INTERIM REPORT

ON

PRELIMINARY STUDIES OF NAM GAM PROJECT

(Nam Pung)

JAPANESE GOVERNMENT INVESTIGATION TEAM

ON THE NAM GAM PROJECT

TOKYO, AUGUST 1962

Forward

This interim report based on field studies conducted in October 1961, the wet season, and from December 1961 to March 1962, the dry season, has been prepared in view of the necessity to discuss immediately with officials of the country concerned, the conclusions arrived to date in the planning and preliminary design work for the integrated development of the Nam Gam Basin which is in the stage of preparation in Tokyo.

It must be pointed out that the figures used in this report are subject to change as a result of discussions with people concerned and with the progress in the planning of the project.

The final plan and figures will be incorporated in the comprehensive report which we hope to have complete and ready in December 1962.

With this report is submitted the preliminary designs for the Nam Pung Hydro-electric Project which the Government of Thailand has indicated its desire to begin construction with priority among the several projects of the integrated development of the Nam Gam Basin.

The Japanese Government Investigation Team on the Nam Gam Project, organized by the Government of Japan, was under the leadership of Mr. Takeshi Tokuno of Electric Power Development Company and consisted of members listed below. The Team conducted studies in the field and after returning to Japan it is engaged in the design work of the project.

Name	Profession	Present Organization
Takeshi TOKUNO (Chief of Team)	Civil engineer	Electric Power Development Co.
* Nobumichi SHUDO	Economist	"
(*)Hitoshi YOSHINAGA	Civil engineer	"
Hamaaki AOKI	Electrical engineer	"
Nasuo TOYAMA	Civil engineer	"
Hiroshi SUETOMI	Geologist	"

Name	Profession	Present Organization
Mitsuhiro OHATA	Civil engineer	Electric Power Development Co.
Ryozo NOGAMI	Surveyor	"
Atsushi ODAIRA	Surveyor	"
Sadao KOYAMA	Statistical engineer	"
Koichi HONDA	Surveyor	"
* Shigekatsu WATANABE	Irrigation engineer	Ministry of Agriculture and Forestry
(*)Gakuji KIMURA	Pedologist	"
Hiroshi KATO	Irrigation engineer	"
Kunio IKI	Irrigation engineer	"
Akira AKIMOTO	Boring specialist	
Masatoshi ATARASHI	Liaison	Office of Mekong International of Japan

Note: * Participated in the wet season survey only

(*) Participated in the wet season and dry season surveys.

C O N T E N T S

I. Introduction

Investigations of the Lower Mekong Basin, under the leadership of the United Nations, which is principally directed to the development of its water resources is progressing satisfactorily.

As the initial step before embarking on the large-scale development of the main Mekong River, it has been strongly proposed by the people concerned that the appropriate way would be to develop with priority specific projects on the tributaries that would serve as pilot and training projects for the main Mekong scheme. As a result, financial assistance from the U.N. Special Fund is being received to investigate and study one project each or a total of 4 projects in the 4 riparian countries with the object of realizing their early development.

Prior to this work, the Government of Japan as her contribution, undertook the reconnaissance survey of major tributaries of the Lower Mekong Basin and recommended that investigations and studies be initiated for the development of 2 pilot projects in each of the 4 riparian countries or a total of 8 projects. Of these, 4 projects have been authorized for study with U.N. Special Fund. In consideration of the requests of the 4 riparian countries the Government of Japan is undertaking the study of one tributary in each of the countries and preparing preliminary designs for the most feasible project.

As a part of the contribution of Japan, the tributary under investigation in Thailand is the Nam Gam and the specific project under study is the Nam Pung multi-purpose development.

The development possibilities of the Nam Gam basin is briefly described in the Comprehensive Reconnaissance Report on the Major Tributaries of the Lower Mekong Basin dated September 1961. It has been found after the report was completed that the hydro-electric potential of the Nam Gam was overestimated because of inadequacy of data which were available at that time and errors in the hydrological data obtained.

The Japanese Investigation Team on the Nam Gam Project, in the course

of its field studies conducted its own necessary surveys and observations, as well as, obtaining all available hydrological and other data. A general description of the development plan prepared so far based on analysis of surveys made by the Team and data obtained in the field is included in this Report.

The Government of Thailand has indicated its eagerness for the early development of the Nam Pung Project. This interim report is presented on the belief that the submission, as early as possible, of the revised project would be in conformity with the desire of the Government of Thailand and would accelerate the development of the Lower Mekong Basin.

Consequently, this Report contains the development of the Nam Pung multi-purpose project which is an integral part of the Nam Gam Basin scheme. The Nam Pung Project is the first stage development project. The development scheme for the entire Nam Gam basin is under study and is not included in this Report.

II. Fundamental Considerations in the Planning of the Project

In the preparation of the development plan for the Nam Gam basin, the basic consideration is the analytical study of the hydrology of Nam Pung and Lake Nong Han which require a relatively high degree of accuracy.

The Team during the course of its field studies paid particular attention to the hydrology of the basin and endeavoured to obtain all available hydrological data, as well as, conducting its own observation. However, available data was far from adequate and the recorded streamflow data at the proposed Nam Pung dam site was available for one year only.

Therefore, the work in Tokyo has been concentrated on the re-examination of our field studies, as well as, conducting analytical studies of all available hydrological data to determine the run-off of Nam Pung and Lake Nong Han. As a result of this study, a part of the development plan will have to be modified. This is described hereinunder.

a) Analysis of hydrological data

Measured streamflow of the Nam Gam basin is available for the year 1961 only at the proposed Nam Pung dam site. This measurement was taken by the National Energy Authority of the Government of Thailand. However, the year 1961 happened to be a wet year and the run-off of a dry year is not known. Other hydrological data available are rainfall records ranging from 5 to 50 years at 3 locations in the basin that are useable, water level measurements for 13 years from 1949 to 1961 at the upstream and downstream of Nam Gam Gate installed at the outlet of Lake Nong Han, and the lake water level fluctuation records for 3 consecutive years from 1959 to 1961.

The Team analyzed these data to estimate the annual run-off of the Nam Gam, the annual inflow to Lake Nong Han and the annual streamflow at the Nam Pung bridge site (records for 1957 and 1958 are available at the Royal Irrigation Department of the Government of Thailand). The results obtained from these analysis were used in preparing the development plan. The analyzed

data are presented in Table 1 and 2. It is evident from the tables that noticeable errors exist in the recorded streamflow at the Nam Pung bridge site.

Table 1 gives the annual streamflow at the Nam Pung bridge site (proposed site for the diversion weir of Nam Pung irrigation district) that was computed from the annual inflow to Lake Nong Han in ratio to the catchment area. From Table 1, it is assumed that the streamflow at the Nam Pung bridge site is 44.9% in 1957 and 27.2% in 1958 of the recorded flow at the gauging station installed at that site by the Royal Irrigation Department. Table 2 gives the annual inflow to and the outflow coefficient from Lake Nong Han. Line "A" in Figure 1 indicates the corelation between these and annual precipitation, and line "B" the corelation between annual precipitation and outflow coefficient at the Nam Pung dam site.

Figure 2 gives the relationship between the annual run-off at the Nam Pung dam site computed from line B in Figure 1 and the annual run-off computed from the inflow to Lake Nong Han in ratio to the catchment area. It will be noted from Figure 2 that the inflow for the 12 years of 1950 to 1961 based on line B is about 1.2 billion m^3 and based on line A it is about 1.54 billion m^3 which is about 128% of line B. For the 8 years of 1954 to 1961, the total inflow based on line B is about 790 million m^3 and based on on line A it is about 880 million m^3 which is about 112% of line B. The Nam Pung Project described in Chapter 3 is based on the estimated annual run-off according to line B from which the reservoir storage capacity and the annual energy production were calculated.

That the outflow coefficient at Nam Pung dam site is 12 to 28% smaller than the outflow coefficient at Lake Nong Han is assumed to be attributable to the fact that vegetation which is extremely heavy in the basin results in the consumption of large quantities of subterranean water, in comparison with other basins, during the dry season by evapo-transpiration.

Table 1 Annual Run-off at Nam Pung Bridge Site

Year	Lake Nong Han: Annual run-off ($10^3 m^3$) (Aug. to Dec.)	Lake Nong Han: Annual inflow ($10^3 m^3$) (Aug. to Dec.)	Lake Nong Han: Annual inflow converted from precipitation (mm) (Aug. to Dec.)	Annual run-off at Nam Pung Bridge Site: Computed from annual inflow to Lake Nong Han (A) ($10^3 m^3$) (Aug. to Dec.)	Annual run-off at Nam Pung Bridge Site: Thai Government data (B) ($10^3 m^3$)	Thai Government data (mm)
1949	837,264	804,062	559.1	476,912	-	-
1950	746,592	833,937	572.6	488,428	-	-
1951	759,969	734,809	502.2	428,377	-	-
1952	629,485	764,158	526.7	449,275	-	-
1953	1,007,743	945,425	653.6	557,521	-	-
1954	420,699	546,494	373.6	318,681	-	-
1955	270,157	339,943	230.5	196,617	-	-
1956	712,511	741,817	512.7	437,333	-	-
1957	336,175	403,790	275.3	234,831	523,000	602
1958	432,521	467,011	319.3	272,363	1,003,000	1,153
1959	309,791	398,014	270.7	230,907	-	-
1960	502,441	592,695	408.4	348,365	-	-
1961	908,390	821,987	568.8	485,186	-	-

Note: 1. (A)/(B): 1957 .... 44.9%
1958 .... 27.2%

2. Catchment area at Nam Pung bridge site is 853 km^2.

Table 2 Annual Inflow and Outflow Coefficient of Lake Nong Han

Year	Annual inflow to Lake Nong Han ($10^3 m^3$) (Aug. to Dec.)	Converted from precipitation (mm) (Aug. to Dec.)	Annual precipitation (mm) Sakol Nakorn	Ban Srang Khor	Nam Gom Gate	Lake Nong Han	Estimate for entire basin	Estimated outflow coefficient of entire basin (%)	Nam Pung Reservoir catchment area 20 Mean precipitation	Mean outflow coefficient
1949	804,062	559.1	1 1,701.0	-	-	-	1,701.0	-	1,701.0	
50	833,937	572.6	1 1,533.4	-	-	-	1,533.4	37.34	1,533.4	
51	734,809	502.2	1 1,364.9	-	-	-	1,364.9	36.79	1,364.9	
52	764,158	526.7	1 1,347.9	-	-	-	1,347.9	39.08	1,347.9	
53	945,425	653.6	0.6 1,704.1	-	0.4 1,541.1	-	1,638.9	39.88	1,704.1	
54	546,494	373.6	0.6 1,464.9	-	0.4 1,324.4	-	1,408.7	26.52	1,464.9	
55	339,943	230.5	0.6 991.9	-	0.4 955.4	-	977.3	23.59	991.9	
56	741,817	512.7	0.5 1,556.2	0.2 1,412.5	0.3 1,575.7	-	1,533.3	33.44	1,556.2	
57	403,790	275.3	0.5 1,108.6	0.2 1,453.0	0.3 1,652.2	-	1,340.6	20.54	1,453.0	
58	467,011	319.3	0.5 1,290.1	0.2 1,527.4	0.3 1,351.8	-	1,356.1	23.55	1,527.4	
59	398,014	270.7	0.25 1,132.3	0.2 1,423.8	0.3 1,154.9	0.25 1,017.6	1,168.7	23.16	1,423.8	
60	592,695	408.4	0.25 1,679.4	0.2 1,315.8	0.3 1,778.2	0.25 1,891.5	1,689.3	24.18	1,315.8	
61	821,987	569.1	0.25 1,656.9	0.2 1,651.7	0.3 1,836.0	0.25 1,855.1	1,775.7	32.04	1,651.7	

Note: 1. Upper figures in column "Annual precipitation" indicates the influence of the respective observation sites to the annual inflow to Lake Nong Han.

2. Data for Sakol Nakorn and Ban Srang Khor are records of gaging stations, and for Nam Gam gate and Lake Nong Hon the observations of the Department of Fisheries.

Fig - 1 Corelation Between Run-off Coefficient & Annual Precipitation

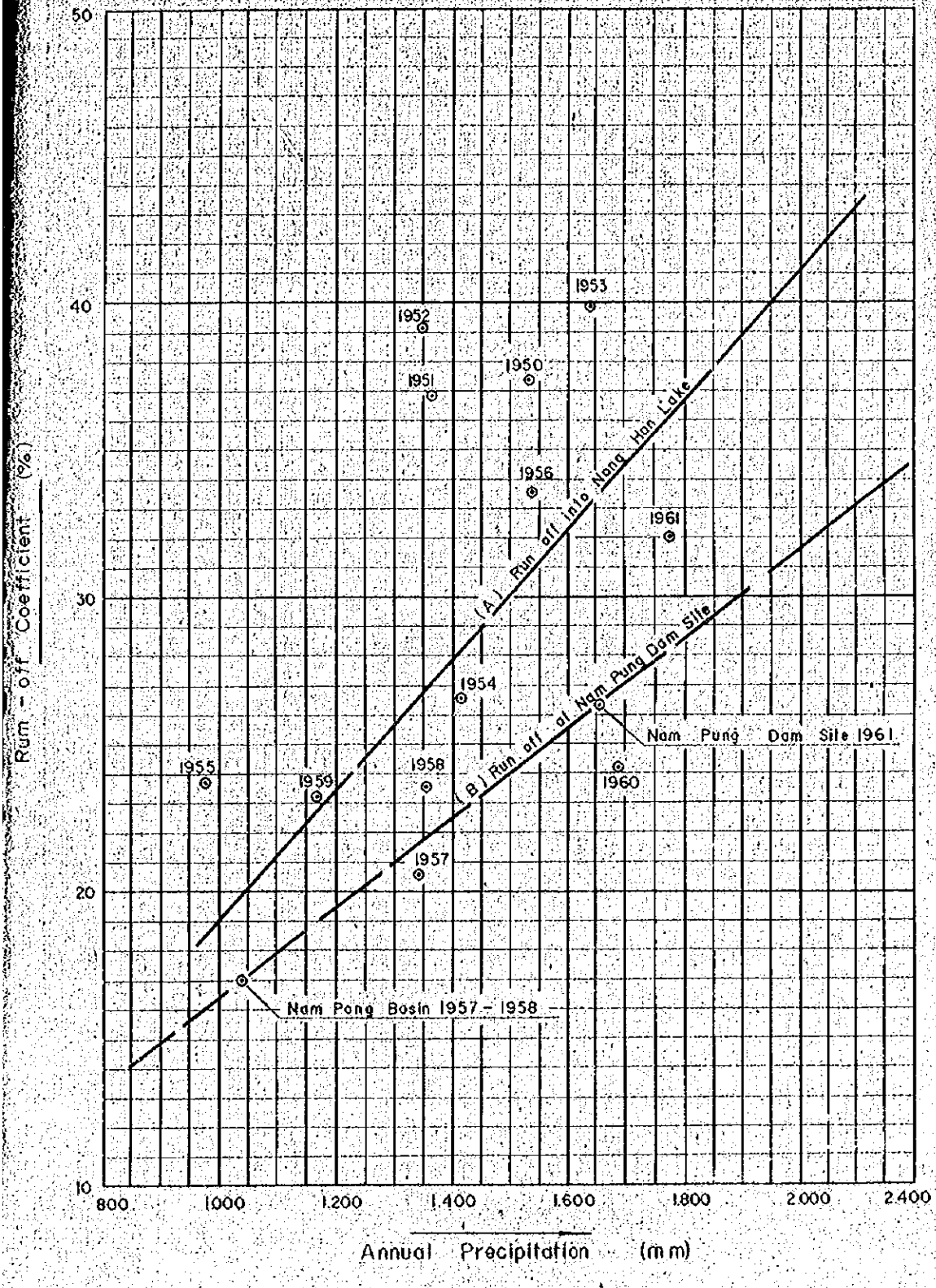
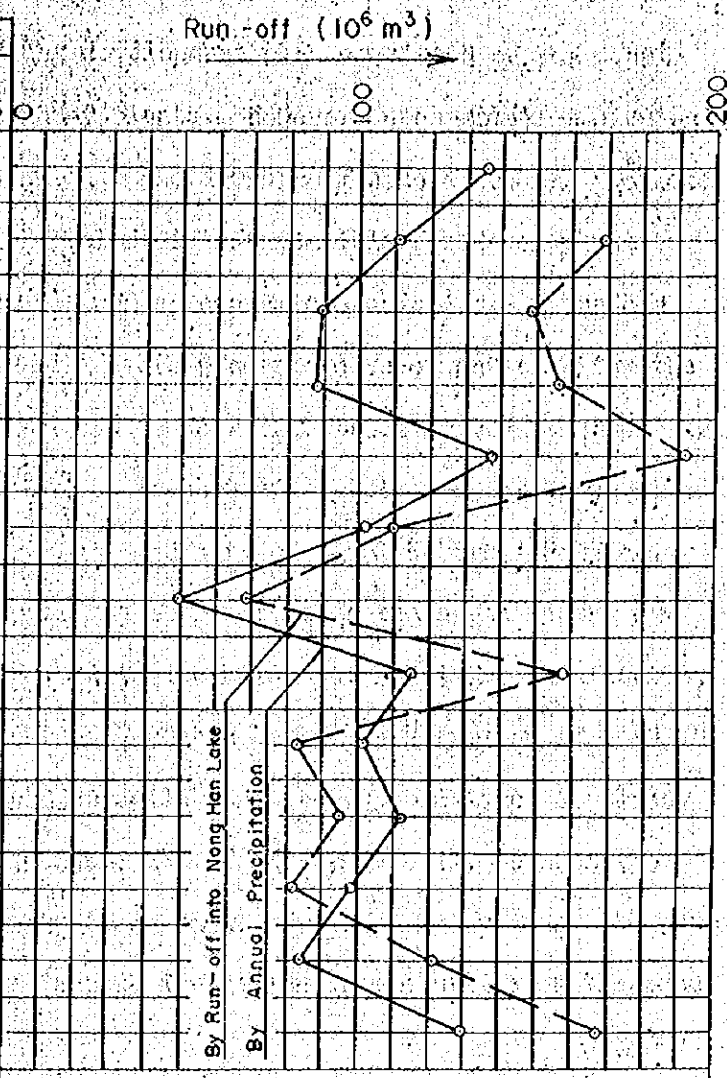


Fig-2 Annual Run-off at Nam Pug Dam site

Year	Run-off (10^6 m^3) By Annual Precipitation	Run-off (10^6 m^3) By Run-off into Nong Han Lake
1949	135.952	—
1950	111.207	169.490
1951	89.273	148.651
1952	86.964	155.903
1953	136.692	193.466
1954	101.912	110.586
1955	48.455	68.228
1956	114.700	151.759
1957	100.640	81.489
1958	110.763	94.513
1959	96.910	80.127
1960	82.968	120.886
1961	129.056	168.365
1950-1961 12 Years Total	100 % 1 209.540	127.6 % 1.543.463
1950-1961 8 Years Total	100 % 785.404	111.5 % 875.953



Remarks :

Annual Precipitation

1949 - 1956 Sakol Nakorn

1957 - 1961 Ban Srang Khor

b) Basic Principles

The integrated development of the Nam Gam basin consists basically of power generation, irrigation (including pump irrigation from Lake Nong Han) and flood control.

1) Electric Power

Originally the Nam Pung development plan consisted of the construction of 2 dams and 2 power plants. However, upon detailed studies in the field, it was found that the downstream site which was proposed for the No. 2 dam and power plant is not feasible for development because of the topography and from an economic standpoint. Therefore, this site was abandoned and a hydro-electric development plan for the upstream site only is being considered. Electricity produced from the Nam Pung Hydro-electric Project is tentatively planned for consumption in the district centered around the city of Sakol Nakorn. However, electricity from the project may be supplied to the areas in the Nam Gam basin and adjoining districts including the Sakol Nakorn district, That Phanom, Nakhon Phanom and Mukdahan by the construction of a 33 KV transmission line. The project will have the capability of supplying 5,400 KW of power and 15,000,000 KWH of energy annually to meet the general power demands in the aforementioned areas, as well as, the power required to operate pumps for the irrigation scheme utilizing the water in Lake Nong Han.

For these purposes the Nam Pung Project has been designed to have 3 sets of turbine-generators rated at 1,800 KW each for a maximum output of 5,400 KW. One of the units which will be operated to supply pump loads only will also be a reserve unit. The potential demand in those areas, however, are thought to be extremely large and the output of the Nam Pung Project which is 3,600 KW with 2 units in operation to supply general demands and 5,400 KW with 3 units in operation will eventually be not sufficient to meet the demands. Therefore, the inter-

connection with other hydro-electric plants should be considered as early as possible, and in the event that such interconnection is not accomplished in time, perhaps diesel power may have to be utilized.

2) Irrigation

The agriculture pattern in the proposed project area is the growing of 1 crop of rice in paddy fields during the wet season. The proposed development program envisages a year-round cultivation, in the wet and dry seasons, by providing appropriate irrigation to grow rice in paddy field and other field crops.

The development plan basically divides the irrigation project into paddy fields and fields. In the management of paddy fields, rice should be grown during the wet season, while in the dry season 1/3 of the paddy fields should be cultivated for rice, and of the remaining acreage 1/3 should be allocated to the raising of green manure and the balance left in farrow. The land should be utilized in this manner by rotating crops annually to nourish the soil.

Field cultivation which has a higher rate of yield than paddy fields can improve agricultural management by the application of fertilizers and providing irrigation water.

An additional benefit that this project aims to realize is the flood control of Lake Nong Han, described in 3) which follows, by installing drainage systems that are designed to prevent the flooding of the proposed irrigation districts, as well as, land under cultivation around Lake Nong Han and along the lower course of Nam Gam. This should stabilize and improve agricultural management in the basin areas.

3) Flood Control Project

Extensive areas around Lake Nong Han and along the lower course of Nam Gam are inundated every year during the wet season because of the inadequate drainage capacity of the Nam Gam river channel.

To prevent this inundation one method would be to improve the river channel to increase the discharge capacity along the course downstream of Nam Gam gate or the alternative method would be to divert water to the upper reaches of Huai Nam Un which is a tributary of the Nam Song Gram.

The first method which is to improve the river channel of Nam Gam would involve a tremendous volume of dredging and this remedial measure will not be able to completely prevent the inundation of land. The alternative method which is to divert the water in Lake Nong Han directly to the adjoining basin, Huai Nam Un a tributary of Nam Song Gram, was found to be more economical and possible to control the flood from Lake Nong Han. Therefore, the development plan is based on the alternative method which is described hereinafter.

III. First Phase Development Plan

The first phase development plan of the Nam Gam basin is the construction of a multi-purpose dam at Nam Pung. Electric power which is one of the benefits of the project is to be supplied to general consumers in the Nam Gam basin area and adjoining districts, as well as, to drive pumps to pump water from Lake Nong Han which combined with the discharge from Nam Pung dam can be utilized to irrigate an extensive area in the basin.

The Nam Gam which extends from Lake Nong Han to its confluence with the Mekong River is not capable of discharging flood flows and, consequently, each year during the wet season a wide area including that around Lake Nong Han is inundated. The construction of a multi-purpose dam at Nam Pung will not remedy the situation and a separate drainage work will be necessary. The drainage work of Lake Nong Han will not only have the merit of improving irrigation benefits but will make possible a higher utilization of arable land around the lake and along the lower course of the Nam Gam.

The Nam Pung dam, powerhouse, irrigation and Lake Nong Han drainage schemes are briefly described hereinafter.

a) Nam Pung dam

Approximately 35 km southwest of the city of Sakol Nakorn which is upstream of Nam Pung there are several rapids creating a head of about 60 m.

Immediately upstream of the rapids where rock is exposed is the site of the proposed dam which will be a fill type structure about 32 m high from foundation rock creating a reservoir 20 km^2 in pondage area at a high water level of 284 m. The storage capacity will be 122,000,000 m^3. With this dam, the storage of water necessary for the first phase development plan may be accomplished. The storage capacity has been calculated as follow:

The streamflow records at the Nam Pung dam site, as mentioned in Chapter II, paragraph (a), is available for the year 1961 only. Therefore, the annual run-off at the dam site was estimated based on the precipitation

records at Ban Srang Khor available for 5 years from 1957 to 1961 and Sakol Nakorn available for 13 years from 1949 to 1961.

Since streamflow records are available for the year 1961 only, the estimation of the outflow coefficient of the basin was made from recorded flow (1952 - 1958) of Nam Pong which, located in the same northeastern region, has climatically and topographically similar features of the Nam Pung basin. Line B of Figure 1 in Chapter II was drawn from estimates made by this method.

The streamflow estimated for 13 years are as follow:

Year	Estimated annual run-off in $10^6 m^3$
1949	135,952
1950	111,207
1951	89,273
1952	86,964
1953	136,692
1954	101,912
1955	48,455
1956	114,700
1957	100,640
1958	110,763
1959	96,910
1960	82,968
1961	129,056

It will be noted from the foregoing table that the least run-off for 5 consecutive years is the period 1951 to 1955 during which the total run-off is 463,296 million m^3 and the annual average is 92.7 million m^3. In order to equalize the run-off during those 5 years the estimated required storage capacity is 53.4 million m^3 and to equalize the annual run-off of 92.7 million m^3 the required storage capacity calculated separately is 58.6 m^3. Taking these values into account and the storage requirements of power for irrigation which is 16 million m^3 (pump irrigation from Lake Nong Han mainly during the dry season) as well as incremental loss from evaporation during the dry season (annual loss 1000 mm) the required storage capacity of the Nam Pung dam is estimated at 122 million m^3. Based on this required storage capacity the year to year high water and lower water levels were

computed from which the annual regulated available flow and the annual available energy production were calculated as shown in Table 3 which follows.

Table 3 Usable Regulated Flow and Electricity Production

Year	Estimated annual run-off ($10^6 m^3$)	Usable flow ($10^6 m^3$)	Mean effective head (m)	Energy production (10^3 Kwh)
1949	135.9	120.6	86.9	23,289
1950	111.2	95.9	86.9	18,519
1951	89.2	77.9	86.65	15,000
1952	86.9	78.6	86.25	15,065
1953	136.6	112.0	86.9	21,628
1954	101.9	86.6	86.9	16,723
1955	48.4	83.9	82.15	15,326
1956	114.7	80.7	85.0	15,243
1957	100.6	79.5	85.75	15,149
1958	110.7	80.8	86.9	15,604
1959	96.9	81.6	86.9	15,758
1960	82.9	78.7	86.15	15,066
1961	129.0	104.5	86.9	20,180

b) Power generation

The power generation scheme includes the construction of a headrace tunnel approximately 970 m long from the Nam Pung reservoir to the powerhouse which will utilize an effective head of 85.5 m (gross head 91.4 m) to produce a maximum of 5,400 KW (3 units of 1800 KW each - 1 unit to supply pump loads only is also a reserve unit) and generate 15,000,000 KWH of electric energy annually.

Electricity produced at the Nam Pung powerhouse may be transmitted at 33 KV to the Nam Gam basin area, Sakol Nakorn and adjoining districts of That Phanom, Nakhon Phanom and Mukudahan to supply general demands in those areas. 3,000 KW of firm peak power will available to supply 10,000,000 KWH of energy annually. In addition, approximately 5,000,000 KWH will be available to supply the load for pumps of the pump irrigation scheme of Lake Nong Han.

Detailed designs with cost estimates of the powerhouse, including transmission and distribution lines are under study. When the plans and other details of the irrigation scheme are complete, the entire project details will be included in the comprehensive report.

c) Irrigation

The irrigation project may be divided into the Nam Pung irrigation scheme and the Lake Nong Han pump irrigation scheme. The revised Nam Pung irrigation project includes the construction of a diversion weir in the vicinity of Nam Pung bridge to divert water released from Nam Pung reservoir (catchment area 296 km^2) and the natural flow of the Nam Pung downstream of the reservoir (catchment area 557 km^2), as well as, supplementing water from Lake Nong Han, as necessary, to irrigate approximately 10,000 ha of arable land on the south shore of Lake Nong Han (left bank of Nam Pung) and the right bank of Nam Gam (right bank of Nam Pung). The revised plan for the pump irrigation from Lake Nong Han includes the installation of a separate pumping station near Ban Tha Rae on the north shore of Lake Nong Han to

pump water from the lake to irrigate approximately 7,000 ha annually of arable land north of the lake.

1) Nam Pung irrigation scheme

The Nam Pung irrigation scheme consists of the irrigation of approximately 10,000 ha of arable land (8,060 ha on the left bank of Nam Pung and 1940 ha on the right bank) by the utilization of approximately 80 to 100 million m^3 annually of usable flow of a total run-off of 169 to 333 million m^3 which includes approximately 78 million m^3 discharged from Nam Pung dam and 91 to 255 million m^3 natural flow (mainly in the wet season) in the basin downstream of the dam.

At present, paddy field rice is cultivated on an extensive scale in this area. The total area under cultivation is about 9000 ha.

The Nam Pung irrigation scheme is to irrigate approximately 9,000 ha of paddy fields and 1,000 ha of field on the right bank of the river by supplying a maximum of 13.5 m^3/s of water, in the wet season, from the Nam Pung and partially supplemented with water pumped from Lake Nong Han. In the dry season approximately 7,000 ha of paddy fields and field are to be irrigated with a maximum of about 6.9 m^3/s of water which will be diverted from the Nam Pung and supplemented from Lake Nong Han.

The pumping station which is tentatively proposed near Ban Muang Lai on the south shore of Lake Nong Han will have pumps with a rated capacity of 1,000 KW capable of pumping of 6.8 m^3/s (maximum) under a maximum head of 8.2 m to supplement irrigation water during the dry season as well as the wet season.

The design of irrigation structures and crop rotation plans for field are now under study and will be included in the comprehensive report.

Pertinent data on the Nam Pung irrigation project are given in Table 4.

2) Lake Nong Han pump irrigation scheme

One of the salient features in the first phase development plan of the Nam Gam basin is the pump irrigation scheme of Lake Nong Han.

In the wet season, the surface area of Lake Nong Han expands by the rise of water level inundating an extensive area around the lake, and in the dry season the outflow from the lake coupled with evaporation losses creates a condition where fish life in the lake is endangered. To prevent this natural phenomenon the Nam Gam gate was installed in order to maintain a minimum water level of the lake during the dry season.

Taking into consideration the lake utilization program of Department of Fisheries of the Government of Thailand, the optimum utilization program of Lake Nong Han is believed to be as follows:

Maximum water level	EL 157.50 m (Lake surface area 127.8 km^2)
Minimum water level	EL 155.50 m (Lake surface area 69.6 km^2)
Gross storage capacity	265.4 million m^3
Effective storage capacity	195.9 million m^3
Effective drawdown	2 m

However, water that may be used for irrigation in the dry season after allowing evaporation losses estimated at 1,000 mm will be about 100,000,000 m^3.

The Nam Pung powerhouse, in view of the load to pump 100,000,000 m^3 of water for irrigation in the dry season, will be required to generato about 3,000,000 KWH additionally during that season in comparison with the average pump load in the wet season.

In consideration of the above requirements the storage capacity of Nam Pung dam has been designed to include a surcharge capacity (effective) of about 16,000,000 m^3.

On completion of the Nam Pung irrigation scheme and Lake Nong Han pump irrigation scheme, the required pump capacity will be 2,400 kw.

The amount of supplementary water, during the dry season, required in the Nam Pung irrigation district based on the run-off of the second driest year (1959) is estimated to be 25,000,000 m^3. The balance of the water (75,000,000 m^3) that may be pumped from Lake Nong Han could be used to irrigate 7,000 ha of land on the north shore of the lake. This area has been selected in view of the population density which is next to the Nam Pung irrigation district, the relatively developed means of communication, and the topography (relatively high elevation and dry land) which is particularly suitable for field crops.

Crop rotation plan for this area is now under study. Table 5 gives the general data of the irrigation plan.

The proposed irrigation area will extend on both sides of a canal to be constructed to drain flood waters of Lake Nong Han to Huai Nam Un which is a tributary of the Nam Song Gram.

Table 4 Nam Pung Irrigation Scheme

Intake water level EL 163.50 m

Irrigation area

	Paddy fields	Field	Total
Left bank	1,940 ha		1,940 ha
Right bank	7,060 ha	1,000 ha	8,060 ha
Total	9,000 ha	1,000 ha	10,000 ha

Note: In dry season paddy field - 3,000 ha and field - 4,000 ha of which 3,000 ha is second crop rice.

Maximum intake

Left bank	2.8 m^3/s
Right bank	10.7 m^3/s
Total	13.5 m^3/s

Main canal

Left bank	16 km
Right bank	37 km
Total	53 km

Pump installation

Diameter 1,200 mm Capacity: 1,000 KW in 2 units

Table 5 Lake Nong Han Pump Irrigation Scheme

Intake water level — Maximum 157.50 m

Minimum 155.50 m

Irrigation area - Wet season

	Paddy field	Field	Total
Left bank	2,000 ha	2,000 ha	4,000 ha
Right bank	1,000 ha	2,000 ha	3,000 ha
Total	3,000 ha	4,000 ha	7,000 ha

Dry season

	Paddy field	Field	Total
Left bank	600 ha	2,800 ha (includes 800 ha second crop rice)	3,400 ha
Right bank	300 ha	2,400 ha (includes 400 ha second crop rice)	2,700 ha
Total	900 ha	5,200 ha	6,100 ha

Maximum intake

Left bank	5.03 m^3/s
Right bank	3.48 "
Total	8.51 "

Main canal

Left bank	23 km
Right bank	33 km
Total	56 km

Pump installations

	Head	Diameter	No. of Unit	Total Capacity
Left bank	10.5 m	850 mm	3	970 KW
Right bank	7.0 m	700 mm	3	450 KW

d) Lake Nong Han flood control

Extensive areas around the shore of Lake Nong Han and along the banks in the lower course of the Nam Gam are inundated during the wet season each year because of the inadequate discharge capacity of the river channel.

As a result of analytical studies of 13 years water level fluctuation records on the upstream and downstream of Nam Gam gate, it was found that the required discharge capacity of the Nam Gam would be as shown in the table which follows and that in order to provide a discharge capacity of 180 m^3/s at a design maximum lake level of 157.5 m, a tremendous volume of work will be involved to improve the river channel in the lower course which alone would be not possible to prevent inundation of land in the Nam Gam basin.

Water level of Lake Nong Han	Water level at Nam Gam gate	Difference in water level between upstream and downstream of gate	Discharge capacity
Recorded maximum water level			
EL 158.72 m	EL 158.27 m	0.23 m	152.8 m^3/s
Design full water level			
EL 157.50 m	EL 156.65 m	0.11 m	54.1 m^3/s
Normal water level in wet season			
EL 156.50 m	EL 155.55 m	0.09 m	23.2 m^3/s

Therefore, instead of releasing wet season run-off from Lake Nong Han to the Nam Gam, the diversion of water by constructing a canal about 7.3 km long, which will create a head of almost 11.5 m, to the Huai Nam Un a tributary of the Nam Song Gram would be more economical. When the Thaknek dam is constructed on the main Mekong in the future, the backwater of the dam is designed to reach up to EL 145.0 m in the Huai Nam Un. At present, during the flood season of the Main Mekong, the Huai Nam Un is affected and flood water reaches EL 144.0 m creating an extensive reach of low marshland which is left unattended. Water to be diverted from Lake Nong Han

will be discharged immediately upstream of this marshland and, therefore, the drainage of areas around Lake Nong Han and along the Nam Gam basin which were inundated in the wet seasons will become possible without causing harmful effect to the Nam Song Gram basin.

Some data of this drainage scheme are given below.

Structure of drainage canal	Discharge capacity with gates open full
Maximum water level in dry season EL 157.5 m	180 m^3/s
Normal water level in wet season EL 156.5 m	110 m^3/s
Water level during abnormal run-off (probability) EL 158.0 m	220 m^3/s
Controllable flood flow	180,600,000 m^3 (EL 156.5 m to EL 158.0 m)
Length of canal	7.3 km
Base width of canal	30.0 m
Depth of canal (at maximum water level)	4.0 m
Gates - 4 sluice gates each 6.0 m high and 4.5 m wide	

Past recorded maximum flood water level is EL 158.72 m. With the installation of the drainage canal, the water level of Lake Nong Han can be maintained at a maximum of 157.5 m during the dry season and at a normal level of 156.5 m during the wet season, and consequently, in the area around Lake Nong Han alone about 2,980 ha of land can be prevented from being inundated.

The duration in days by years of inundation at a water level of 157.5 m and over 156.5 m, which is obtained from the 13 years observation records, are shown in Table 6.

The estimated costs of the drainage scheme and its benefits are under study and these will be included in the comprehensive report.

Table 6

Year	Maximum water level (m)	Over 157.5 m		Over 156.5 m	
		Duration in days	Area inundated (ha)	Duration in days	Area inundated (ha)
1949	158.72	47	3,820	91	6,800
1950	157.83	38	970	150	3,950
1951	157.67	11	520	157	3,500
1952	157.95	41	1,420	139	4,400
1953	158.07	30	1,720	155	4,700
1954	157.84	18	1,020	104	4,000
1955	156.89	-	-	126	1,200
1956	158.28	54	2,420	144	5,400
1957	157.07	-	-	125	1,700
1958	157.45	-	-	98	2,800
1959	157.19	-	-	43	2,100
1960	157.93	20	1,320	135	4,300
1961	158.26	39	2,320	147	5,300
Total		298	15,530	1,614	50,150
Average		23	1,195 ha	124	3,858 ha
Maximum		54	3,820 ha	157	6,800 ha

IV. Future Studies and Investigations

Based on the results of investigation conducted in October 1961 (wet season) and December 1961 to March 1962 (dry season), the Team was able to prepare the first phase development plan, comprising principally of the construction of Nam Pung multi-purpose dam, for the integrated development of the Nam Gam basin.

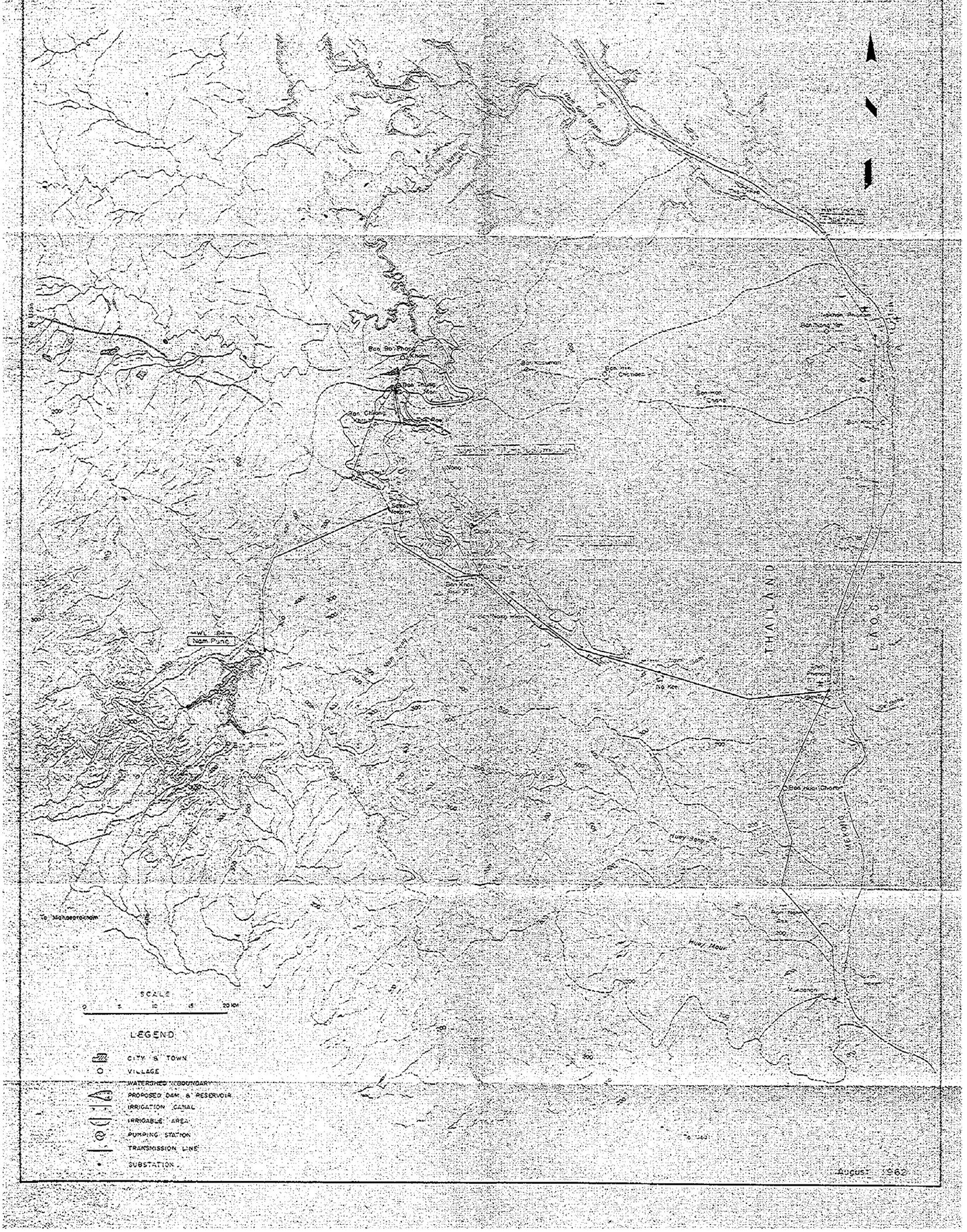
The field studies during the dry season were mainly surveying, exploratory drilling and gathering data which were essential for the formulation of a development plan. With the size and scale of the project taking shape, it was found that supplemental field studies are necessary in order to prepare construction plans and cost estimates. Therefore, the Team, after submission of this Interim Report, will meet with officials of the Government of Thailand to discuss several matters related to the design of the project, as well as, conducting the supplemental field studies.

The final development plan for the Nam Gam basin, that is, studies of future development possibilities will be continued. If low cost hydroelectric power is developed in the basin, there are great possibilities of expanding irrigation projects in the basin areas by diverting water from the main Mekong river.

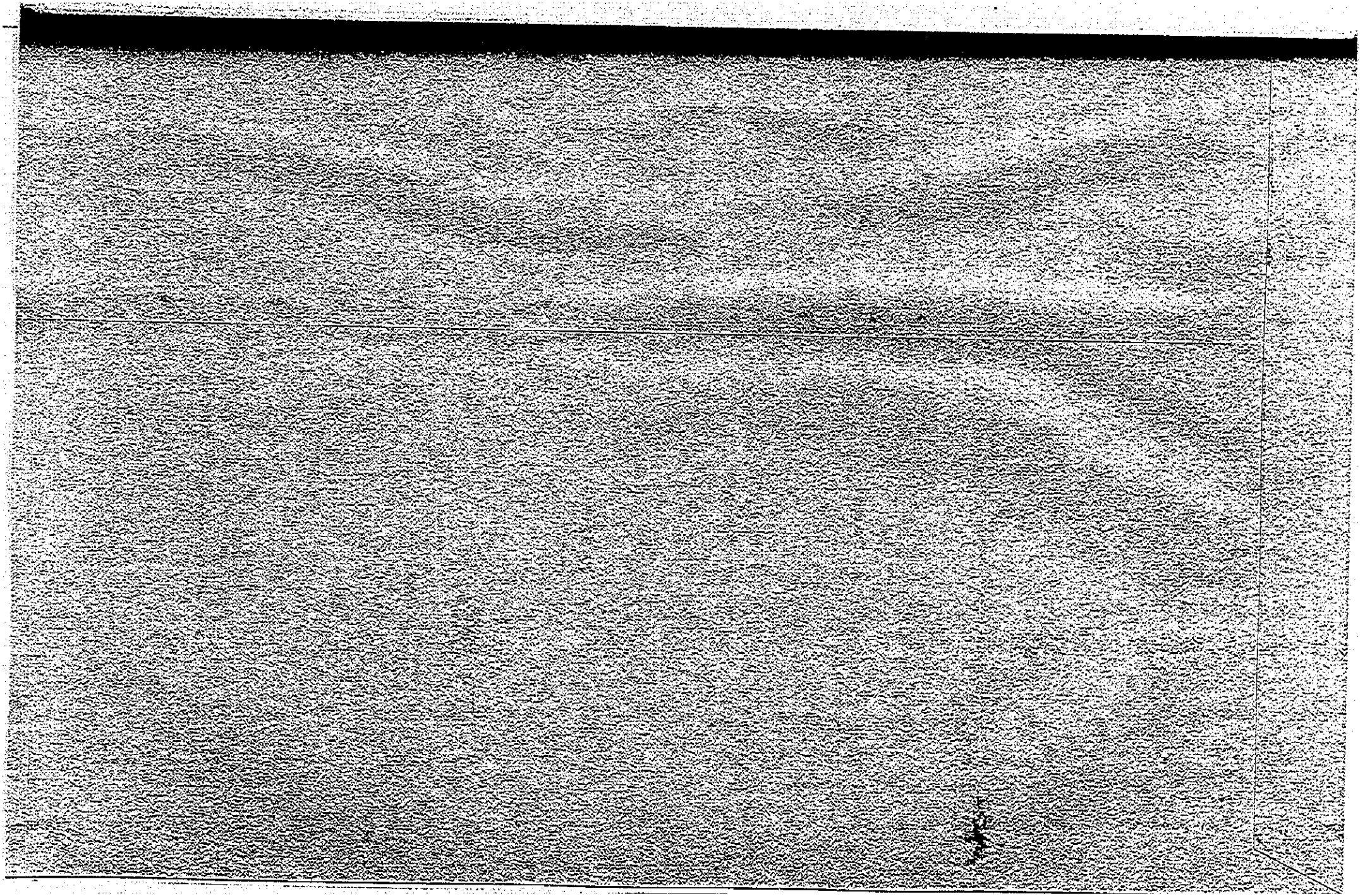
Studies of these projects, we believe, would give an indication to the nature of studies for the development of the basin after the Nam Pung Project is started, and also would be of some information in the pursuance of the development of the Lower Mekong River. Therefore, the results of our studies will be incorporated in the Comprehensive Report.

GENERAL MAP OF NAM GAM BASIN

GENERAL MAP OF NAM GAM BASIN



August 1962



APPENDIX

PRELIMINARY DESIGN (DRAFT) OF NAM PUNG HYDRO-ELECTRIC PROJECT

C O N T E N T S

A. General Description

The Nam Gam, a relatively small tributary of the Mekong River, flows through the north eastern part of Thailand. It has a catchment area of about 3,440 km^2. The site for the Nam Pung Project has been selected at Nam Pung, on the tributary of Nam Gam, 30 km south west from Sakol Nakorn which is the central city of the area. Upstream of Nam Pung, there are several falls creating a developable head of approximately 60 m. The project consists of the construction of a fill-type dam, about 32 m in height, on exposed bed rock immediately upstream of the falls to store the run-off from its catchment area of 296 km^2 in a reservoir which will have effective storage capacity of 122 million m^3. With this reservoir it will be possible to regulate the annual run-off which may be released to supplement run-off in dry years and to utilize it for the generation of electricity and irrigation. About 50% of the stored water (effective capacity) will be discharged during the dry season.

The geological formation of the dam site consists mainly of sandstone and partially with alternate layers of conglomerate and slate. In consideration of this geology which is by no means sound and of the difficulty to obtain aggregates for concrete in the vicinity of the site, a fill-type dam which the geology of the site will sustain would be more suitable.

In the following pages are given the general description of the Nam Pung project. It should be pointed out that run-off on which this project has been planned was estimated from precipitation recorded for 13 years since run-off data available was that of the year 1961 only. Therefore, on re-examination of data, it is probable that modifications of the project may become necessary in the future.

The Nam Pong project consists of a rockfill dam 32 m high, with a total embankment of 744,000 m^3, creating a reservoir capable of storing 122,000,000 m^3 of water which will regulate several years of annual run-off of the river. Water in the reservoir will be conducted to a site approximately 1 km down-

stream of the dam where a power station with a maximum output of 5,400 kw is to be built.

High water level	EL 284 m
Tailrace level	EL 192.6 m
Gross head	91.4 m
Effective head	85.6 m
Maximum discharge of turbines	8.5 m^3/s
Installed capacity	5,400 kw
Annual output	15,000,000 KWH

The dam will be equipped with a spillway having a capacity of 300 m^3/s and an outlet to lower the water level to below EL 270 m. An intake tower of reinforced concrete structure, 22.5 m in height, with a roller gate 2.5 m high and 3.0 m wide, will be constructed on the right bank immediately upstream of the dam. Water taken in by the tower will be guided through a 450 m long pressure conduit which will connect to a 122 m long pressure tunnel that will terminate at a simple surge tank, 6 m in diameter and 34 m in height. Connection from the surge tank to the power station will be by a penstock, 2 m in diameter which will taper down to 1.5 m.

B. Reservoir

Catchment area	296 km^2
Gross storage	133 x 10^6 m^3
Available drawdown	14 m
Effective storage	122 x 10^6 m^3
Reservoir area	20 km^2
High water level	EL 284 m
Low water level	EL 270 m

The operation of the reservoir, as a principle, in normal run-off years, will be to store run-off in the rainy season of June to October, fill

the reservoir by the end of October and discharge water in the dry season of November to June to supplement natural run-off. In dry years, the reservoir may not fill up to capacity, but a reserve in the storage volume has been included which will be possible to carry over the year water that may be released to supplement natural run-off.

C. Description of structures

(1) Dam

Type	center core type rock-fill dam
Height	32 m
Crest length	1,719 m
Crest width	7.5 m
Elevation of dam crest	EL 286.5 m
Total embankment	744,000 m^3

The dam will comprise of downstream rockfill, downstream filter, impervious clay core, upstream filter and upstream rockfill zones. The stability of the dam against sliding and the slopes against fluctuation of water level, as well as, to maintain a high impermiability are duly considered in the design of the structure. At the foundation of the impervious clay core, a concrete pat will be placed to facilitate foundation grouting and to prevent percolation of water from the foundation rock.

(2) Spillway

Type	chute spillway		
Width of chute	20 m		
Length of chute	195 m		
Elevation of flood water level	EL 285.5 m		
Capacity	300 m^3/s		
Gate	2 - sluice gates	Height	3.0 m
		Width	6,0 m

A combination overflow weir and a gate controlled chute type spillway is to be constructed near the left abutment utilizing a saddle. (Center 154 m from abutment.) The overflow weir section will be 30 m wide and the crest 284 m above sea level. The gate controlled section will have 2 sluice gates, each 3 m high and 6 m wide. With the gates open full, the spillway will have a capacity of 300 m^3/s at an overflow elevation of 285.5 m.

The assumed probable maximum flood flow (probability 1,000 years) of 640 m^3/s can be reduced to 300 m^3/s by a surcharge of 1.5 m included in the structure.

(3) Outlet

Type		pressure conduit outlet
Dimensions	Height	2.5 m
	Width	2.0 m
Length		190 m
Capacity		max. 5 m^3/s
Gate		1 slide gate 1 m dia. and 1 Howell-Bunger valve

During construction a reinforced concrete culvert will be constructed along the center the river bed to by-pass water. This culvert will latter be remodeled into a permanent outlet which will connect at the downstream end to a valve chamber that will be equipped with a slide gate and a Howell-Bunger valve.

(4) Intake

Type		concrete tower intake
Width		7.0 m
Height		22.5 m
Gate	Roller gate	1
	Height	2.5 m
	Width	3.0 m

An intake tower, EL 286.5 m at the top and EL 264 m at the foundation, will be constructed on the right bank immediately upstream of the dam. The front of the intake will be excavated to allow the uninterrupted inflow of water. A bridge will be erected from the dam crest to the top of the intake tower to permit access to the intake.

The intake will be a bell mouth type, 2.0 m inner diameter and the center is at elevation 265 m. The capacity of the intake will be 8.5 m^3/s. A roller gate 2.5 m high and 3.0 m wide will be installed in the intake.

(5) Pressure conduit and pressure tunnel

Type		horseshoe shape
Inner diameter		2.0 m
Length	pressure conduit	450 m
	pressure tunnel	122 m

The intake tower will be connected to a pressure conduit of horseshoe type 450 m long which will connect to a pressure tunnel 122 m long that will terminate at a surge tank.

(6) Surge Tank

Type	simple surge tank
Inner diameter	6.0 m
Height	34 m

A simple surge tank of reinforced concrete structure, 6.0 m inner diameter and 34 m high, will be constructed at a site 572 m from the intake tower to absorb surges resulting from sudden loads and shut-down of the power station.

(7) Penstock

Tunnel section

Inner diameter	2 m
Length	242 m

Steel penstock

Inner diameter	2 m tapering to 1.5 m from where it will bifurcate into 3 pipes that will taper down to 0.8 m.
Length	173 m

The penstock which will consist of a reinforced concrete lined tunnel section and partially of welded steel pipe, 40 m in length, will connect to a steel penstock.

(8) Powerhouse

Width	9 m
Length	17.2 m
Turbine	
Type	horizontal shaft Francos turbine
Number of units	3
Maximum capacity	1,950 KW each
Speed	750 r.p.m.
Generator	
Type	horizontal shaft 3-phase synchronous generator
Number of units	3
Frequency	50 cycles
Capacity	2,200 KVA each
Voltage	3.3 KV
speed	750 r.p.m.
Transformer	
Type	3-phase oil immersed self-cooled type with inert air sealed
Capacity	2,200 KVA each
Number of units	3
Voltage primary	3.3 KV
secondary	33.0 KV

The powerhouse will have three units of turbine-generators which will have a combined maximum capacity of 5,400 KW. The step-up transformers will be installed outdoor on the south side of the powerhouse. The third unit which is to be operated to supply pump loads only will also be a reserve unit. Water discharged from the draft tubes will be released through a 22.6 m long gravity flow tunnel 2.2 m high and 2.5 m wide into the natural bed of the Nam Pung. The river channel of the Num Pung will require improvement for a distance of about 400 m to permit the discharge of run-off at the prescribed water level.

(9) Transmission line

With a 33 KV transmission line, in consideration of the transmission distance from the power station to the centers of load and the output of the plant, the economic distance of transmission that is technically possible is up to Sakol Nakhon. However, in view of the strong desire of the Government of Thailand, a transmission system, as shown in the attached drawing "General Map of Num Gam Basin", has been designed to supply power to as many consumers as possible. With a voltage of 33 KV, however, satisfactory operation may not be possible, depending on the type of load, without the installation at the end of the line special equipment, such as, static condenser.

a) Conductor

In the selection of the conductor for the line, economic factors, the load to be carried, mechanical strength, etc., were studied and from these considerations it was concluded that a 90 sq. l AL (7/4.0) cable would be suitable.

b) Supports

Since the transmission line will cross mostly flat country where load from wind pressure is rather low, creosote-injected wood poles which can be obtained locally have been selected. Suspension type

insulators with 3 - 250 mm discs to a string are believed to be suitable.

c) Other facilities

A communication system will be necessary for the maintenance and operation of the power facilities. The type of communication which will be either cable, power line carrier or wireless shall be determined after further studies taking into consideration the special features of the country.

(10) Transformers

Transformers to step-down electricity from 33 KV to 6 KV will be installed at the sub-stations listed below.

Sub-station	Installed capacity	Remarks
Sakol Nakhon	350 KVA x 7 units	One reserve unit included.
Nakae	200 KVA x 1 unit	3 ϕ
Nakhon Phanon	350 KVA x 3 units	
That Phanon	350 KVA x 3 units	One reserve unit included.
Mukudahan	350 KVA x 2 units	
Nam Pung Bridge site	350 KVA x 3 units	

The salient characteristics of the facilities are as follows:

a) Adoption of single phase transformers

Although outage ratio of a transformer is very low nowadays, in view of their location which are the remote areas in the north eastern territory, single phase units were deliberately adopted in contemplation of difficulties that may be encountered in the event of outage. The transformers are of uniform capacity to provide interchangeability and two spare units will be provided for the system.

b) Installation of static condensers

The distance between the power station and the terminal of the