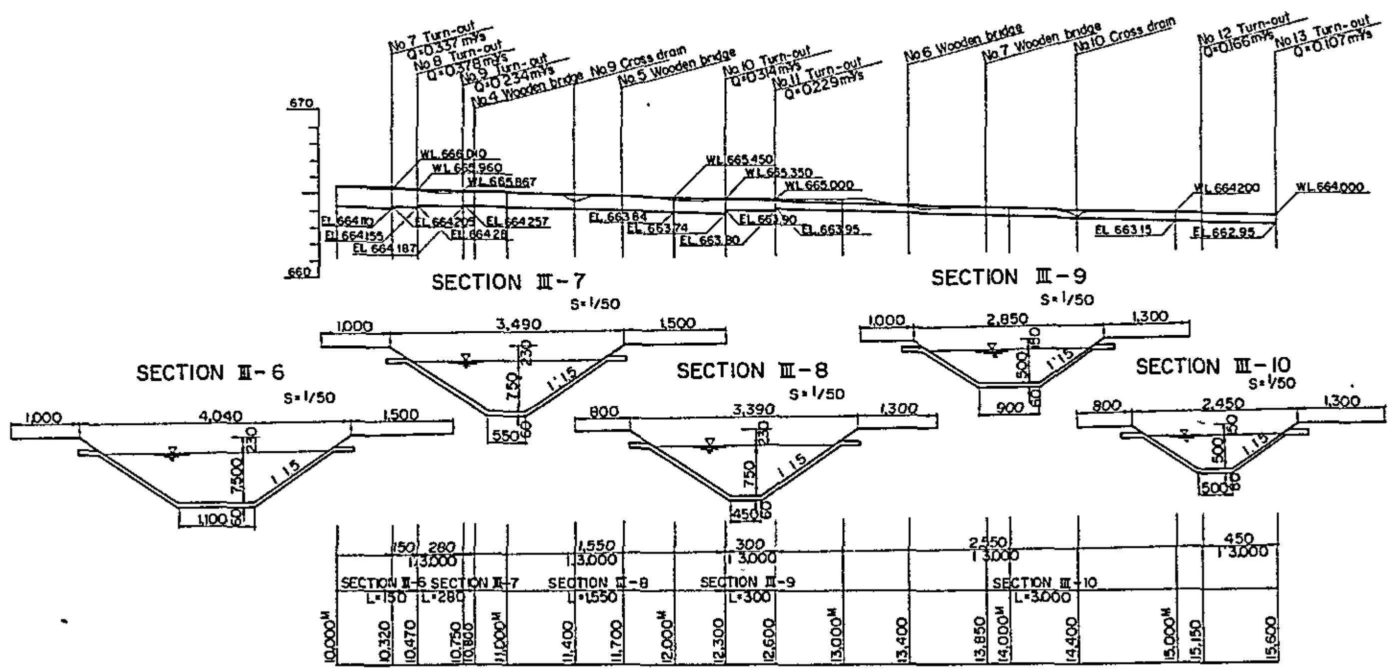
OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN

UPPER KRONG BUK SUB AREA III - MAIN CANAL PLAN AND PROFILE
(PLAN ET PROFIL DE CANAL PRINCIPAL NO 3 DE LA SUB DIVISION DU KRONG BUK SUPERIEUR)

NIPPON KOEI CO., LTD. TOKYO
(CONSULTING ENGINEERS)

DRAWN — OFFICE TOKYO		DWG NO 13
CHECKED — DATE MAY 30 1963		
SUBMITTED — RECOMMENDED		SHEET NO
APPROVED		





OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN

UPPER KRONG BUK SUB AREA III-MAIN CANAL PLAN AND PROFILE
(PLAN ET PROFIL DE CANAL PRINCIPAL NO 3 DE LA SUB DIVISION DU KRONG BUK SUPERIEUR)

NIPPON KOEI CO., LTD. TOKYO
(CONSULTING ENGINEERS)

DRAWN OFFICE TOKYO	DWG NO 14
CHECKED DATE MAY 30 1963	
SUBMITTED RECOMMENDED	SHEET NO
APPROVED	