RESTRICTED
OP-32 F-5

Auth: DCI
18/8/47
wm

WDC

WASHINGTON DOCUMENT CENTER

TRANSLATION

Number 27 29 Aug 1946

VOLUME I

File Copy

ISSUED UNDER THE JOINT AUSPICES OF
THE INTELLIGENCE DIVISION, W D G S
AND
OFFICE OF NAVAL INTELLIGENCE, U.S. NAVY DEPARTMENT

RESTRICTED

WARNING

This document contains information affecting the national defense of the United States within the meaning of the Espionage Act, 50 U.S.C., 31 and 32, as amended. Its transmission or the revelation of its contents in any manner to any foreign agencies or other unauthorized person is prohibited by law. Reproduction of the intelligence in this publication is prohibited without special authority from the Director of Intelligence, WDGS, War Department.

A-2

25 91559

COMPLETE TRANSLATION

A JAPANESE PLAN FOR HYDROELECTRIC DEVELOPMENT OF THE YELLOW RIVER IN CHINA

Far Eastern Research Section
Survey Committee No 2
North China Committee
Subcommittee No 4
May 1941

Note: This report comprises translations of four documents as follows:

1. Document 252519 is the basic report containing the plan for the hydroelectric development of the Yellow River. It was issued by the Far Eastern Research Section in May 1941 and is made up of 10 parts.

2. Document 252533 is a revision of Part 1 of the basic report issued by the North China Electric Works in August 1941. The corrections, amendments and revisions contained in this document have been incorporated in Part 1 of this report wherever applicable.

3. Document 252536 is a further revision of other parts of the basic report issued by the Far Eastern Research Section in August 1941. The corrections, amendments and revisions contained in this document have been incorporated in the report wherever applicable.

4. Document 252528 is an addendum to the basic report issued by the Far Eastern Research Section in May 1941. It contains four sets of tables and graphs giving a detailed analysis of the flow of the Yellow River at Shan.

A table of contents for the entire report is given on the page immediately following.

TABLE OF CONTENTS

RESTRICTED

WASHINGTON DOCUMENT CENTER

TRANSLATION

Number 27 29 Aug 1946

A JAPANESE PLAN FOR HYDROELECTRIC DEVELOPMENT OF THE YELLOW RIVER IN CHINA

VOLUME I
(Parts 1 - 5)

ISSUED UNDER THE JOINT AUSPICES
OF
THE INTELLIGENCE DIVISION, W D G S
AND
OFFICE OF NAVAL INTELLIGENCE, U.S. NAVY DEPARTMENT

Distribution List

Hq AAF	2
White House	5
OCE	2
BJSM	5
CAS	3
ID	6
OP-32 F	1
OP-32 F-14	1
OP-32 F-2	1
OP-32 Y-1	1
OP-32 Y-2	1
OP-20-2 (via OP-32 Y-1)	1
COMNAVCHINA	1
CINCPAC	1
COMSEVENTHFLEET	2
Total	33

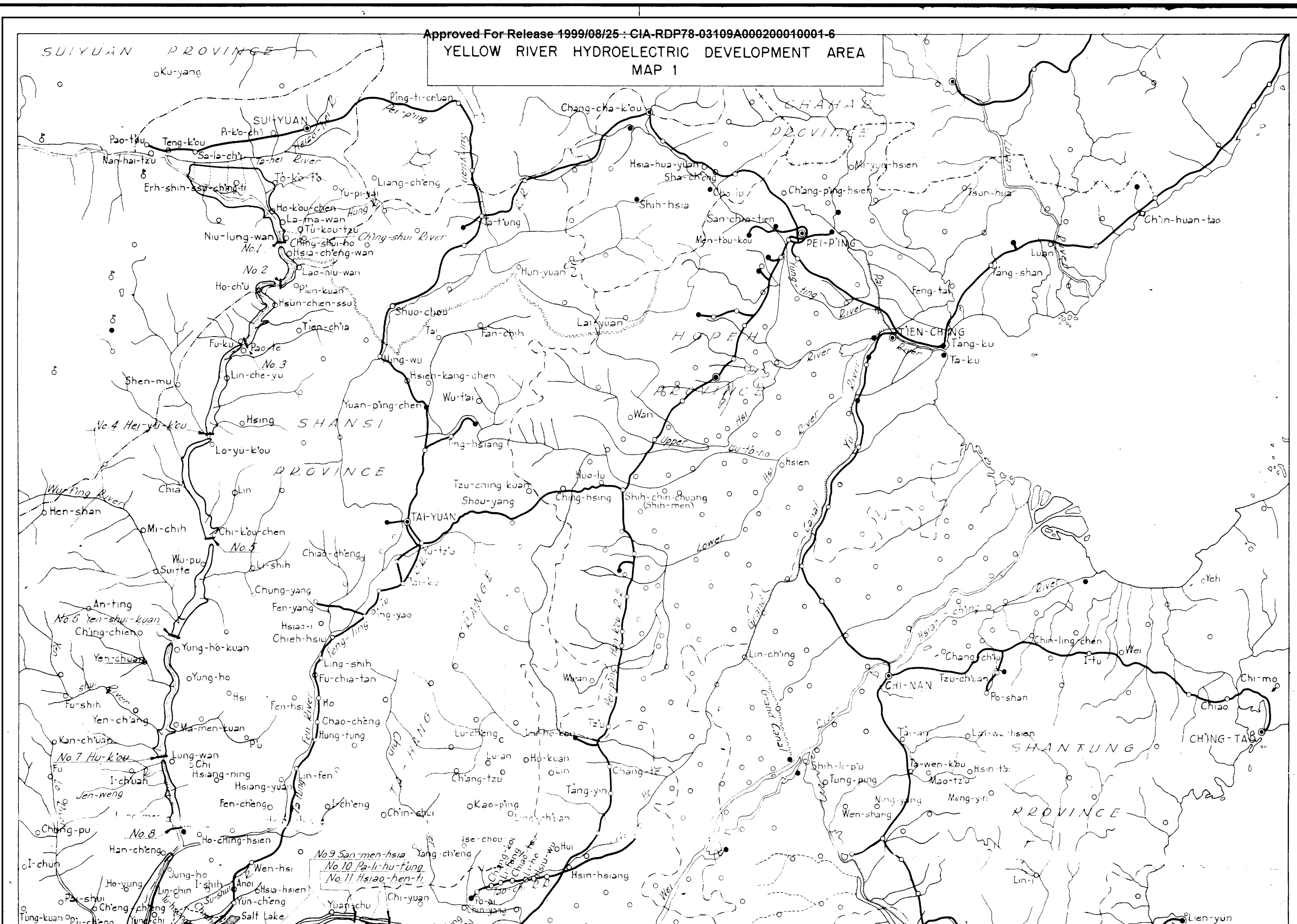
PREFACE

This is a report on a plan for the hydroelectric development of the Yellow River in North China, and the use of the power thus produced by electrochemical and similiar industries. The report includes data on the area's subsurface resources, industrially usable water, etc.

The hydroelectric developments have been designed to contribute to river control and to activities which depend on water, excluding water transporation. If inclusion of the latter should be deemed necessary, the present plan will require revision to increase the heights of the dams, etc., but the parts dealing with the generation of electricity will not be affected. It was felt that the production of electricity is fundamental to the utilization of the water of the Yellow River. When its problems are solved, all other problems will solve themselves.

MEN WHO PARTICIPATED IN THE SURVEY

Chairman	OCHIAI Kaneyuki	North China Electrical Industries Co Ltd
Secretary	AKIYAMA Masao	"
Members	OTA Asakura	"
	MORITA Fukuichi	"
	ISAWA Kimisachi	South Manchurian Railway, North China Economic Research Dept
	ISHIKAWA Nagatoshi	"
	TAKEYAMA Toshio	"
	SAKAGUCHI Tadashi	"
	HORIUCHI Kazuo	"
	ARAI Yuzuru	"
	ORAI Saburo	East Asia Development Co
	ARISAKA Masayoshi	Main Construction Office
	YANO Katsumasa	"
	AKIGUSA Isao	"
	HARAGUCHI Yoshimasa	North China Development Co Ltd
Special Member	OCHIAI Kushiro	North China Electrical Industries Co Ltd



YELLOW RIVER HYDROELECTRIC DEVELOPMENT AREA
MAP 1
SUIYUAN PROVINCE
Ku-yang
SUI-YUAN
Pao-t'ou
Teng-k'ou
Nan-hai-tzu
Sa-la-ch'i
Ta-hei River
To-k'o-to
Erh-shih-ssu-ch'ing-ti
Liang-ch'eng
Yu-pi-yai
Ho-k'ou-chen
La-ma-wan
Niu-lung-wan
No. 1
Ch'ing-shui-ho
Hsia-ch'eng-wan
Ch'ing-shui River
No. 2
Lao-niu-wan
Ho-ch'u
Hsün-chien-ssu
Tien-ch'ia
Fu-ku
Pao-te
No. 3
Lin-che-yu
Shen-mu
No. 4 Hei-yü-k'ou
Hsing
Lo-yü-k'ou
SHANSI
PROVINCE
Wu-ting River
Hen-shan
Chia
Lin
Mi-chih
Chi-k'ou-chen
No. 5
Wu-pu
Suite
An-ting
No. 6 Yen-shui-kuan
Ch'ing-chien
Yung-ho-kuan
Yung-ho
Fu-shih
Yen-ch'ang
Ma-men-kuan
Kan-ch'üan
No. 7 Hu-k'ou
Lung-wan
I-ch'uan
Chi
Hsiang-ning
Fen-ch'eng
No. 8
Ho-ch'ing-hsien
Han-ch'eng
Ch'eng-pu
I-chün
Wen-hsi
Pai-shui
Salt Lake
Yun-ch'eng
Ch'eng-ch'eng
Pu-ch'eng
Ta-li
Fu-p'ing
T'ung-kuan
Hua-yin
Wen-hsiang
Ling-pao
Wei-nan
Lin-t'ung
Shan
Lo-ning
Lo-nan
Lu-shih
HONAN PROVINCE
No. 9 San-men-hsia
No. 10 Pa-li-hu-t'ung
No. 11 Hsiao-hen-ti
Yuan-chu
Chi-yuan
Hsin-an
Meng-chin
Mien-ch'ih
Wu-chia-chai
Hsin-cheng
KAI-FENG
Cheng-chou
Lung-hai R.R.
Hsü-chou
Hai-chou
Lien-yun
Ch'ang-ch'eng
P'ing-ti-ch'uan
Chang-chia-k'ou
CHAHAR PROVINCE
Hsia-hua-yuan
Sha-ch'eng
Ch'ang-p'ing-hsien
Mi-yun-hsien
Shih-hsia
San-chia-tien
Men-t'ou-kou
PEI-P'ING
Ta-t'ung
Hun-yuan
Shuo-chou
Lai-yuan
Tai
Fan-chih
Ning-wu
Hsien-kang-chen
Wu-t'ai
Yuan-p'ing-chen
Ting-hsiang
HOPEH PROVINCE
Wan
Tzu-ching-kuan
Shou-yang
Huo-lu
Ching-hsing
Shih-chia-chuang (Shih-men)
TAI-YUAN
Yu-tz'u
Chiao-ch'eng
Chung-yang
Fen-yang
P'ing-yao
Chieh-hsiu
Ling-shih
Fu-chia-tan
Chao-ch'eng
Hung-t'ung
Lin-fen
Ch'ang-tzu
Ho-kuan
Kao-p'ing
Chin-ch'eng
Hsin-hsiang
Chang-te
T'ang-yin
Fen River
Feng-ling-tu
Tien-ching
Tang-ku
Ta-ku
Feng-tai
T'ang-shan
Luan
Ch'in-huan-tao
Tsun-hua
Yung-ting River
Pai River
Upper Hu-t'o-ho
Lower
Hsien
Grand Canal
Lin-ch'ing
CHI-NAN
Tzu-ch'uan
Po-shan
Chin-ling-chen
I-tu
Wei
Chi-mo
Chiao
CH'ING-TAO
Yeh
Hsiao-ch'ing River
SHANTUNG PROVINCE
T'ai-an
Ta-wen-k'ou
Hsin-t'ai
Mao-tzu
Meng-yin
Tung-p'ing
Wen-shang
Lin-i
Shih-li-p'u
Ning-yang
Scale 1 2,000,000
50 0 50 100 150 200 250 Kilometers

A JAPANESE PLAN FOR HYDROELECTRIC DEVELOPMENT OF THE YELLOW RIVER IN CHINA

Far Eastern Research Section
Survey Committee No 2
North China Committee
Subcommittee No 4
May 1941

VOLUME I

TABLE OF CONTENTS

S U M M A R Y O F C O N T E N T S

A Japanese Plan for Hydroelectric Development of the Yellow River in China
(WDC Doc 252519, -33, -36, -28)

This is a translation of four documents prepared by the Japanese Far Eastern Research Section in 1941. They constitute a broad survey of the possibilities of hydroelectric development of the Yellow River in China, indicating eleven sites where power generating stations might be advantageously constructed.

The translations are published in three volumes. The basic document, WDC No 252519, containing ten parts, has been divided. Parts 1 - 5 are in Volume I, and Parts 6 - 10 are in Volume II. Two documents, WDC 252533 and 252536 include revisions and corrections of material contained in the basic report, 252519. The material from them has been incorporated in the main body of the report, wherever applicable, rather than being presented as separate translations. Volume III contains the complete translation of WDC 252528, which constitutes an addendum to the basic report and gives a detailed study, in graphs and tables, of the flow of the Yellow River at Shan.

The basic document deals with such topics as a basic survey, plans for the generation of electricity, economic factors, relation of the hydroelectric development plan to flood control and water conservation, industrial potentialities of the Yellow River, geology and subsurface resources of the Yellow River basin, the trend of supply and demand for electric power, plans for extensive industrial development, and plans for the hydroelectric site at the San-Men Gorge. These are supplemented with numerous tables, graphs and maps, including a large map of the entire area under study and detailed maps of the eleven projected hydroelectric development sites.

These are from a series of documents on economic and industrial subjects which were acquired by a US government mission to Japan and China in the Fall of 1945, and which are being translated by WDC.

Pages 1 through 136

RESTRICTED

A JAPANESE PLAN FOR HYDROELECTRIC DEVELOPMENT OF THE YELLOW RIVER IN CHINA

Far Eastern Research Section
Survey Committee No. 2
North China Committee
Subcommittee No 4
May 1941

PART 1 INTRODUCTION

TABLE OF CONTENTS

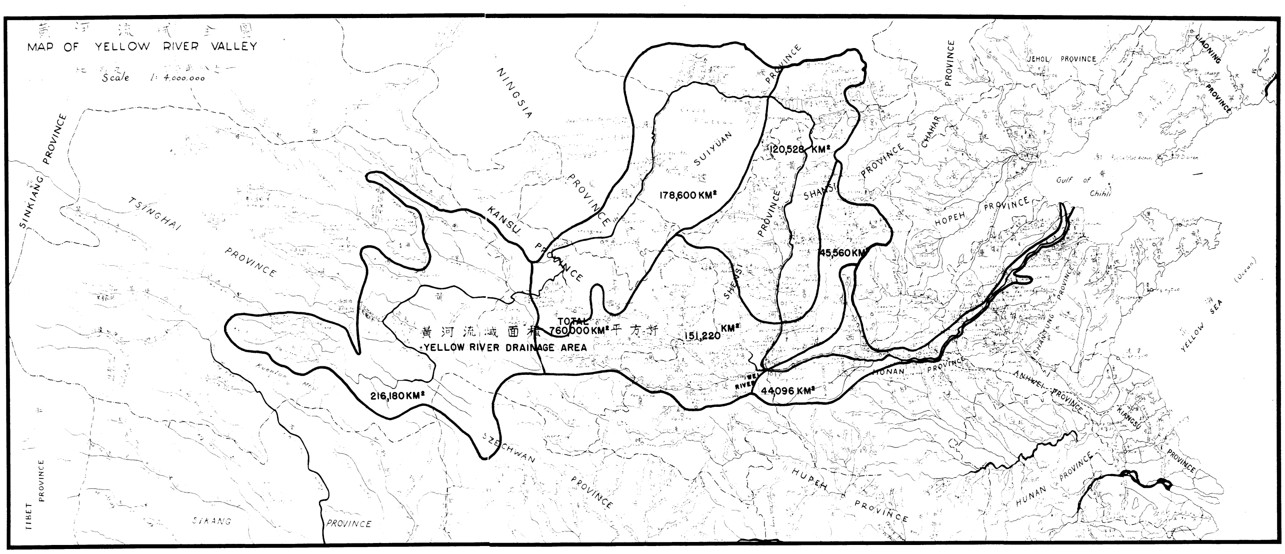
RESTRICTED

I Potential Water Power

Although in ancient times the Yellow River was known only as the River of Sorrow, it was said that he who controls this river has control of the country. Its tremendous potential value has become evident with the development of modern engineering. East Asia, facing the modern world situation, cannot afford to overlook this natural resource. Although the present investigation was limited to those parts of the river which were believed to be valuable for water power, it disclosed eleven sites for hydroelectric power plants in the approximately 1000-kilometer stretch between Pao-t'ou and Meng-chin. This stretch could produce more than eight million kilowatts per day (at 60 per cent load factor) and in an average year supply over 40,000,000,000 kilowatt-hours of electric power, as is shown in the table on the following page.

Approved For Release 1999/08/25 : CIA-RDP78-03109A000200010001-6

NOTE
RED LINE INDICATES BOUNDARIES OF THE SEVERAL DRAINAGE AREAS



6A

Potential Hydroelectric Power of the Yellow River

(If the San-men Gorge and Ch'ing-shui-ho Dams are completed)

Note: Refer to Map No I at start of publication. Hsiao-hen-ti also appears in the document as Hsiao-lang-ti

No	Location	Maximum			Average			Annual Electric Power Output (million kw-hr)
		Volume of Usable Water (cu m/sec)	Effective Head (m)	Generating Power (1,000 kw)	Volume of Usable Water (cu m/sec)	Effective Head (m)	Generating Power (1,000 kw)	
1	Ch'ing-shui-ho	1,000	56	468	600	51.0	256	2,240
2	Ho-ch'u	1,000	57	477	600	56.5	283	2,480
3	T'ien-ch'iao	1,030	129	1,111	620	127.0	660	5,780
4	Hei-yu-k'ou	1,060	64	567	635	62.0	329	2,880
5	Chi-k'ou-chen	1,120	74	702	670	73.0	410	3,590
6	Yen-shui-kuan	1,180	73	720	705	71.0	418	3,660
7	Hu-k'ou	1,230	65 (*1)	647 (*1)	740	61.0	377	3,300
8	Yu-men-k'ou	1,230	65	669	740	64.5	398	3,460
9	San-men Gorge	2,100	64	1,123	1,250	59.0	617	5,410
10	Pa-li-hu-t'ung (*2)	2,100	107	1,878	1,250	106.5	1,110	9,740
11	Hsiao-hen-ti (*2)	1,050	26	229	750	25.5	159	1,390
	Total			8,591			5,017	43,950 [sic]

*1 (TN: O J Todd, in Journal of the Association of Chinese and American Engineers, Vol XVI No 9, July-August 1935, page 207, planned to develop only 100,000 hp or 74,600 kw with a head of 110 feet at this site.)

*2 (TN: Pa-li-hu-t'ung appeared as Yuan-ch'u in the August 1941, revision. Hsiao-hen-ti appeared as Meng-chin in the August 1941, revision.)

The following table shows the basic cost of electric power, calculated as 12.5 per cent of the total construction cost per kilowatt-hour of output. This latter figure includes interest, operation and maintenance costs, taxes, etc., and is calculated on the assumption of total consumption of electric output. The rough estimate of engineering costs is based on present commodity prices, and assumes that the methods used on the Yalu River, which has a considerable larger flow, can be utilized here. It includes costs of construction, railways and other temporary installations.

For each kilowatt of output the construction cost is about 430 yen and the average basic cost of electric power is 1.1 sen, at the coal mines. The construction costs are calculated according to the standard costs in 1935, and, although they may be low, conditions for the project are ideal. (See table on following page.)

RESTRICTED

Basic Cost of Electric Power

(If the Ching-shui-ho and San-men Gorge Dams are completed)

Location	Total Engineering Cost (thousand yen)	Maximum Power Output (thousand kw)	Annual Electric Power Output (million kw-hr)	Construction Cost per kw output (sen) [sic]	Construction cost per kw hr output (sen)	Basic Cost of Electric Power at Source (sen)
Ch'ing-shui-ho	316,000	468	2,240	675	14.1	1.1 (1.7)
Ho-ch'u	174,900	477	2,480	367	7.1	0.9
T'ien-ch'iao	520,870	1,111	5,780	468	9.0	1.1
Hei-yu-k'ou	300,990	567	2,880	546	10.7	1.3
Chi-k'ou-chen	334,620	702	3,590	477	9.3	1.2
Yen-shui-kuan	330,280	720	3,660	459	9.0	1.1
Hu-k'ou	407,130	647	3,300	630(*1)	12.3	1.5
Yu-men-k'ou	253,870	669	3,480	380	7.3	0.9
San-men-Gorge	442,130	1,123	5,410	394	8.2	1.0
Pa-li-hu-t'ung (*2)	528,100	1,878	9,740	281	5.4	0.7
Hsiao-hen-ti (*2)	102,780	229	1,390	446	7.4	0.9
Total	3,711,680 [sic]	8,591	43,950	432 [sic] (Average)	8.4 [sic] (Average)	1.1 (Average)

*1 (TN: TODD and ELIASSEN, in "Journal of the Association of Chinese and American Engineers," Vol XX No 3, May-June 1939, page 133, state that a $3,000,000 project here would develop 100,000 hp. This would make the cost $40.20 per kilowatt in US currency.)

*2 (TN: Pa-li-hu-t'ung appeared as Yuan-ch'u in the August 1941 revision. Hsiao-hen-ti appeared as Meng-chin in the August 1941 revision.)

RESTRICTED

II Main Considerations in the Hydroelectric Developments of the Yellow River

The following are the main points which should be kept in mind when considering the hydroelectric potentialities of the Yellow River:

A. Supplementary Sources of Electricity Unnecessary

One plan of power development would, it is calculated, produce a maximum of 8,000,000 kilowatts (at about 60 per cent load factor). According to this plan, the largest reservoirs which could be produced by building the Ch'ing-shui-ho and San-men Gorge dams would compensate for the enormous sacrifices involved by securing definite control of the erratic water volume of the Yellow River and thus insuring an even flow. Supplementary sources of electric power would therefore be necessary. This is a great economic advantage.

B. Important Subsurface Resources Located Close at Hand

Fortunately, inexhaustible coal and limestone deposits are found along both banks of the river in the stretch where dam projects are contemplated. Over 1,000,000,000 metric tons of gypsum are buried near T'ai-yuan, and electricity could be transmitted economically to the alumina deposits in Shantung. Electricity could thus be supplied to many electrochemical industries.

C. Low Basic Cost of Producing Electricity and Small Quantity of Materials Needed for Construction Work

The Yellow River offers hydroelectric generating sites which have few equals anywhere in the world. This makes the amount of construction material required per unit of power output exceptionally small and the construction cost correspondingly low. Construction costs which allow for more than enough material at the present high commodity cost prices would, as shown in the section on construction costs, still allow electricity to be delivered at the coal mines at an average rate of 1.1 sen per kilowatt-hour. This construction cost may perhaps be higher than that of previous projects, but this is due to the present high cost level. It is believed that this project would actually cost less than any other project if constructed during the same period.

It would be profitable to compare this project with one to produce electricity by coal in North China. North China is short of industrially usable water. Whatever water is available is hard water and would require considerable additional labor and necessitate a relatively high unit cost. The construction cost in kilowatts of output would be about the same for the Yellow River project and a steam-generated project. There are rich coal deposits but mining them would require extensive equipment, capital, and labor, and in time, progressively less economic veins would have to be worked, so that the cost of the coal would certainly not decrease below its present figure. Electricity so produced would not become much more economic than it would be at first. Hydroelectric power on the other hand would become progressively cheaper. It would probably require less and certainly no more iron and steel than a steam-generated electric project which would require a large quantity of special steels.

Thus, even from this viewpoint, the hydroelectric project would be more economical.

D. Yellow River Flood Control

Water power sites on the Yellow River would all require large dams. Those at Ch'ing-shui-ho and San-men Gorge would impound especially large volumes of water. The completion of the dam at San-men Gorge and use of its enormous reservoir would alone make possible the control of the floods which have raged for 4,000 years.

E. Benefits to Shipping and Irrigation in the Lower River and to Food Production

The construction of the San-men Gorge dam alone would make possible an equalized flow of the Yellow River throughout the year. It would help down-river shipping when the Hsiao-hen-ti (Meng-chin) irrigation dam draws off water for the canals and farm land and it would also greatly increase agricultural production. Diverting part of the Yellow River into its old canals would also make its water available for irrigation anywhere along these canals, and would produce a very great increase in agricultural production in those areas.

F. Problems Involved in the Water Power Development of the Yellow River

As shown above, hydroelectric development of the Yellow River would bring great benefits, but its negative aspects must also be considered. Most points where electricity would be generated are far inland. All sites except the San-men Gorge and the two dams below it have poor communications. The reservoirs in the Ch'ing-shui-ho and San-men Gorge areas would be very large and flood an enormous area of farm land, (about 1560 and 780 square miles respectively). The latter encompasses an especially important and densely populated agricultural area. However, these disadvantages are not insurmountable. Although sites are far inland, industrial products can easily be transported to the coastal region by train or canal, and with modern techniques it is not impossible to transmit electricity as far as the coast. Since each site would have a large power output (averaging 750,000 kilowatts), extensive railroad construction is economically very feasible.

Finally there is seepage from the still water, but this problem could be solved with a little work and study. When one considers how many times this area would be saved from floods and how greatly agricultural production would be increased, the water loss by seepage is relatively unimportant. Fortunately, the sites are all exceptionally favorable, so that even if extensive countermeasures were taken, the basic cost of electric power would still be very low.

In this connection it must be remembered that although the stagnant reservoirs at Ch'ing-shui-ho and the San-men Gorge would have very large losses from seepage because of their size, the dams there must be built to the calculated height or the other sites will suffer. Should they not be built to that height, the volume of flow of the Yellow River could not be equalized; the other power sites could not produce the calculated amount of electric power throughout the year, and maximum output could not be maintained during the dry season. This would necessitate supplementary steam electric power stations. To avoid this waste and to utilize completely the full natural value of the Yellow River, it is clear that the dams at Ch'ing-shui-ho and the San-men Gorge must be at least 60 and 70 meters high respectively (distance between normal river level and the lake surface when full).

III Methods of Utilizing and Transmitting Electric Power

As mentioned above, the Yellow River area has very rich deposits. Coal deposits along the river in Shansi, Shensi and Honan are almost inexhaustible and limestone is found all along the Yellow River. Industries which use coal, limestone, water and air as raw materials can be established anywhere along the river as the hydroelectric project is developed. If locations are selected where industrially usable water is available, the unlimited supply of air could be utilized to produce artificial fertilizers (ammonium sulphate and ammonium nitrate) and synthetic gasoline, as well as carbide and finished products made with carbide. This region could thus produce a large quantity of the raw materials needed for the defense and national development of China. With the modern technique of high-tension transmission, all of North China could be supplied with electricity, which could be utilized for the refining of aluminum from alumina shale. It could also be utilized in the production of steel.

Areas where a large consumption of electricity by future electrochemical industries may be expected were determined from consideration of: (1) proximity to sources of electricity, (2) proximity to rich, usable mineral deposits, (3) abundance of industrially usable water, and (4) transportation facilities. These areas are as follows:

Ta-t'ung Area
T'ai-yuan - Shih-chia-chuang Area
Hsin-hsiang - Chang-te Area
T'ien-ching - T'ang-ku - Pei-p'ing Area
Chiao - Chi-nan Area
Han-k'ou Area

All these districts are situated from 250 to 600 kilometers from hydroelectric sources and could therefore be supplied with the large amounts of electric power required. However, it must be assumed that if the 220,000 volt transmission cables, as used in Japan and Manchuria in the past, were used, it would present many difficulties. In order to transmit such high voltage it will be necessary to study the direct transmission of 400,000 volts research on which is at present being undertaken by Germany, Russia and the United States.

RESTRICTED

The table on the next page shows those products vital to East Asia which would be produced and the quantities in which they could be produced if these contemplated developments were near completion.

(Table follows on next page)

RESTRICTED

Approved For Release 1999/08/25 : CIA-RDP78-03109A000200010001-6

Location of Hydroelectric Plant	Volume of Active* Consumption of Electric Power (million kw-hrs per yr)		Consuming District	Industry	Annual Output (thousand metric tons)	Electric Power Required per Year (million kw-hrs)		Surplus Electric Power (million kw-hrs per yr) (Difference between A and B)
		Total (A)				by Industries	District Totals (B)	
Ch'ing-shui-ho	1,610		Ta-t'ung	Iron: Pig Iron	700			
				Steel	450	175		
Ho-ch'ou	1,790	7,560		Synthetic Oil	600	1,047	4,628	
				Carbide	300	1,200		
				Aluminum	20	440		
				Ferrous Alloys	50	275		
				Coal Mining Developments	(200,000 kw)	1,051		
				Ta-t'ung Coal Transportation Lines	(100,000 kw)	440		
T'ien-ch'iao	4,160		T'ien-ching T'ang-ku Pei-ping	Iron: Pig Iron	4,100			875
				Steel	3,400	1,025		
				Synthetic Oil	500	388		
				Artificial Fertilizer	500	500	2,057	
				Electrically Refined Steel	300	144		
Hei-yu-k'ou	2,070	7,290	T'ai-yuan Shih-chia-chuang	Iron: Pig Iron	100			
Chi-k'ou-chen	2,580			Steel	50	25		
Yen-shui-kuan	2,640			Synthetic Oil	200	94		
				Artificial Fertilizer	300	300	6,745	545
				Carbide	1,450	5,800		
				Coal Mining Developments	(100,000 kw)	526		
Hu-k'ou	2,380	2,380						2,380
Yu-men-k'ou	2,520	2,520						2,520
San-men-gorge	3,720		Hsin-hsiang Chang-te	Synthetic Oil	700	635		
				Artificial Fertilizer	500	500		
				Alumina	100	1,700		
				Aluminum	20	440		
				Carbide	1,250	5,000		
				Electrically Refined Steel	200	96	9,734	
Pa-li-hu-t'ung (Yuan-chu)	7,080	11,820		Ferrous Alloys	50	275		
				Lubricants	20	100		
				Synthetic Graphite	20	200		
				Coal Mining Developments	(150,000 kw)	788		135
Hsiao-hen-ti (Meng-chin)	1,020		Electricity transmitted to Han-k'ou Area		(300,000 kw)	1,500	1,500	
			Chiao-chi-nan	Synthetic Oil	300	141	451	
				Artificial Fertilizer	300	300		
				Iron	100	100		
TOTAL	31,570	31,570				25,115	25,115	6,455

* The volume of active consumption of electric power is 70% of the calculated maximum output of each location (taking into account the local variations).

25 94898

Approved For Release 1999/08/25 : CIA-RDP78-03109A000200010001-6

IV Sequence of Developments

The water power development of the Yellow River could begin at any point dictated by electric power needs, but for flood control, the San-men Gorge dam should be developed first. This should be followed by the dam at Ch'ing-shui-ho. Further developments should be determined by the demand for electric power and the problems of establishing construction railroads. This report arranges the other dams in the following order: Chi-k'ou-chen, Ho-ch'u, Hsiao-hen-ti (Meng-chin), Tien-ch'iao, Pa-li-hu-t'ung (Yuan-ch'u), Hu-k'ou, Yu-men-k'ou, Yen-shui-kuan.

Following is a comparative list of electric power installations of the leading world powers (total production of hydro- and steam-electric power).

United States	37,466,000 kw	(1937)
Germany	15,270,000 kw	(1937)
France	11,268,000 kw	(1937)
Russia	8,116,000 kw	(1937)
Japan (Proper)	6,977,000 kw	(1937)
Japan (Total)	7,930,000 kw	(1937)
England	8,913,000 kw	(1937)
Canada	6,308,000 kw	(1937)
Italy	5,618,000 kw	(1938)
China	1,006,000 kw	(1938)

This shows that the United States occupies the top position, and that Japan follows after Germany, France and Russia. Next in order is England; but if the outputs of England and Canada are combined, it can be seen that Japan cannot be called a first rate power. Since it is generally accepted that a nation's industrial power is reflected in its volume of iron, coal and electric power, the expansion of Japan's electric power must be considered a serious problem. In the present war, it can be said that Germany's industrial strength is due largely to its great electric power.

In order to be a true leader in the Far East, Japan must expand its industrial production; and in order to provide sufficient electric power for this expansion the development of the Yellow River basin is very promising.

World hydroelectric power development is as follows (statistics for 1938):

North America	20,100,000 kw
South America	1,000,000 kw
Europe	20,900,000 kw
Asia	4,550,000 kw
Africa	140,000 kw
Oceania	600,000 kw
Total	47,330,000 kw [sic]

Hydroelectric production has been increasingly markedly in recent years. Even North America, where coal is abundant, generates a large amount of electricity from water power. It will be shown later that even in Northern China, which is also rich in coal, hydroelectricity enjoys a definite advantage over steam-generated electricity.

But the importance of electricity to Japan makes it imperative that the Yellow River basin be developed.

V. Investigation of Terrain and Soil at Dam Sites

This is chiefly a theoretical plan based on existing publications and maps, and the sites are not rigidly fixed. The only actual field investigation made by the survey committee, since it began work in 1939, was on the Ch'ing-shui-ho dam site in late 1940.

According to this investigation, the Yellow River above Ho-ch'u is approximately 300 meters wide and flows through a continuous gorge of precipitous cliffs (about 60 degrees), which in some places are 200 meters high. The rock is mostly limestone, and suitable for dam construction.

The investigation by North China Area Army in early June 1941, of the dam site at the San-men Gorge, showed that a stratum of diorite-porphyrite several thousand meters wide cuts across the river there. Moreover, the lower reaches are psammite and psephite. This geology favors the construction of dam some 100 meters in height. These investigations have yeilded practically the same results as our theorectical planning.

Until further field investigations are made, the feasibility of building dams at other points is uncertain. Maps and technical publications give the width of the river between Ho-k'ou-chen and Yu-men-k'ou as 300 to 500 meters. At the points selected for projected dam sites, the river seems to be narrow and flows between steep cliffs. We cannot tell, without actual examination, whether the rock structure at all the sites is suited to dam construction, but according to surveys made by the Chinese there are at least two or three suitable locations. Deductions from maps about the other sites would probably be largely correct. It can be assumed from the surveys by the army and the Chinese that there is definitely a dam site near Yuan-ch'u, one of the two possible sites downstream from the San-men Gorge. The sites chosen in the present survey may not be the best, but the best ones are certainly located somewhere near them. The sites farthest downstream should be investigated within the next few months.

VI. The San-men Gorge Hydroelectric Site

As has been explained, the site at the San-men Gorge should be the first one developed because of the enormous quantity of electric power it would produce and its great effect on flood control and irrigation downstream. Following is a summary of data concerning the San-men Gorge project:

A. Dam

Location	Approx 25 km downstream from P'ing-lu, Shansi Province.
Height	Approx 70 m (the difference between the normal water level and the level of the reservoir-lake when full).
Length	Base: Approx 300 m Crest: Approx 500 m
Concrete Required	Approx 1,400,00 cu m.

B. Reservoir

Maximum Water Level	350 m above sea level
Maximum Length	Approx 200 km
Area Inundated	Approx 2,200 sq km (including river bed)
Total Volume of Reservoir Water	Approx 40,000,000,000 cu m
Reservoir Water Available for Water Power	Approx 27,000,000,000 cu m
Time Required to Fill Reservoir with Sediment	over 40 years

C. Volume of Flow

Average Total Annual Flow	Approx 43,000,000,000 cu m (1,350 cu m per sec)
Maximum Flow Available for Water Power	2,100 cu m per sec

D. Electric Power

Maximum Capacity	1,123,000 kw (60% load factor)
Annual Output	Before development of Ch'ing-shui-ho site Approx 4,720,000,000 kw-hr After development of Ch'ing-shui-ho site 5,410,000,000 kw-hr.

E. Rough Estimate of Construction Cost

Total Cost	442,000,000 yen (Includes cost of construction of railroads, cement manufacturing plants, steam-electric power plants and compensation for flooded land)
Construction Cost per kw	394 yen
Construction Cost per kw-hr	8.2 sen
Basic Cost of Electric Power per kw-hr	1.0 sen
	(12.5% of construction cost)

It was decided to charge the entire cost to electric power. However, since the project would contribute directly to flood control and irrigation, these could reasonably be assigned part of the burden. This cost distribution would greatly reduce the basic cost of electric power and make it the cheapest electricity available in East Asia.

RESTRICTED

A JAPANESE PLAN FOR HYDROELECTRIC DEVELOPMENT OF THE YELLOW RIVER IN CHINA
(Continued)

Far Eastern Research Section
Survey Committee No 2
North China Committee
Subcommittee No 4
May 1941

PART 2. BASIC SURVEY

ARISAKA Masayoshi

TABLE OF CONTENTS

RESTRICTED

I. Introduction

The Yellow River is over 4,500 kilometers in length and drains an area of 760,000 square kilometers. The stretch of over 1,000 kilometers between Pao-t'ou and Cheng-chou is a succession of gorges and gives the river great possibilities as a source of water power.

This part of the report formulates the plan for developing this water power and takes up the basic natural factors which affect its potential value. The water power of a river is proportional to the volume of water times its fall. These two factors must first be determined.

The fall in the Yellow River cannot be utilized without damming up the water at topographically suitable places where the mountains press in the river valley. It is necessary to ascertain the river profile at dam sites. This determines reservoir capacity, the main factor in utilizing water power. The usable volume of water is then calculated from the natural flow and the size of reservoirs.

The flow of a river is determined by the area drained, the rainfall in that area and the percentage of runoff. These factors can be determined by actual field survey. The character of the flow must be determined from such climatic factors as rainfall and evaporation, and from the percentage of runoff. The capacity of potential reservoirs, which depends on topography, determines the percentage of natural flow that will be usable. However, the area of these reservoirs affects their volume of evaporation and thus somewhat reduces their value.

In addition, reservoirs precipitate the silt held in suspension in the river. In the course of several years or decades this sediment becomes a factor in determining the usable volume of water.

The subject of reservoirs is taken up in Part 3. Part 2 deals with such other factors in the problem as terrain, climate, amount of silt in the current, etc.

Following is a list of the chief sources consulted in the preparation of Part 2:

HU Huan-Yung, editor: "Thoughts on the Yellow River" (Huang-ho Chin), 3 volumes

CHANG Han-Ying: "Yellow River Problems" (Huang-ho Wen-t'i), Volume 1 of "Water Supply Problems in China" (Chung-kuo Shui-li Wen-t'i), edited by CHI Shu-T'ien

League of Nations, Technical Committee on Transportation and Communication: "Research Material on Improvement of the Yellow River," by YOKODA, an engineer.

(Note: Much of the material in the text of this translation is covered in another publication of the League of Nations, Cooperation between the Organization for Communications and Transit of the League of Nations and the National Government of China: "Report by the Committee of Experts

on Hydraulic and Road Questions in China." Geneva, 1936. Library of Congress TC101.L4 1936.)

ELIASSEN S: "Flood Control of the Yellow River through Detention Basins," translated into Japanese by MONOBE, Ph D; from the monthly publication of the Chung-mei Kung-ch'eng-shih Hsieh-hui, No 4, Volume 17, 1936

TODD Oliver J & ELIASSEN: "Yellow River Problem," in American Society of Civil Engineers magazine, December 1938 /Vol 64, No 10, pp 1921-91. Library of Congress TA1.A52/

OKOSHI Hiraoka: "Treatise on Control of the Yellow River" (Koka Chisui Ron)

WATANABE Kinzo: "Treatise on Flood Control of the Great Yellow River" (Dai-Koka Chisui Ron) (TN: His "Plea for the Yellow River Flood Control Plan" (Koka Chisui Keikaku Sokushin No Kengen) is available in WDC Library)

Committee on National Economics (Chuan-kuo Ching-chi Wei-yuan-hui): "National Meteorological Reports" (Chuan-kuo Ch'i-hsiang Pao-kao), 1933 and 1934

Same: "National Hydrological Reports"(Chuan-kuo Shui-wen Pao-Kao)

CHANG Han-Ying: "Discussion Series on River Control" (Ch'ih-ho Yu-yeh)

LU Jo-Yu: "Survey on the Acceleration of Gravity in North China" (Hua-pei Li-li Chia-su-tu Chih Ts'e-ting), Pei-p'ing National University, Physics Department, 1933

CHANG Hung-Chi: Same (1935)

TODD: "Hydroelectric Survey of Shansi Province and Preliminary Plans /for Its Development/" (TN: Probably incorporated in Todd: "A Study of Shansi's Rivers," in Association of Chinese and American Engineers Journal, Vol 15, No 1, Jan 1934, pp 7-14. Library of Congress TA4.87.)

The following were the principal maps used:

Land Survey Department (Lu-ti Ts'e-chih Pu): "East Asia Maps," 1:500,000 (Tung-ya Wu-shih-wan-fen Chi I Ti)

Same: "Aerial-Photograph Maps of the Yellow River Area," 1:50,000 (Wu-wan-fen Chih I Huang-ho Yen-an K'ung-chung Hsieh-chen Yao-t'u)

Same: "Mimeographed Map Series," 1:50,000 (Chia-chih Wu-wan-fen Chih I Ch'ieh-ho Ti-t'u)

Same: "Large Scale Maps of Shansi and Honan Provinces," 1:1000,000 (Shu-chih Shan-hsi-sheng Chi Ho-nan-sheng Shih-wan-fen Chi I Ti-t'u)

Same: "Aerial-Photograph Maps of Inner Mongolia," 1:100,000 (Shih-wan-fen Chih I Meng-ch'iang K'ung-chung Hsieh-chen Yao-t'u)

Army Staff of Suiyuan Province, China: "Suiyuan Province Maps," 1:100,000 (Sui-yuan-sheng Shih-wan-fen Chih I Ti-t'u)

Army Staff of Shansi Province, China: "Shansi Province Maps," 1:100,000 (Shan-hsi-sheng Shih-wan-fen Chih I Ti-t'u)

Committee on Yellow River Water Supply (Huang-ho Shui-li Wei-yuan-hui), 1936: "Survey Maps of Yellow River near San-men Gorge," 1:50,000 and 1:5,000 (San-men-hsia Fu-chin Huang-ho Wu-wan-fen Chih I Chi Wu-ch'ien-fen Chih I Shih-ts'e-t'u)

Same: "Survey Maps of Yuan-ch'u," 1:50,000 and 1:10,000 (Yuan-ch'u Wu-wan-fen Chih I Chi I-wan-fen Chi I Shih-ts'e-t'u)

North China Transit Company, (Hua-pao Chiao-t'ung Hui-she So-ts'ang): "Profile of Lung-Hai Railroad Line" (Lung-hai-hsien Tsung Tuan-t'u)

Same: "Profile of Ta-t'ung - Feng-ling-tu Railroad Line" (T'ung-p'u-hsien Tsung-tuan-t'u)

Same: "Profile of Pei-p'ing - Suiyuan Railroad Line" (Ching-pao-hsien Tsing-tuan T'u)

Army Staff of Shensi Province, China: "Shensi Province Maps," 1:50,000 (Shan-hsi-sheng Wu-wan-fen Chih I Ti-t'u)

II Description of the Yellow River and its Drainage Basin

A. Introduction

The Yellow River is, next to the Yangtze, the largest river in China. It is 4,670 kilometers in length ("Thoughts on the Yellow River"). Its drainage area above the Pei-p'ing - Han-k'ou railroad bridge is approximately 760,000 square kilometers. If the downstream alluvial plains are included, its drainage basin is 1,260,000 square kilometers. One hundred and forty million people live in this area.

The river rises in Ch'ing-hai, in the Pa-yen-k'o-la Mountains and in the Kuen-lun Mountain. It flows through Kansu and along the Ningsia - Suiyuan border, makes a great circuit around the Ordos Plateau through Inner Mongolia and then flows southward through the gorge forming the boundary between Shansi and Shensi, taking in many tributaries on the way. At T'ung-kuan, where it joins the Wei River, it makes a right angle and flows east through a second gorge to Meng-ching, where it enters open country. Below the Pei-p'ing - Han-k'ou railroad bridge, the Yellow River is confined within dikes and meanders across relatively level land, so that not a single tributary joins it until it reaches the foot of the Shantung Mountains.

The drainage basin of the Yellow River is shown on Map II [at the beginning of this report].

The Yellow River and the Great Rivers of the World

RIVER NAME	LOCATION	AREA of DRAINAGE BASIN (sq km)	STREAM LENGTH (km)	NOTES
1. Amazon	Brazil	7,000,000	5,500	
2. Congo	West Africa	3,723,000	4,200	
3. Mississippi	USA	3,250,000	6,500	Several large dam-type power stations on its tributaries: the Missouri and the Tennessee
4. La Plata	Argentine	3,100,000	4,700	
5. Ob'	Siberia	2,950,000	5,200	
6. Nile	Egypt	2,842,000	5,500	Several large irrigation dams including Assvan
7. Yenisei	Siberia	2,600,000	5,200	Large dam-type power stations planned and being built on its tributary, the Angara [sic]
8. Lena	Siberia	2,435,000	4,600	
9. Zambezi	Southeast Africa	2,200,000	2,660	
10. Niger	West Africa	2,100,000	4,160	
11. Amur	Manchuria-Siberia	2,000,000	4,480	Large dam-type power station at Ta-feng-men on the upper Sungari, a tributary
12. Yangtze	China	1,970,000	3,120	
13. Ganges	India	1,581,000	2,400	
14. Volga	Russia	1,409,000	3,200	Several large dam-type power stations planned and being built on this stream
15. Orinoco	Venezuela	1,086,000	2,220	

The Yellow River and the Great Rivers of the World (Contd)

RIVER NAME	LOCATION	AREA of DRAINAGE BASIN (sq km)	STREAM LENGTH (km)	NOTES
16. St Lawrence	Canada	1,029,000	3,800	Several dam-type power stations on this stream
17. Murray	Australia	950,000	1,100	
18. Indus	India	917,000	3,180	Large irrigation dam being planned and built at Sakka
19. Mekong	Indo-China	923,000		
20. Yellow River	China	760,000	4,600	
21. Orange	South Africa	830,000	1,860	
22. Danube	Central Europe	804,000	2,700	
23. Columbia	USA	625,000	2,000	Large dam-type power stations at Grand Coulee and several other sites
24. Colorado	USA	580,000	2,000	Large dam-type power stations at Boulder and several other sites
25. Dnieper	Russia	510,000	2,150	The large Dnieper dam-type power station
26. Euphrates	Iraq	765,000	2,000	
27. Mackenzie	Canada	1,660,000	3,780	
28. Saskatchewan	Canada	1,080,000	2,400	
29. Yukon	Alaska	900,000	3,600	
30. Irrawaddy	Burma	430,000	2,000	
31. Don	Russia	429,000	1,860	

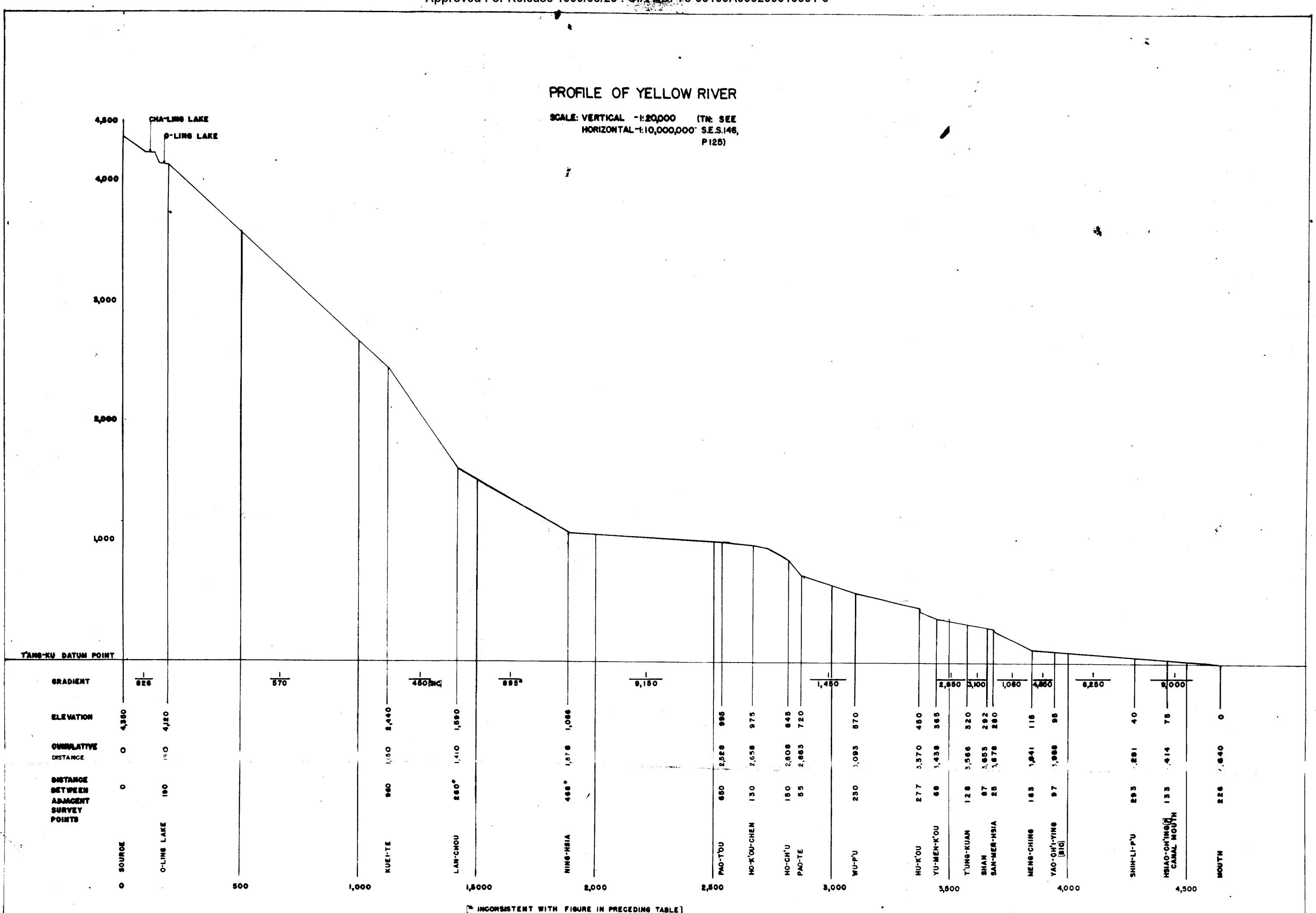
B. Gradient of the Yellow River

The Yellow River falls from an elevation of 4,120 meters at O-ling Lake to 2,440 meters at Kuei-te in Kansu, 1,590 meters at Lan-chou, 1,066 meters at Ning-hsia, 995 meters at Pao-t'ou and 321 meters at T'ung-kuan. At the Pei-p'ing - Han-k'ou railroad bridge it enters the alluvial plain at 92 meters above sea level. This gradient is shown in greater detail in the table below, and in the profile chart of the river which follows.

Gradient of the Yellow River

Section	Distance (kilometers)	Fall (meters)	Mean Gradient (m/km)	Upper Elevation (meters)
O-ling Lake to Kuei-te	960	1,680	1.75	4,120
Kuei-te to Lan-chou	382*	850	2.225	2,440
Lan-chou to Ning-hsia	348*	524	1.506*	1,590
Ning-hsia to Pao-t'ou	650	71	0.109	1,066
Pao-t'ou to T'ung-kuan	1,038	675	0.654	995
T'ung-kuan to Shan	87	28	0.322	320
Shan to Meng-ching	188	177	0.941	292
Meng-ching to Yao-ch'i-Ying [sic]	97	20	0.206	115
Yao-ch'i-ying to mouth	724*	95	0.131*	94

(TN: Asterisked figures in the above table are inconsistent with those in the profile which follows. Presumably the figures in the table are correct.)



Approved For Release 1999/08/25 : CIA-RDP78-03109A000200010001-6

C. Gradient of the Yellow River in the Area covered by the Water Power Project

A detailed profile of the Yellow River between Pao-t'ou and Meng-ching, the area of potential water power, was compiled from various sources. The elevations of important points in this area are indicated below:

	Elevation	Exact Position	Remarks
Pao-t'ou	1,005	Pao-t'ou Railroad Station	Elevation above Pei-p'ing - Suiyuan Railroad Line datum. (from "Profile of Pei-p'ing - Suiyuan Railroad Line")
Ho-ch'u	945		LU Jo-Yu: "Survey on the Acceleration of Gravity in North China" (Pei-p'ing National University, Physics Department) 1933
Pao-te	823		CHANG Hung-Chi: Same, (1935)
Wu-p'u	518		"
Hu-k'ou	450		Todd: "Hydroelectric Survey of Shansi Province and Preliminary Plans [for Its Development]"
Yu-men-k'ou	365		"
P'u-chou	349		"
T'ung-kuan	320 Mean river level		"Field Survey by the Yellow River Water Supply Committee" (Elevation above T'ang-ku datum)
Shan	292 "		"
San-men Gorge	280 "		"
Yuan-ch'u	196 "		"
Meng-ching	115 "		"
Cheng-chou	93 "		"

The figures in the table (preceding page) for T'ung-kuan and below give the mean river level as determined by the survey of the Yellow River Water Supply Committee, and may be considered accurate. The other figures do not represent mean water level and are based on various datum points. They are not accurate and many serious problems arise in trying to enter them on the profile. They must be corrected from the contour lines on the 1:100,000 scale maps of Shansi and Shensi.

For example, "Thoughts on the Yellow River" gives the elevation of Pao-t'ou as 914 meters, while many other sources give figures of over 1,000 meters. Allowing for the difference between these figures and the water level of the Yellow River there, the mean river level at Pao-t'ou may be figured at 995 meters.

The following table shows the number of 20-meter contour lines cut by each section of the Yellow River on the 1:100,000 maps of Shansi and Shensi:

Section	Contour Lines Cut	Total Fall
Pao-t'ou to Ho-k'ou-chen	1	20 m
Ho-k'ou-chen to Ch'ing-Shui-ho	1	20 m
Ch'ing-shui-River to Ho-ch'u	6	120 m
Ho-ch'u to Pao-te	6	120 m
Pao-te to Wu-p'u	8	160 m
Wu-p'u to Hu-k'ou	4	80 m

This table shows eight contour lines between Pao-t'ou and Ho-ch'u, a fall of 160 meters, whereas the previous table gives the fall as only 55 meters. Allowing for the location of Ho-ch'u on top of a rather high cliff above the Yellow River and the difference in datum points, the estimated elevation of the normal water level of the Yellow River at Ho-ch'u should be reduced 100 meters, to read 845 meters. Pao-te is an exact parallel, and its water-level estimate should be reduced to 723 meters. These figures keep the 120-meter fall from Ho-chu to Pao-te which these sources give, and also agree with the number of contour lines cut. There are eight contour lines between Pao-te and Wu-p'u, a fall of 160 meters. This would yield an elevation of 560 meters for Wu-p'u, which is quite different from the 518 meters in the previous table. The latter figure would, with Yu-men-k'ou at 450 meters, give a gradient of 1:4,600, which is too gentle for this stretch. The elevation at Wu-p'u was therefore assumed to be 570 meters.

Todd's calculated elevation for Hu-k'ou, 450 meters, yields a mean gradient between Wu-p'u and Hu-k'ou of 1:2,300. Todd's elevation figures were used for the stretch between Hu-k'ou and Yu-men-k'ou but the distances were calculated from aerial photographs.

From Yu-men-k'ou to the Pei-p'ing - Han-k'ou railroad bridge, the elevation figures of the Yellow River Water Supply Committee survey were principally used, while Eliassen's report was used for reference. The distance of 600 kilometers between Pao-t'ou and T'ung-kuan given in "Thoughts on the Yellow River" is much shorter than that calculated from the 1:50,000 and 1:500,000 aerial-photograph maps of the Land Survey Department, or given in OKOSHI's "Koka Jisui".

Here the distances were estimated principally from the 1:50,000 aerial-photograph maps, with Eliassen's "Flood Control of the Yellow River" and OKOSHI's "Koka Jisui" as reference. These gradient calculations were used to construct the detailed profile between Pao-t'ou and the Pei-p'ing - Han-k'ou railroad bridge. The plan for water-power development is based on this profile.

D. The Drainage Area

Varying figures were found for the drainage area of the Yellow River above the Pei-p'ing - Han-k'ou railroad bridge. The principal ones are as follows:

PAI Mei-Ch'u: "Introduction to the Topography of China" (Min-kuo Ti-chih Tsung-lun)	- 530,000 sq km
Yellow River Water Supply Committee	- 730,000 " "
"Thoughts on the Yellow River Problems"	- 756,000 " "
Todd & Eliassen: "Yellow River Problems"	- 756,000 " "
Eliassen: "Flood Control of the Yellow River through Detention Basins"	- 756,000 " "

From these sources, the drainage area of the Yellow River may be taken as 756,000 square kilometers. Breaking this down, we find that the area above Kuei-te is 172,500 square kilometers, the largest tributary in this sector being the T'ao River, with an area of 29,200 square kilometers. The total drainage basin above Lan-chou is 216,180 square kilometers and that above Pao-t'ou is 394,780 square kilometers in area. However, most of the 178,600 square-kilometer drainage area between Lan-chou and Pao-t'ou consists of the basin of the Ch'in River and alluvial plains similar to those farther downstream, and does not increase the volume of flow.

Between Pao-t'ou and Yu-men-k'ou 120,528 square kilometers of drainage area are added to the river, and many tributaries join the river from Shensi and Shansi. The principal ones are the Ta-hei River with 12,080 square kilometers, the Wu-ting River with 23,152 square kilometers, the Shen-mu River with 9,052 square kilometers and the Yen River with 7,160 square kilometers.

From Yu-men-k'ou to T'ung-kuan the Yellow River is joined by tributaries bringing the total/drainage area/to 712,588 square kilometers. These include the Lo, the Wei and the Ching Rivers from Shensi, and the Fen and Su-shui Rivers from Shansi. There are only small tributaries between T'ung-kuan and Meng-ching, but a little below this point, the Ch'in and Tan Rivers [sic-see Map II at beginning of this publication] join from the north, and the Lo and I Rivers from the south.

The following table shows the drainage area of sections of the Yellow River, as given in "Thoughts on the Yellow River":

YELLOW RIVER DRAINAGE AREAS

Above Lan-chou	216,180 sq km
Lan-Chou to Pao-t'ou	178,600 sq km (Total area above Pao-t'ou 394,780 sq km)
Pao-t'ou to Yu-men-k'ou	120,528 sq km (Total area above Yu-men-k'ou 515,308 sq km)
Fen River	40,240 sq km
Su-shui River	5,320 sq km
Wei River	144,760 sq km
Above Ta-yin	29,880 sq km
Ta-yin to Hsien-yang	18,140 sq km
Ching River	58,930 sq km
Lo River (Shensi)	27,020 sq km
Tributaries between Hsien-yang and T'ung-kuan	10,790 sq km (Total area above T'ung-kuan 712,088 sq km)
TN: Blank - possibly T'ung-Kuan to Shan	16,960 [or 6,960] sq km
Lo River (Honan)	13,028 sq km
I River	14,960 [or 4,960] sq km
Ch'in River	10,500 sq km
Fan-shui [sic] River	1,820 [or 820] sq km
Other tributaries between T'ung-kuan and Cheng-chou	14,788 [or 4,788] sq km
Total above Pei-p'ing - Han-k'ou railroad bridge	756,684 sq km [sic]

III Climate

A. Introduction

The Yellow River basin is in North China. It has an oceanic temperate monsoon climate except in the northwestern part, which is continental with extreme temperature variation and especially cold winters. In Pei-p'ing, for instance, the average January temperature is -4.7°C while that at T'ai-yuan is much colder (-8°C), although their annual average temperatures are nearly the same. The continental influence is even greater in Shensi and Kansu.

The total annual rainfall is very light, compared to that of Southern and Central China, and is more concentrated in summer, the winter being very dry. This is the outstanding characteristic of this area. Seventy-one percent of the total annual rainfall comes in summer, compared to only 40 percent in Central China, but there is some precipitation in winter.

Another striking characteristic in North China is the great variation in total precipitation from year to year. The total annual precipitation varies an average of over 30 percent from the average annual precipitation. For example, a location with an average annual rainfall of 500 millimeters will have an annual precipitation of anywhere from 350 to 650 millimeters.

This is only the average variation and these limits may be exceeded occasionally. Over a long period the maximum and minimum variation may be several times this average. Because of this, floods and droughts have, since ancient times, frequently brought crop failures and famine to the region, and exerted a tremendous influence on the agriculture of North China.

B. Precipitation

Rainfall observation stations in the Yellow River area are unevenly distributed. There are only three stations in the whole headwater area, Chinghai and Kansu, and six stations in all Ninghsia and Suiyuan, while Shansi and Shensi have 14 and 20-odd stations respectively.

The following tables list the rainfall observation stations by provinces and river basins, and show the monthly average rainfall at each.

Principal Rainfall Observation Stations and Average Annual Rainfall in the Yellow River Drainage Area

Province	Station	Drainage Basin	Years Recorded	Average (mm)
Kansu	Lan-chou	Yellow River	1933 - 1934	365.5
	Ning-hsien	Ta-yen River	1934	
	Ch'ing-shui	N'u-t'ou River	1934	
Suiyuan	Sa-la-ch'i	Yellow River	1921, 1923 - 1928, 1931 - 1933	
	Sui-yuan	Hsiao-hei River	1920 - 1925	
	Erh-shih-ssu-ch'ing-ti	Ta-hei River	1917, 1920 - 1930	
	YU-PI-YAI [sic*]	Ch'ien River	1920 - 1925	
Shensi	I-ch'uan	Jen-weng River [sic]	1932 - 1933	
	Ch'ang-wu	Ching River	1932 - 1933	
	Ch'eng-ch'eng	Lo River	1932 - 1934	
	Chao-i	Yellow River	1932 - 1934	
	Fu-p'ing	Wei River	1932 - 1934	
	Hsi-an	"	1932 - 1933	
	T'ung-ta-fa	"	1921, 1923, 1925, 1933	416
Shansi	Shuo-chou	Fen River	1932 - 1934	
	T'ai-yuan	"	1929 - 1933	391.3
	Shou-yang	"	1922 - 1926, 1934	325.3
	T'ai-ku	"	1932 - 1933	
	P'ing-yao	"	1920 - 1931	350.0
	Hsin-chiang	"	1932 - 1933	446.4
	Chieh	Su-shui River	1931 - 1933	

*(TN: Possibly She-pi-yai. See "Contour Map of the Inundated Area and the Ch'ing-shiu-ho Dam," which will appear in Part B, Chapter IV)

Principal Rainfall Observation Stations and Average Annual Rainfall in the Yellow River Drainage Area (Contd)

Province	Station	Drainage Basin	Years Recorded	Average (mm)
Honan	Hsin-hsiang	Yellow River	1931, 1933, 1934	
	Shan-hsien	"	1919 - 1931	426.9
	Lo-yang	Lo River	1931 - 1934	401.9
	Meng-ching	Yellow River	1932 - 1934	
	Yen-shih	I River	1931, 1932, 1934	
	Cheng-chou	Yellow River	1931, 1932, 1934	

Approved For Release 1999/08/25 : CIA-RDP78-03109A000200010001-6

RESTRICTED

MONTHLY PRECIPITATION IN YELLOW RIVER DRAINAGE AREA

Province	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Year of Maximum Rainfall	Year of Minimum Rainfall	Years Recorded
Kansu	Lan-chou	1.3	7.2	6.8	8.9	24.6	14.1	89.0	148.0	39.0	23.9	0.4	6.4	369.6			1933-1934
	Ning-hsien	3.9	2.2	21.0	26.0	45.7	38.0	55.0	82.0	42.0	67.0	4.2	13.0	410.0 [sic]			1934
	Ch'ing-shui	2.1	2.2	1.6	8.9	113.1	82.0	53.0	84.4	128.4	21.3	24.1	1.6	651.1 [sic]			1934, 1921 [sic]
Sui-yuan	Sa-la-ch'i (2)	6.8	5.9	9.4	5.0	31.9	43.1	111.9	67.4	36.3	15.6	7.5	10.7	351.5	1933 632.4	1925 235.3	1923-1928
	Sui-yuan (1)	0.4	4.5	3.5	7.0	23.3	59.0	75.9	121.0	63.5	20.7	3.8	2.1	384.7			1931-1933 1920-19[illegible]
	Erh-shih-ssu-ch'ing-ti	2.0	4.0	8.0	8.0	23.0	45.0	98.0	74.0	52.0	14.0	3.0	5.0	336.0	1920 435.0	170.0	1917, 1920-1930
	Yu-pi-yai [sic]	4.3	3.8	3.2	8.5	21.5	70.0	84.0	71.9	46.4	18.9	6.4	1.1	340.0	1922 390.3	1924 289.8	1920-1925
Shensi	I-ch'uan	0.0	1.0	0.0	2.0	64.0	24.0	116.0	129.0	80.0	0.0	0.0	1.5	417.5	1933 433.0	1932 402.0	1932-1933
	Ch'ang-wu																
	Ch'eng-ch'eng	4.2	7.3	13.4	7.9	36.6	18.3	62.2	77.8	35.0	15.9	6.8	7.5	296.3 [sic]	1932 470.0	1934 182.0	1932-1934
	Ch'ao-i	2.3	11.8	11.7	27.2	49.0	21.0	72.2	95.8	48.3	25.8	21.2	6.6	392.4 [sic]	1932 496.2 [sic]	1932 303.7 [sic]	1932-1934
	Fu-p'ing	5.2	2.6	13.2	19.3	48.1	39.0	64.6	91.3	61.9	38.6	15.2	7.8	444.2 [sic]	1933 532.9	1932 394.3	1932-1934
	Hsi-an (2)	3.4	3.7	17.4	40.8	57.9	63.7	74.6	103.1	89.6	52.3	8.9	3.0	518.4			1922-1933
	T'ung-ta-fa (2)	11.4	6.9	10.2	53.4	42.6	71.1	92.2	104.4	50.4	48.2	16.1	13.7	520.6	1929 763.8	1923 436.4	1921-1923 1925-19[illegible]
Shansi	Shuo-chou	6.0	17.5	6.5	3.0	34.5	33.5	117.7	124.7	55.0	9.0	2.7	3.7	409.0 [sic]			1932-1934
	T'ai-yuan	2.3	3.7	3.7	9.9	27.4	56.7	115.8	112.6	43.8	11.9	0.2	3.3	391.3			1929-1933
	Shou-yang (1)	2.5	2.7	5.8	24.9	32.7	26.6	108.2	72.5	37.8	5.0	8.6	2.0	325.3 [sic]	1923 400.5	1934 218.5	1922-1926, 1934
	T'ai-ku	0.3	1.2	14.4	7.3	25.3	85.3	150.1	171.3	94.1	5.9	1.0	5.0	561.3 [sic]			1932-1933
	P'ing-yao (2)	4.6	3.5	9.1	26.9	27.0	33.0	81.5	92.4	37.8	17.8	9.1	7.3	350.6 [sic]			1920-1931
	Hsin-chiang	0.0	0.0	0.0	17.4	61.6	37.0	53.1	91.4	84.0	8.2	11.4	0.0	364.2 [sic]			1932-1933
	Chieh	4.3	5.6	8.2	17.4	54.5	74.9	87.4	130.5	60.5	24.5	25.4	6.4	508.6 [sic]			1931-1933
Honan	Hsin-hsiang	7.1	3.2	15.2	39.8	37.6	43.3	31.7	105.4	28.3	32.4	24.6	6.2	404.8 [sic]	1933 444.4	1931 344.8	1931, 1933, 1934
	Shan-hsien (2)	8.8	6.6	13.1	32.3	45.0	46.6	92.3	91.9	49.5	22.7	10.6	7.5	426.9			1919-1931
	Lo-yang	14.9	10.0	17.6	19.3	35.1	86.7	85.9	132.7	120.5	65.9	31.9	26.4	646.9	1934 972.6	1933 401.9	1931-1934
	Meng-ching	18.6	4.3	23.3	23.8	32.5	34.6	91.0	103.5	72.5	14.0	18.3	24.0	508.0 [sic]	1932 649.5	1933 314.5	1932-1934
	Yen-shih	13.2	9.9	18.0	28.5	33.6	36.7	80.6	107.2	31.4	17.9	19.1	11.3	406.5 [sic]	1934 478.7	1933 295.8	1931, 1932, 1934
	Cheng-chou																

Footnotes to above:
(1) Observations made over a period of 5 to 10 years.
(2) Observations made over a period of 10 years or more.

RESTRICTED

32 AB

25 94899

Approved For Release 1999/08/25 : CIA-RDP78-03109A000200010001-6

The map on the following page shows the average annual isohyets in the drainage area of the Yellow River, drawn from the above data. There was no data for the furthest upstream area of Chinghai, but the trend of the isohyets shows that the rainfall there must be between 400 and 600 millimeters. Kansu has about 450 millimeters; the great bend of the Yellow River on the Ninghsia - Suiyuan boundary has the least, 250 millimeters; northern Shensi and Shansi have from 300 to 400 millimeters; central Shensi and Shansi, 400 to 500 millimeters, and southern Shensi and Honan, 500 to 600 millimeters of rainfall.

1 ISOHYET MAP OF NORTH CHINA
(mm of rainfall)
Scale: 1:6,000,000

2 Lan-chou

3 Ning-hsia

4 Pao-t'ou

5 Sui-yuan

6 Chang-chia-k'ou

7 Peip'ing

8 T'ien-ching

9 Ta-ku

10 Shih-chia-chuang

11 T'ai-yuan

12 Chi-nan

13 Hsu-chou

14 K'ai-feng

15 T'ung-kuan

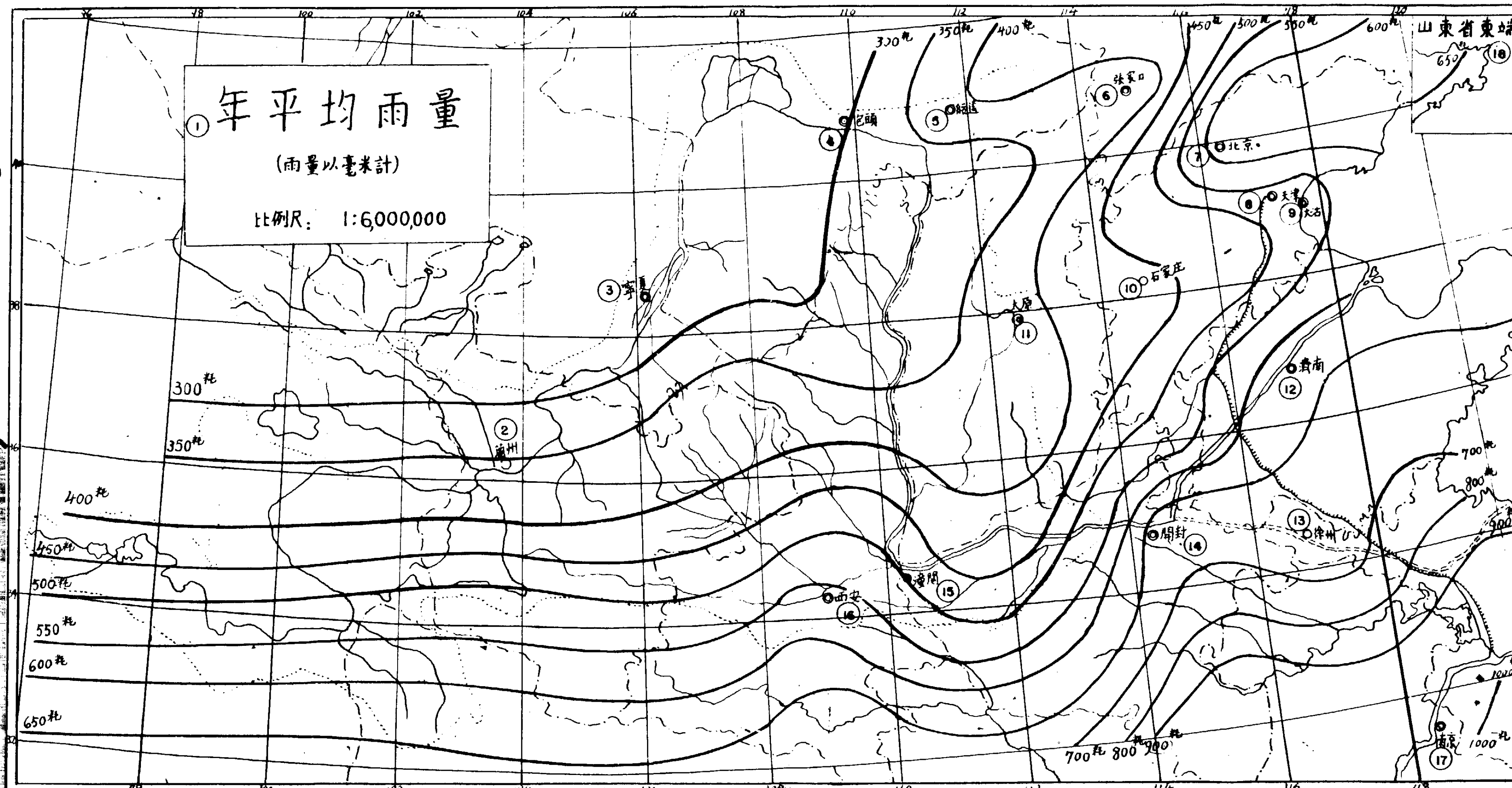
16 Hsi-an

17 Nan-ching

18 Eastern Shantung

Note: The character (粍) which appears after the figures designating the isohyet lines indicates "millimeters."

第三號圖（2）



年平均雨量
（雨量以毫米計）
比例尺： 1:6,000,000
山東省東端
300粍
350粍
400粍
450粍
500粍
550粍
600粍
650粍
700粍
800粍
900粍
1000粍
包頭
歸綏
張家口
北京
天津
大沽
石家庄
太原
寧夏
蘭州
西安
潼關
開封
徐州
濟南
南京

The following table shows the annual precipitation of the entire drainage basin area calculated from the preceding isohyet map.

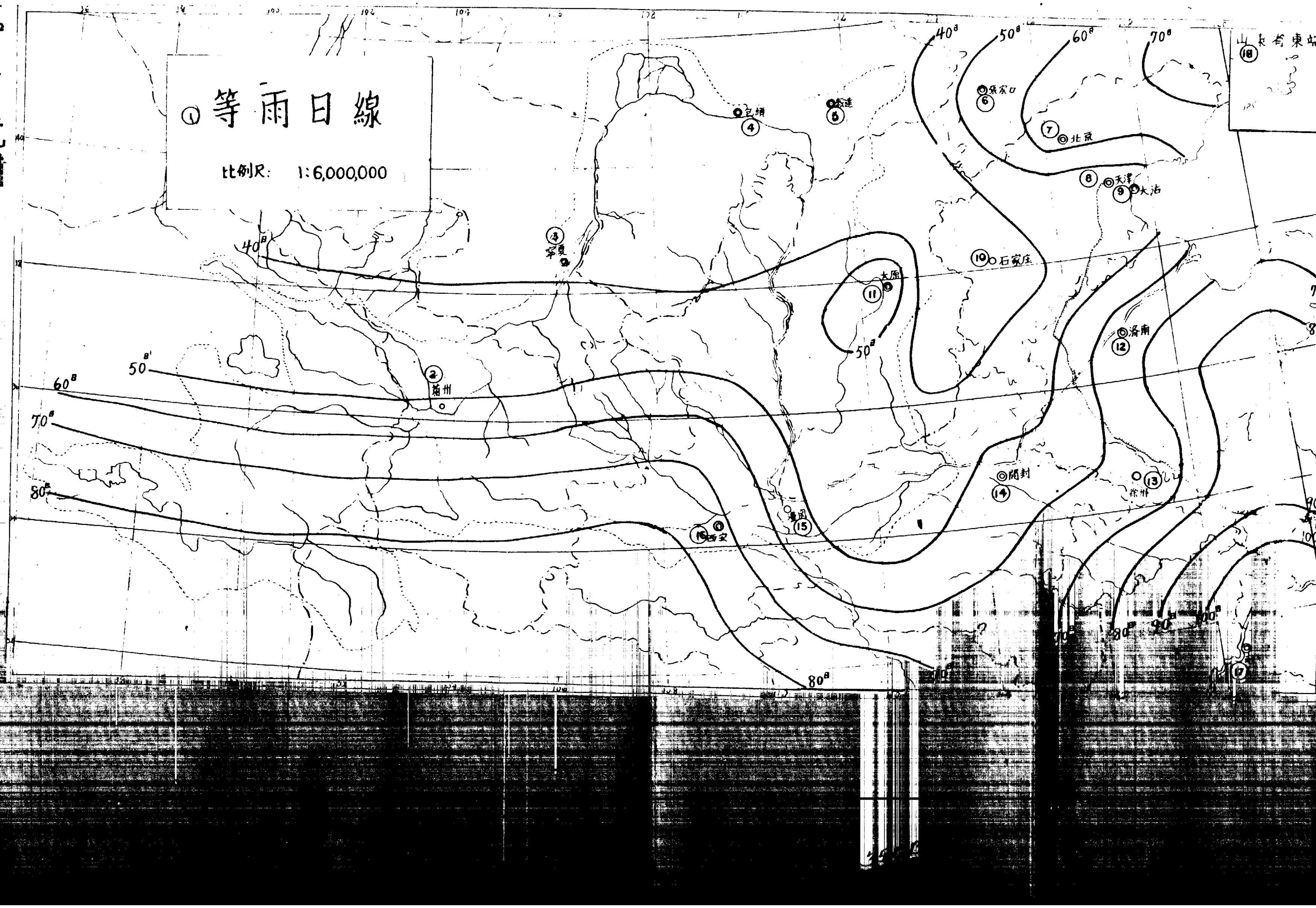
Precipitation in Sections of Yellow River Drainage Basin

	Drainage Area (sq km)	Average Annual Precipitation (cu/m)	Average Rainfall (mm)
Above Lan-chou	216,200	84,600,000,000	390
Lan-chou to Pao-t'ou	178,600	53,370,000,000	300
Pao-t'ou to Yu-men-k'ou	120,530	42,190,000,000	350
Wei, Lo and Ching Rivers	151,220	65,860,000,000	435
Fèn River	45,560	17,950,000,000	395
T'ung-kuan to Shan	6,190	2,910,000,000	470
Shan to Pei-p'ing - Han-k'ou Railroad Bridge	37,910	17,650,000,000	465
Total	756,000 [sic]	274,530,000,000 [sic]	364 [sic]

C. Number of Days of Rainfall

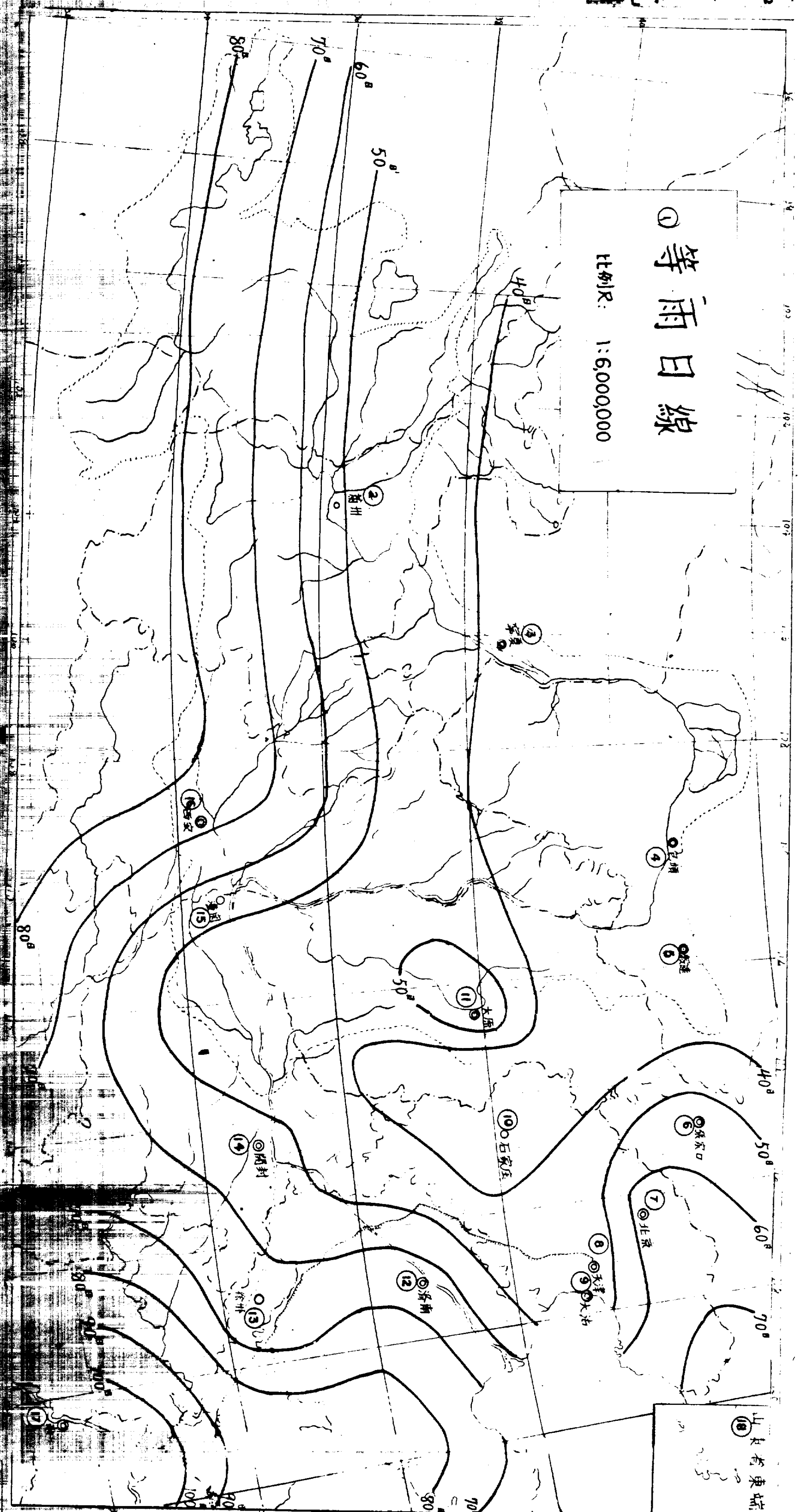
The following table shows the number of days of rainfall per year at the principal observation stations in the Yellow River drainage basin. This table, and the subsequent map on days of precipitation, show that the number of days of rainfall varies with the isohyets. Ninghsia and Suiyuan have 30 days of rainfall, and northern and central Shansi and Shensi have from 30 to 40 days. The number of days increases southward, with southern Shansi, southern Shensi and Honan having from 50 to 70 days.

第四號圖（2）



Approved For Release 1999/08/25 : CIA-RDP78-03109A000200010001-6

第四號圖（2）



Approved For Release 1999/08/25 : CIA-RDP78-03109A000200010001-6

1 PLACES [IN NORTH CHINA] HAVING SAME NUMBER OF DAYS OF RAINFALL PER YEAR
Scale: 1:6,000,000

2 Lan-chou

3 Ning-hsia

4 Pao-t'ou

5 Sui-yuan

6 Chang-chia-k'ou

7 Pei-p'ing

8 T'ien-ching

9 Ta-ku

10 Shih-chia-chuang

11 T'ai-yuan

12 Chi-nan

13 Hsu-chou

14 K'ai-feng

15 T'ung-kuan

16 Hsi-an

17 Nan-ching

18 Eastern Shantung

Note: The character (日) which appears after the figures designating the isohyet lines indicates "days."

Number of Days of Rainfall per Year in the Yellow River Drainage Basin

Province	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Years Recorded
KANSU	Lan-chou	4.0	2.0	3.0	4.0	5.0	9.0	11.0	14.0	13.0	3.0	0.0	3.0	71.0	1932-1933
	Ning-hsien														
	Ch'ing-shui														
SUIYUAN	Sa-la-ch'i	0.8	0.8	1.5	1.7	4.0	5.4	9.7	8.5	2.8	1.5	0.8	1.3	38.8	1921,1923-1925,1927-1933
	Sui-yuan	0.4	1.7	1.3	1.2	4.2	4.8	6.6	8.8	4.2	2.2	1.0	0.4	36.8	1920-1925
	Erh-shih-ssu-ch'ing-ti [sic]	1.1	1.3	1.5	2.1	3.9	5.2	9.3	7.8	4.4	1.7	1.2	1.6	41.1	1925-1933
	Yu-pi-yai [sic]	2.7	5.0	4.0	6.3	9.3	12.3	2.7	14.3	9.3	5.4	1.0	3.0	84.3 [sic]	1920-1922
SHENSI	I-ch'uan														
	Ch'ang-wu														
	Ch'eng-ch'eng														
	Ch'ao-i														
	Fu-p'ing														
	Hsi-an	3.4	3.6	4.8	7.0	7.4	6.6	9.0	10.0	9.6	8.0	3.6	3.0	76.0	1923-1925,1932-1933
	T'ung-ta-fa	4.0	2.6	2.6	4.1	5.7	6.3	13.0	8.2	5.6	6.1	2.6	4.5	65.3	1921-1923,1925-1933
SHANSI	Shuo-chou														
	T'ai-yuan	1.8	1.9	2.4	3.2	4.7	7.0	10.2	8.3	6.1	2.8	1.6	2.0	52.0	1916-1933
	Shou-yang	1.3	1.3	2.0	2.7	3.0	2.7	12.7	8.3	4.3	2.0	1.0	0.4	41.7	1923-1925
	T'ai-ku														
	P'ing-yao	0.7	0.7	0.3	3.3	4.0	4.3	9.3	8.3	5.7	1.0	0.7	1.0	39.3	1923, 1925, 1932
	Hsin-chiang														
	Chieh														
HONAN	Hsian-hsiang														
	Shan-hsien	1.8	1.0	2.7	4.7	6.3	4.3	8.3	6.0	4.5	2.8	1.7	1.4	45.5	1921-1925, 1932
	Lo-yang	4.5	4.5	1.3	3.3	3.4	6.0	4.0	5.6	2.7	2.5	1.0	2.0	40.8	1930-1933
	Meng-ching														
	Yen-shih														
	Cheng-chou														

D. The Rainy Season and Variations from Year to Year

The seasonal distribution of rainfall in the drainage basin of the Yellow River varies greatly, more than 60 percent falling during the summer season and only 3 percent in winter. The following table shows this seasonal distribution for a few stations.

Seasonal Distribution of Rainfall in the Yellow River Drainage Basin (mm)

Province	Location	Spring	Summer	Autumn	Winter	Total
Kansu	Lan-chou	40.3	251.1	63.3	14.9	369.6
Suiyuan	Sa-la-ch'i	46.3	222.4	59.4	23.4	351.5
Shensi	Hsi-an	116.1	241.4	150.8	10.1	518.4
"	T'ung-ta-fa	106.2	267.7	114.7	32.0	520.6
Shansi	T'ai-yuan	41.0	285.1	55.9	9.3	391.3
"	Chieh	80.1	292.8	110.4	16.3	499.6
Honan	Shan	90.4	230.8	82.8	22.9	426.9
"	Lo-yang	72.0	305.3	218.3	51.3	646.9
Average		74.1	262.1	107.0	22.5	465.7 [sic]

One of the main characteristics of the North China climate is the great variation in amount of precipitation from year to year. This variation is general in the Yellow River drainage area. The following table bears this out for Sa-la-ch'i, P'ing-yao and Shan where observations have been made for the longest period of years.

Yearly Variation in Precipitation

Province	Location	Years Observed	Annual Average	Maximum Year	Minimum Year	Ratio of Maximum to Minimum
Suiyuan	Sa-la-ch'i	1921-1933 (except for 3 years)	351.0	622.0	235.0	2.64
Shansi	P'ing-yao	1920-1931 (except for 3 years)	350.0	514.5	201.7	2.55
Honan	Shan	1919-1933	426.9	682.6	198.2	3.46

Each year averages a change of 50 to 100 percent from the preceding year, and normally averages a difference of 30 percent from the average year.

E. Evaporation

Evaporation is one of the elements which determine the volume of flow of the river. It is particularly important in calculating the volume of water lost by evaporation from large reservoirs. The only statistics on evaporation in the Yellow River basin are the Shensi Water Supply Bureau's figures on Hsi-an and Hsien-yang. These are given in the following table, together with similar data for T'ien-ching, San-chia-tien, Hsien and Lin-ch'ing on the North China plain.

Evaporation
(mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Hsi-an	34.8	25.1	172.1	113.8	178.4	202.2	181.0	131.7	79.8	35.6	32.2	21.0	1,213.7 [sic]
Hsien-yang	21.1	30.6	81.6	81.5	152.1	157.2	151.5	117.4	62.5	43.2	36.2	14.7	949.1 [sic]
T'ien-ching	33.45	56.05	96.01	202.23	273.09	256.84	106.44	138.51	166.33	134.83	103.49	439.4	1,711.21 [sic]
San-chia-tien	26.2	72.9	67.9	117.2	175.9	151.9	105.5	80.9	86.8	54.0	43.5	37.8	1,020.6 [sic]
Hsien	30.0	41.6	107.6	148.2	187.7	216.3	165.9	77.31	94.6	62.9	53.6	31.4	1,217.1 [sic]
Lin-ch'ing	21.0	25.4	118.6	171.52	281.0	274.5	276.0	134.1	162.1	104.7	81.2	27.9	1.677.9 [sic]

In general, the amount of evaporation varies from 1,000 to 1,500 millimeters.

IV Relation Between Rainfall and Volume of Flow

The volume of flow of the Yellow River at Shan, Honan and Nan-hai-tzu near Pao-t'ou, Suiyuan, is essential to the water power plan. The records at Shan cover a 17-year period from 1919 to 1935 and are sufficiently reliable, but those at Pao-t'ou cover less than four years and are unreliable. We shall, therefore, first discuss the volume of flow at Shan and then discuss that at Pao-t'ou in the light of the data from Shan, the rainfall, etc.

A. Volume of Flow at Shan

Most of the drainage area of the Yellow River is above Shan. Observations have been made there over many years. They are the only reliable ones for the hydroelectric development plan.

Sources of Data on Volume of Flow at Shan

Apr 1919 to Aug 1921	-	Hsu-chih Water Supply Committee
Sep 1921 to Oct 1928	-	Average estimate
Nov 1928 to Oct 1929	-	North China Water Supply Committee
Nov 1929 to Oct 1930	-	Average estimate
Nov 1930 to Jun 1931	-	Missing
Sep 1931 to Aug 1933	-	Survey by River Office, Honan Province
Sep 1933 to Nov 1933	-	Missing
Dec 1933 to Dec 1935	-	Yellow River Water Supply Committee

Data is discontinued here.

The monthly and yearly average flow at Shan for the 17-year period are shown in the folliwing chart and in Addendum A*. The dailv flow is shown in Addendum B* and Addendum C*.

The flow during the greatest rise in the river, in July, August and September, is from 2,000 to 4,000 cubic meters per second. All the great floods have occurred during this period. The volume of water finally begins to decrease in October, and in mid-November the river enters its low-water period.

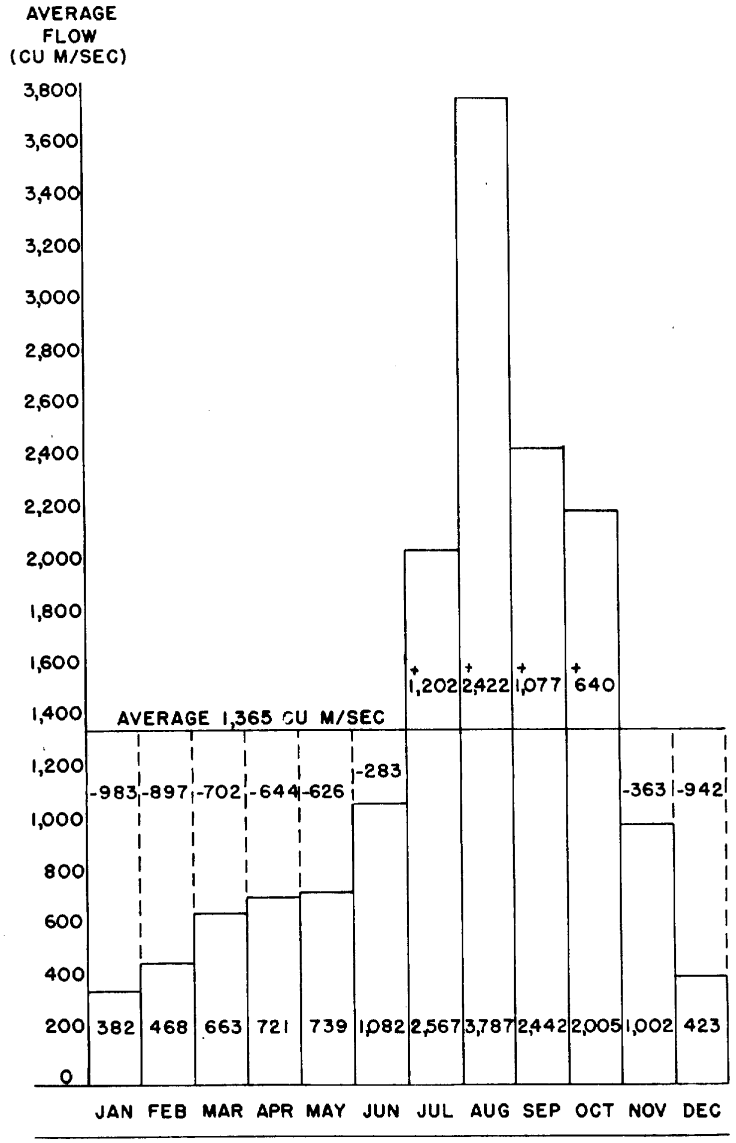
In early October 1934 the flood water reached a flow of 10,000 cubic meters per second, but this is a rare occurrence Winter ordinarily has the least flow of the year, an average

*(Note: These Addenda will appear in Volume III of this report.)

of 300 to 450 and sometimes as little as 250 cubic meters per second. With the spring thaw and summer melting, the flow gradually increases. There is another low in May-June but this is not as marked as the winter one.

RESTRICTED

AVERAGE FLOW AT SHAN



RESTRICTED

42HB

The average volume of flow at Shan during the 17-year period 1919 - 1935 was 1,365 cubic meters per second, or 43,000,000,000 cubic meters a year. The maximum year was 1923, with 2,110 cubic meters per second, or a total of 67,700,000,000 cubic meters. The minimum year, 1928, had 648 cubic meters per second, or a total of 20,700,000,000 cubic meters. The ratio between flow in maximum and minimum years was 3.16:1, a very high figure. The maximum is 1.45 times the average, while the minimum is 0.46 times. This means that equalization of flow during the year will require very large reservoirs.

The following table gives the flow at Shan for 1922 and 1927, which were nearly average years.

Average Monthly Flow at Shan in Average Years (cu m/sec)

	1919-1935 Average	1922	1927
Jan	382	463	279
Feb	468	593	337
Mar	666	692	688
Apr	721	822	1,257
May	739	875	828
Jun	1,082	703	1,362
Jul	2,567	2,625	1,680
Aug	3,787	4,375	2,489
Sep	2,442	3,200	2,899
Oct	2,005	1,242	1,849
Nov	1,002	855	1,056
Dec	423	414	447
Monthly Average	1,365 [sic]	1,465 [sic]	1,271 [sic]

Low and High Water at Shan in Average Years

	No of Days*	Average 1919-1935	1922	1927
Drought Flow	25 days	294 cu m/sec	320 cu m/sec	355 cu m/sec
Slightly more than Drought Flow	60 "	382 "	415 "	400 "
Low Water Flow	90 "	466 "	540 "	480 "
Average Flow	90 "	739 "	760 "	1100 "
High Water Flow	90 "	2005 "	1420 "	1705 "

(*TN: Totals 355 days.)

Graphs of the flow for 1919-1935 are given in Addendum D [which will appear in Volume III of this report].

B. Volume of Flow at Nan-hai-tzu near Pao-t'ou

The volume of flow at Pao-t'ou is basic to the plan to develop water power between Pao-t'ou and T'ung-kuan, but the existing data is limited to the following:

Period	Source of Data
Jun to Oct 1919	Suiyuan
Apr to Nov 1930 (once a month)	
Apr to Nov 1931 (several times a month)	
Apr to Nov 1932 (" " " ")	
Jul to Dec 1933	"Thoughts on the Yellow River"

The above yields the following average monthly flow figures for Pao-t'ou:

	1919	1934 [1933?]	1930 1931	No of Times Observed	1942 [1932?]	No of Times Observed	Monthly Average
Jan	No data	No data	No data		No data		
Feb	"	"	"		"		
Mar	"	"	"		"		
Apr	"	"	420	2	317	3	369
May	"	"	1,020	1	287	3	654
Jun	602	"	844	5	412	4	619
Jul	849	642	No data		690	3	724 [sic]
Aug	900	1,875	1,641	8	719	7	1,284
Sep	809	2,037	1,549	10	No data		1,465
Oct	778	1,676	1,058	8	1,270	3	1,195 [sic]
Nov	No data	970	870	7	960	1	933 [sic]
Dec	"	859	No data		No data		(859)

Since these figures are inadequate, they must be supplemented by data on the volume of rainfall and the runoff from the drainage area. The drainage area above Pao-t'ou is 394,780 square kilometers, but most of the drainage area between Lanchou and Pao-t'ou is an almost level plain and its rainfall contributes little to the flow of the Yellow River. There are, moreover, many irrigation ditches around Ning-hsia, Wu-yuan and Sa-la-ch'i which draw water from the main stream. This stretch is very dry, with desert conditions in many places, and the Yellow River is greatly diminished in volume by its meandering of several hundred kilometers here.

According to the four-year survey and report by the International Famine Relief Commission, from which the above data was derived, the flow during April was under 200 cubic meters per second, and reached a low of 145 in April 1931. It is evident that most of this water comes from the headwater area above Lan-chou. Flood water at Pao-t'ou rarely exceeds 4,000 cubic meters per second.

In normal years the summer flood water at Pao-t'ou is 2,000 cubic meters per second, but in 1933 it reached 3,600. At that time, the maximum flow at Lan-chou was 7,000 cubic meters per second. In 1934 the maximum flow at Pao-t'ou was 2,200 cubic meters per second, and that a Lan-chou was 5,400. The average flow at Lan-chou in August 1934 was 3,712 cubic meters per second, while that at Pao-t'ou was 1,875. The loss of water between Lan-chou and Pao-t'ou during the summer amounts to approximately 50 percent. Therefore, although the loss during the other seasons is somewhat less than in summer, it can be assumed that the loss for the entire year is 40 percent. The volume of flow at Pao-t'ou will be estimated from the rainfall and the relation between the flow at Lan-chou and at Pao-t'ou.

The Yellow River drainage area above Lan-chou is 216,180 square kilometers, and has an annual rainfall of 400 to 600 millimeters. The average for the entire basin will be taken as 450 millimeters. The area has extensive forests and pastures which prevent the rivers from carrying away the quantity of silt that would be expected from the extensive loess deposits. Since most of the area is mountainous, the runoff percentage must be quite high. Following are the runoff percentages of rivers in Manchuria and North China:

Upper Sungari River	–	52%
Mu-tan River	–	40%
Luan River	–	18%
Yung-ting River	–	9%
Hu-t'o River	–	18%
Yalu River	–	60%

Although the runoff from the headwater area of the Yellow River is not as great as that of the Upper Sungari or Yalu Rivers, it is far greater than that of the Luan or Hu-t'o Rivers and is about the same as that of the Mu-tan River. The annual runoff may, therefore, be quite safely set at 40 percent.

The annual flow at Lan-chou is thus

$$216{,}180 \times (1000^2) \times \frac{450}{1000} \times \frac{40}{100} = 390 \times 10^8$$

With a 40 percent loss of flow between Lan-chou and Pao-t'ou, the total annual flow at Pao-T'ou is 22,200,000,000 cubic meters, or an average of 705 cubic meters per second.

Since the above statistics contain no data for January, February or March, these figures must be estimated from the data for the Upper Sungari River.

The drainage area above Lan-chou is 216,180 square kilometers and the average annual rainfall 450 millimeters, while the drainage of the Upper Sungari River above Hsiao-feng-man is 43,900 square kilometers and the average annual rainfall 800 millimeters. The volume of flow in winter at Lan-chou would, calculated from the drainage area and rainfall, be 2.78 times the flow at Hsiao-feng-man [sic]. The flow at Pao-t'ou is only 80 percent of that at Lan-chou. The following table shows the flow at Pao-t'ou, with estimated data for December, January, February and March.

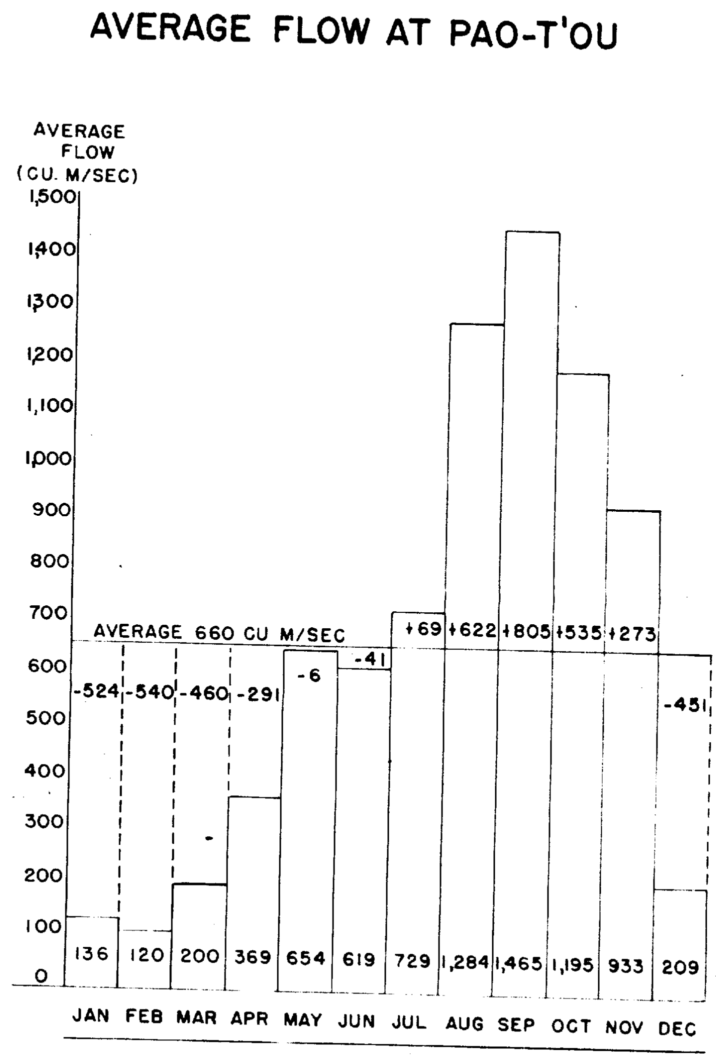
Calculated Flow at Pao-t'ou

	Pao-t'ou (cu m/sec)	Lan-chou (cu m/sec)	Upper Sungari River above Hsiao-feng-man [sic] (5-yr average)	Shan on Yellow River	Ratio of Pao-t'ou to Shan Flow
Jan	136	170	62	382	0.356:1
Feb	120	150	54	468	0.256:1
Mar	200	250	90	663	0.304:1
Apr	369		733	721	0.512:1
May	654		540	739	0.883:1
Jun	619		745	1,082	0.576:1
Jul	729		1,260	2,567	0.273:1
Aug	1,284		1,345	3,787	0.339:1
Sep	1,465		606	2,442	1.600:1
Oct	1,195		432	2,005	0.594:1
Nov	933		242	1,002	0.910:1
Dec	209	261	94	423	0.495:1
Year	660		520 [sic]	1,365 [sic]	0.485:1 [sic]
Total flow (cu in)	20,800,000,000	37,000,000,000	16,400,000,000	43,000,000,000	

This data yields an average annual flow at Pao-t'ou of 660 cubic meters per second or a total flow of 20,800,000,000 cubic meters, which is only slightly less than the figure calculated from the rainfall and runoff. This figure has therefore been adopted for the calculations.

The above table gives the ratio of annual flow of Pao-t'ou to Shan as 0.485:1. The summer and winter ratios vary between 0.25:1 and 0.35:1, while the spring and autumn ratios vary from 0.5:1 to 0.6:1. In May and September it reaches 0.9:1. The following chart shows the average monthly flow. In winter, the extremely low temperature and freezing in the headwater area results in less flow than in the downstream area, while in summer the entire drainage area receives heavy rainfall, producing severe floods in the lower river.

RESTRICTED



RESTRICTED

48AR

C. Volume of Flow between Pao-t'ou and Shan (see following chart)

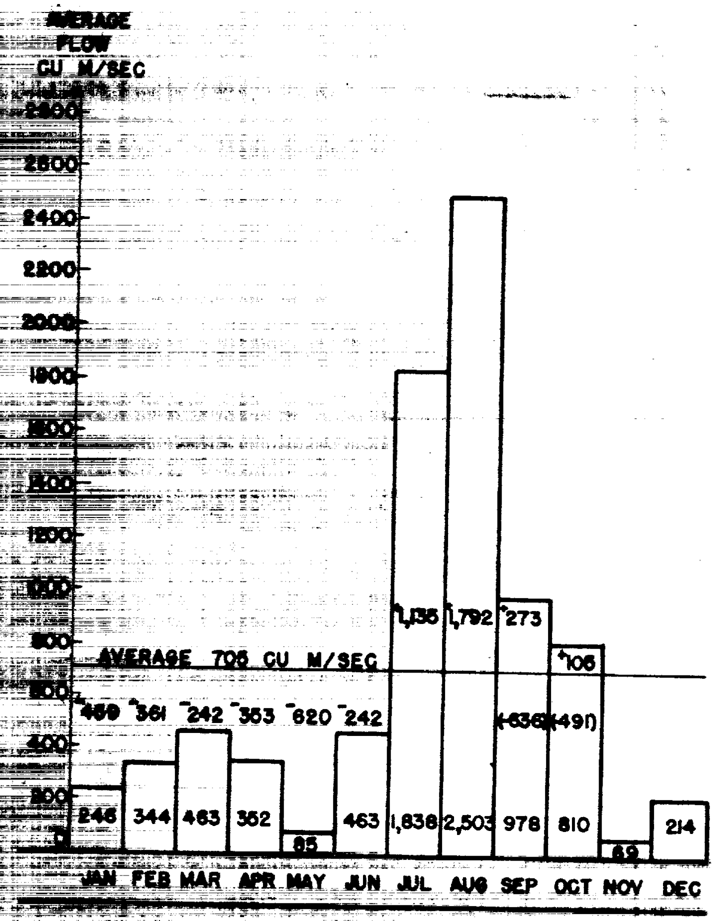
The difference between the total annual flow of 43,000,000,000 cubic meters at Shan and 20,800,000,000 at Pao-t'ou leaves a total annual flow between these points of 22,200,000,000 cubic meters. The drainage area of the Yellow River between these points is 320,000 square kilometers. It has an annual rainfall of 300 to 600 millimeters, so that the average may be considered 450 millimeters. There are extensive loess deposits and flat-topped mountains. All the land is cultivated, including the foothills, except where barren, which means that a high percentage of land is under cultivation. The area thus may be assumed to have a runoff percentage equal to or slightly less than that of the Luan or Hu-t'o Rivers. The annual runoff is therefore set at 15 percent. The annual runoff between Pao-t'ou and Shan may be calculated in the following manner:

$$320{,}000 \times (1000^2) \times \frac{450}{1000} \times \frac{15}{100} = 216 \times 10^8 \text{ cu/m}$$

This result largely agrees with the figure calculated from the difference in flow between Pao-t'ou and Shan. The 126,000 square kilometers in northeastern Shensi and northwestern Shansi which form part of this drainage basin have a direct influence upon increasing the flow to the various water power sites between Pao-t'ou and Yu-men-k'ou. The rainfall increases from 300 millimeters in the north to 500 in the south, and averages 400 millimeters for the entire basin. Therefore, the total runoff for this area, calculated at 15 percent, would be as follows:

$$120{,}000 \times (1000^2) \times \frac{400}{1000} \times \frac{15}{100} = 72 \times 10^8$$

INCREASE IN FLOW BETWEEN
PAO-TOU AND SHAN



D. Flood Volume

Subcommittee No 2 of the North China Committee made a detailed study of flood volume, so this report will only summarize its results.

Records and data about the maximum flood water volume were collected at Shan, Lung-men and Pao-t'ou. The normal maximum flood volume at Shan is estimated, on the basis of the 17-year record from 1919 to 1935, at 15,000 cubic meters per second. If so, the maximum flood volume of the Yellow River above T'ung-kuan and that of the Wei River do not coincide. There is, however a definite possibility, that they may sometimes coincide and then the maximum flood volume at Shan would probably exceed 23,000 cubic meters per second.

The following table shows the factors in the maximum Yellow River flood in 1933, and the maximum flood volume of its tributaries.

Factors in the 1933 Yellow River Flood at Shan

	Drainage Area sq km	Contribution to Flood at Shan	Maximum Flood of Each Tributary	Maximum Flood Possible in Each Drainage Area
			cu m/sec	
T'ung-kuan to Shan	4,000		300	
Wei River System				
Lo River	25,000	300	2,500	4,500
Ching "	38,000	12,000	12,500	15,000
Wei "	59,000	4,000	6,000	7,000
Fen River	40,000	1,800	3,000	4,500
Pao-t'ou to Lung-men	140,000	2,300	8,000	10,000
Above Pao-t'ou		2,200	3,600	5,000
Total		22,600		41,000 [sic]

The maximum possible flood water volume at Shan is 41,000 cubic meters per second, but in actuality it is safe to assume that only two or three floods will coincide. Consequently, the maximum possible flood water volume at Shan is really between 25,000 and 33,000 cubic meters per second.

No record has been kept of the maximum flood water volume at Lung-men. According to reports on Hu-k'ou and Lung-men by the Geological Survey Bureau, the 1933 summer volume of flow at Lung-men was approximately 8,000 cubic meters per second. In that year, estimating from marks left by the floodwaters, the flow reached approximately

10,000 cubic meters per second. The flow at Pao-t'ou was at that time 2,000 cubic meters per second, so that approximately 8,000 cubic meters per second must have been added to the river between these points.

During floods the river at Lung-men is 600 meters wide and touches steep cliffs on both sides. Three to four meters of silt are washed up from the river bed, making the river six to seven meters deep during the maximum flow. The cross-sectional area of the river reaches at least 4,000 to 6,000 square meters. If the average rate of flow is three meters per second, the maximum volume of flow must reach 12,000 to 18,000 cubic meters per second.

Floodwater is greatly reduced at Pao-t'ou from the floods which reach Ning-hsia by the Ning-hsia - Suiyuan river course. The summer volume of flow at Pao-t'ou therefore, varies only slightly from 2,000 cubic meters per second. In the summers of 1933 and 1934, the maximum flow at Lan-chou was 7,000 and 5,000 cubic meters per second respectively. By the time it reached Pao-t'ou the volume had been reduced to 3,600 and 2,200 cubic meters per second respectively.

At the mouth of the Min-sheng Canal, 20 kilometers downstream from Pao-t'ou, the volume is said to never go beyond 4,000 to 5,000 cubic meters per second. The estimated maximum flood volumes may be summarized as follows:

Shan	-	30,000 cu m/sec
Lung-men	-	15,000 "
Pao-t'ou	-	5,000 "

V Silt Content

A. Introduction

The Yellow River carries a heavier silt load than any other river in the world. This characteristic is very important for the electric power development plans as well as for flood control. The great quantity of silt in the Yellow River comes from loess-covered hills, which comprise 25 percent of the drainage basin. According to WENG Wen-Hao, head of the Geological Survey Bureau, loess occupies the following areas in the drainage basin:

Loess Areas in the Yellow River Basin

Drainage Basins	Amount of Loess
Above Lan-chou	60,000 sq km
Lan-chou to Ning-hsia	55,000 " "
Wei River	26,000 " "
Ching River	2,000 " "
Lo River (Shensi)	16,000 " "
Fen River	11,000 " "
Hsi-an to Kuan-yin-t'ang	1,000 " "
Lo River (Honan)	2,000 " "
Other	15,000 " "
Total	188,000 " "

From the middle of November to May the silt content in the Yellow River between T'ung-kuan and the mouth is not more than six-one thousandths by weight. In the winter low-water season it is considerably less. This silt is eroded by the swift mountain streams in the headwater area and washed downstream. The silt content decreases after the river enters the alluvial plains.

In the spring, with the rise in the river, the silt content also increases, multiplying several times within a few hours. Thereafter, the silt content varies above 1 percent and does not go below the winter load. However, in a long dry spring, when the flow remains below 500 cubic meters per second for a protracted period, the silt content may decrease further.

During the summer flood season the silt content reaches a percentage unequalled by any river in the world except for one or two others in northern China. In some of its tributaries, the silt amounts to 50 percent by weight (40 percent by volume). The silt is practically all mineral matter, varying in size from very fine sand to clay. This silt is washed out by the torrential summer rains, from the extensive loess and tertiary clay deposits in the Yellow River basin. Most of the silt comes from Shensi, Shansi and Kansu below Pao-t'ou, and relatively little from the headwater area of Ch'in-ghai, Kansu and Ning-hsia.

According to the report by the International Famine Relief Commission, the silt content at-Pao-t'ou and at-Lan-chou is almost the same, so most of the silt load at Pao-t'ou must originate above Lan-chou. However, the slight gradient in the 1000-kilometer stretch between Pao-t'ou and Lan-chou reduces the volume of flow. This is similar to the situation between Shan and the river mouth. The silt content at Lan-chou should therefore be far greater than that at Pao-t'ou, the silt settling out before the river reaches there. At any rate, silt brought from above Pao-t'ou has very little effect upon the lower river. Most of the silt load at Shan comes from the Wei River basin.

B. Silt Content

The only available data on the silt content of the upper Yellow River was taken at Shan, Lung-men and Pao-t'ou over a period of several years.

Silt Content Data on the Upper Yellow River

Location	Years	Source of Data	Remarks
Shan	1920	"Thoughts on the Yellow River"	Averaged from a few observations each month.
	1921	"	"
	1929	"	Averaged from a few observations each month, (including December 1928)
	1933	National Hydrological Report	Maximum and minimum
	1934	"	Average, maximum and minimum
	1935	"	"
Pao-t'ou	1930	Internation Famine Relief Commission	Averaged from a few observations each month.
	1931	"	"
	1933	"	"
	1934	National Hydrological Report	Average, maximum and minimum
	1935	"	"

These sources show that the greater portion of the silt load at Shan comes from below Pao-t'ou. Since all the water power sites are below Pao-t'ou, some research on silting in reservoirs is necessary, especially at the San-men Gorge and the other sites below the junctions with the Fen and Wei Rivers.

C. The Yellow River Alluvial Plains

The following information was extracted from the recent observations upon the Yellow River alluvium deposition published by the League of Nations in "Research Material on Improvement of the Yellow River." Floods, especially very destructive ones, have not occurred at yearly intervals during the last few centuries. For instance, during the 300-year period of 1552 to 1852, when the river last changed its course, 98 floods are recorded, only 13 of which caused widespread destruction.

These 98 floods occurred during 83 of the 300 years (some years had two or more floods). During the other 217 years the dikes held. The entire volume of alluvial soil, less the amount deposited on the river bed, was carried to the sea.

Hydrological experts who have studied the Yellow River estimate that the average annual volume of alluvium carried down during floodless years varies between 300,000 and 600,000 cubic meters. The mean figure, 450,000 cubic meters, has been taken for purposes of calculation. If an annual average of 75,000 cubic meters is deposited on the river bed, 375,000 cubic meters is the average volume carried out to sea.

During the 217-year period, 810,000,000 cubic meters of alluvial soil were deposited in the sea. It may be assumed that during the years of the 13 destructive floods, most of the alluvium was deposited at the breaches in the dikes. The maximum flow of water which will not cause a breach in the dike rarely exceeds 8,000 cubic meters per second. The maximum floods can reach 25,000 to 30,000 cubic meters per second, as stated before. The mean average of the maximum flow which will not cause a breach in the dikes (8,000 cubic meters per second), and the flow during the 13 great floods, is 16,000 cubic meters per second.

Other things being equal, the silt load increases more rapidly than the rate of flow. (Some contend that the silt load is the fourth power of the depth of water.) Since more adequate data was not available, the Committee estimated 1,350,000 cubic meters as the volume of alluvium washed down by each of the 13 great floods. These figures are believed accurate enough to serve as a basis for subsequent calculations.

The volume of alluvium washed down during the remaining 70 years of comparatively minor floods was taken as 900,000 cubic meters, the average of the two former figures (450,000 and 1,350,000 cubic meters).

Since there is no other suitable source material, the Committee prepared the following hypothetical table to show the average percentage of silt content by weight at Shan.

Average Silt Content at Shan

(Percentage by Weight)

	1920		1921		1929		1933		1935		Average
	Silt Content	No of Times Ob-served	Silt Content	No of Times Ob-served	Silt Content	No of Times Ob-served	Silt Content	No of Times Ob-served	Silt Content	No of Times Ob-served	
Jan					0.35	3	0.32		1.23		0.63
Feb					2.53	5	0.40		1.50		0.81 [sic]
Mar			1.13	7	1.20	16	0.32		1.93		1.15
Apr			1.17	7	0.89	15	1.13		1.91		1.28
May			1.08	7	0.64	6	1.22		2.17		1.28
Jun	1.99	4	2.08	10			1.75		1.68		1.87
Jul	2.29	6	3.47	20			6.86		4.46		4.28
Aug	4.36	7	1.33	6	7.30	8	9.01		5.31		5.46
Sep	3.17	8			3.00	12	3.77		2.17		3.03
Oct	2.83	9			2.20	7	4.04		1.99		2.76
Nov	1.39	6					2.13		1.40		1.63
Dec	0.75	5			1.26	6	1.62		0.98		1.15

Approved For Release 1999/08/25 : CIA-RDP78-03109A000200010001-6

The following table compares the silt content at Shan with that at the Pei-p'ing-Han-k'ou Railway Bridge, as observed in a study of China's water supply problem.

Silt Content at Shan and at the Pei-p'ing - Han-k'ou Railway Bridge

	Shan		Pei-p'ing - Han-k'ou Railway Bridge	
	Average Flow (cu m/sec)	Silt Content (%)	Average Flow (cu m/sec)	Silt Content (%)
Jan	385	0.63	300	0.4
Feb	458	0.81	500	0.6
Mar	655	1.15	700	0.8
Apr	715	1.28	700	1.0
May	741	1.28	600	1.5
Jun	1,076	1.87	800	1.5
Jul	2,651	4.28	2,000	3.0
Aug	12,818	5.46	3,000	5.0
Sep	2,440	3.03	2,500	3.0
Oct	2,017	2.76	1,500	2.0
Nov	1,027	1.63	1,000	1.5
Dec	423	1.15	600	1.0
Year				3.3 [sic]

According to this table, the volume of silt at Shan is approximately 10 percent greater than that at the Pei-p'ing - Han-k'ou Railway Bridge. The silt content at the railway bridge is 3.3 percent. With an average annual flow of 1,210 cubic meters per second, the river carries an average of 25 cubic meters of silt per second, or 2,160,000 cubic meters a day. In a year this amounts to 946,000,000 [sic] cubic meters. Therefore, the annual volume of silt carried past Shan is 1,000,000,000 to 1,100,000,000 cubic meters, an average of 1,050,000,000 cubic meters.

The flow at the Grand Canal is 1,200 cubic meters per second, and its silt content is 1.5 percent. Thus half the silt carried past Shan settles between the Pei-p'ing - Han-k'ou Railway Bridge and the Grand Canal, and the remainder is carried on to the sea.

The plains east of the Pei-p'ing - Han-k'ou Railway Bridge and north and south of Ch'in-tai (TN: perhaps Shensi Pocket) are covered with 700 billion cubic meters of silt from the many tributaries of the Yellow River. If the silt content of the river has always remained constant, this silt must have been deposited during a period of 7,700 years.

The ratio of monthly and flood period silt load to annual silt load carried past Shan in 1934 and 1935, shown in the following table, was taken from Todd and Eliassen's "Yellow River Problems".

Monthly and Flood Silt Load Percentages at Shan

Periods	Silt Content	Percentage of Year's Total
1934 Total	1,452,000,000 cu m	100.00
July	138,700,000 cu m	9.52
August	709,400,000 cu m	48.80
September	163,800,000 cu m	11.25
(Subtotal)	1,012,900,000 cu m/sic/	69.70/sic/
7 Jul to 12 Jul	46,000,000 cu m	3.17
9 Jul to 17 Aug	473,000,000 cu m	32.60
1 Oct to 8 Oct	115,000,000 cu m	7.93
(Subtotal)	634,000,000 cu m	43.60/sic/
1935 Total	1,272,000,000 cu m	100.0
July	229,500,000 cu m	18.0
August	585,900,000 cu m	46.0
September	123,400,000 cu m	9.7
(Subtotal)	938,800,000 cu m	77.3/sic/
6 Jul to 1 Jul /sic/	35,600,000 cu m	2.8
6 Aug to 2 Aug /sic/	320,000,000 cu m	25.2
(Subtotal)	375,600,000 cu m/sic/	29.5/sic/

This table shows that the volume of silt carried by one or two short floods is nearly half the annual total (43.6 percent during three floods in 1934, and 29.5 percent during two floods in 1935). Nearly 80 percent of the total annual silt load of 1,250,000,000 /sic/ cubic meters is carried during July, August and September (69.7 percent in 1934 and 77.3 percent in 1935), and 50 percent during August (48.8 percent in 1934 and 46 percent in 1935).

The average silt load at Pao-t'ou during July, August and September is one-third to one-fifth of the load at Shan; during the rest of the year it is about one-half.

The total annual silt load at Shan is 1,050,000,000 /sic/ cubic meters, 80 percent /sic/ of which is carried during July, August and September. The total summer silt load at Shan is 840,000,000 cubic meters. The silt load at Pao-t'ou is one-fourth of that at Shan and the flow is one-half, leaving a total summer load there of 105,000,000 cubic meters. The total silt load at Shan for the remainder of the year is 210,000,000 cubic meters.

The silt load at Pao-t'ou is one-half that at Shan and the flow is also one-half, which gives a total load of 50,000,000 cubic meters. The total annual load at Pao-t'ou is 155,000,000 cubic meters, 15 percent of that at Shan, and the average silt load does not exceed 1.2 percent of the total annual flow of 20,800,000,000 cubic meters at Shan.

The following tables compare the silt load in 1934 and 1935 at Pao-t'ou with that at Lung-men and Shan.

Approved For Release 1999/08/25 : CIA-RDP78-03109A000200010001-6

RESTRICTED

Average Silt Load at Pao-t'ou
(%)

	1930 and 1931		1932		1934		1936		Average
	Silt Content	No of Times Ob-served	Silt Content	No of Times Ob-served	Silt Content	No of Times Ob-served	Silt Content	No of Times Ob-served	
Jan									
Feb									
Mar									
Apr	0.26	2	1.16	1					0.71
May	0.53	1	1.32	1					0.93
Jun	0.35	5	1.48	4					0.92
Jul			1.18	3	0.89		0.87		0.98
Aug	0.79	8	1.79	7	1.48		1.01		1.27
Sep	1.52	10			1.47		0.98		1.30 [sic]
Oct	1.43	8	0.42	3	1.38		0.98		1.07 [sic]
Nov	1.26	3	0.27	1			0.61		0.71
Dec							0.32		0.32

RESTRICTED

Approved For Release 1999/08/25 : CIA-RDP78-03109A000200010001-6

RESTRICTED

Comparative Table of Silt Load at Pao-t'ou, Shan and Lung-men

(% by Volume)

	PAO-T'OU			LUNG-MEN			SHAN		
	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average
1934 Jan							0.35	0.30	0.32
Feb							0.56	0.29	0.40
Mar							1.22	0.40	0.82
Apr							3.15	0.62	1.13
May							2.30	0.69	1.22
Jun							3.05	1.02	1.75
Jul	2.55	0.17	0.89	38.00	1.98	8.20	20.16	2.37	6.86
Aug	2.35	0.88	1.48	36.22	1.70	6.36	38.14	3.03	9.01
Sep	2.13	1.08	1.47	6.38	0.97	2.35	8.14	2.23	3.77
Oct	1.96	0.99	1.38	2.57	0.89	1.52	7.62	2.77	4.04
Nov				1.52	0.43	0.82	2.71	1.39	2.13
Dec				0.70	0.07	0.27	1.85	1.20	1.62
Year	2.10			8.32			14.52 [sic]		
(% of Shan load)				(57.13) [sic]			(100.00)		

RESTRICTED

RESTRICTED

Comparative Table of Silt Load at Pao-t'ou, Shan and Lung-men (Contd)

(% by Volume)

1935	PAO-T'OU			LUNG-MEN			SHAN		
	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average
Jan				0.31	0.03	0.17	1.95	0.91	1.23
Feb				0.78	0.04	0.22	1.95	1.23	1.50
Mar				2.78	0.26	0.87	3.05	1.64	1.93
Apr				1.11	0.34	0.60	2.94	1.59	1.91
May				1.35	0.44	0.82	2.68	1.61	2.17
Jun				1.38	0.54	0.97	2.55	1.00	1.68
Jul	1.11	0.72	0.37 [sic]	13.37	0.75	3.81	14.71	1.17	4.40
Aug	1.14	0.81	1.01	33.46	0.53	3.28	19.34	1.88	5.31
Sep	1.00	0.78	0.91 [sic]	3.73	0.75	1.54	4.10	0.99	2.17
Oct	1.22	0.68	0.98	1.87	0.64	1.10	3.22	1.17	1.99
Nov	0.94	0.42	0.61	1.25	0.32	0.69	1.98	0.85	1.40
Dec	0.46	0.20	0.32	0.55	0.03	0.17	1.45	0.32	0.98
Year	2.01			7.48 [sic]			12.72 [sic]		
(% of Shan load)	(15.75)			(58.88)			(100.00)		

RESTRICTED

With the exception of the amount which settled on the river bed, he entire volume of alluvium carried by the 13 floods was assumed to ave been deposited on the plains. Excluding that which settled on he river bed, one half of the alluvium carried down by the floods of he remaining 70 years was deposited on the plains. It can thus be alculated that, during the three centuries prior to 1852, some 10,000,000,000 cubic meters of silt were carried down to the sea, 5,000,000,000, cubic meters were deposited on the plains and ,250,000,000 cubic meters settled on the river bed. This totals 57,250,000,000 cubic meters, or an annual average of 520,000,000 ubic meters.

These figures are not mathematically precise and merely serve to ndicate the percentages. The estimated volume of silt deposited on he plains is too conservative. Although a single flood carried 72,000,000 [sic] cubic meters of silt, as shown in the table on page , the above estimate of 1,350,000 [sic] cubic meters is far too low. lso, the estimated silt load in floodless years is too low. Judging rom those figures, the amount of sediment deposited on the plains hould be three to five times the stated figure, and the amount which ettled in the river bed should also be several times the figure given. he average annual silt load should be twice the stated 524 million, r 1,050,000,000 cubic meters.

The volume of alluvium deposited on the plains fluctuates etween 40 and 100 percent of the volume of that carried on the sea. f breaches in the dikes were prevented, the rise in the river bed ould increase 40 to 100 percent. Thus the rise, which has formerly mounted to 1.5 meters in a century, would probably increase to two r three meters.

RESTRICTED

A JAPANESE PLAN FOR HYDROELECTRIC DEVELOPMENT OF THE YELLOW RIVER IN CHINA (Continued)

Far Eastern Research Section
Survey Committee No. 2
North China Committee
Subcommittee No. 4
May 1941

PART 3 PLANS FOR THE GENERATION OF ELECTRICITY

ARISAKA Masayoshi

TABLE OF CONTENTS

RESTRICTED

I Introduction

River Conditions, Gradient, Width and Effective Fall as They Affect Water Power

Broadly speaking, the Yellow River may be divided into three major water-power areas: an upstream area from Kuei-te through Lan-chou to Chung-wei; a middle area from Ho-k'ou-chen to Yu-men-k'ou, and a downstream area from Shan to Meng-ching. Data for the upstream area is scarce, and the area is far away from present potential consumers of water power. This discussion is, therefore, largely limited to the middle and downstream areas.

The upper stream from Lan-chou to Chung-wei flows through a rock-strewn gorge. Near Ning-hsia it flows out upon the Ordos plain and meanders in a great bend for a distance of 1000 kilometers. At Ho-k'ou-chen, the beginning of the midstream section, it again enters a gorge and flows directly south, forming the boundary between Shansi and Shensi.

Following is a description of this mid-stream section (based on "Thoughts on the Yellow River," "Water Supply Problems in China," Mr OKOSHI's "Treatise on the Control of the Yellow River" and on aerial photograph maps):

Below Ho-k'ou-chen the mountains gradually close in from both sides until, at La-ma-wan, the river enters precipitous loess cliffs 20 to 30 meters high, which constrict the width of the river to about 300 meters. At this point the water is from two to five meters deep and flows at 1.2 to 1.5 meters per second.

Near the confluence with the Ching-shui River both banks are limestone cliffs which reach 100 meters and more in height, and continue past Hsia-chieng-wan and Lao-niu-wan on the Suiyuan-Shansi border to a point 15 kilometers above Ho-ch'u. Favorable dam sites can be found almost anywhere along this stretch.

The gradient of the river between Pao-t'ou and La-ma-wan, a distance of 170 kilometers, ranges from 1/6,500 to 1/3,000; in the 110-kilometer ravine area from La-ma-wan to Ho-chiu, it ranges from 1/3,000 to 1/820.

Near Ho-ch'u, the river broadens to 1,000 meters, but at Hsun-chien-ssu, it again enters a series of gorges like those around Hsia-ch'eng-wan. Below Pao-te, and also near T'ien-chiao, midway between Hsun-chien-ssu and Pao-te, the river contains large boulders which produce swift rapids. Of all the Yellow River gorges, this stretch between Ho-chiu and Pao-te presents the maximum gradient--approximately 1/445 for a distance of about 55 kilometers.

From Pao-te past Lin-che-yu, Hei-yu-k'ou and Lo-yu-k'ou to Chi-k'ou-chen, a distance of approximately 208 kilometers, the gradient is 1/1,540. The width of the river ranges from 300 to 500 meters and cliffs exceeding 100 meters in height are found on both sides of the river. Chia-chou, which is located on a

100-meter cliff on the Shensi side in this stretch, is one of the chief cities along the gorges of the Yellow River. The other important cities, such as Pao-te and Chi-k'ou-chen, are likewise situated rather high above the river.

From Chi-k'ou-chen past Wu-pu to the vicinity of Yen-shui-kuan, the cliffs on both sides of the river become still higher. At Ma-men-kuan, just above Hu-k'ou, they are over 400 meters high. The course of the river through the gorges in this area is especially winding, measuring 300 kilometers on the 200 kilometer air-line distance between Chi-k'ou-chen and Hu-k'ou. The gradient is only 1/2,300.

At Hu-k'ou, where the river is approximately 200 meters wide, there is a waterfall with a fall of over 10 meters. Below this point, the river has a pronounced gradient. A comparatively short canal here (approximately 2,000 meters long) would achieve a fall of over 30 meters. For 68 kilometers between Hu-k'ou and Yu-men-k'ou, the river is at its narrowest--approximately 200 meters. However, it is at least 8 to 10 meters deep and the water is exceedingly calm. The average gradient below the Hu-k'ou waterfall is 1/1,100.

Below Yu-men-k'ou, the cliffs suddenly open; the slope becomes gradual and the impression of a gorge disappears.

Throughout the great bend from Yu-men-k'ou to T'ung-kuan and Shan, the average width of the river ranges from 3,000 to 6,000 meters, narrowing to 1,000 meters or widening to 10 kilometers in a few places. The average gradient ranges from 1/3,000 to 1/4,000. The banks level off and there is no site suitable for dam construction.

Below Shan the width of the river gradually diminishes to an average of 300 to 500 meters at flood level. A 20 per cent grade at both banks forms a gorge 160 kilometers long which extends to a point 25 kilometers above Meng-ching, where the river gradually widens again and enters its dyked portion. This gorge generally resembles the terrain between Ho-k'ou-chen and Yu-men-k'ou.

The topography and soil conditions of this area have been surveyed by Mr ELIASSEN and in the survey maps of the Yellow River Water Supply Committee. The elevation at Shan is 290 meters while that at Meng-ching is 118 meters, a fall of 172 meters in a distance of 215 kilometers. This yields an average gradient of 1/1,200. The gradient in the gorge between Ching-tzu-yuan [sic] and San-men gorge is slightly more than 1/1,250--roughly 1/1,000 (San-men gorge is 25 kilometers downstream from Shan, while Ch'ing-tzu-yuan is the same distance upstream). Favorable dam sites are found all along this gorge, but Mr ELIASSEN has recommended three sites: above the San-men gorge; at Pa-li-hu-t'ung, 30 kilometers below Yuan-ch'u; and at Hsiao-hen-ti.

As has been explained, a total fall of approximately 970 meters exists between Pao-t'ou and Meng-ching. Along the gorges of the middle area and the downstream area, there are favorable dam sites everywhere, so that most of this fall (about 900 meters) can readily be utilized by the plan for generating electricity.

II Basic Factors in the Plan and the Selection of Sites

A. Basic Considerations in the Plan for Generation of Electricity

As stated above, the river's gradient in the gorges of the middle and downstream portion largely ranges from 1/800 to 1/1,500; accordingly, the hydroelectric plants should adjoin the dams, and have very short canals or none at all. The gorge itself is narrow in comparison to the amount of flood water. There are probably very few sites where a hydroelectric plant can be built next to a dam, as in the case of the Ta-feng-men Dam on the upper Sungari River and the Sui-ho Dam on the Yalu River. Consequently, it is thought that hydroelectric plants similar to those at the Boulder and Parker Dams on the Colorado River would be more suitable. At Hu-k'ou and San-men gorge, however, where there is a fairly appreciable fall downstream from the dam, considerable study could be devoted to increasing the effective fall by use of canals.

In establishing an over-all plan for the utilization of Yellow River water power, the extreme yearly and seasonal variations must be taken into account. To produce electricity efficiently, there must be large reservoirs. Their capacity must total at least 20,000,000,000 to 30,000,000,000 cubic meters, to allow for variations in the flow and for silting.

There are only two possible sites for reservoirs of the required capacity: Ch'ing-shui-ho at the upper extremity of the middle portion, and the San-men-gorge at the upper extremity of the downstream portion. It is very important to determine the size of the reservoirs required for the water power plan, balanced against the area of land flooded, compensation for this land and reservoir capacity for flood control.

Even though Ch'ing-shui-ho, at the upper end of the midstream sector, were to equalize the annual flow sufficiently for the hydroelectric plan, if the water level at the San-men gorge rose 40 meters above the mean water level, property destruction from flood would increase rapidly. At 70 meters, the salt lakes in southern Shansi would be endangered. Since a satisfactory study of countermeasures to dam off this territory has not yet been made, the hydroelectric plan was divided into two phases.

The first phase avoids flooding too extensive areas. Flood water at Tung-kuan will reach only to 45 meters above mean water level, just enough for flood control and for carrying through the three-month drought season.

The second phase will provide better river control and will be accomplished as soon as possible after the property rights in the flooded areas have been transferred. Its high water level of 350 meters is calculated not to endanger the Shansi salt lakes.

Almost all Yellow River hydroelectric sites are isolated by poor transportation and lack any facilities. The construction work will require enormous installations for communications, housing, material processing plants, etc. It would therefore be better to have as few sites as possible with a maximum capacity. With modern engineering techniques as developed as they are in Japan the maximum water level in these dams should be 130 to 140 meters. Barring special considerations, no dam in the plan should have a high-water level of less than 70 or 80 meters.

B. Existing Source Material on Hydroelectric Power Plant Sites

The Yellow River offers highly suitable terrain for the construction of hydroelectric power dams. In the last ten-odd years when this possibility was attracting general attention, gigantic dam construction came into worldwide use for flood control, generation of electricity, irrigation and water transportation. The Yellow River was also studied from this viewpoint. The following sites were suggested as suitable for dams or hydroelectric power sites:

Ch'ing-shui-ho	:	ABE Koryo of South Manchurian Railway, 1938
		Actual field survey by the Committee, 1940
Near Ho-ch'u	:	Draft of Shansi Water Supply Construction Plan
Hy-k'ou	:	Mr TODD: "Hu-k'ou Waterfall Hydroelectric Plan," 1934 [TN: Probably TODD: "A Study of Shansi's Rivers," in Association of Chinese and American Engineers Journal, Vol 15, No 1 January 1934, p 7 to 14]
		Profile and a 1/50,000 Plan made from actual surveys, 1934
Yu-men-k'ou	:	Same
San-men gorge	:	Draft of Shansi Water Supply Construction Plan. S ELIASSEN: "Flood Control of the Yellow River by a Detention Basin" Topographic maps 1/5,000 and a 1/50,000 based on a 1936 survey by the North China Water Supply Committee
Near Yuan-chiu	:	Topographic maps 1/50,000 and 1/20,000 based on a 1936 survey by the North China Water Supply Committee
Pa-li-hu-t'ung	:	ELIASSEN: "Flood Control of the Yellow River by Detention Basin," 1936
		Ground survey
Hsiao-hen-ti	:	Same

C. Policy Governing the Selection of Sites

As shown above, the Yellow River Committee made an actual ground survey of only one site in the middle section of the river. The other sites were selected on the basis of: the above material; 1/30,000 aerial photos taken by the Army Ground Survey Department, and 1/50,000 maps prepared from the photos.

Existing source material was relied on wherever possible. Where lacking, selection was made with the help of general literature and the 1/50,000 aerial photograph maps. Sites were chosen where the river is narrowest, both banks have comparatively steep slopes and the site is enclosed by large mountain blocks. The number of dams required was determined from the preceding figures on required reservoir capacity, assuming the dams to correspond to the heights set forth.

Sites are as follows:

No 1 - Ch'ing-shui-ho
No 2 - Ho-ch'u (since there is a pronounced gradient between Ch'ing-shui-ho and Pao-te)
No 3 - T'ien-ch'iao
No 4 - Hei-yu-k'ou (the next site downstream between Pao-te and Yu-men-k'ou)
No 5 - Chi-k'ou-chen
No 6 - Yen-shui-kuan
No 7 - Hu-k'ou
No 8 - Yu-men-k'ou
No 9 - San-men gorge (the site selected by ELIASSEN, between Shan and Meng-ching)
No 10 - Pa-li-hu-t'ung
No 11 - Hsiao-hen-ti

Eight of these sites--Ch'ing-shui-ho, Ho-ch'u, Chi-k'ou-chen, Hu-k'ou, Yu-men-k'ou, San-men gorge, Pa-li-hu-t'ung and Hsiao-hen-ti--have been proposed previously, while three sites--T'ien-ch'iao, Hei-yu-k'ou and Yen-shui-kuan--are here proposed for the first time.

The following table shows the location and drainage area of each site. The hydroelectric plan is shown in Map 1 [at front of this publication], and in the profile chart.

Dam	Exact Location of Site	Location of Hydro-electric Plant	Drainage Area (sq km)
1 Ch'ing-shui-ho	6 km above Hsia-ch'eng-wan, Suiyuan	Directly below dam	425,150
2 Ho-ch'u	17 km above Ho-ch'u, Ho-ch'u District, Shansi	Same	428,850
3 T'ien-ch'iao	3 km below T'ien-ch'iao, Pao-te District, Shansi	Same	433,800
4 Hei-yu-k'ou	20 km below Hei-yu-k'ou, Hsing District, Shansi	Same	442,350
5 Chi-k'ou-chen	2 km below Chi-k'ou-chen, Lin District, Shansi	Same	458,950
6 Yen-shui-kuan	21 km above Yung-ho-kuan, Yung-ho District, Shansi	Same	488,450
7 Hu-k'ou	Lung-wang, Chi District, Shansi	2,000 m down-stream from dam	508,550
8 Yu-men-k'ou	5 km above Yu-men-k'ou, Ho-ching District, Shansi	Directly below dam	514,800*
9 San-men gorge	25 km below Shan, Honan	Same	721,500*
10 Pa-li-hu-t'ung	30 km below Yuan-ch'u, Shansi	Same	725,250*
11 Hsiao-hen-ti	28 km above Meng-ching, Honan	Same	728,000*

III. Dams

The gorges of the Yellow River are almost all V-shaped with very steep banks, narrow in proportion to flood-water volume, and require considerable width to get flood water downstream without overflowing the banks.

Gravity overflow dams with spillways over most of the crest are best suited to this situation.

One very important fact in the design of a dam is the relation of the river cross-section at the site to the flood volume which has to pass there. Determination of the spillway width required at each dam requires calculation of the flood volume there. This is given in the table below.

The source material gives maximum flood data for only three sites--Ch'ing-shui-ho (actually Pao-t'ou), Hu-k'ou and San-men gorge (actually Shan). The flood flow at the sites between Ch'ing-shui-ho and Hu-k'ou was determined from these figures and the respective drainage areas. The plan to use the San-men gorge site as a detention reservoir would decrease the flood discharge there from 30,000 to 15,000 cubic meters per second, permitting the flood gates there to be designed for this lighter load, as well as the modification of the dams downstream.

Maximum Flood Discharge At Dam Sites

Site	Drainage Area (sq km)	Drainage Area Added (sq km)	Calculated Flood Discharge (cu m/sec)	
1 Ch'ing-shui-ho	425,150		7,500	
2 Ho-ch'u	428,850	3,700	8,000	
3 T'ien-ch'iao	433,800	4,950	8,500	
4 Hei-yu-k'ou	442,350	8,550	9,500	
5 Chi-k'ou-chen	458,950	16,600	11,000	
6 Yen-shui-kuan	488,450	29,500	13,500	
7 Hu-k'ou	508,550	20,100	14,500	
8 Yu-men-k'ou	515,310*	6,760	15,000	
9 San-men gorge	722,010	206,700	30,000	To be reduced to 15,000 cubic meters per second by flood control
10 Pa-li-hu-t'ung	725,860	3,850	30,000	To be reduced to 20,000 cubic meters per second by flood control
11 Hsiao-hen-ti	728,510	2,650	30,000	Same

*TN: Drainage area map at beginning of this volume gives 515,308

The high-water level at the Ch'ing-shui-ho site must be below the limit shown in the profile of the Yellow River (compiled from data given in Part 2, so as not to interfere with the Pei-p'ing-Suiyuan railroad line. Since the lowest point on this line is 986 meters high, the high-water level must be 985 meters.

The San-men gorge site will have a 325-meter high-water level at T'ung-kuan during the first phase and a 350-meter level during the second phase. This will not injure the salt lakes. The other sites will normally have a high-water level 3 meters lower than the mean river level at the next site upstream, in order to keep the backwater from injuring that site during floods.

A series of 22 maps follows. The first 11 show the sites and their vicinities in detail, on the basis of 1/50,000 aerial-photograph maps and other maps. The last 11 show the cross-section of the river at each site.

These maps are preceded by a table which summarizes the most important findings for each site.

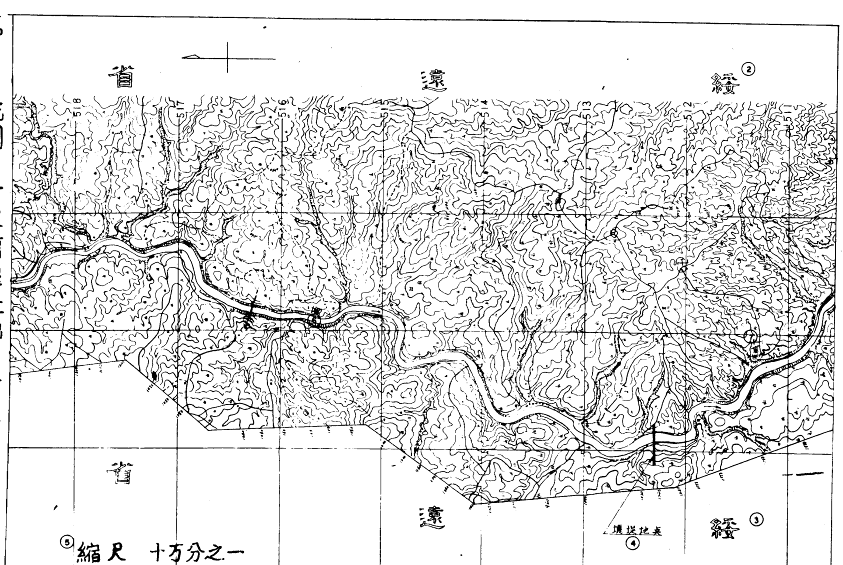
[Table appears on next page, followed by series of 22 maps]

Figures on Summary of Dam Sites

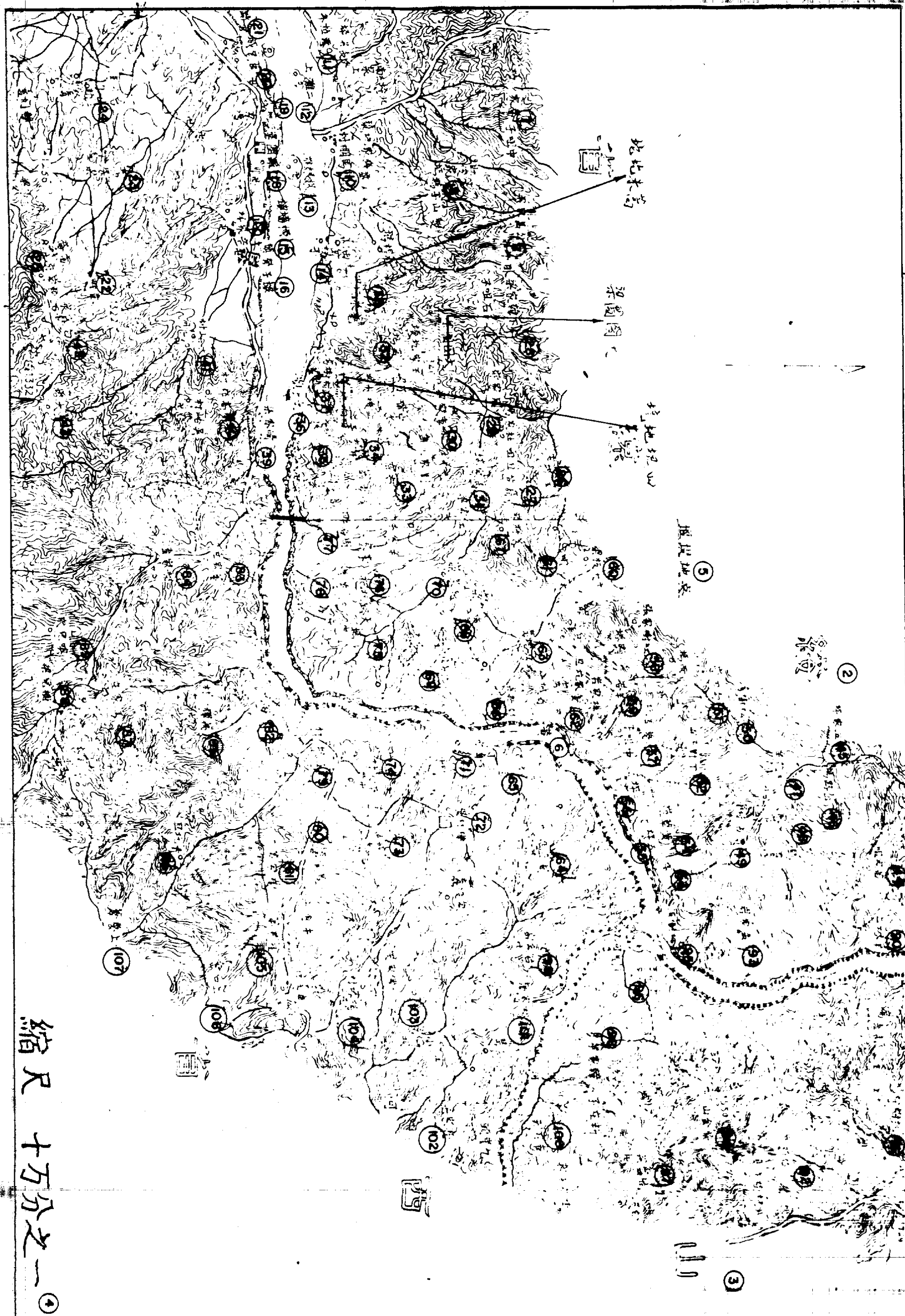
	Site	Mean River Level (m)	Planned High-Water Level (m)	Height above Mean River Level (m)	Safety Margin	Height of Mean River Level above Foundation (m)	Planned Over-all Height of Dam (m)	Length of Crest (m)	Concrete Required (1000 cu m)	Height of Gates (m)	Spillway	
											Effective Length (m)	Total Length (m)
1	Ch'ing-shui-ho	927	985	58	2	25	85	420	1,228	10	110	140
2	Ho-ch'u	865	924	59	2	20	81	325	827	10	120	150
3	T'ien-ch'iao	731	862	131	3	15	149	835	4,940	10	130	165
4	Hei-yu-k'ou	662	728	66	2	20	88	630	2,104	10	140	175
5	Chi-k'ou-chen	582	659	77	2	15	94	685	2,364	10	160	200
6	Yen-shui-kuan	504	579	75	2	20	97	585	2,141	12	150	190
7	Hu-k'ou	450	501	51	2	15	68	615	1,214	12	160	200
8	Yu-men-k'ou	365	432	67	2	20	89	460	1,531	12	165	210
9	San-men gorge	281	325 350	44 69	2 2	15 15	61 86	395 450	685 1,400	12 12	165	210
10	Pa-li-hu-t'ung	166	275	109	3	15	127	475	2,240	12	220	280
11	Hsiao-hen-ti	135	163	28	2	20	50	450	374	12	220	280

Approved For Release 1999/08/25 : CIA-RDP78-03109A000200010001-6

第三號圖 清水河堰堤地點附近平面圖



第四號圖(3) 河曲堰堤地點附近平面圖



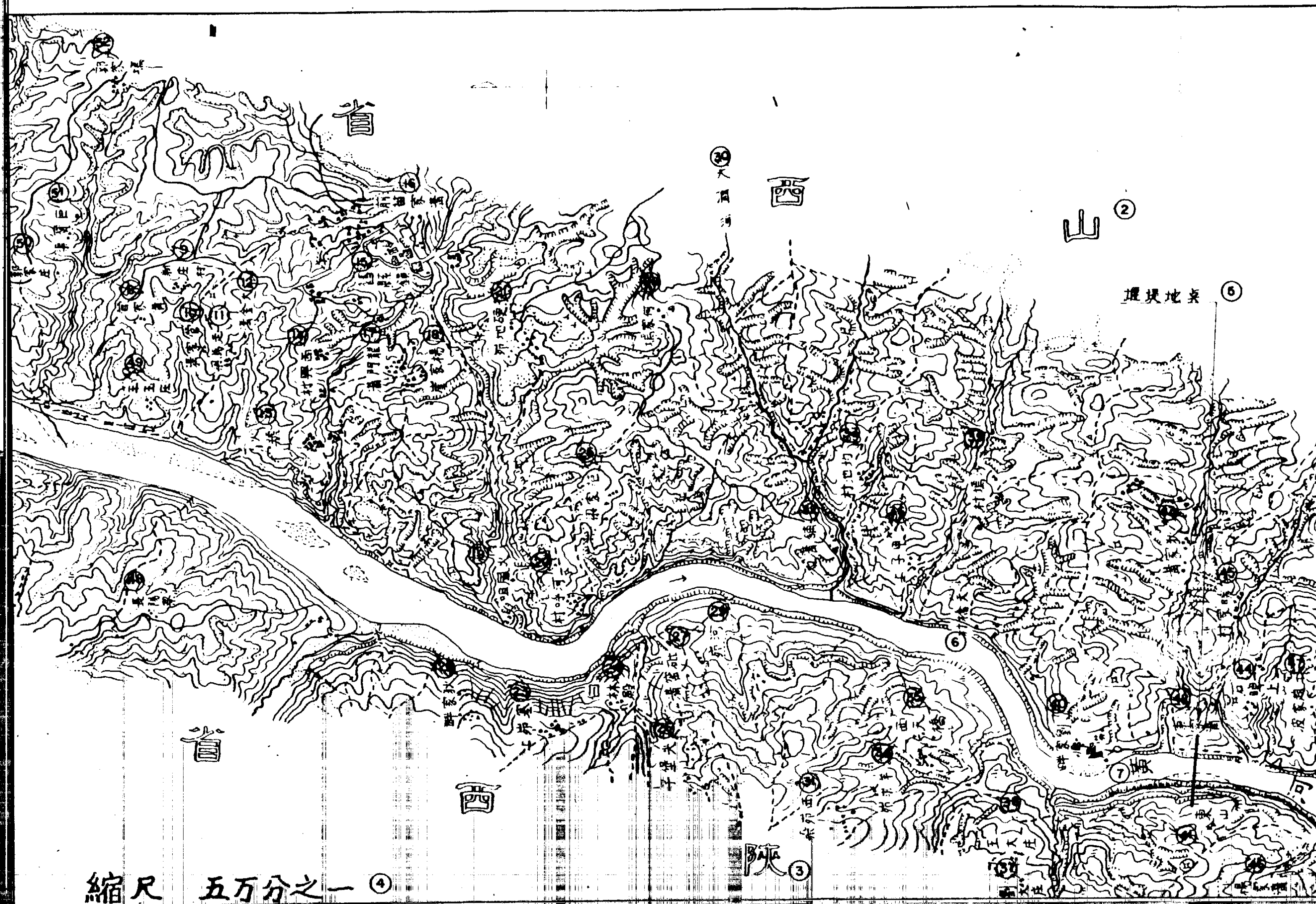
縮尺 十万分之一

1. CONTOUR MAP OF THE CH'ING-SHUI-HO DAM SITE AND VICINITY
2. Suiyuan
3. Suiyuan
4. Dam Site
5. Scale - 1:100,000
6. Yellow River
7. Hsia-ch'eng-wan

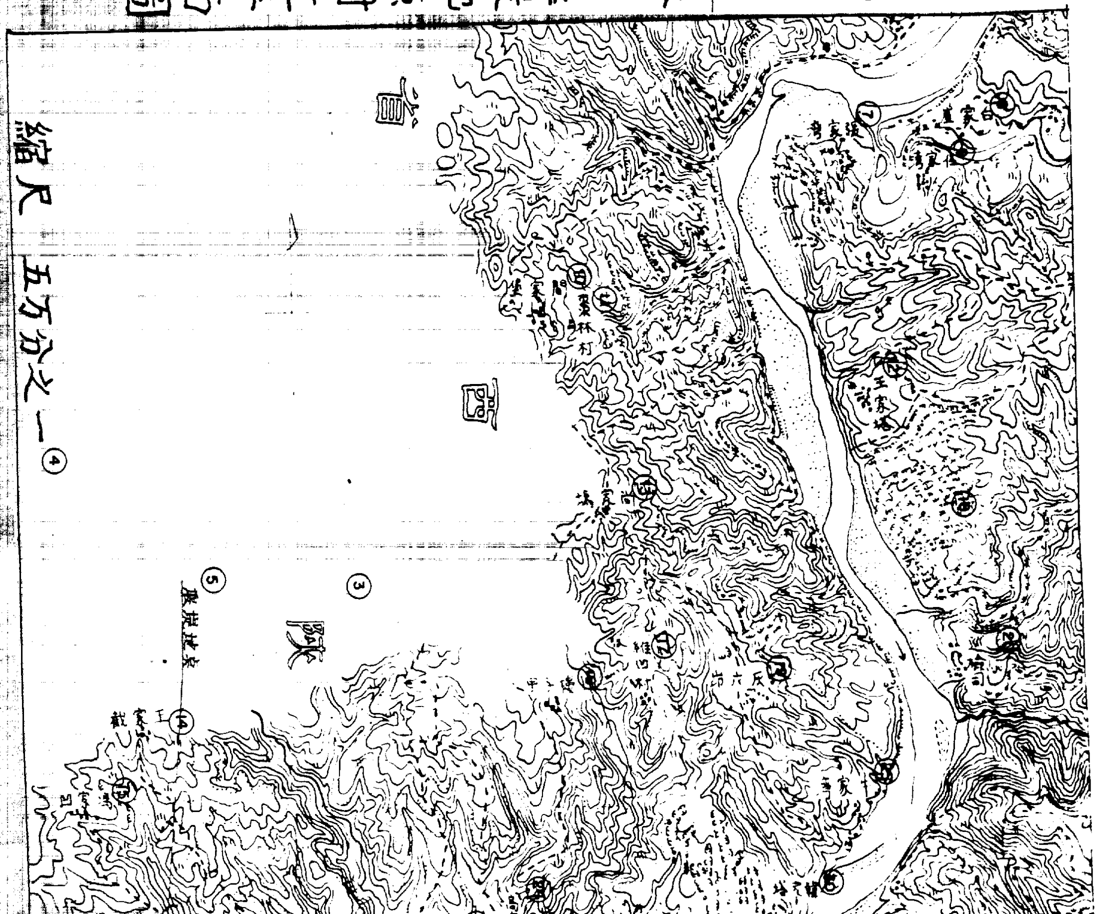
1. CONTOUR MAP OF HO-CH'U DAM SITE
2. Suiyuan
3. Shansi
4. Scale 1:100,000
5. Dam Site
6. Huang Ho (Yellow River)
7. Ch'iao-chia-sha-yen
8. Kuang-kai-chia-liang
9. Shuang-shan-tzu-yen
10. Ma-p'eng-ts'un
11. Wu-la-ch'i
12. Erh-t'an-shang
13. Niang-niang-t'an
14. Yu-ch'a-kuei-tzu
15. Heng-ch'iang-lou
16. Lou-tzu-ying-chen
17. Hsin-chiao-p'ing
18. Lo-ch'uan-pao
19. T'u-ti
20. Chiao-wei-ch'eng
21. Ying-lu
22. Wei-pan
23. Yu-fang-liang
24. Chao-chia-kou
25. Chia-chia-kou
26. Yang-t'a
27. Hu-lu-chieh-tsui
28. Hsia-han-chia-liang
29. Chou-chia-mao
30. K'ang-chia-liang
31. Ma-chia-yen
32. Sha-yao-yen
33. Nan-yao-tzu-liang
34. Ching-kou-tzu
35. Erh-lang-shang
36. T'ai-tzu-t'an
37. Yu-shu-wan
38. Hao-mi-ko-t'o
39. Chi-chia-liang
40. Kao-mao-ts'un
41. Ta-yu-ts'un
42. Pai-lu-ch'uan
43. Ta-t'a
44. Miao-chia-tsui
45. Wu-chia-p'ing
46. Ch'a-lu-yen
47. Sung-hua-yao
48. Fan-chia-mao
49. Chia-chan-hao
50. Kou-shu-mao
51. Kou-ssu-mao
52. Hsia-tui-tzu-liang
53. Erh-p'ing
54. Huang-ts'ao-mao
55. Wu-p'ing
56. Ch'i-p'ing
57. Meng-ching-ko-tan
58. Hung-shu-chia-chang
59. Yang-t'a
60. Ta-pan-liang
61. T'ai-sha-tsui
62. Tung-chia-ko-tan
63. Fang-t'a-kou
64. Hei-tou-yen
65. Wa-yao-mao
66. Hao-pa-liang
67. Lo-chiang-mao
68. Nuan-ch'uan-liang
69. Pieh-tsui
70. Chao-chia-mao
71. Ssu-kou-ho
72. Hua-lin-pao
73. Sha-yen-liang
74. P'ing-t'ou-ts'un
75. Sha-yen
76. Ta-lu-ko-pa
77. Chou-ko-pan
78. San-tao-kou
79. Hou-ch'eng-ts'un
80. Ch'ang-wei-kou
81. Ts'ui-chia-ti-erh
82. Miao-erh-wa
83. Tung-chia-chuang
84. Ho-chia-kou
85. Wan-hui-i-ts'un
86. Ch'ing-ko-tan
87. Feng-chia-chuang
88. Shu-erh-liang
89. Ch'ou-erh-wa
90. Yang-t'a-shang
91. T'ao-shu-p'ing
92. Ku-ku-an
93. Meng-chia-yen
94. Tzu-chin Shan (mt)
95. Liu-shu-wan
96. Chien-chao-wan
97. Yen-pan-liang
98. Han-chia-liang
99. Lu-chia-yao
100. Mo-shih-t'an
101. Yang-chia-ling
102. Kao-chia-liang
103. Hsiao-p'ien-t'ou
104. Yang-t'a-ts'un
105. Ts'ui-chia-ti-i
106. Shang-hou-hui
107. Shang-yang-ts'ang

1. CONTOUR MAP OF T'IEN-CH'IAO DAM SITE
2. Shansi
3. Shensi
4. Scale 1:50,000
5. Dam Site
6. T'ien-ch'iao
7. Huang Ho (Yellow River)
8. Chien-chia-kou
9. Hsin-chuang-ts'un
10. Chien-chia-kou
11. Tsou-ma-liang
12. Ta-chin-kou
13. Hsiao-huo-hao
14. Hsi-hsing-ts'un
15. Chiu-hsien-chen
16. Ch'ien-miao-chia-kou
17. Lung-men-kou
18. Yang-chia-yai
19. Huo-feng-tsui
20. Ho-hu-ts'un
21. Ying-ti-mao
22. Ti-chia-pan
23. Sai-mao-shang
24. Pai-lin-tien
25. Fan-chia-liang
26. Chien-pao-tzu
27. P'i-yao-kou
28. Ho-chia-yen
29. Ho-mao
30. Ta-chien Ho (River)
31. Hsi-mao-jan
32. P'u-kou
33. Chun-ch'ih-ts'un
34. Yang-chiu-mao
35. Hsi-t'ien-ch'iao
36. Chia-tzu-shang
37. Liu-ta-chuang
38. Wang-ta-chuang
39. Sha-yen-ts'un
40. Liu-chia-pan
41. Tung-shan
42. K'ang-chia-kou
43. Ti-chia-kou
44. Shih-pei-shang
45. Nuan-chia-ts'un
46. Yang-chia-kou
47. Chao-chia-po
48. Ch'ang-yang-liao
49. Wang-yu-chuang
50. Kuo-chia-chuang
51. Chu-pao-ch'u
52. Kuo-chia-yen

① 第五號圖 ③ 天橋堰堤地點附近平面圖



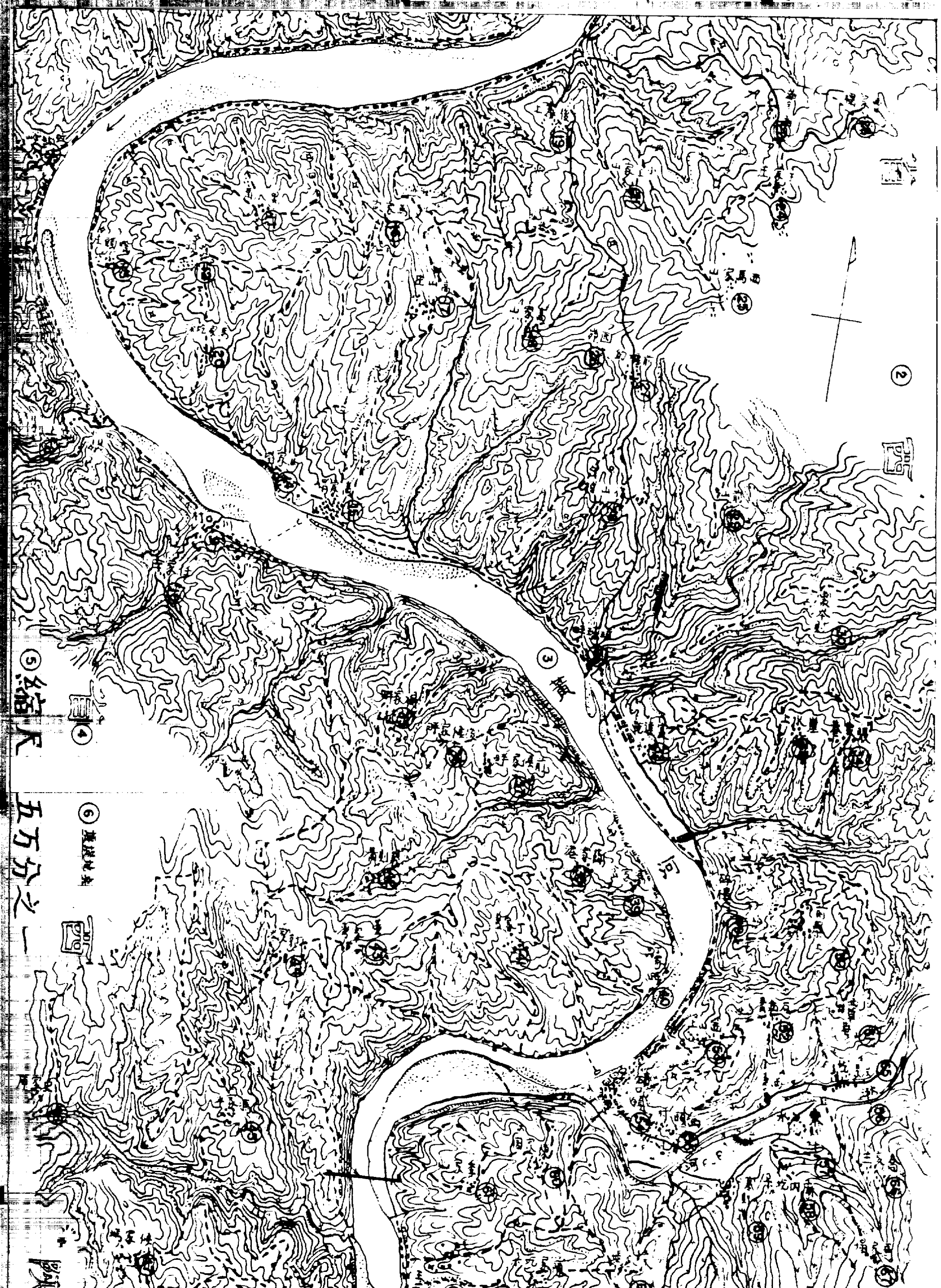
第六號圖(3)黑峪口堰堤地點附近平面圖



縮尺 五万分之一

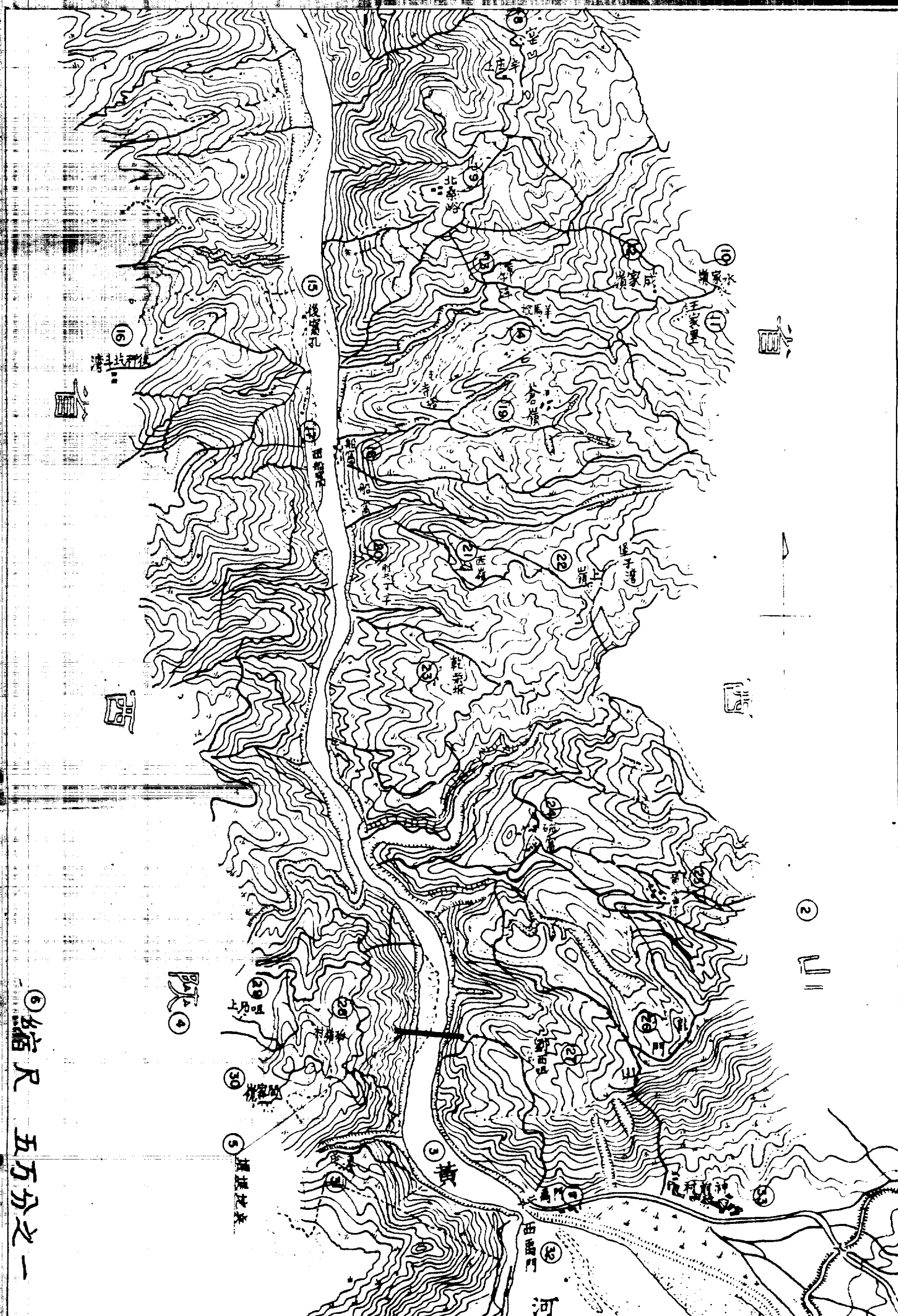
1. CONTOUR MAP OF HEI-YU-K'OU DAM SITE
2. Shansi
3. Shensi
4. Scale 1:50,000
5. Dam Site
6. Huang Ho (Yellow River)
7. Chang-chia-wan
8. Pai-chia-yai
9. Jen-chia-wan
10. Chien-chia-pao
11. Tsao-lin-ts'un
12. Wang-chia-t'a
13. Shang-chia-wu
14. Wang-chia-chieh
15. Feng-chia-wa
16. Lou-tzu-li
17. Wei-wa-ts'un
18. Yuan-t'iao-ts'un
19. Hui-liu-mao
20. Hsun-chien-ssu
21. Hou-kao-chia-shan
22. Tao-ho-wan
23. Wang-chia-kou
24. Kao-chia-ko-leng
25. Niu-chia-wan
26. Huang-chia-wa
27. Ho-chia-p'o
28. Wang-chia-p'o
29. Wang-chia-p'ing
30. Han-chia-t'a
31. Pao-t'ou-ts'un
32. Wang-chia-liang
33. Ch'iang-chia-shan
34. T'ien-t'ai
35. T'an-t'ou-ts'un
36. Chung-chi-ts'un
37. Yen-t'ou-ts'un
38. Pai-chia-liang
39. Niu-chia-liang
40. Niu-chia-t'a
41. Niu-chia-liang
42. Ta-p'ing-yuan
43. Shan-p'o-shang
44. Sha-yuan-mao

① 第七號圖 (3) 磧口鎮據點附近平面圖



Approved For Release 1999/08/25 : CIA-RDP78-03109A000200010001-6

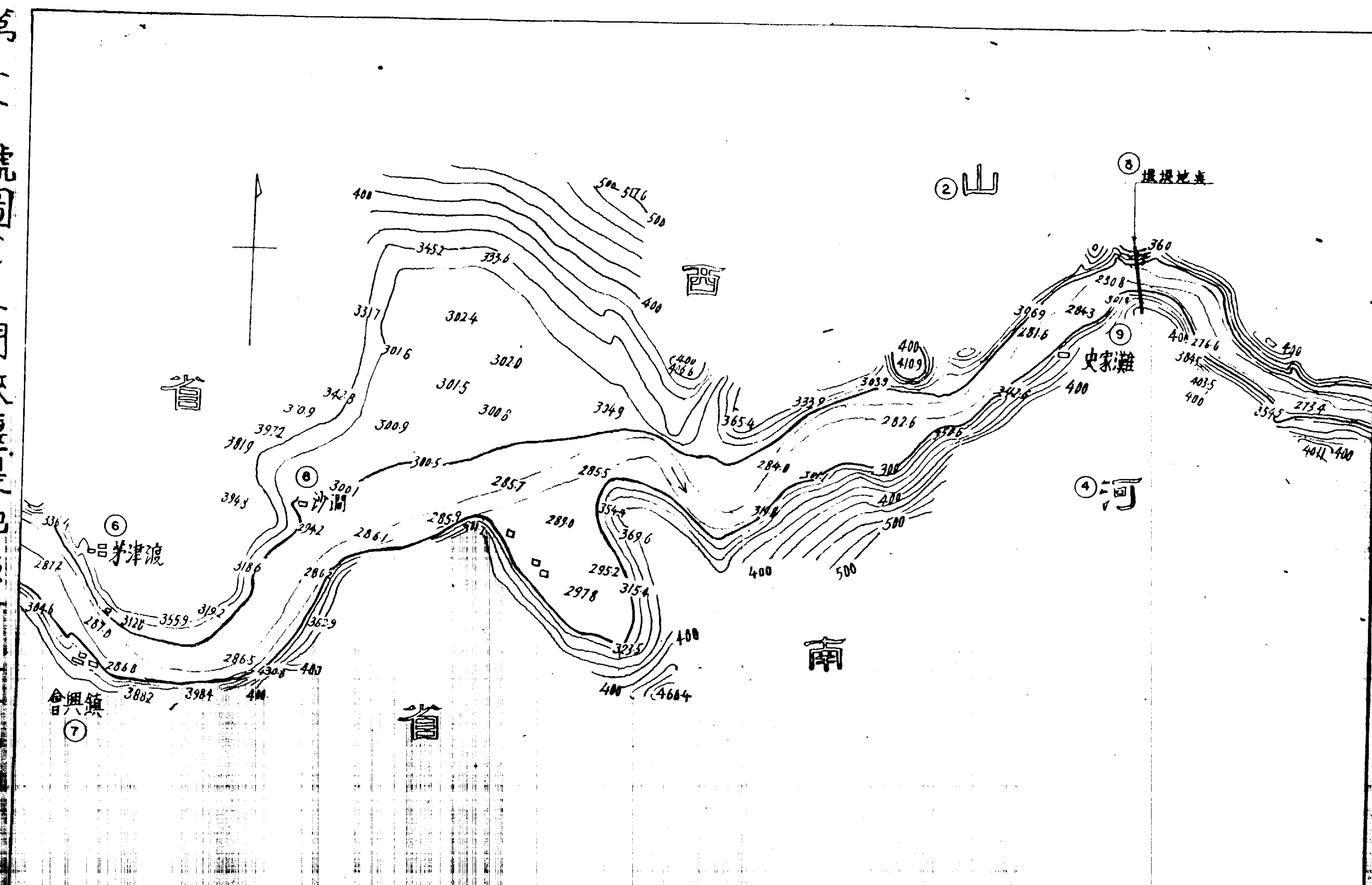
第一〇號圖(3) 禹門口擾提地點附近平面圖



縮尺 五万分之一

1. CONTOUR MAP OF YU-MEN-K'OU DAM SITE
2. Shansi
3. Huang Ho (Yellow River)
4. Shensi
5. Dam Site
6. Scale 1:50,000
7. Yu-men-k'ou
8. Yao-wa
9. Pei-sang-yu
10. Shui-chia-ling
11. Wang-chia-li
12. Ch'eng-chia-ling
13. Yuan-tzu Kou (Stream)
14. Yang-ma-p'o
15. Hou-wo-k'ung
16. Hou-ch'eng-ko-tou-wan
17. Hsi-ch'uan-wo
18. Ch'uan-wo
19. Ts'ang-ling
20. Kung-ting-tzu
21. Hsi-ling
22. Shang-ling
23. Kan-ch'ai-fan
24. Wan-wo
25. Huang-yao-ts'un
26. Lung-men Shan (mt)
27. Liu-hsi-tsui
28. Hu-ling-ts'un
29. Tsui-erh-shang
30. Yen-chia-ling
31. Tung-qhuang
32. Hsi-yu Men (Strait)
33. Shen-ch'ien-ts'un

① 第一一號圖③三門峽堰堤地點附近平面圖



⑤縮尺 五万分之一

Approved For Release 1999/08/25 : CIA-RDP78-03109A000200010001-6

RESTRICTED

1. CONTOUR MAP OF CHI-K'OU-CHEN DAM SITE
2. Shansi
3. Huang Ho (Yellow River)
4. Shensi
5. Scale 1: 50,000
6. Dam Site
7. Wen-li-yu
8. Shang-ts'un
9. Ch'uan-ts'un
10. Jen-chia-chuang
11. Hei-shui-kou
12. Tsui-t'ou
13. Tsui-t'ou-chuang
14. Ma-chia-t'a
15. Kao-chia-t'a
16. Ma-chia-wa
17. Kao-shan-chuang
18. Kao-chia-shan
19. Hou-chai-shang
20. Ma-chia-ko-to
21. Hsiao-wang-chia-shan
22. Lo-ch'an-yen
23. Ts'ao-chia-t'a
24. Wang-chia-chuang
25. Hsi-ma-chia-shan
26. Yuan-mao
27. Ch'ien-yen-yueh
28. Hou-shan-ts'un
29. Ch'ien-shan
30. Tsao-ling-tse
31. Liu-li-pan
32. Shih-ta-kan
33. Yai-shui-shang
34. Chang-chia-hsiang
35. Yang-chia-pan
36. Hou-hou-chia-pan
37. Ch'ien-hou-chia-pan
38. Hsieh-chia-chiang
39. Feng-chia-ch'a
40. Ting-chia-pan
41. Ting-chia-wan
42. Ch'ien-tse-kou
43. Tung-chia-wan
44. Kuo-chia-ling
45. Feng-chia-p'an
46. Shih-chia-yuan
47. Hou-chia-yen
48. Hsia-shan-p'an
49. Sui-lou
50. Chien-chai-shang
51. Hsi-ts'ao-chiang
52. Shih-hsi-kou
53. Hsi-shan-shang
54. Chi-k'ou-chen
55. Hsi-t'ou-ts'un
56. Chiu-shui Ho (River)
57. Tung-tse-p'ing
58. Ma-nei-ko-to
59. Chai-tse-shan
60. Ch'en-chia-yuan
61. Li-chia-shan
62. Wang-chia-shan
63. Ch'en-chia-ko-to
64. Mu-kua-yen
65. T'an-meng-ko
66. Ch'iao-chia-chuang
67. Feng-chia-t'a

RESTRICTED

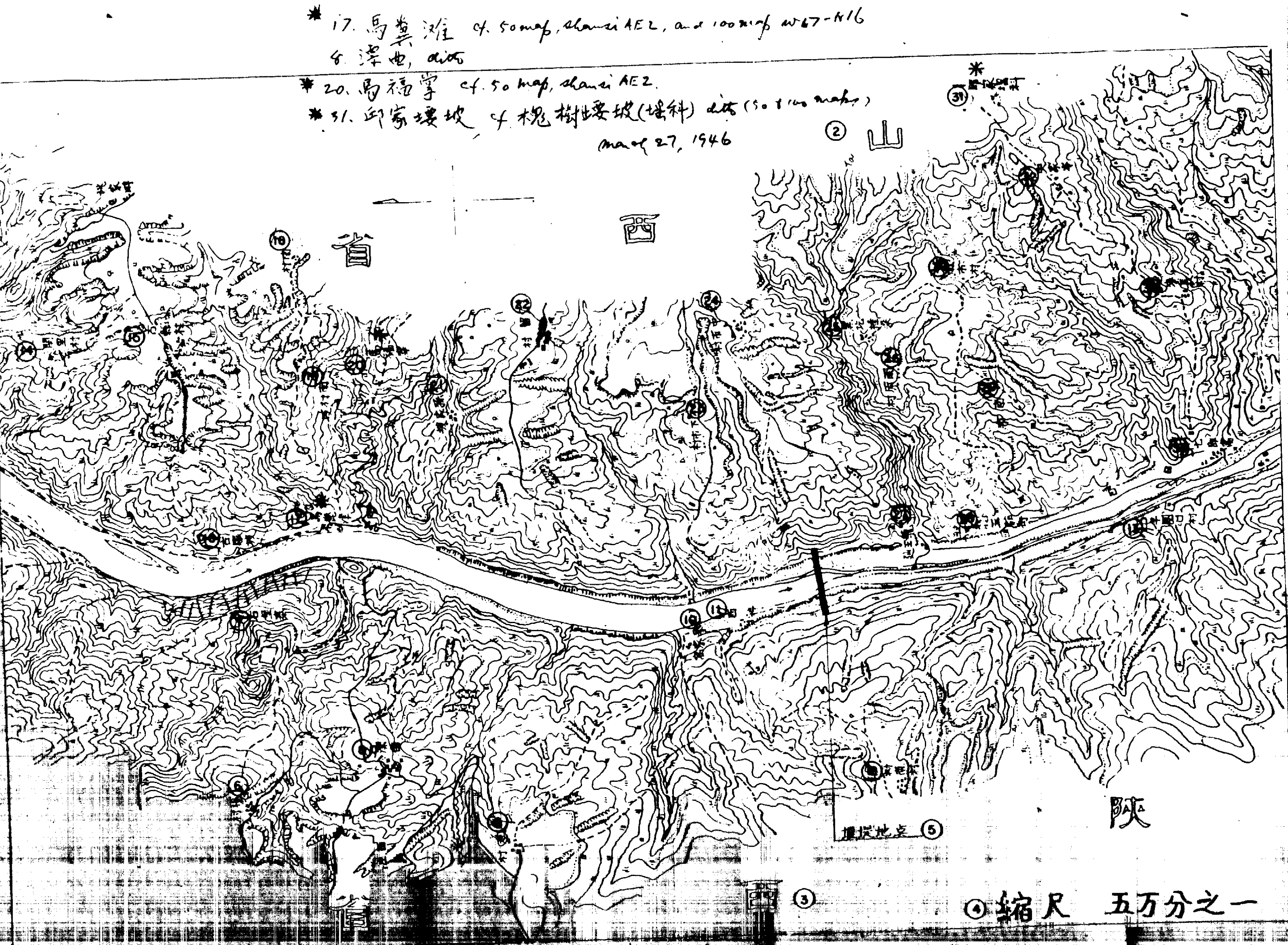
第八號圖(3)延水關堰堤地點附近平面圖

縮尺 五万分之一

1. CONTOUR MAP OF YEN-SHUI-KUAN DAM SITE
2. Shansi
3. Shensi
4. Huang Ho (Yellow River)
5. Scale 1:50,000
6. Dam Site
7. Wu-ting Ho (River)
8. Chang-chia-pan
9. Hsi-hsin Kuan (Pass)
10. Wang-shia-shan
11. Liu-chiao-pan
12. Wu-chia-wang
13. Wang-chia-ho
14. Ho-k'ou-ts'un
15. Tsao-chuang-ts'un
16. Ho-chia-wa
17. Tsui-t'ou-ts'un
18. Li-chia-pan
19. Leng-shui-p'ing
20. Li-chia-wa
21. Liu-chia-pan
22. Chao-chia-pan
23. Tu-tzu-li
24. Feng-chia-pan
25. Nan-tsui-shang
26. Yen-wa-ts'un
27. Ho-chia-wa
28. Ho-chia-ts'un
29. Kuo-chia-shan
30. An-chia-pan
31. Hsia-wa-li
32. Pao-chia-shan
33. Ho-chia-pan
34. Ma-chia-ch'i
35. Kao-chia-pan
36. Yang-chia-shan

Approved For Release 1999/08/25 : CIA-RDP78-03109A000200010001-6

① 第九號圖 壺口堰堤地點附近平面圖



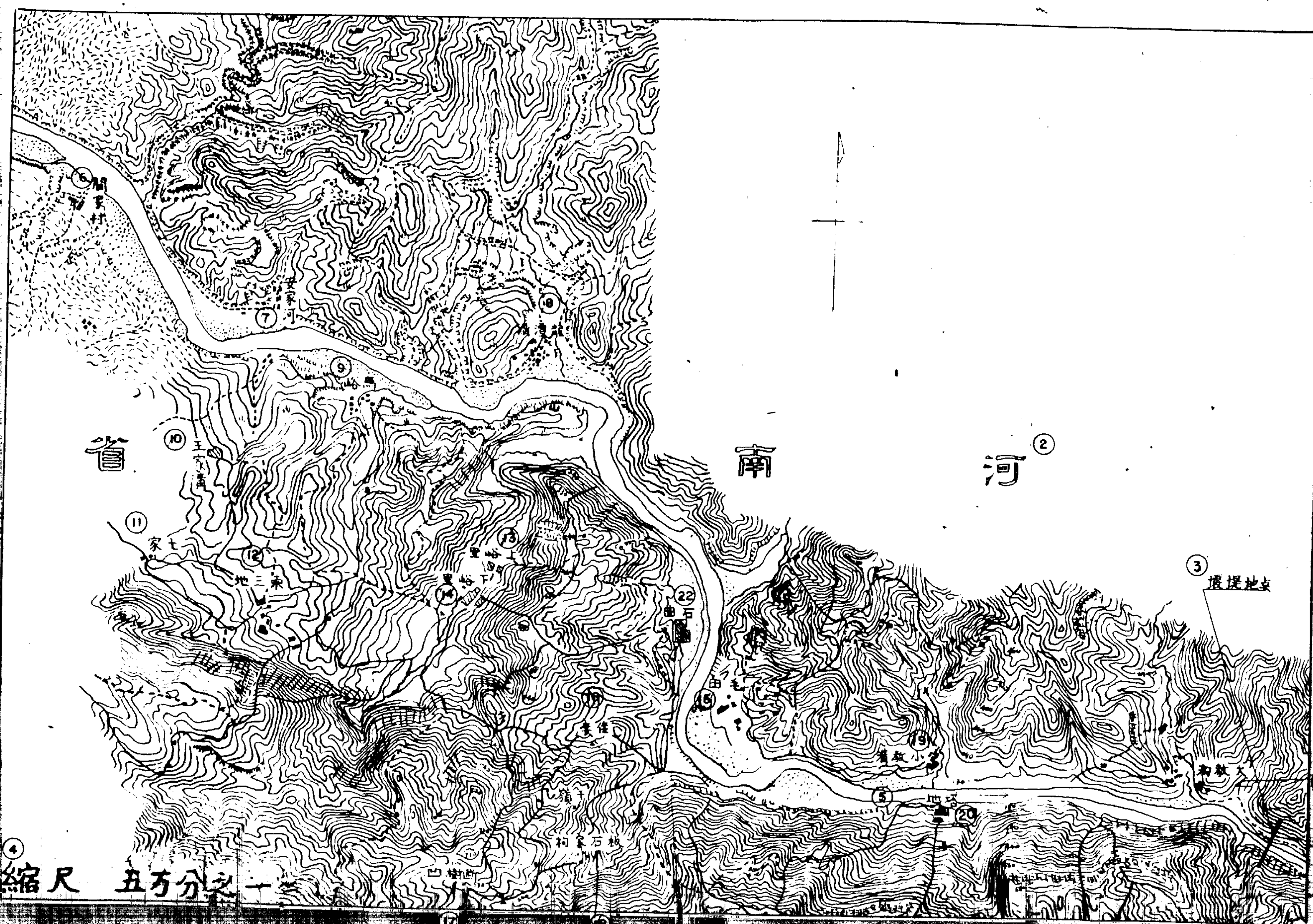
Approved For Release 1999/08/25 : CIA-RDP78-03109A000200010001-6

1. CONTOUR MAP OF HU-K'OU DAM SITE
2. Shansi
3. Shensi
4. Scale 1:50,000
5. Dam Site
6. Yang-ts'un
7. Shih-pao-chai
8. P'iao-ch'u
9. Chao-ts'un
10. P'an-chia-wo
11. Hsi-hsien
12. Shu-nan-ts'un
13. Yang-ch'uan-k'ou-ts'un
14. Kuan-li-ts'un
15. Ku-hsien-ts'un
16. Ku-chen-p'o
17. Ma-fen-t'an
18. Nan-ts'un
19. Nan-ts'un-p'o
20. Ma-fu-chang
21. Sun-chia-p'o
22. Liu-ts'un
23. Hsia-shih-ts'un
24. Chung-shih-ts'un
25. Hei-ko-ta-liang
26. Yu-yuan-ts'un
27. Lung-wang-hsien
28. Lung-wang-miao-chieh
29. Nan-shih
30. Nan-shih-ts'un
31. Ch'iu-chia-yao-p'o
32. Sung-chia-ling
33. Mai-chang-ts'un
34. Ch'i-lang-wo

1. CONTOUR MAP OF SAN-MEN GORGE DAM SITE
2. Shansi
3. Dam Site
4. Honan
5. Scale 1:50,000
6. Mao-ching-tu
7. Hui-hsing-chen
8. Sha-chien
9. Shih-chia-t'an

1. CONTOUR MAP OF PA-LI-HU-TUANG DAM SITE
2. Honan
3. Dam Site
4. Scale 1:50,000
5. Huang Ho (Yellow River)
6. Kuan-chia-ts'un
7. An-chia-ho
8. Lung-t'an-kou
9. Ma-yu
10. Wang-chia-kou
11. Ch'i-chia
12. Tung-sen-ti
13. Shang-yu-li
14. Hsia-yu-li
15. Mao-t'ien
16. Chia-li
17. Tuan-shu-wa
18. Pan-shih-chia-kou
19. Hsiao-chiao-kou
20. T'a-ti
21. Ta-chiao-kou
22. Shih-ch'u

① 第一二號圖 ③ 八里胡同堰堤地點附近平面圖



④ 縮尺 五万分之一

1. CONTOUR MAP OF HSIAO-HEN-TI DAM SITE
2. Honan
3. Dam Site
4. Honan
5. Scale 1: 50,000
6. Huang Ho (Yellow River)
7. Lao-p'ien Ling (Pass)
8. Wang-Kuai
9. Hu-shu-kou
10. Hu-shu-kou
11. Ma-Shih-kou
12. Hu-shu-ts'un
13. Hsia-i-yang
14. Ta-kou-ch'iao
15. Chu-yu
16. Yen-ts'ang
17. Wang-chuang
18. Hsi-lu-pien
19. Li-shu-tsui
20. Tsu-shih-miao
21. Wang-chuang
22. Fan-p'o
23. Wang-kuai
24. Ts'ui-chia-chuang
25. Lo-yu
26. Chou-li
27. Liu-shu-t'an-kou
28. Hsiang-Fang-kou
29. Hou-chuang
30. Liu-chuang
31. Hsi-wa-yao
32. Chiao-tui
33. Ch'ing-ho-k'ou
34. Shang-shan
35. Tung-chuang
36. Wang-chia-chuang
37. Tseng-chia-chuang
38. Ta-yai-kou
39. Hsi-p'o
40. Chien-pei
41. Ta-yu-mu
42. Nan-wei-yuan
43. Nieh-chuang
44. Hsia-tung-p'o
45. Liang-chuang
46. Lo-chuang
47. Ma-t'i Kou (Stream)
48. Hu-chuang
49. Lung-wang-miao
50. Huang-shu-chuang
51. Kuo-chia-ling
52. Yang-p'ing
53. Liu-kou
54. An-t'ou
55. Chu-yuan-ts'un
56. Pai-kou
57. K'ou-t'ou-miao
58. Hsiao-lang-ti
59. Ts'ao-ling
60. T'ung-shu-ling
61. Chu-wo-yao
62. Ssu-yuan-ch'eng
63. Hsieh-chia-ling
64. Ho-men
65. Wa-yao-kou
66. Lai-wu
67. Lan-chu-wo
68. Chou-chia-chuang

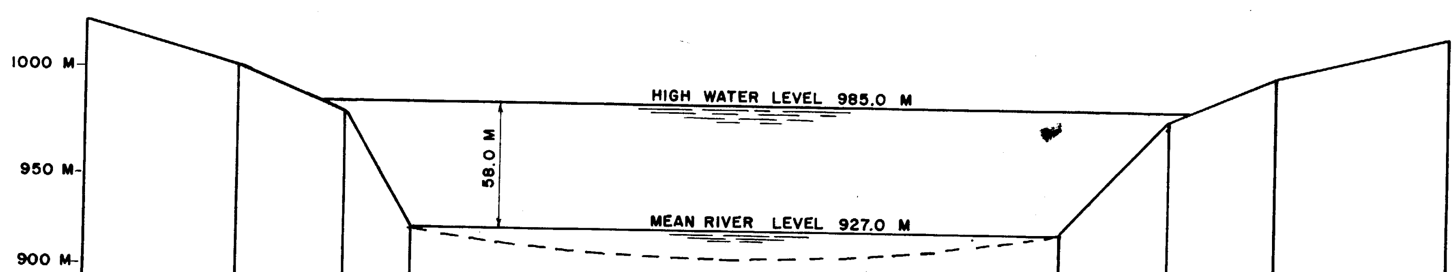
第一三二號圖 (3) 小狼堤把握點附近平面圖

縮尺 五万分之一

RESTRICTED

CROSS-SECTION OF CH'ING SHUI-HO DAM SITE

SCALE 1:2,000



ELEVATION (M)	1020	1000	980	927	927	980	1000	1200
CUMULATIVE DISTANCE BETWEEN READINGS (M)	0	70	120	150	450	500	550	630
DISTANCE BETWEEN ADJACENT READINGS (M)	0	70	50	30	300	50	50	80

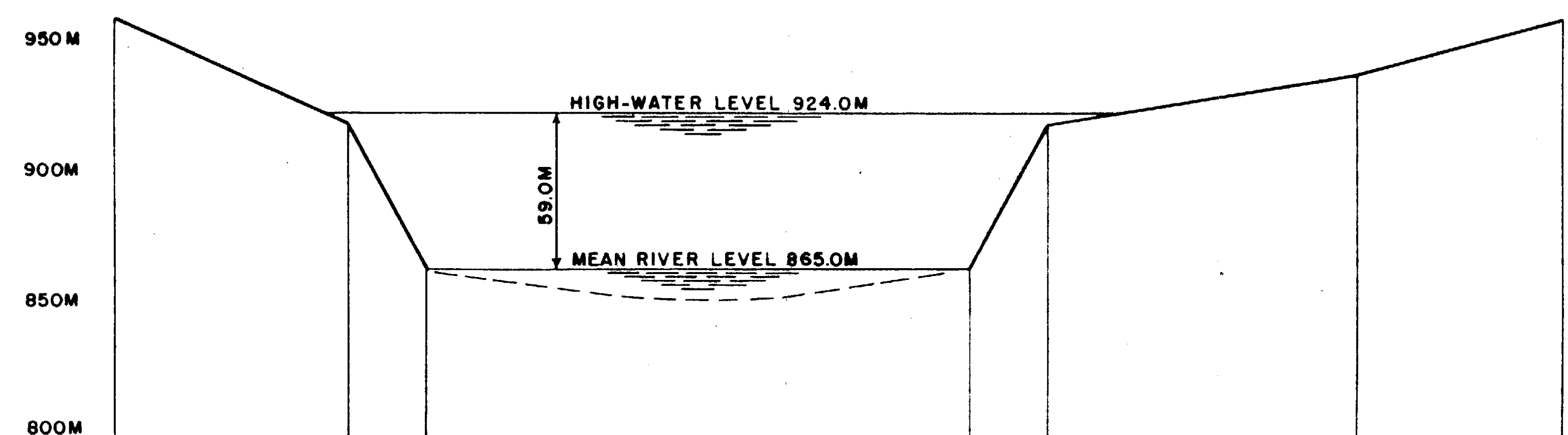
RESTRICTED

Approved For Release 1999/08/25 : CIA-RDP78-03109A000200010001-6

RESTRICTED

CROSS-SECTION OF HO-CH'U DAM SITE

SCALE 1:2,000



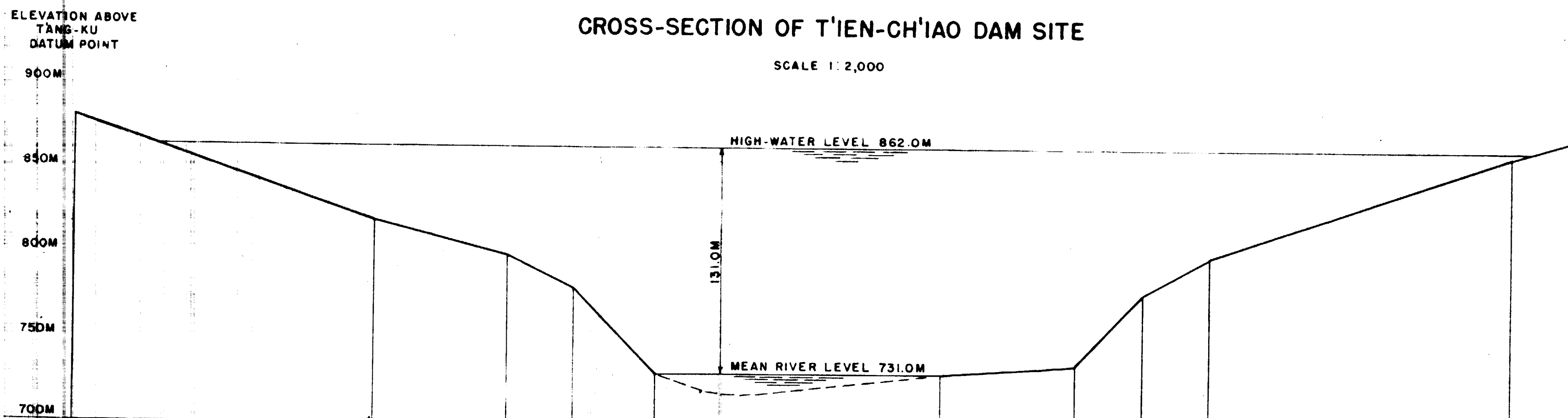
ELEVATION (M)	960	920	865	865	920	940	960
CUMULATIVE DISTANCE BETWEEN READINGS (M)	0	90	120	330	360	480	560
DISTANCE BETWEEN ADJACENT READINGS (M)	0	90	30	210	30	120	80

RESTRICTED

RESTRICTED

CROSS-SECTION OF T'IEN-CH'IAO DAM SITE

SCALE 1:2,000



ELEVATION (M)	880	820	800	780	731	731	735	780	800	860	87
CUMULATIVE DISTANCE BETWEEN READINGS (M)	0	180	260	300	350	520	600	640	680	860	90
DISTANCE BETWEEN ADJACENT READINGS (M)	0	180	80	40	50	170	80	40	40	180	4

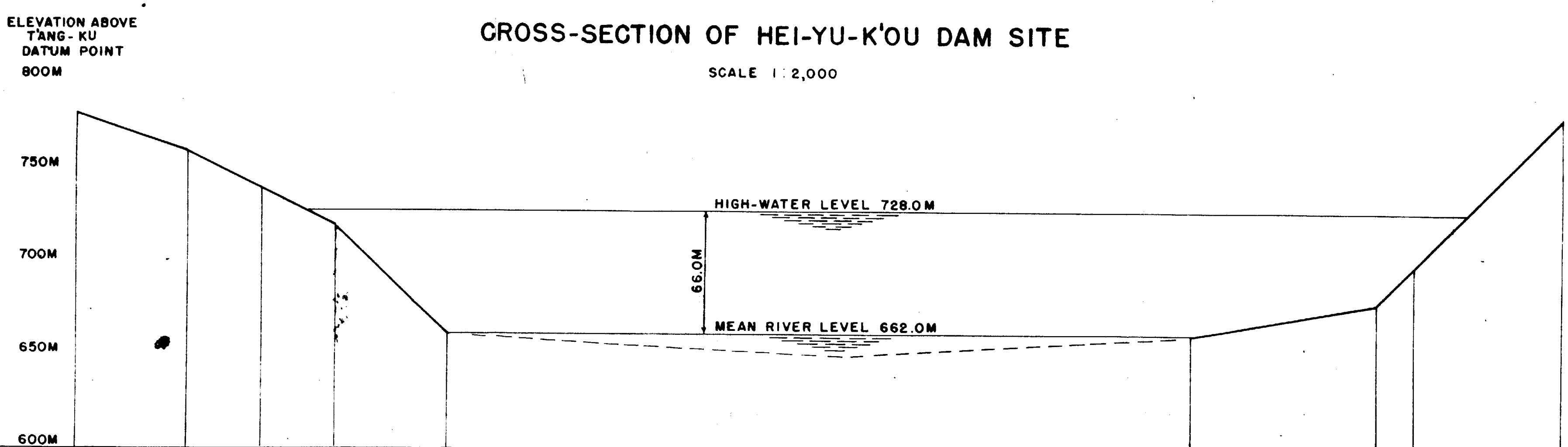
RESTRICTED

Approved For Release 1999/08/25 : CIA-RDP78-03109A000200010001-6

RESTRICTED

CROSS-SECTION OF HEI-YU-K'OU DAM SITE

SCALE 1 : 2,000



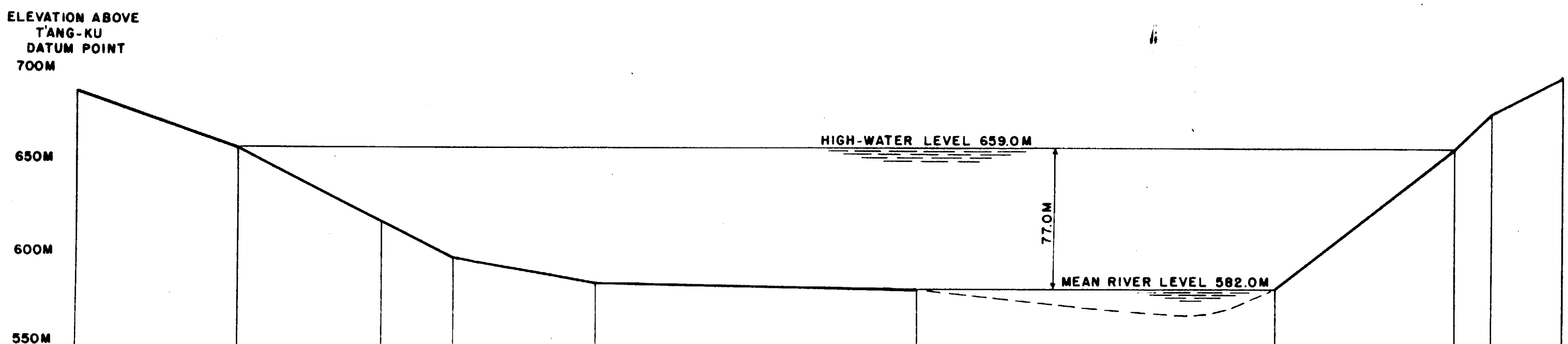
ELEVATION (M)	780	760	740	720	662	662	680	700	780
CUMULATIVE DISTANCE BETWEEN READINGS (M)	0	60	100	140	200	600	700	720	800
DISTANCE BETWEEN ADJACENT READINGS (M)	0	60	40	40	60	400	100	20	80

RESTRICTED

Approved For Release 1999/08/25 : CIA-RDP78-03109A000200010001-6

CROSS-SECTION OF CHI-K'OU-CHEN DAM SITE

SCALE 1:2,000

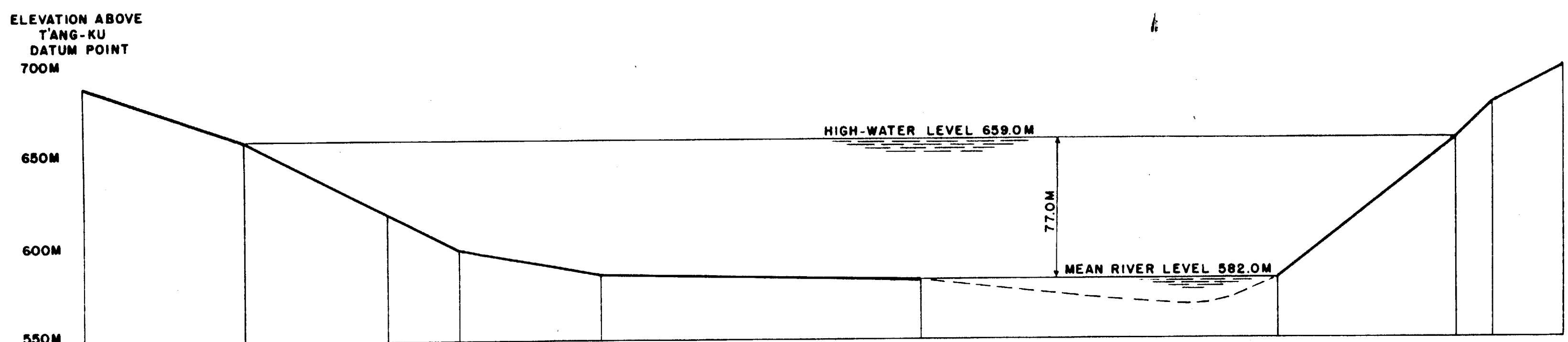


ELEVATION (M)	690	660	620	600	585	582	582	660	680	700
CUMULATIVE DISTANCE BETWEEN READINGS (M)	0	90	170	210	290	470	670	770	790	830
DISTANCE BETWEEN ADJACENT READINGS (M)	0	90	80	40	80	180	200	100	20	40

RESTRICTED

CROSS-SECTION OF CHI-K'OU-CHEN DAM SITE

SCALE 1:2,000



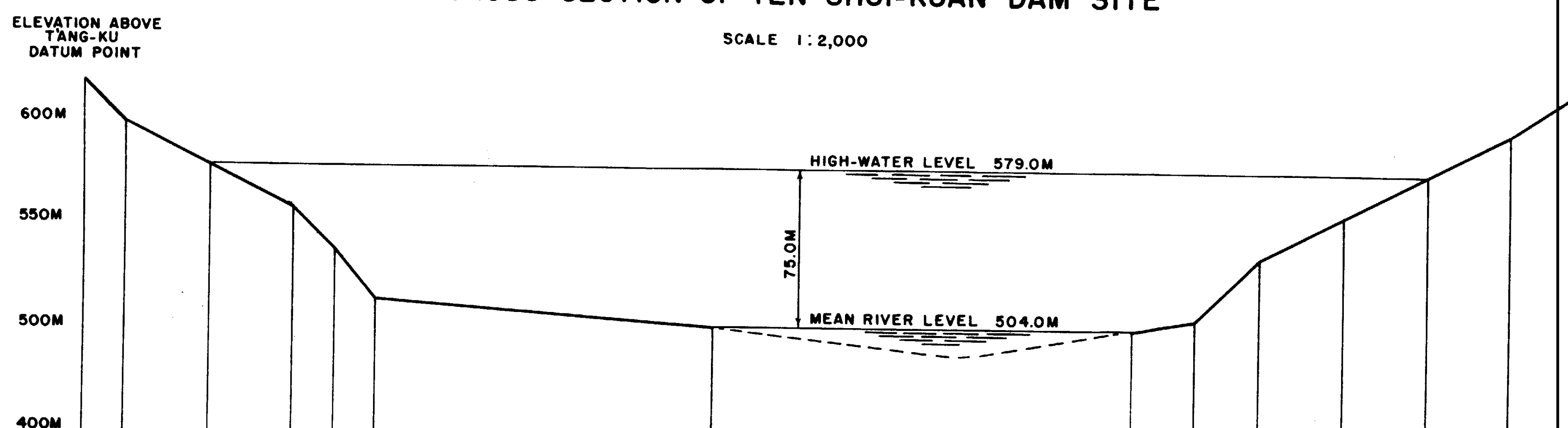
ELEVATION (M)	690	660	620	600	585	582	582	660	680	700
CUMULATIVE DISTANCE BETWEEN READINGS (M)	0	90	170	210	290	470	670	770	790	830
DISTANCE BETWEEN ADJACENT READINGS (M)	0	90	80	40	80	180	200	100	20	40

RESTRICTED

RESTRICTED

CROSS-SECTION OF YEN-SHUI-KUAN DAM SITE

SCALE 1:2,000



ELEVATION (M)	620 600	580	560 540 515	504	504	510	540	560	580	600	620		
CUMULATIVE DISTANCE BETWEEN READINGS (M)	0 20	60	100 120 140	300	500	530	560	600	640	680	710		
DISTANCE BETWEEN ADJACENT READINGS (M)	0 20	40	40 20 20	160	200	30	30	40	40	40	30		

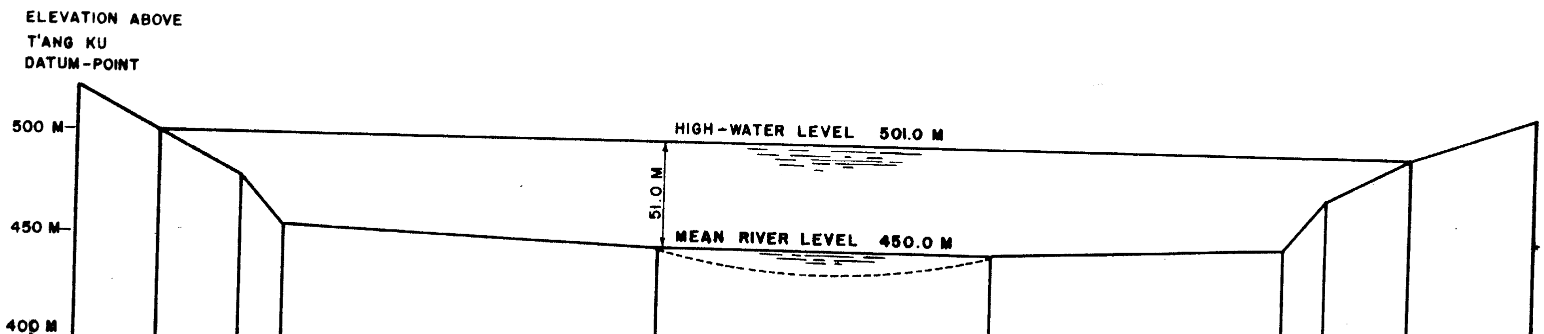
RESTRICTED

Approved For Release 1999/08/25 : CIA-RDP78-03109A000200010001-6

RESTRICTED

CROSS-SECTION OF HU-KOU DAM SITE

SCALE 1:2,000



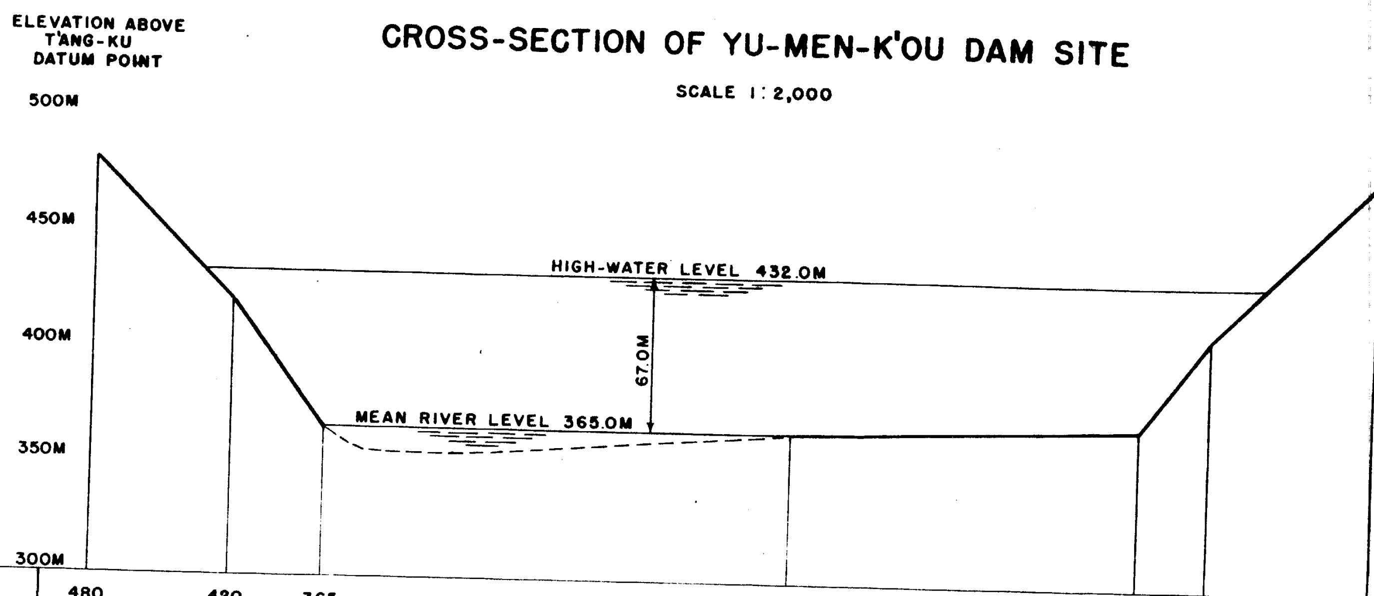
ELEVATION (M)	520	500	480	455	450	450	455	480	500	520
CUMULATIVE DISTANCE BETWEEN READINGS (M)	0	40	80	100	280	440	580	600	640	700
DISTANCE BETWEEN ADJACENT READINGS (M)	0	40	40	20	180	160	140	20	40	60

RESTRICTED

RESTRICTED

CROSS-SECTION OF YU-MEN-K'OU DAM SITE

SCALE 1: 2,000



ELEVATION (M)	480	420	365	365	370	410	480
CUMULATIVE DISTANCE BETWEEN READINGS (M)	0	60	100	300	450	480	550
DISTANCE BETWEEN ADJACENT READINGS (M)	0	60	40	200	150	30	70

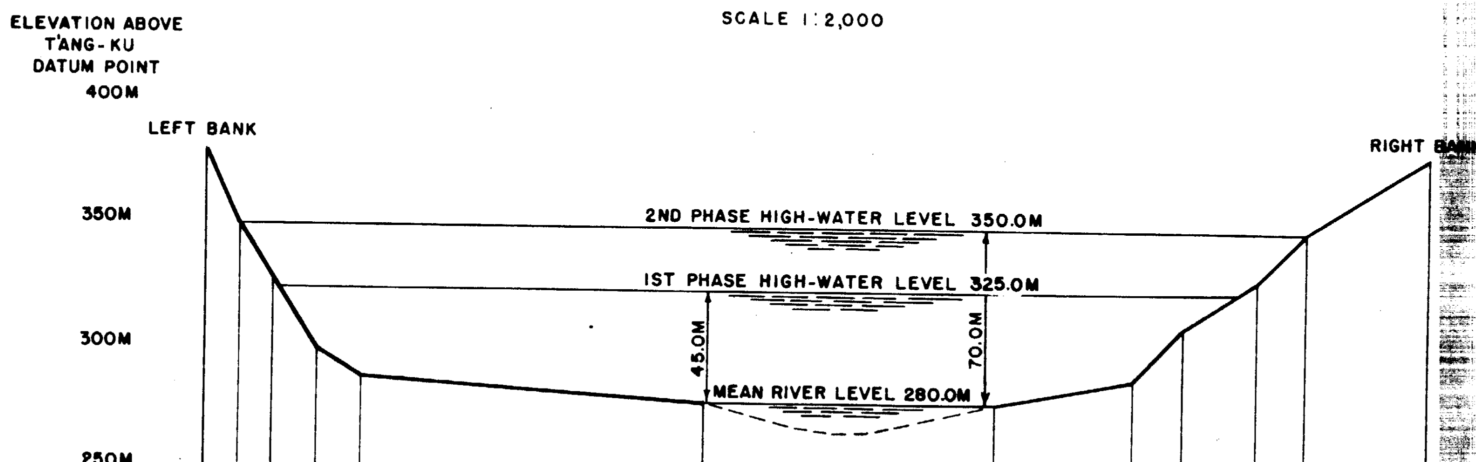
RESTRICTED

Approved For Release 1999/08/25 : CIA-RDP78-03109A000200010001-6

RESTRICTED

CROSS-SECTION OF SAN-MEN-HSIA DAM SITE

SCALE 1:2,000



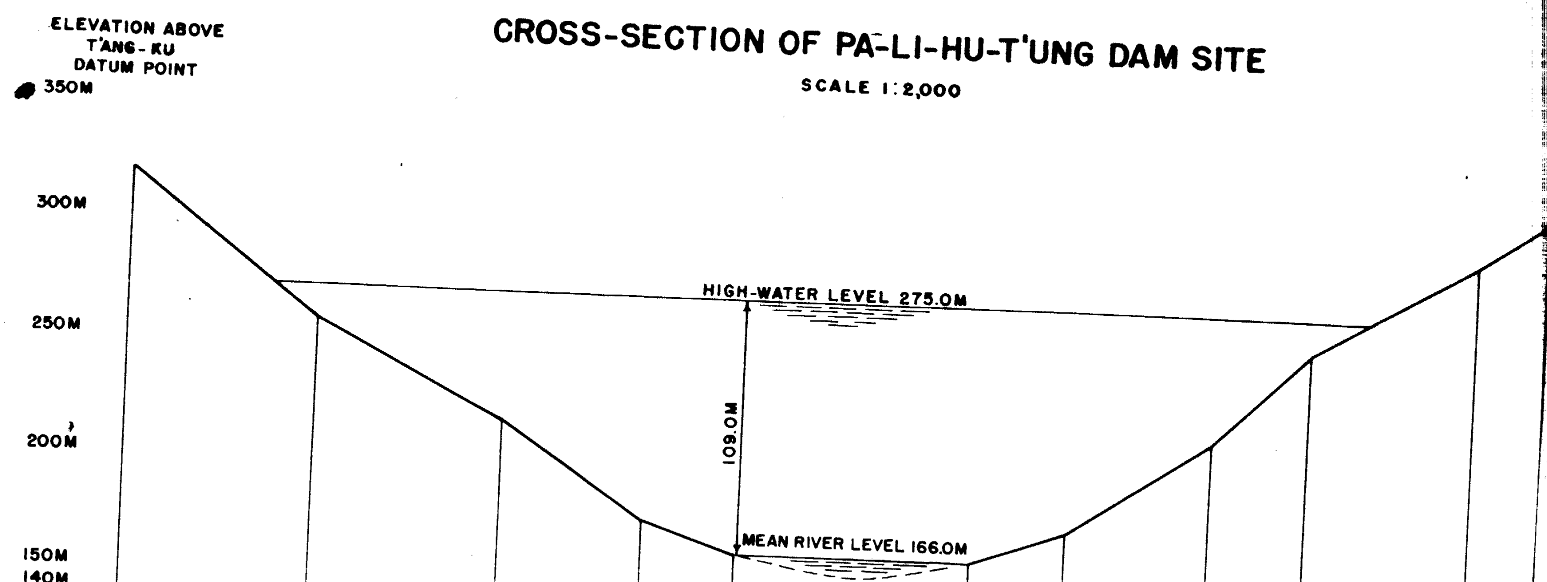
ELEVATION (M)	380	350	330	300	290	280	280	290	310	330	350	380
CUMULATIVE DISTANCE BETWEEN READINGS (M)	0	13	28	46	64	204	324	380	400	430	450	500
DISTANCE BETWEEN ADJACENT READINGS (M)	0	13	15	18	18	140	120	56	20	30	20	50

RESTRICTED

RESTRICTED

CROSS-SECTION OF PA-LI-HU-T'UNG DAM SITE

SCALE 1:2,000



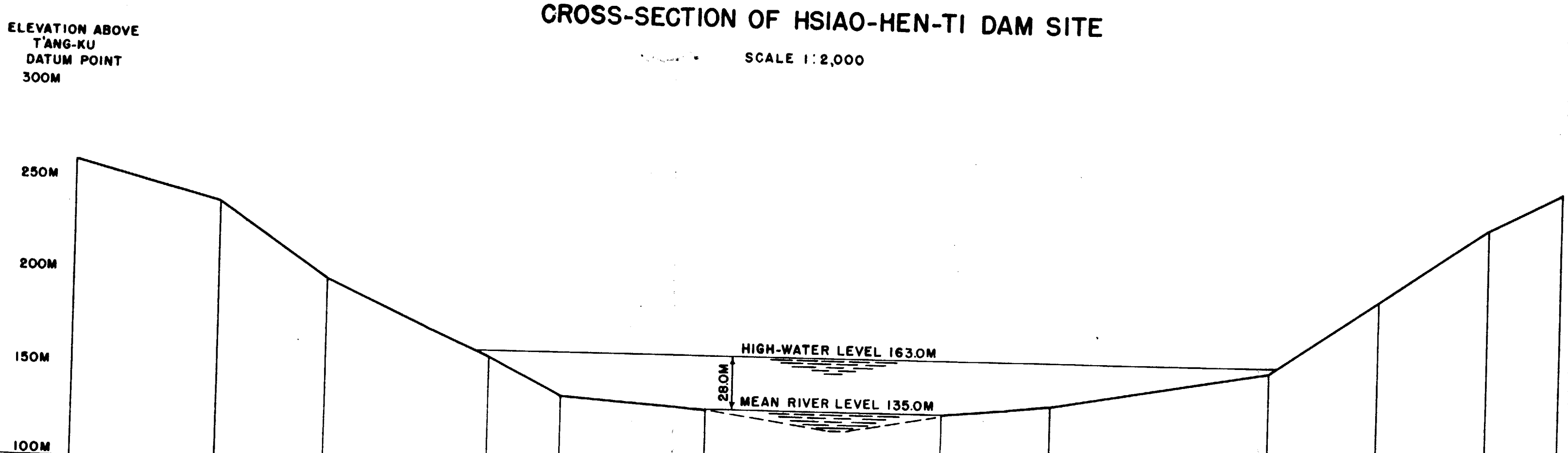
ELEVATION(M)	320	260	220	180	166	166	180	220	260	300	320
CUMULATIVE DISTANCE BETWEEN READINGS(M)	0	80	160	220	260	360	400	460	500	570	600
DISTANCE BETWEEN ADJACENT READINGS(M)	0	80	80	60	40	100	40	60	40	70	30

RESTRICTED

RESTRICTED

CROSS-SECTION OF HSIAO-HEN-TI DAM SITE

SCALE 1:2,000



ELEVATION (M)	260	240	200	160	140	135	135	140	160	200	240	260
CUMULATIVE DISTANCE BETWEEN READINGS (M)	0	80	140	230	270	350	480	540	660	720	780	820
DISTANCE BETWEEN ADJACENT READINGS (M)	0	80	60	90	40	80	130	60	120	60	60	40

RESTRICTED

IV. Reservoirs

The still water areas were measured from the 1:50,000 aerial-photograph maps and other maps and profiles. The reservoir capacities and other important figures calculated from them are shown on the following table.

The upper portion of the storage capacity of the San-men gorge reservoir is to be used for flood control.

/Table follows on next page/

Reservoirs

Site	High-Water Level (m)	Expansion of Backwater (km)	Still-Water Area (sq km)	Total Capacity of Reservoir (1,000,000 cu m)	Usable Depth (m)	Effective Capacity of Reservoir (1,000,000 cu m)	Capacity for Silting (1,000,000 cu m)	Villages Inundated	Maximum Depth of Water (m)
1 Ch'ing-shui-ho***	985	143	2,300.0	24,000	15.0	22,500 [sic]	2,500 [sic]		58
2 Ho-ch'u	924	48	31.9	530	1.5	40	490	3	59
3 T'ien-ch'iao	862	63	101.3	4,430	6.0	580	3,850	41	131
4 Hei-yu-k'ou	728	91	89.6	1,970	6.0	490	1,480	46	66
5 Chi-k'ou-chen	659	117	122.5	3,460	6.0	750	2,710	62	77
6 Yen-shui-kuan	579	163	87.5	2,170	6.0	480	1,690	35	75
7 Hu-k'ou	501	118	65.4	1,120	6.0	350	770	19	51
8 Yu-men-k'ou	432	66	37.5	840	1.5	60	780	13	67
9 San-men gorge*** (1st Phase)	325	132	500.0	6,000	15.(6m*)	2,500* 2,000**	1,500		45
(2d Phase)	350	200	2,244.5	40,070	18.(3m*)	6,500* [sic] 2,000**	11,500 [sic]		70
10 Ha-li-hu-t'ung	275	98	95.8	2,370	1.5	[sic] 100	2,270	41	109
11 Hsiao-hen-ti	163	24	28.3	280	1.5	40	240	14	28
TOTAL (1st Phase at San-men gorge)				47,170			18,280		
(2d Phase at San-men gorge)				81,240			28,280		

*For flood control
**For generation of electricity
***(TN: Figures differ from those on graphs)

Of the sites listed in the preceding table, the Ch'ing-shui-ho and San-men gorge reservoirs have the largest capacity, and exert a great influence in the determination of the volume of available water. However, their enormous still-water area will inundate extensive arable land and many homes. The reservoir capacity at each water level and the corresponding contour lines should be studied to determine the destruction of property which each level will cause.

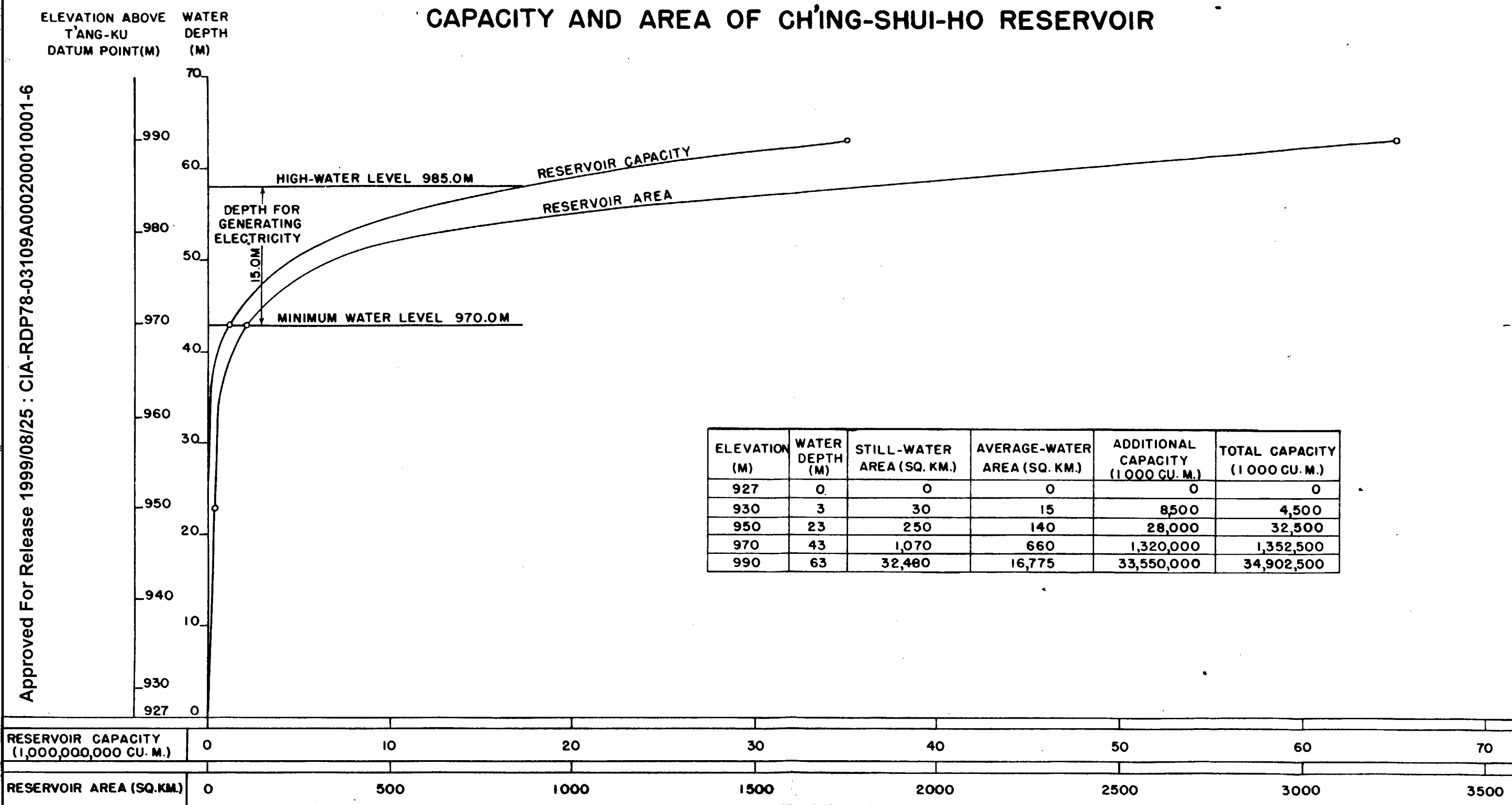
A. The Ch'ing-shui-ho Reservoir

The following table and graph were constructed, with slight correction, from the 1:100,000 map and the profile of the Pei-p'ing-Suiyuan Railroad line. They show the still-water area and capacity of the reservoir at each water level.

Capacity of Ch'ing-shui-ho Reservoir at Different Water Levels

Water Level (m above sea level)	Depth of Water (m)	Still-water Area (sq km)	Storage Capacity (cu m)
927	0	0	0
930	3	3	45,000,000
950	23	25	325,000,000
970	43	107	1,350,000,000
990	63	3,248	34,900,000,000

CAPACITY AND AREA OF CH'ING-SHUI-HO RESERVOIR



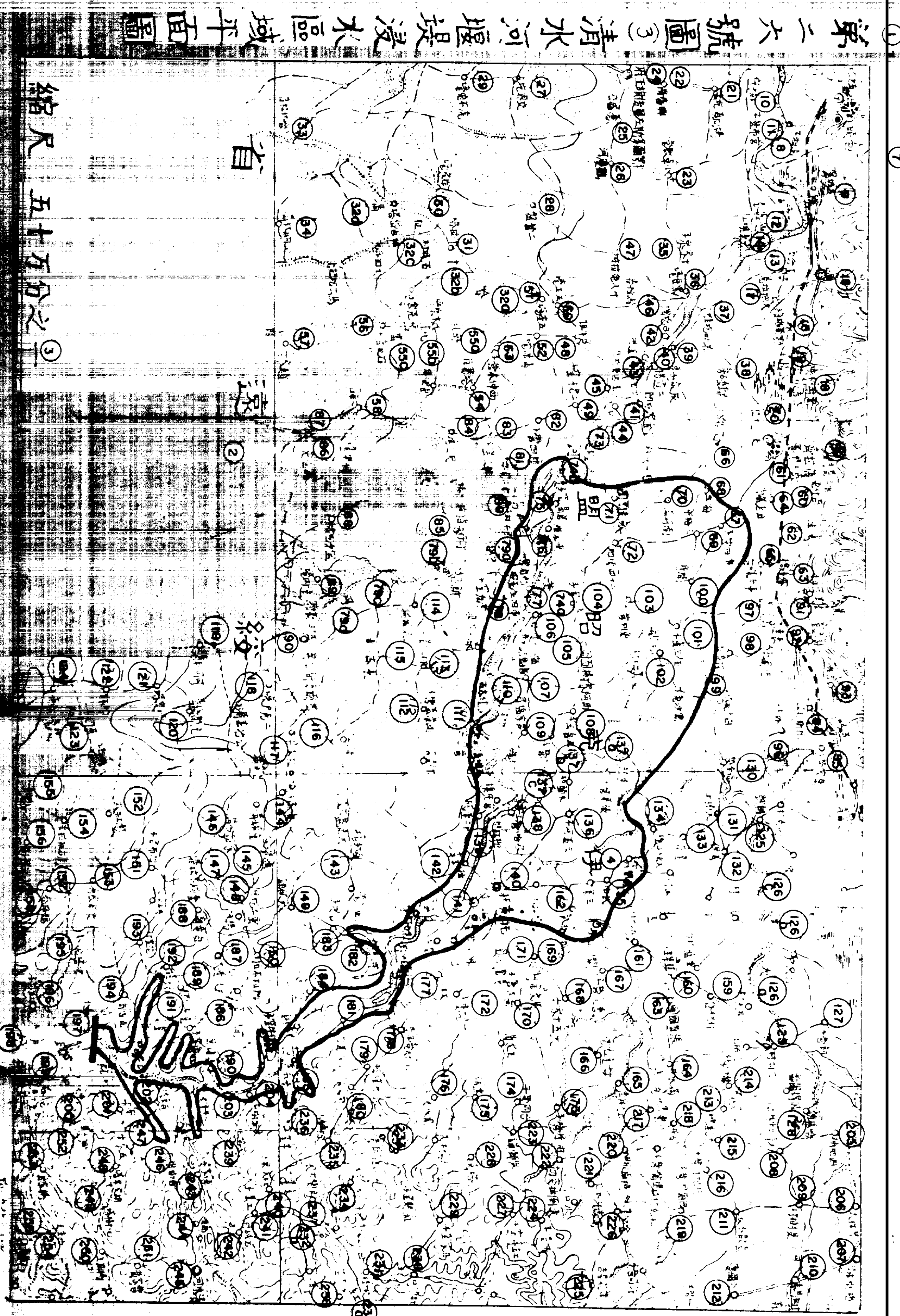
ELEVATION (M)	WATER DEPTH (M)	STILL-WATER AREA (SQ. KM.)	AVERAGE-WATER AREA (SQ. KM.)	ADDITIONAL CAPACITY (1 000 CU. M.)	TOTAL CAPACITY (1 000 CU. M.)
927	0	0	0	0	0
930	3	30	15	8,500	4,500
950	23	250	140	28,000	32,500
970	43	1,070	660	1,320,000	1,352,500
990	63	32,480	16,775	33,550,000	34,902,500

Approved For Release 1999/08/25 : CIA-RDP78-03109A000200010001-6

1. MAP OF INUNDATED AREA BEHIND CH'ING-SHUI-HO DAM
2. Suiyuan
3. Scale of 1:50,000
4. I-k'o-chao-meng
5. Hsia-ch'eng-wan
6. Lao-niu-wan
7. Pao-t'ou
8. Nan-hai-tzu
9. Ku-ch'eng-wan
10. Hung-tung-wan
11. Kung-pu-ying-tzu
12. Te-sheng-t'ai
13. T'u-ho-ch'i
14. Tung-pa-shang
15. Sha-erh-pi
16. O-erh-ko-chen
17. Ta-pa-la-kai
18. Hei-ma-pan-hsia
19. Kung-chi-pan
20. Chu-erh-ko-tai
21. Yang-t'ung-shun-ko-tu
22. Hsing-sheng-lung
23. Hsiao-cho-chiao-t'ang
24. O-erh-to-ssu Tso-i Hou-ch'i Wang-tu (Ordos left wing, rear banner prince's headquarters)
25. Te-sheng-kung
26. Hao-ch'ing-ho
27. Chiao-chieh-ko-shang
28. Erh-ying-p'an
29. Hu-pu-t'u-hao
30. Hsu-chia-hao
31. Shih-la-t'a
32. Ha-shih-la-kou (River)
33. Ha-shih-la-chao
34. Hsiao-na-lin-kou
35. Shih-chia-ch'uan-tzu
36. Hei-tou-hao
37. Pao-t'ien-ko-tu
38. Wu-nien-fang
39. Hui-ch'ang-tzu-tu-k'ou
40. Erh-tao-kuai
41. Hsia-chin-chia-ko-wa
42. Pai-yen-nao
43. Erh-tao-kuai
44. Erh-mang-tu-k'ou
45. Li-chan-wang-ko-tieh
46. Ma-lung-feng
47. Shih-pa-t'u-la-hai
48. Kuan-niu-pa
49. Erh-lao-nan-yao-tzu
50. Wang-cheng-hao
51. Wu-tso-t'a
52. Ma-pao-hao
53. Hsi-shen-mu-ying-tzu
54. T'a-pin-ch'en
55. Mu-hua-kou (River)
56. Shih-tso-yao-tzu
57. Chao-chia-ts'un
58. Hung-chao
59. Shui-ch'ang-Kou-men
60. Pai-shih-t'u
61. Saratsi (ch'ang-han-k'uo-luan) (Sa-la-ch'i)
62. Sha-pin-yai
63. Mai-ta-ch'iao
64. Hsi-lao-ts'ang-ying
65. Tung-lao-ts'ang-ying
66. Ch'en-chia-hu-lu-t'ou
67. K'ang-ssu-ying-tzu
68. Hai-tzu
69. San-ko-chia
70. Nan-ho-t'ou
71. Ch'ang-su-luan-k'uo
72. Erh-shih-ssu-ch'ing-ti
73. Hung-yen-yao-tzu-tu-k'ou
74. Huang Ho (Yellow River)
75. Ts'ang-kou-yao-tzu-tu-k'ou
76. Chia-pi-t'an
77. Mien-li-ying-tzu
78. Lao-li-yao-tzu
79. Hu-ssu-t'ai Ho (River)
80. Liu-lin-tzu
81. Shih-erh-ch'ing-ti
82. Chao-ssu-ying-tzu
83. Hsing-erh-yao-tzu
84. Ch'ih-san-hao
85. Kou-hang-chao-chu-kou-ko-pa
86. Wu-kai-shih-li-hao
87. Ma-kai-t'u-chao
88. Pao-shao-ko-tu
89. Ta-nei-hao
90. O-erh-to-ssu Tso-i Ch'ien-ch'i Pei-lo-fu (Ordos left wing front banner beileh's headquarter
91. Mei-tai-chen
92. Shang-hsi-li-ch'i
93. Ku-yen
94. T'o-ssu-ho-chen
95. Ch'iao-chia-ying-tzu
96. Hsi hai-tzu (Lake)
97. Su-po-kai
98. Ch'iao-erh-ch'i
99. Pai-yen-ch'ang-han
100. San-chien-fang
101. Jen-san-yao-tzu
102. Mao-tai-chen
103. Mien-li-ying-tzu
104. Shih-yao-tzu
105. Hsi-o-chia-shu-hu-lun
106. Meng-k'eng-tu-k'ou
107. Chu-kuei-tien-ko-liang
108. Wang-hsi-yao-tzu

(Continued)

109. Lu-chia-yen-fang
110. Shih-ta-ku
111. Chih-hu-lun
112. Hsi-chang-kai-ying-tzu
113. Ts'un-kou-yao-tzu
114. Po-erh-tung
115. Tung-ch'ang-han-su
116. Se-la-pen-liang
117. K'ung-tui-p'u
118. Kung-yeh-kai-kou
119. K'o-k'o-li-kou
120. K'un-tu-lun-kou
121. Sun-chia-t'a
122. Na-lin
123. Pai-tung-liang
124. Hou-hao-lai-wan
125. Ch'ao-hao
126. Ta-hei Ho (River)
127. Hsin-ying-tzu
128. Ha-lin-ch'ao
129. San-liang-ts'un
130. Kao-ch'uan-ying
131. Ta-nao-shang
132. Shan-tan
133. Ta-tai
134. Ta-tu-li-pa
135. Wu-shen
136. San-tao-ho-tzu
137. Huang Ho (Old course)
138. Ch'a-ha-ying-tzu
139. Liu-lin-t'an
140. Tokoto (T'o-k'o-t'o)
141. Ho-k'ou-chen
142. La-tzu-wan
143. Ku-tzu-hao
144. Tung-ch'ang-han-nao
145. Kuang-yuan-kung
146. Chia-ssu-ling-kou
147. K'uei-t'ung-pu-la-kou
148. Yao-tzu-ko-tan
149. Ta-fan-p'u
150. A-la-pu-la
151. T'a-pu-yao-tzu
152. Chao-hung-t'ai
153. Hou-ho-chia-wan
154. Hu-shih-t'ao-la-hai
155. Nien-fang-tzu
156. Ch'i-hao-tzu-p'ing
157. Fu-lu-t'a
158. Miao-liang
159. Shih-erh-teng
160. Chiu-ts'ai-t'an
161. Wu-pa-shih-yai
162. Hu-la-ko-ch'i
163. Chang-suan-hu-lun
164. Man-shui-ching
165. Kang-fang-kou
166. Ha-ta-t'u-hao
167. T'u-chia-ying-tzu
168. Ta-wu-shih-chia-tzu
169. Ma-chia-tang-p'u-liang
170. Ch'ang-chia-ying-tzu
171. Yang-tang-luan-k'uo
172. I-chien-fang-tzu
173. Yu-fang-ying-tzu
174. Ho-t'ung-ying-tzu
175. Hei-ch'eng
176. Hei-shui-ch'uan-tzu
177. Ta-yang-ch'ang
178. Feng-yen-tang-fang-kou
179. Hsiao-hsi-hao-lai
180. Nan-hao-lai
181. Hsiao-chang-kai-ying
182. Pan-kou
183. Shih-kuai-tzu
184. Hou-ko-pa
185. La-ma-wan
186. Ch'ien-ma-san-yao-tzu
187. Wu-liang-su-t'ai
188. Pai-lung-miao
189. Ta-tzu-ko-leng
190. Liang-chen-yao
191. Yao-kou
192. Hsu-chia-t'a
193. Fan-chia-ts'un
194. Tien-tai-kou
195. Sha-t'a-tien
196. Hung-t'ai-tzu
197. Sha-shih-yen
198. Ching-tzu-kou
199. Pai-t'ou-lang
200. Chung-hao-tzu
201. Nan-liang
202. Pai-ts'ao-t'a
203. Niu-lung-wan
204. Ta-yu-shu-wan
205. Ssu-ti-pu
206. Mao-lin-t'ai
207. Kuai-la-ma
208. Ta-ta-lai-tan-pa
209. Shuang-shu-ts'un
210. Shih-la-wu-su
211. Lao-lung-pu-lang
212. Sha-erh-ch'ing
213. Ku-hung-tai
214. Ch'iao-fu-ying-tzu
215. T'ao-su-hao
216. Ch'iao-erh-shih-ying-tzu
217. Tung-hei-sha-t'u
218. I-chien-fang
219. Pa-erh-tan-ying-tzu
220. Nao-erh-pan-chia
221. Ch'ien-ch'ang-han-ko-tung
222. Tung-tao-la-t'u-ho


第二六號圖(3)清水河堰堤浸水區域平面圖
縮尺 五十万分之一

(Continued)

223. Chia-lai-chen
224. Ch'eng-kou-tzu
225. Huang-hua-feng-chi
226. She-pi-yai
227. Kang-fang-yao-tzu
228. T'a-k'o
229. Ma-chia-yao-tzu
230. Hung-sha-k'ou
231. San-chih-shu
232. Hung Ho (River)
233. Ch'ien-shih-la-wu-su
234. Hu-san-yao-tzu
235. Fan-p'u-yen
236. Yang-wa
237. Wu-lan-pu-lang
238. Kuang-sheng-chuang
239. Ching-lu-tsui
240. Hung-shui-ch'uan-tzu
241. T'u-kou-tzu
242. Shih-pei-ts'an
243. Fu-chia-liang
244. Hsi-tsui
245. Ch'ing-shui-ho (Tsingshuiho)
246. Hsing-shu-pei
247. Wu-chia-liang
248. Hu-chia-yang-t'a
249. Hau-shu-t'a
250. Yang-chuang-wang
251. Ts'ao-chia-kou
252. Shih-tzu-kou
253. Yang-chia-ch'a
254. Hsi-chuang-wang
255. Kan-kou

The area of inundated arable land, the number of inundated villages and the dispossessed population were calculated, under appropriate assumptions, from Mr KOBAYASHI's investigation. Findings are given in the following table and map.

Inundation Loss From Ch'ing-shui-ho Reservoir

Water Level (m above sea level)	Depth of Water (m)	Arable Land Inundated (*)	No of Village Inundated	No of Houses Inundated	No of Persons Dispossessed
930	3	3,500*	2	19	84
950	23	30,000*	9	273	799
970	43	1,263,000*	74	1,453	7,075
990	63	4,150,000*	774	22,435	139,530

*(TN: It is not certain whether the unit of measurement referred to here is the Chinese unit MOU [733.5 sq yd] or the Japanese unit SE [118.6 sq yd] since both units are represented by the same ideograph.)

B. San-men Gorge Reservoir

The table and the two graphs which follow show the still-water area and storage capacity of the San-men gorge reservoir at different water levels. This material was prepared from 1:50,000 aerial-photograph maps, from a composite map showing the water level as surveyed by the Yellow River Water Supply Committee, and from the profile of the Lung-Hai Railroad Line.

A portion of the still-water area, along the Su-shui River in southern Shansi, is constricted near its junction with the Yellow River but is very extensive above this point. The possibility has been considered of damming this off from the rest of the still-water area as a safety valve in case of very heavy flood, to keep the still water from spreading too far.

Since no actual investigation has yet been carried out, a high-water level of 350 meters, which would not inundate the salt lakes, was set for the last stages of the 2d phase. The following table gives figures for the still-water area and storage capacity at different water levels, both when the Su-shui River area is held separate and when it is treated as an integral part of the still-water area.

[Table and two graphs follow on next pages]

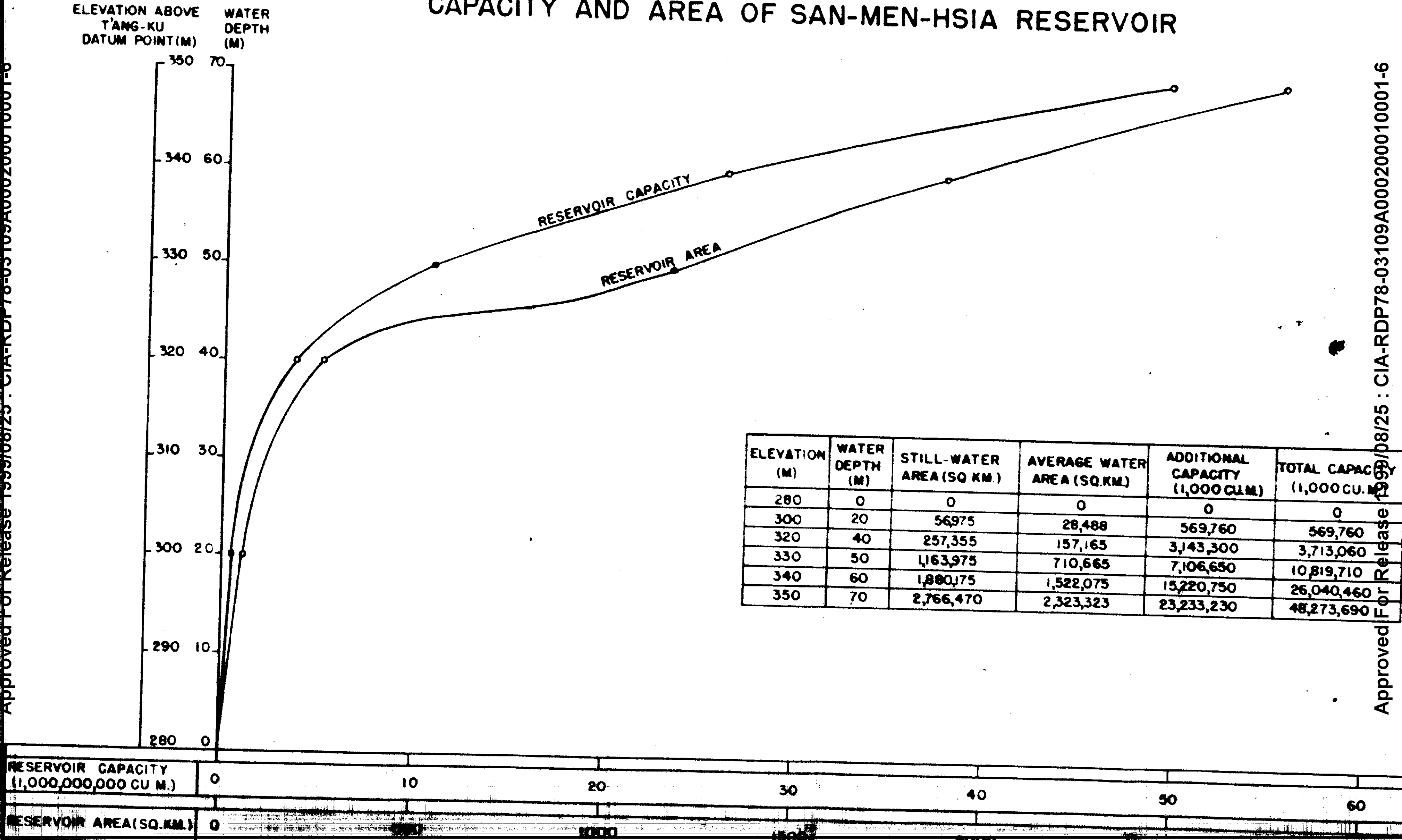
Water Level and Capacity of San-men Gorge Reservoir

Water Level (m above sea level)	Depth of Water (m)	WHEN THE SU-SHUI RIVER AREA IS CLOSED OFF		WHEN THE SU-SHUI RIVER AREA IS NOT CLOSED OFF	
		Still-water Area (sq km)	Capacity of Reservoir (cu m)	Still-water Area (sq km)	Capacity of Reservoir (cu m)
280	0				
300	20	57.0	570,000,000	57.0	570,000,000
320	40	257.4	3,710,000,000	257.4	3,710,000,000
330	50	906.5	9,530,000,000	1,164.0	10,820,000,000
340	60	1,478.6	21,460,000,000	1,880.6	26,040,000,000
350	70	2,244.6	40,070,000,000	2,766.5	49,270,000,000

Approved For Release 1999/08/25 : CIA-RDP78-03109A000200010001-6

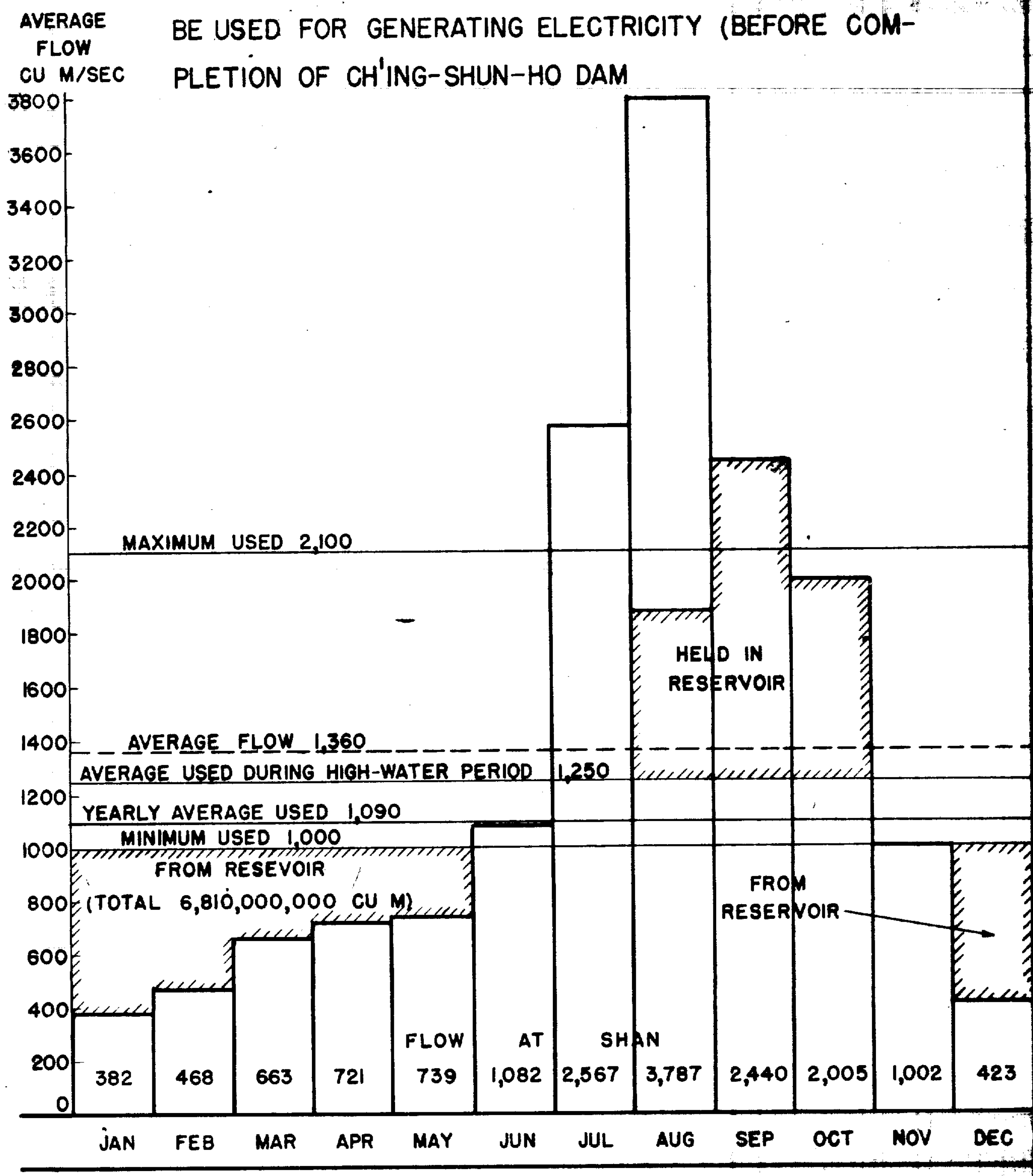
RESTRICTED

CAPACITY AND AREA OF SAN-MEN-HSIA RESERVOIR



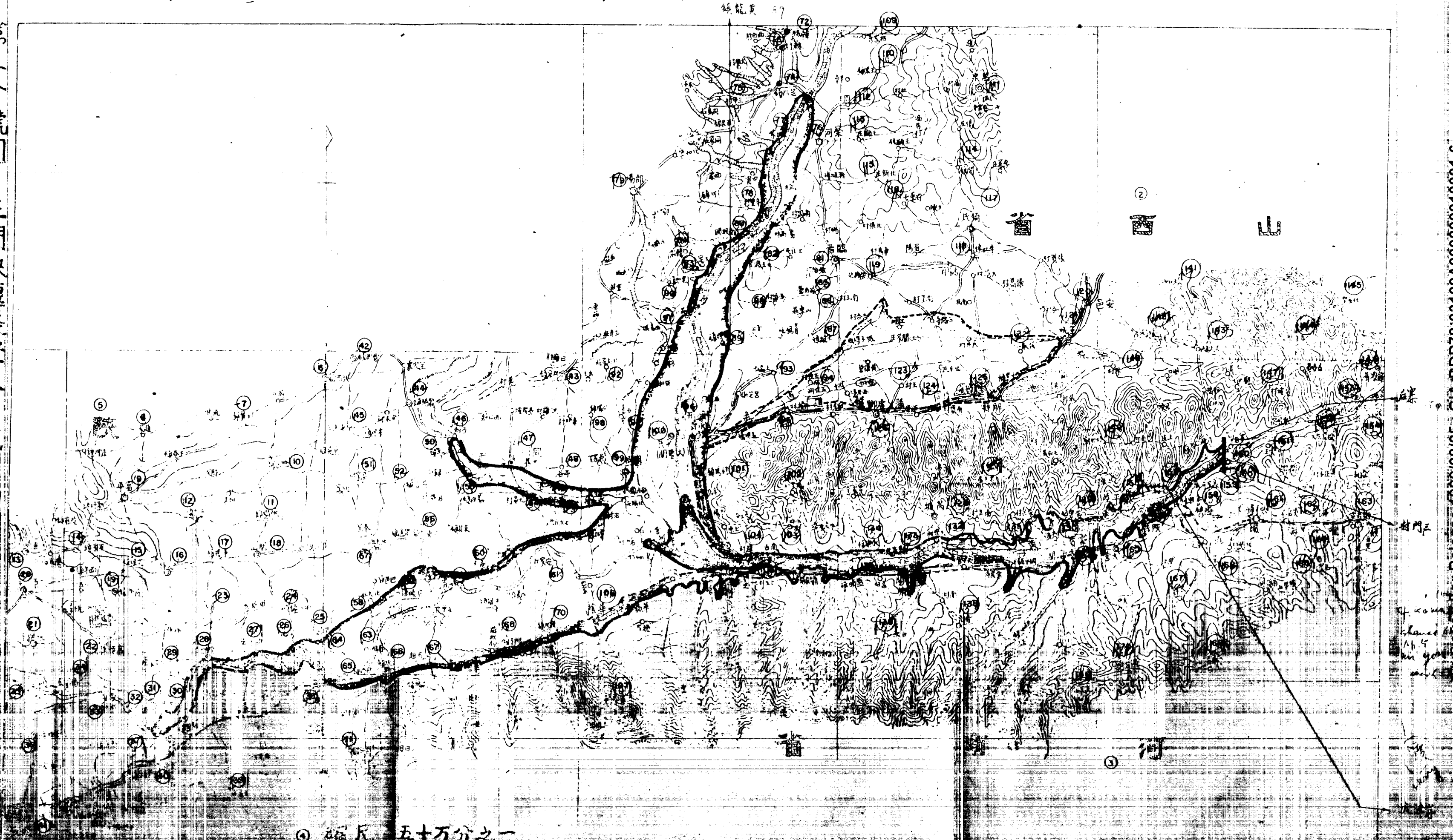
ELEVATION (M)	WATER DEPTH (M)	STILL-WATER AREA (SQ KM)	AVERAGE WATER AREA (SQ.KM.)	ADDITIONAL CAPACITY (1,000 CU.M.)	TOTAL CAPACITY (1,000 CU.M.)
280	0	0	0	0	0
300	20	56,975	28,488	569,760	569,760
320	40	257,355	157,165	3,143,300	3,713,060
330	50	1,163,975	710,665	7,106,650	10,819,710
340	60	1,880,175	1,522,075	15,220,750	26,040,460
350	70	2,766,470	2,323,323	23,233,230	48,273,690

SECOND PHASE OF SAN-MEN-HSIA: AMOUNT OF WATER TO BE USED FOR GENERATING ELECTRICITY (BEFORE COMPLETION OF CH'ING-SHUN-HO DAM



93Ac

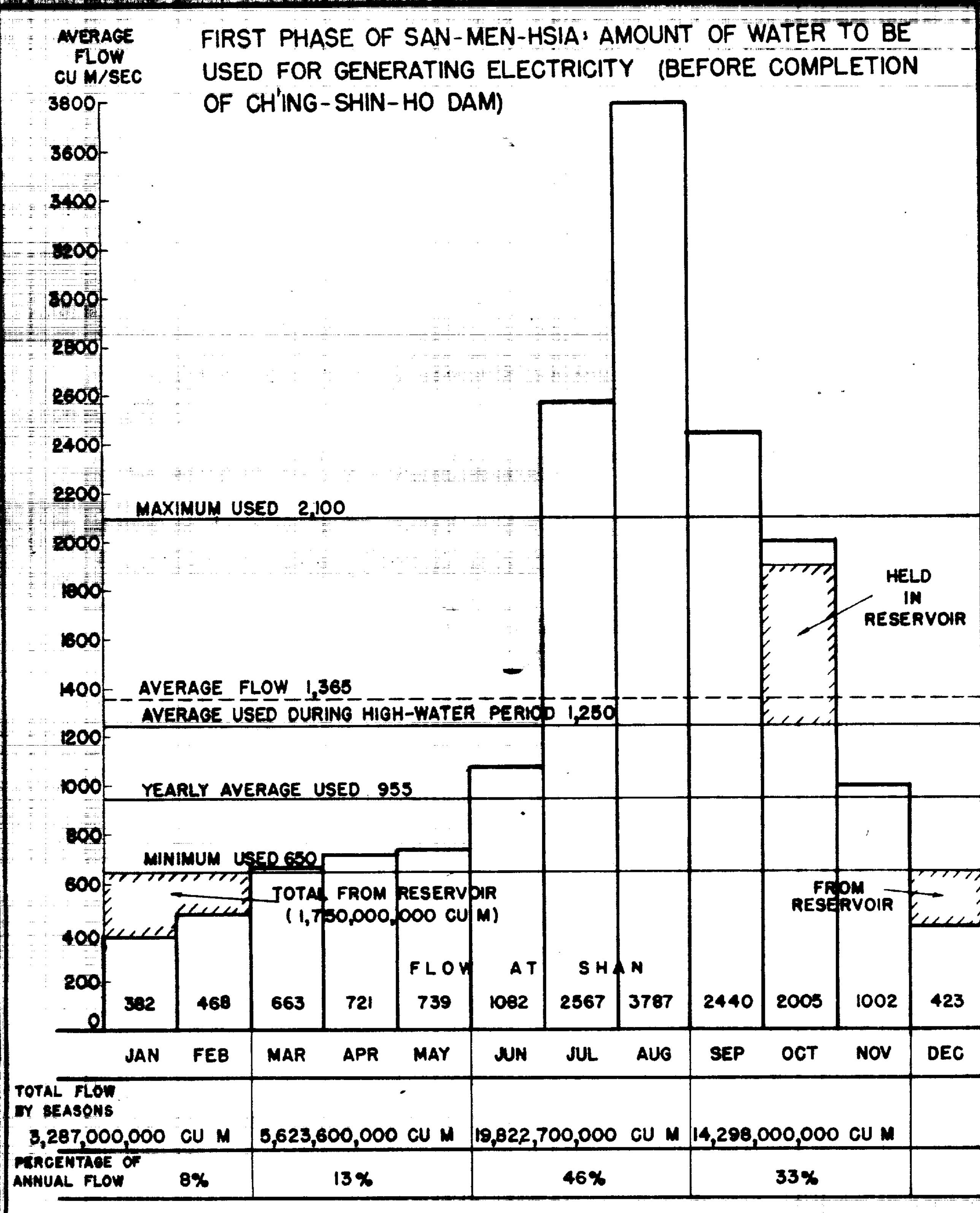
① 第二八號圖③ 三門峽堰堤浸水區域平面圖



④ 縮尺 五十万分之一

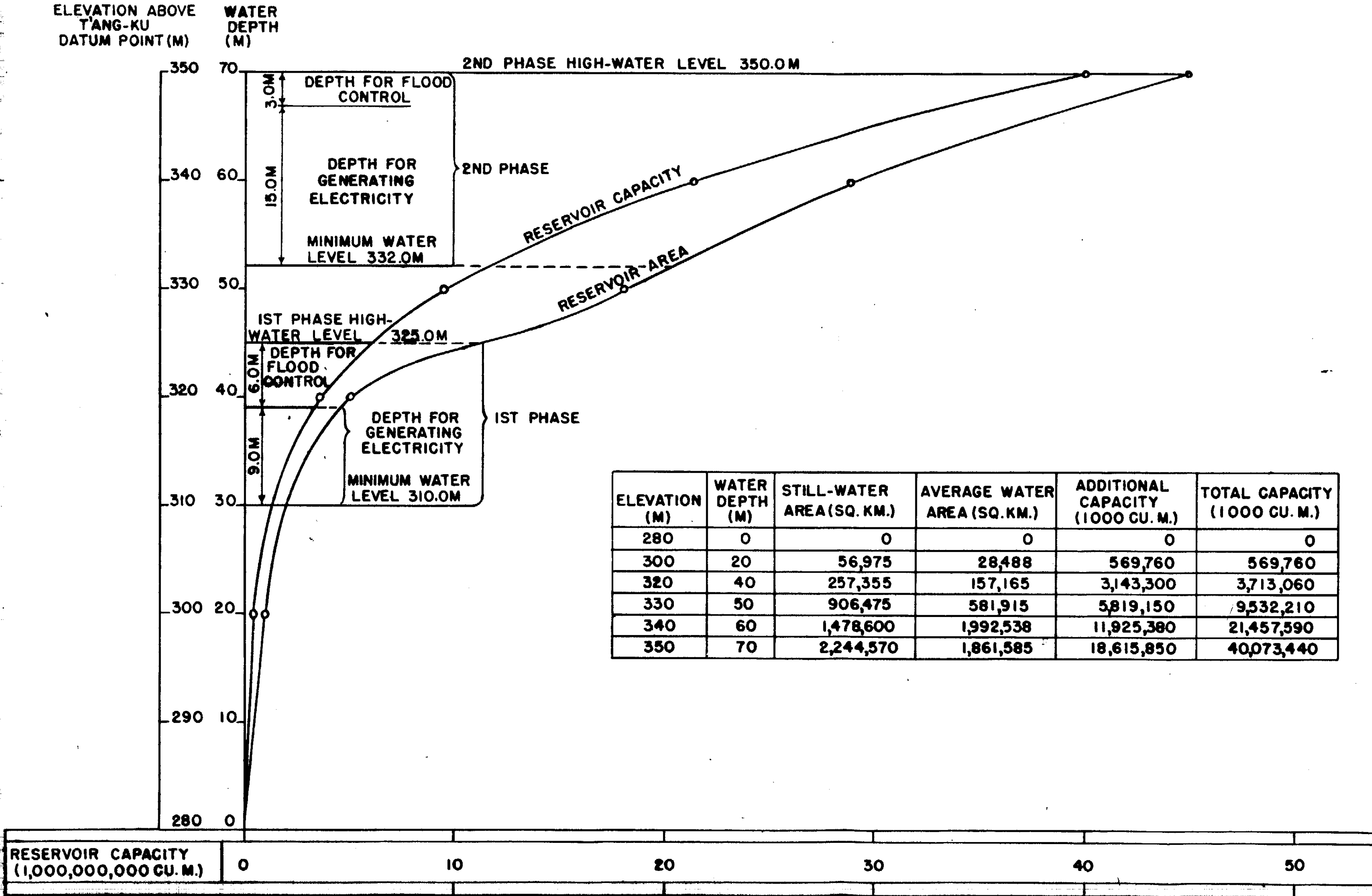
alternate 89. 黃螺鎮 vk Tay 82
v "龍" 50 map, AMZ

1. MAP OF FLOODED AREA OF SAN-MEN GORGE DAM
2. Shansi
3. Honan
4. Scale 1:500,000
5. Shensi
6. Hsing-shih-chen
7. Tao-hsien-chen
8. Chao-chia
9. Fu-p'ing
10. Shih-chia-chen
11. Chang-ch'iao-chen
12. Chin-ku-chen
13. Lu-ch'iao-chen
14. Hu-shen-t'ou
15. Wen-ch'èng-chen
16. Yen-liang-chen
17. K'ang-ch'iao-chen
18. Kuan-shan
19. Po-hsi-chen
20. San-yuan
21. Yung-lo-chen
22. Kao-ling
23. Kuo-chia
24. T'ien-shih-chen
25. Hsin-shih-chen
26. Cha-chi-ts'un
27. Yu-fang-chieh
28. Chiao-k'ou
29. Chu-chia-chuang
30. Yu-chin-t'un
31. Yuan-t'ou-ko
32. Pei-t'ien
33. Chiao-ch'iao-t'an
34. Yang-kuen-chi
35. Chin-p'ing-chuang
36. Ts'ao-t'an-chen
37. Lunghai Railway
38. Wei-nan
39. Tung-yueh-miao
40. Lin-t'ung
41. Hsi-an (Ch'ang-an)
42. Ku-ch'u-chen
43. Shuang-ch'uan-chen
44. Lung-yang-chen
45. Tung-chuang-tzu
46. Ch'uan-she-tu
47. T'ung-chou (Ta-li)
48. P'ing-lo
49. Lo Ho (River)
50. Ling-erh-t'ou
51. Kao-chia-ts'un
52. P'ing-hsin-chen
53. Ch'iang-pai-chen
54. Chiu-lung-ts'un
55. Pa-shih
56. Chiao-hsieh-chen
57. Ku-shih-chen
58. Pei-t'ai-chuang
59. Ts'ang-t'ou-chen
60. Su-ts'un
61. An-chia-ts'un
62. Wei Ho (River)
63. Nan-t'an
64. Shang-chang-chen
65. Hsin-shih-chen
66. Ch'ih-shui-chen
67. Hua-hsien
68. Lo-wen-chen
69. Liu-tzu-chen
70. Fu-shui-chen
71. Ch'ung-ning-chen
72. Han-ch'eng
73. Su-ts'un
74. Chih-ch'uan-chen
75. San-chia-ts'un
76. Jung-ho
77. Tung-fu-meng
78. Hsin-li-ts'un
79. Ho-yang
80. Nan-fan-t'ou
81. Lin-chin
82. Wu-wang-tu
83. Ta-ting
84. Han-chuang
85. Liu-shang-ying
86. Nan-wang-ts'un
87. Ch'i-chi-chen
88. Feng-liu-ts'un
89. (Huang-leng-chen) Huang-lung-chen
90. Hei-ch'ih-chen
91. Wu-jen
92. Pei-pei-chia-chuang
93. Shang-kao-shih
94. Wu-hsing-hu
95. Yu-lin
96. P'u-chou (Yung-chi)
97. Pu-ch'ang
98. Pai-chung-chen
99. Chao-i
100. P'ing-min (Ta-ch'ing-kuan)
101. Han-yang-chen
102. Yang-chia-Yu
103. Hsiao-hsi-chiao
104. Chao-ts'un
105. T'ung-kuan
106. Hua-yin
107. Hua Yueh (mt)
108. San-li-ch'ang
109. Ch'i-chia-wan
110. Wang-hei-chen
111. Wan-ch'uan
112. Chou-wang
113. Wang-hsien-chuang
114. Ta-hsien-kuan


FIRST PHASE OF SAN-MEN-HSIA: AMOUNT OF WATER TO BE USED FOR GENERATING ELECTRICITY (BEFORE COMPLETION OF CH'ING-SHIN-HO DAM)
AVERAGE FLOW CU M/SEC
3800
3600
3400
3200
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
MAXIMUM USED 2,100
HELD IN RESERVOIR
AVERAGE FLOW 1,365
AVERAGE USED DURING HIGH-WATER PERIOD 1,250
YEARLY AVERAGE USED 955
MINIMUM USED 650
TOTAL FROM RESERVOIR (1,750,000,000 CU M)
FROM RESERVOIR
FLOW AT SHAN
382 468 663 721 739 1082 2567 3787 2440 2005 1002 423
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
TOTAL FLOW BY SEASONS
3,287,000,000 CU M
5,623,600,000 CU M
19,822,700,000 CU M
14,298,000,000 CU M
PERCENTAGE OF ANNUAL FLOW
8%
13%
46%
33%

93AB

CAPACITY AND AREA OF SAN-MEN-HSIA RESERVOIR WHEN SU-SHUI RIVER AREA IS CLOSED OFF



ELEVATION (M)	WATER DEPTH (M)	STILL-WATER AREA (SQ. KM.)	AVERAGE WATER AREA (SQ. KM.)	ADDITIONAL CAPACITY (1000 CU. M.)	TOTAL CAPACITY (1000 CU. M.)
280	0	0	0	0	0
300	20	56,975	28,488	569,760	569,760
320	40	257,355	157,165	3,143,300	3,713,060
330	50	906,475	581,915	5,819,150	9,532,210
340	60	1,478,600	1,992,538	11,925,380	21,457,590
350	70	2,244,570	1,861,585	18,615,850	40,073,440

RESTRICTED

(Continued)

115. Pei-hsin-chuang
116. Chiang-chun-t'un
117. I-shih
118. Niu-she-chen
119. Fan-ch'iao-chan
120. An-i
121. Yun-ch'eng
122. Chang-keng
123. Wang-ts'un
124. Tungpu Railway
125. Chieh-hsien
126. Lu-hsiang
127. Lao-ssu-kou
128. Jui-ch'eng
129. Ch'ang-lo-chen
130. Liu-wan
131. Huang Ho (Yellow River)
132. Ta-an-ts'un
133. Cheng-chia-ts'un
134. Yung-lo-chen
135. P'an-t'ou-chen
136. Wen-hsiang
137. Ling-pao
138. Yung-ch'uan
139. Pai-chia-ts'un
140. Wang-chia-shan (mt)
141. Wang-yu-k'ou
142. Tung-kuo-chen
143. Chang-tien-chen
144. Wu-lung-miao
145. Jen-chia-yao
146. Lung-t'an-kou
147. Yao-p'o-ts'un
148. Chieh-ts'un
149. T'u-ti-miao
150. Chai-hou
151. Tung-chuang
152. Ch'eng-chia-ko-ta
153. Shih-chia-t'an
154. Yen-tzu
155. P'ing-lu
156. Mao-chin-chen (50,000 Mao-chin-tu)
157. Shan-hsien
158. Hui-hsing-chen
159. Ma-chia-ho-ti
160. San-men-ts'un
161. Chang-mao-chen
162. Hsia-shih
163. Kuan-yin-t'ang
164. Lung-hai Railway
165. Ta-ying
166. Ts'ai-yuan
167. Chang-ts'un
168. Shih-yao
169. Mo-kou
170. Fo-chai-miao

RESTRICTED

This table, and the preceding map, show the area of inundated arable land, the number of inundated villages and the population of flooded areas, made under the appropriate assumptions.

Inundation Damage from the San-men Gorge Reservoir (When the Su-shui River Area is Closed Off)

(Calculated by KOBAYASHI Toku)

Water Level (m above sea level)	Depth of Water (m)	Area of Arable Land Inundated			Number of Inundated Villages		Number of Inundated Houses	Number of Persons Dispossessed
		Cultivated Land (1000 MOU [or SE])	Old River Bed (1000 MOU [or SE])	Total (1000 MU [or SE])	Total	District Capitals		
300	20				2	0	110	608
320	40	130		130	6	1	2,100	11,616
330	50	580	364	944	142	4	26,000	137,384
340	60	1463	522	1985	334	6	45,500	245,667
350	70	2170	522	2692	525	8	67,800	322,668

Notes:

1. Average land value of cultivated land is 50 yen per MOU [or SE].
2. Average land value of old river bed is 20 yen per MOU [or SE].

V. Control of Flow, and Amount of Usable Water

There has already been considerable discussion on the flow and reservoirs of the Yellow River from the standpoint of water-power development. The questions arise as to whether generation of electricity at gigantic dams is advantageous on the Yellow River, where there is a great volume of flood water and a tremendous annual and seasonal variation in flow, and as to what can be done with the water stored in the reservoirs and used to generate electricity. Except for a sudden increase between the middle and the downstream sections of the potential water-power area of the Yellow River, the drainage area increases very slowly along the river's course.

Control of the annual flow can be achieved at the upper extremities of the middle and downstream sections, Ch'ing-shui-ho and the San-men gorge. Consideration of the other sites is unnecessary since they require relatively little storage capacity.

A. Ching-shui-ho Site

The drainage area for the Ch'ing-shui-ho site is 30,000 square kilometers larger than that at Pao-t'ou. If this area averages 300 millimeters of rainfall a year, and has a runoff of 10 per cent, the annual outflow would be 900,000,000 cubic meters.

This would give the Ch'ing-shui-ho site an annual inflow of 21,700,000,000 cubic meters, or an average of 690 cubic meters per second.

To equalize this annual flow would require a usable storage capacity of 6,000,000,000 cubic meters, as shown in the preceding graphs and in the following table, based on calculations from the flow at Pao-t'ou.

[Table on following page]

Equalization of Flow at Ch'ing-shui-ho (Average Year)

	Average Flow (cu m/sec)	Total Monthly Flow (1000 cu m)	Average Volume of Usable Water (cu m/sec)	Monthly Excess or Deficiency (cu m/sec)	Monthly Excess or Deficiency (1000 cu m)
Jan	136	364,300	660	(-) 524	(-) 1,403,500
Feb	120	300,700	660	(-) 540	(-) 1,353,000
Mar	200	535,700	660	(-) 460	(-) 1,232,100
Apr	369	956,400	660	(-) 291	(-) 754,300
May	654	1,751,700	660	(-) 6	(-) 16,100
Jun	619	1,604,400	660	(-) 41	(-) 106,300
Jul	729	1.952,600	660	(+) 69	(+) 184,800
Aug	1,248	3,439,100 [sic]	660	(+) 624	(+) 1,671,300
Sep	1,465	3,797,300	660	(+) 805	(+) 2,086,600
Oct	1,195	3,200,700	660	(+) 535	(+) 1,432,900
Nov	933	2,418,400 [sic]	660	(+) 273	(+) 707,600
Dec	209	559,800	660	(-) 451	(-) 1,208,000
Total	660	20,880,000	660		(+) 6,070,000 +6,083,200 -6,073,300

It is very difficult to provide for equalization of flow from year to year, supplementing the flow during dry years with water stored up from wet years, because of inadequate data at Pao-t'ou. If the situation is similar to that at Shan, it would work out as follows:

Capacity Required at Ch'ing-shui-ho to Equalize

the Flow from Year to Year

Minimum Average Amount of Usable Water (cu m/sec)	Capacity Required (cu m)
200	500,000,000
300	1,500,000,000
400	5,250,000,000
500	10,500,000,000
600	22,500,000,000

The annual flow at Ch'ing-shui-ho could be equalized with a reservoir capacity of 24,000,000,000 cubic meters, a depth of usable water of 15 meters, and an effective capacity of 22,500,000,000 cubic meters. If the reservoir at high water is 2,300 square kilometers in area, it will, with an annual evaporation of 1,000 millimeters, lose 2,300,000,000 cubic meters a year through evaporation. This leaves a usable balance of 19,000,000,000 cubic meters a year, or 600 cubic meters per second. At 60 per cent load factor, this is equivalent to a maximum flow of 1,000 cubic meters per second.

B. Sites between Ch'ing-shui-ho and Yu-men-k'ou

The sites between Ch'ing-shui-ho and Yu-men-k'ou have somewhat greater volumes of water available from their individual drainage basins.

Water Available Between Ch'ing-shui-ho and Yu-men-k'ou

Site	Average Flow from Upstream Sites (cu m/sec)	Increased Flow from Individual Drainage Basin (cu m/sec)	Total	Average Amount of Usable Water (cu m/sec)	Maximum Volume of Usable Water (cu m/sec)
1 Ch'ing-shui-ho				600	1,000
2 Ho-ch'u	600	8	608	600	1,000
3. T'ien-ch'iao	608	12	620	620	1,030
4. Hei-yu-k'ou	620	17	637	635	1,060
5 Chi-k'ou-chen	637	34	671	670	1,120
6 Yen-shui-kuan	671	64	735	705	1,180
7 Hu-k'ou	735	48	783	740	1,230
8 Yu-men-k'ou	783	17	800	740	1,230

C. San-men Gorge Site

The annual average flow at San-men gorge is 1,365 cubic meters per second, or a total of 43,000,000,000 cubic meters. Before completion of the Ch'ing-shui-ho Dam, a dam at this site would, as shown in the following table, require an effective capacity of 14,200,000,000 cubic meters to equalize the flow during an average year. To keep the flow at 650 cubic meters per second during the dry period would require only 1,750,000,000 cubic meters.

Equalization of Flow at the San-men Gorge (Average Year)

Month	Average Monthly Flow (cu m/sec)	Total Monthly Flow (1,000,000 cu m)	Average Volume of Usable Water (cu m/sec)	Monthly Excess or Deficiency (cu m/sec)	Monthly Excess or Deficiency (1,000,000 cu m)
Jan	382	1,021 [1,023]	1,365	(-) 983	(-) 2,634
Feb	468	1,133 [1,132]	1,365	(-) 897	(-) 2,169
Mar	663	1,776	1,365	(-) 702	(-) 1,880
Apr	721	1,869	1,365	(-) 644	(-) 1,669
May	739	1,979	1,365	(-) 626	(-) 1,677
Jun	1,082	2,804	1,365	(-) 283	(-) 734
Jul	2,567	6,875	1,365	(+) 1,202	(+) 3,219
Aug	3,787	10,114 [sic]	1,365	(+) 2,422	(+) 6,488 [6,487]
Sep	2,442	6,331 [6,330]	1,365	(+) 1,077	(+) 2,793 [2,791]
Oct	2,005	5,371 [5,370]	1,365	(+) 640	(+) 1,715 [1,714]
Nov	1,002	2,596 [2,597]	1,365	(-) 363	(-) 942 [940]
Dec	423	1,113 [sic]	1,365	(-) 942	(-) 2,524 [2,523]
Total	1,365 [sic]	43,031 [sic]			(±) 14,230 [+ 14,215] [- 14,229]

The total annual flow at this site varies between 20,350,000,000 and 67,000,000,000 cubic meters. The problem of equalizing the flow from year to year, and increasing the flow appreciably and providing for the dry years, can be understood from the table and graph which follow. They show the relation between the minimum average volumes of usable water and the required storage capacity, as taken from 17-years' observations at Shan.

[Graph on following page]

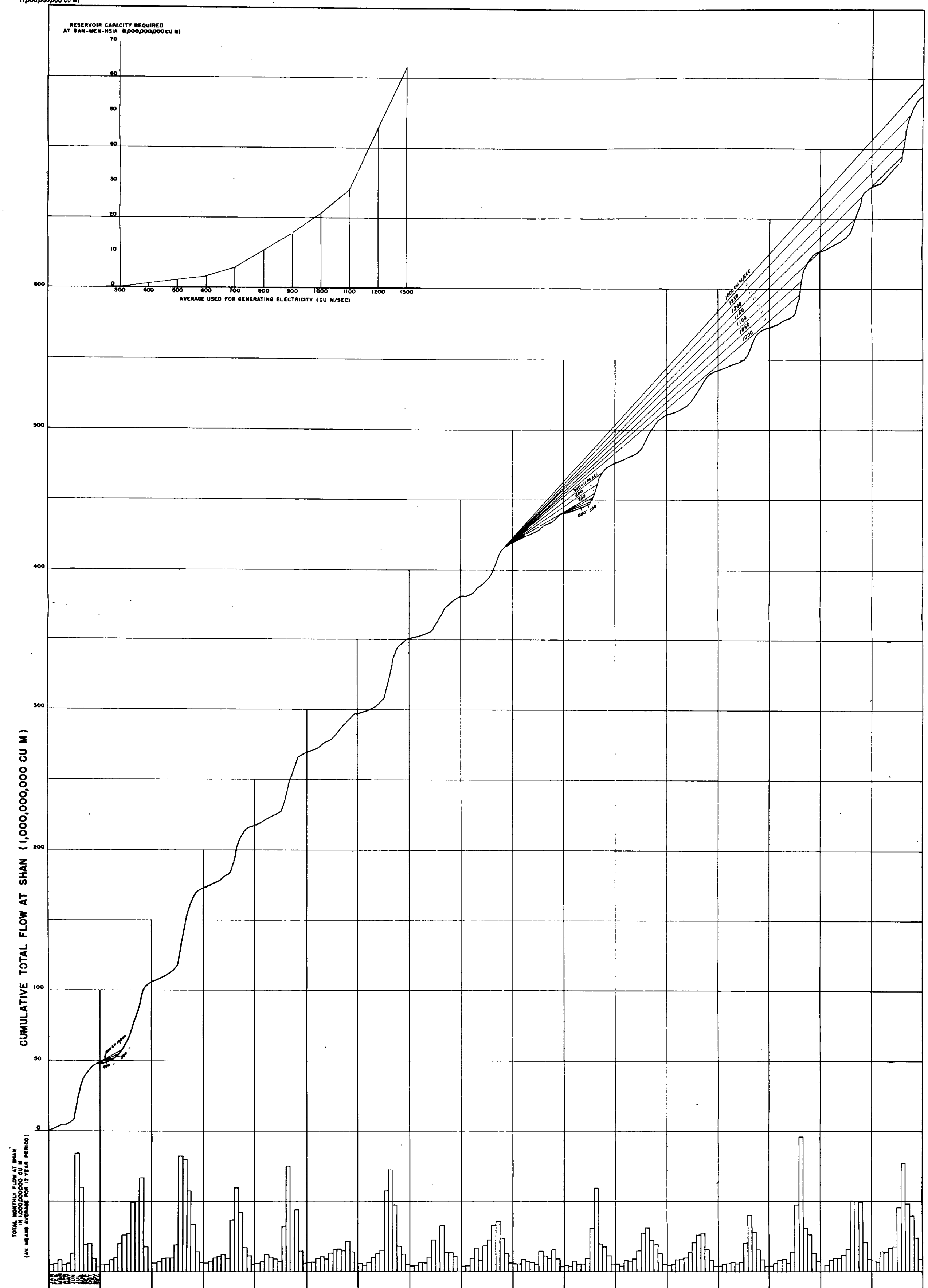
Capacity Required at the San-men Gorge to Equalize Flow from Year to Year

Average Volume of Usable Water (cu m/sec)	Capacity Required (cu m)
400	1,000,000,000
500	2,000,000,000
600	3,000,000,000
700	5,500,000,000
800	10,500,000,000
900	15,500,000,000
1,000	21,000,000,000
1,100	28,000,000,000
1,200	45,000,000,000
1,300	63,000,000,000

[Graph follows on next page]

RESTRICTED

FLOW AT SHAN: RESERVOIR CAPACITY REQUIRED PER VOLUME USED FOR GENERATING ELECTRICITY AT SAN-MEN-HSIA



RESTRICTED

100 A B

In the 1st phase of the plan, the San-men gorge reservoir will require an effective storage capacity for electric generation of 2,000,000,000 cubic meters (actually 1,770,000,000 cubic meters) to maintain the minimum flow of 650 cubic meters per second during the drought period of average years. The flow will drop to 500 cubic meters per second during dry years.

At the completion of the 2d phase, the effective storage capacity will be 28,500,000,000 cubic meters, of which 22,000,000,000 cubic meters will be available for generation of electricity. According to graph on the preceding page, the minimum average volume of usable water will be 1,000 cubic meters per second, to maintain 80 per cent of electric power output during dry years.

A capacity of 8,910,000,000 cubic meters will be required during an average year to equalize the flow between Pao-t'ou and Shan in coordination with the Ch'ing-shui-ho reservoir, as is shown in the table below. However, to equalize the flow from year to year and maintain a minimum average utilized flow of 600 cubic meters per second will require 22,500,000,000 cubic meters, as shown in the table on "Capacity Required at Ch'ing-shui-ho to Equalize Flow from Year to Year." When coordinated with the Ch'ing-shui-ho reservoir, there can be an almost complete flow equalization from year to year, with a minimum average usable flow of 1,200 cubic meters per second.

Flow Equalization Between Pao-t'ou and Shan (Average Year)

	Average Flow (cu m/sec)	Total Monthly Flow (1,000,000 cu m)	Average Volume of Usable Water (cu m/sec)	Monthly Excess or Deficiency (cu m/sec)	Monthly Excess or Deficiency (1,000,000 cu m)
Jan	246	658	705	(-) 459	(-) 1,229
Feb	344	833 /832/	705	(-) 361	(-) 868
Mar	463	1,240	705	(-) 242	(-) /sic/ 648
Apr	352	912	705	(-) 353	(-) 915
May	85	227	705	(-) 620	(-) 1,661
Jun	463	1,200	705	(-) 242	(-) 627
Jul	1,838	4,922	705	(+) 1,135 /1,133/	(+) 3,040
Aug	2,503	6,705 /6,704/	705	(+) 1,798	(+) /sic/ 4,816
Sep	978	2,534	705	(+) 273	(+) 708
Oct	810	2,170	705	(+) 105	(+) 281
Nov	69	178 /179/	705	(-) 636	(-) 1,649
Dec	214	572 /573/	705	(-) 491	(-) 1,315
Complete Year	705	22,150 /22,150/	705		(±) 8,910 /- 8,912/ /+ 8,845/

RESTRICTED

If the annual evaporation is 1,000 millimeters, this reservoir's high-water area of 2,240 square kilometers will lose 2,240,000,000 cubic meters annually through evaporation. Added to the evaporation loss of 2,300,000,000 at Ch'ing-shui-ho, this totals 4,540,000,000 cubic meters. This leaves available 38,460,000,000 cubic meters of water, or 1,250 cubic meters per second. If the average volume of usable water at San-men gorge is 1,250 cubic meters per second, the maximum amount of usable water at 60 per cent load factor will be 2,100 cubic meters.

During the 1st phase the maximum amount of usable water will thus be 3.3 times the minimum. The graph on the following pages show that an average usable flow of 955 cubic meters per second will be sufficient for generation of electricity, calculated to be on the safe side, at 60 per cent load factor even during the high-water period.

Later in the first phase, when the Ch'ing-shui-ho reservoir has equalized the annual flow at 600 cubic meters per second, the San-men gorge reservoir will be able to equalize the natural increase in flow between Pao-t'ou and Shan. The graph on the following pages show the results of these calculations. The annual average flow between Pao-t'ou and Shan is 705 cubic meters per second, with a November minimum of 69 cubic meters per second.

After silting, the effective capacity for electrical generation at the San-men gorge reservoir will be 650,000,000 cubic meters. Only 200 cubic meters per second of this will come from the drainage area between Pao-t'ou and Shan, making a flow of only 800 cubic meters per second at the San-men gorge. If a maximum of 60 per cent could be used during the high-water season, the annual average usable flow would be 995 cubic meters per second.

The graph on the following pages similarly shows the annual average usable flow after the 2d phase as 1,090 cubic meters per second. After completion at Ch'ing-shui-ho and the 2d phase at San-men gorge, this would reach 1,250 cubic meters per second.

The flow at Pa-li-hu-t'ung and Hsiao-hen-ti is almost equal to that at San-men gorge, but the planned canalling above Hsiao-hen-ti would reduce the usable flow there.

[Graph follows on next page]

VI Effective Head

A. Maximum Effective Head

There is a loss of maximum effective head of 1 meter between the high-water level and the discharge level when the hydroelectric plant is constructed directly below the dam, and of 1 meter for every 1,000 meters the canal is extended at Hu-k'ou.

Maximum Effective Head

Site	High-water Level (m)	Discharge Level (m)	Total Head (m)	Loss in Head (m)	Maximum Effective Head (m)	
1 Ch'ing-shui-ho	985	928	57	1	56	
2 Ho-ch'u	924	866	58	1	57	
3 T'ien-ch'iao	862	732	130	1	129	
4 Hei-yu-k'ou	728	663	65	1	64	
5 Chi-k'ou-chen	659	583	76	1	75	
6 Yen-shui-kuan	579	505	74	1	73	
7 Hu-k'ou	501	435	66	3	63	
8 Yu-men-k'ou	432	366	66	1	65	
9 San-men gorge (1st Phase)	325	282	43	1	36	Depth for flood control 6 meters
(2d Phase)	350	282	68	1	64	Depth for flood control 3 meters
10 Pa-li-hu-t'ung	275	167	108	1	107	
11 Hsiao-hen-ti	163	136	27	1	26	

B. Average Effective Head

The average water level in normal years will be two-thirds of the difference between the high-water level and the low-water level. The effective head of this water level is the average effective head.

Average Effective Head

Site	High Water Level (m)	Minimum Water Level (m)	Usable Water Depth (m)	Average Water Level (m)	Average Total Head (m)	Head Loss (m)	Average Effective Head (m)	
1 Ch'ing-shui-ho	985	970.0	15.0	980.0	52.0	1	52.0	[sic]
2 Ho-ch'u	924	922.5	1.5	923.5	57.5	1	56.5	
3 T'ien-ch'iao	862	856.0	6.0	860.0	128.0	1	127.0	
4 Hei-yu-k'ou	728	722.0	6.0	726.0	63.0	1	62.0	
5 Chi-k'ou-chen	659	653.0	6.0	657.0	74.0	1	73.0	
6 Yen-shui-kuan	579	577.0	6.0 [sic]	577.0	72.0	1	71.0	
7 Hu-k'ou	501	495.0	6.0	499.0	64.0	3	61.0	
8 Yu-men-k'ou	432	430.5	1.5	431.5	65.5	1	64.5	Plus 6 m depth for flood control
9 San-men gorge (1st Phase)	325	310.0	9.0 [sic]	316.0	34.0	1	33.0	
(2d Phase)	350	332.0	15.0 [sic]	342.0	60.0	1	59.0	Plus 3 m depth for flood control
10 Pa-li-hu-t'ung	275	273.5	1.5	273.5	107.5	1	106.5	
11 Hsiao-hen-ti	163	161.5	1.5	162.5	26.5	1	25.5	

VII Electric Power Output

A. Maximum Output

The following are estimates of the efficiency of a turbo-generators, based on the maximum output;

Turbine efficiency - 89.0%

Dynamo efficiency - 96.0%

Over-all efficiency - 85.3%

Site	Maximum Volume of Usable Water (cu m/sec)	Maximum Effective Head (m)	Maximum heoretical Power (1,000 kw)	Maximum Output (1,000 kw)
1 Ch'ing-shui-ho	1,000	56	549	468
2 Ho-ch'u	1,000	57	559	477
3 T'ien-ch'iao	1,030	129	1,303	1,111
4 Hei-yu-k'ou	1,060	64	665	567
5 Chi-k'ou-chen	1,120	75	823	702
6 Yen-shui-kuan	1,180	73	844	720
7 Hu-k'ou	1,230	63	759	647
8 Yu-men-k'ou	1,230	65	784	669
9 San-men gorge				
(1st Phase)	2,100	36	741	632
(2d Phase)	2,100	64	1,317	1,123
10 Pa-li-hu-t'ung	2,100	107	2,202	1,878
11 Hsiao-hen-ti				
(San-men gorge 1st Phase)	750	26	192	163
(San-men gorge 2d Phase)	1,050	26	267	229
Total				
(1st Phase)				8,034
(2d Phase)				8.591

B. Average Output

The average output was calculated on the assumption, for sites between Ch'ing-shui-ho and Yu-men-k'ou, that the Ch'ing-shui-ho reservoir be completed.

For sites below San-men gorge, it is assumed that, in the 1st phase, the Ch'ing-shui-ho reservoir be completed before San-men gorge reservoir becomes silted up.

After Completion at Ch'ing-shui-ho and 1st Phase of San-men gorge

In this instance, the minimum average volume of usable water at San-men gorge is 800 cubic meters per second; 500 cubic meters per second is canalled off above the Hsiao-hen-ti dam, leaving it a minimum average of 300 cubic meters per second.

Site	Average Volume of Usable Water (cu m/sec)	Average Effective Head (m)	Average Theoretical Power (1,000 kw)	Average Output (1,000 kw)	Annual Output (1,000,000 kw hr)	Annual Load Factor
1 Ch'ing-shui-ho	600	51.0	300	256	2,240	54.7
2 Ho-ch'u	600	56.5	332	283	2,480	59.4
3 T'ien-ch'iao	620	127.0	772	660	5,780	59.4
4 Hei-yu-k'ou	635	62.0	386	329	2,880	58.1
5 Chi-k'ou-chen	670	73.0	480	410	3,590	58.4
6 Yen-shui-kuan	705	71.0	490	418	3,660	58.1
7 Hu-k'ou	740	61.0	442	377	3,300	58.3
8 Yu-men-k'ou	740	64.5	467	398	3,480	59.5
(Subtotal)				(3,131)	(27,410) [sic]	
9 San-men gorge	995	33.0	322	274	2,400	43.3
10 Pa-li-hu-t'ung	995	106.5	1,039	886	7,850	47.2
11 Hsiao-hen-ti	400	25.5	100	85	750	44.2
Subtotal				(1,245)	(11,000)	
Total				4,376	38,410	

After Completion of Ch'ing-shui-ho and 2d Phase of San-men gorge

In this instance, the minimum average volume of water used at San-men gorge is 1,200 cubic meters per second, and 500 cubic meters per second is canalled off above the Hsiao-hen-ti dam.

Site	Average Volume of Usable Water (cu m/sec)	Average Effective Head (m)	Average Theoretical Power (1,000 kw)	Average Output (1,000 kw)	Annual Output (1,000,000 kw hr)	Annual Load Factor
Ch'ing-shui-ho to Yu-men-k'ou	Unaffected by status of the San-men gorge reservoir			3,131	27,410	
9 San-men gorge	1,250	59.0	723	617	5,410	54.*
10 Pa-li-hu-t'ung	1,250	106.0	1,300	1,110	9,740	59.*
11 Hsiao-hen-ti	750	25.5	187	159	1,390	69.4
(Subtotal)			(2,110) [sic]	(1,886)	(16,540)	
Total				5,077 [sic]	43,950	

(*) [Decimal is illegible]

If Lower River is Developed During 1st Phase of San-men gorge before Completion of Ch'ing-shui-ho

In this instance, the minimum average volume of usable water at San-men gorge is 650 cubic meters per second; 400 cubic meters per second is canalled off above the Hsiao-hen-ti dam, leaving a minimum average of 250 cubic meters per second.

Site	Average Volume of Usable Water (cu m/sec)	Average Effective Head (m)	Average Theoretical Power (1,000 kw)	Average Output (1,000 kw)	Annual Output (1,000,000 kw hr)	Annual Load Factor
9 San-men gorge	955	33.0	315	268	2,350	42.*
10 Pa-li-hu-t'ung	955	106.5	995	849	7,440	45.*
11 Hsiao-hen-ti	390	25.5	97	84	730	43.*
Total			1,407	1,201	10,520	

(*) [Decimal is illegible]

If Lower River is Developed During the 2d Phase of the San-men gorge Site Before Completion of Ch'ing-shui-ho

In this instance, the minimum average volume of usable water at San-men gorge is 1,000 cubic meters per second; 500 cubic meters per second is canalled off above Hsiao-hen-ti dam, leaving a minimum average of 500 cubic meters per second.

Site	Average Volume of Usable Water (cu m/sec)	Average Effective Head (m)	Average Theoretical Power (1,000 kw)	Average Output (1,000 kw)	Annual Output (1,000,000 kw)	Annual Load Factor
9 San-men gorge	1,090	59.0	631	539	4,720	47.8
10 Pa-li-hu-t'ung	1,090	106.5	1,138	970	8,500	51.4
11 Hsiao-hen-ti	590	25.5	147	125	1,190	54.6
Total			1,916	1,634	14,410	

VIII Silting of Reservoirs

A. Outline

As stated in Part 2, the silt content of the Yellow River averages two to three per cent and totals 900,000,000 to 1,100,000,000 cubic meters a year. Reservoir capacity would therefore be reduced very rapidly by silting. Consequently, the question of how long a reservoir can be kept effective must be considered.

It is obvious that silting will vary with the size of the reservoir and its manner of operation.

The reservoirs at Ch'ing-shui-ho and the San-men gorge in its 2d Phase are enormous compared to the total flow entering them in a year. If they equalize the flow from year to year, they will ordinarily absorb every flood, releasing the water only at the average flow. They will thereby precipitate most of the silt in the water. However, during the 1st Phase at San-men gorge the reservoirs there and downstream will control floods but permit over half the flow to continue past the dams, carrying part of its silt load with it.

The proportion of sediment which will settle and which will be carried downstream with the flood water will depend on the effective storage capacity of the reservoir, the magnitude of the flood, the total discharge flow and the manner in which the dam is operated. This matter is particularly important for the Yellow River, where over half the silt load is carried during floods.

Half of the annual silt is carried during a single summer month—30 to 40 per cent in a single flood. If as much as half of the silt carried by flood water is carried past the dams, the life of their reservoirs will be extended considerably.

Another important factor affecting silting of reservoirs is the way the water is released downstream—in other words, the way the dams are handled. Silting in a reservoir will eventually reach a final equilibrium which depends on the dam's construction. In an unadjustable overflow dam, the water will spill over the crest and lacking facilities to eliminate silt, this will eventually be deposited up to the crest until the rate of deposition equals the river's power to pick up sediment.

If the crest is of the adjustable overflow type with the floodgates opened completely during floods, sediment will eventually be deposited in a similar manner up to the bottoms of the floodgates. This sedimentation will gradually fill the back water area. The remaining capacity of such a dam will be that of the floodgates, which is a rather small capacity. In the swift Japanese rivers, however, it is equivalent, after silting in the reservoir reaches equilibrium, to the capacity of a dam half the height of the floodgates.

If a reservoir can accommodate practically all flood water during an ordinary year, almost all the silt will be dropped, but if most of the flood water is passed directly downstream sedimentation would be cut in half.

A reservoir with floodgate control will, no matter what the stage of sedimentation, never become completely filled with sediment, and at final equilibrium will still have considerable capacity. This remaining capacity will, judging from other cases, correspond to the capacity of a dam one-half to one-third the height of the floodgates.

B. <u>Silting at Ch'ing-shui-ho Reservoir</u>

The Ch'ing-shui-ho Reservoir allows 1,350,000,000 cubic meters of space for the 155,000,000 cubic meters of silt annually washed into it by the river. Its generative capacity would, therefore, be unaffected for 8.75 [sic] years, after which time continued silting would have some effect on generative capacity. However, 10,500,000,000 cubic meters storage capacity would be sufficient to maintain a minimum flow for electric generation of 500 cubic meters per second, with 10,150,000,000 cubic meters to absorb silting. It would take 65.5 years for the minimum average flow of usable water to fall from 600 to 500 cubic meters per second. Even if the effective storage capacity were to fall below 10,500,000,000 cubic meters, an effective flow of at least 600 cubic meters per second could be maintained seven months of the average year. The loss of output from this decreased flow is calculated as follows:

$$\frac{600 - 500}{600} \times \frac{5}{12} \times 100 = 6.92\%$$

Consequently, the annual average loss in generative capacity will not exceed 0.106 per cent. This increase in the amortization rate will produce so slight an increase in the basic cost of electricity that it may be ignored.

C. San-men Gorge, 1st Phase

The total capacity of the San-men gorge reservoir during the 1st Phase will be 6,000,000,000 cubic meters, of which 2,500,000,000 cubic meters behind the floodgates is for flood control. Of the remaining capacity, 2,000,000,000 cubic meters will be for generation of electricity and 1,500,000,000 for silting.

In this instance, the flood waters will merely be evened out, most of the water passing directly through the reservoir. Probably at least half the silt content during flood periods will be discharged with this water. Of the 1,050,000,000 cubic meters of silt carried into the San-men gorge reservoir each year, 840,000,000 cubic meters will be brought in during the July, August and September flood period, and only 210,000,000 cubic meters during the rest of the year. If half the silt content for the flood season and the total content for the rest of the year were to settle in the reservoir, silting would amount to 630,000,000 cubic meters a year, filling the sediment absorption capacity of the reservoir in three to four years.

During the 1st Phase, both banks of the still-water area between San-men gorge and T'ung-kuan will have a grade of approximately 10 per cent. It is believed that since the reservoir area will not be much greater than that of the present course of the river, silting may fill the bottom of the reservoir but little sediment will come from either bank. An adjustable overflow dam will consequently have considerable residual storage capacity above that at the crest of an unadjustable dam. Sediment is deposited in reservoirs at a gradient of 1/3,000 to 1/6,000, by swift Japanese rivers, but the loess in the Yellow River is very fine and has a very slight angle of stability in flowing water. Judging from the downstream alluvial plains and those between Ning-hsia and Pao-t'ou, the Yellow River reservoir gradient would become 1/8,000 to 1/10,000. Floodgates raising the water level 12 meters in the San-men gorge reservoir, would add 4,200,000,000 cubic meters to the effective storage capacity. Two-thirds of this, or approximately 3,000,000,000 cubic meters, would be permanent capacity.

Although reservoir silting below the permanent crest would be rapid, it would probably be slower above this point. If it is half as rapid, it would take about ten years to reach a state of sedimentation equilibrium during the 1st Phase at San-men gorge.

If the Ch'ing-shui-ho reservoir is built 10 years after completion of the San-men gorge dam, it will increase the average flow available for hydroelectric purposes there and aid flood control by reducing somewhat its flow of flood water.

Even if the Ch'ing-shui-ho reservoir is not completed, storage of the flood water of July, August and September and of any other surplus flow, together with the October surplus, will carry through the dry season of December, January, February and March. After the completion of Ch'ing-shui-ho, the storage volume at San-men gorge, even after the silting of the reservoir, will be replenished easily from the flow during May and November. The replenishment of storage volume can then be accomplished from the surplus of the rest of the year, excluding the three-month flood season, without jeopardizing flood control. Silting will thus present no serious problem in the generation of electricity.

D. San-men Gorge: 2d Phase

In this case the total storage capacity will be 40,000,000,000 cubic meters and the effective storage capacity 28,500,000,000 cubic meters, leaving 11,500,000,000 cubic meters for silting. The annual average silt load of 1,050,000,000 cubic meters would fill this surplus capacity in 11 years, after which it will gradually decrease the effective storage capacity. This loss must be prevented by construction of the Ch'ing-shui-ho reservoir within these 11 years.

However, the silt content of the Yellow River is so enormous that even this large capacity would be filled in a few decades and the reservoir would reach a state of sedimentation equilibrium. The terrain above Tung-kuan is quite different from that below. The river banks have gentle slopes, and a slight rise in the water level would inundate a very large area of flat land and lakes. It would have no effective storage capacity after complete sedimentation of the reservoir. The permanent effective storage capacity in equilibrium would not be much greater than that of Phase 1.

When equilibrium is reached, with a total deposition of 11,500,000,000 cubic meters of silt, continued silting of 630,000,000 cubic meters per year would, at a reduced effective storage capacity of 3,000,000,000 cubic meters, give the reservoir an additional life of 40 years, totaling 25,500,000,000 cubic meters of sedimentation in that time. The total life of the reservoir during the 2d Phase will thus be 50 years.

If just the San-men gorge dam were constructed, the average amount of usable water would decrease from 1,090 cubic meters per second to 955, a loss of 12.4 per cent in generative capacity or 0.25 per cent in annual output. This increase in amortization cannot be ignored, but will not greatly increase the basic cost of electricity.

With the heavy silt load of the Yellow River, even enormous reservoirs could have a life of only a few decades. There is no alternative but to make the reservoirs semi-permanent by soil conservation and forestation of the water sources.

A JAPANESE PLAN FOR HYDROELECTRIC DEVELOPMENT OF THE YELLOW RIVER IN CHINA

Far Eastern Research Section
Survey Committee No 2
North China Committee
Subcommittee No. 4
May 1941

PART 4 ECONOMIC FACTORS

OCHIAI Kushiro

TABLE OF CONTENTS

Approved For Release 1999/08/25 : CIA-RDP78-03109A000200010001-6

I. Introduction

This section deals with economic factors involved in the hydroelectric development of the Yellow River. The electric power plan is so great an undertaking that an over-all view of its economic aspects is very difficult in a short discussion. This section is principally concerned with estimates on essential materials and construction costs, and the basic cost of the electric power.

Water transportation between Pao-t'ou and Meng-ching has not been considered. In the future, extensive underground resources along the Yellow River may be developed along with the water power, and require large-scale transportation facilities. This will make water transportation very important, especially if the flow can be increased to permit the required boats to use the lower river during the low-water period.

If this now unimportant problem should, in the future, require solution, limited changes in this plan would satisfy it. There are two plans for the San-men Gorge site; the first, to raise the water level to a 350-meter elevation, and the second to have the maximum water level at a 325-meter elevation during its first phase. Later, in a second phase, it will be raised to the 350-meter mark with further engineering work. Plan No 1 and the second construction phase of Plan No 2 would have the same results.

II. Sequence of Development of Hydroelectric Power Plant Sites

There is no telling how long the development of the Yellow River water power sites will take, but it must be achieved as rapidly as possible because of the need to supply cheap and abundant electric power, along with developing the extensive Shansi coal belt, to establish a strong national defense.

From the standpoint of hydroelectric engineering, similar projects in other countries indicate that each site will require an average of five years for complete development. Work could be started on two sites in a single year. Since each dam will have to equalize the Yellow River flow throughout the year, all will require large reservoirs. It is, therefore, very important which site is developed first. The first site to be developed should be either at Ch'ing-shui-ho or at the San-men Gorge. The San-men Gorge site would be more effective, as flood control would require a construction railroad several .. kilometers in length, compared with over 100 kilometers for the Ch'ing-shui-ho site. In addition, it is near the source of demand for electric power. It should, therefore, be developed first. The second site to be developed should equalize the flow in the upper river, a condition met only by the Ch'ing-shui-ho site. The sequence for the other sites, as shown in the table on the following page, was determined on the basis of anticipated industrial demands.

Proposed Development of Yellow River Power Plants:
San-men Gorge Site Completed in One Continuous Construction Period

	Maximum Output (1000 kw)	1945 1950 1955 1960 1965 1970 1975	Adjacent Consuming Districts*	Distant Consuming Districts*
1. Ch'ing-shui-ho	468		Inner Mongolia, including Ta-t'ung and Northern Shansi	T'ien-ching
2. Ho-ch'u	477			Pei-p'ing
3. T'ien-ch'iao	1,111			
4. Hei-yu-k'cu	567		T'ai-yuan	Shih-men [sic]
5. Chi-k'ou-chen	702			
6. Yen-shui-kuan	720		Lin-fen	Hsi-an
7. Hu-k'ou	647			Hsin-hsiang
8. Yu-men-k'cu	669			
9. San-men Gorge	1,123		Hsin-hsiang	Chi-nan
10. Pa-li-hu-t'ung	1,878		Cheng-chou	Hsu-chou
11. Hsiac-hen-ti	229			Han-kou

* (TN: Compare with consuming districts in table in Part 1)

It must be decided whether to build the San-men Gorge dam to 350-meters elevation at once, or to stop at 325 meters and finish the dam to the maximum water level of 350 meters at a later date. In the first case, the reservoir will be large enough to absorb silting for several decades and could equalize the river's flow, while in the second case, during the first phase, the flow could not be equalized or the same power output maintained throughout the year. It would be impossible to send a regular flow downstream for irrigation and water transportation. The Ch'ing-shui-ho reservoir would have to be constructed immediately after completion of the San-men Gorge dam to maintain a regular flow throughout the year. This sequence is shown on the following chart.

(Table follows on next page)

Proposed Development of Yellow River Power Plants:
San-men Gorge Site Completed in Two Construction Phases

Sites	Maximum Output (1000 kw)	1945 1950 1955 1960 1965 1970 1975	Adjacent Consuming Districts	Distant Consuming Districts
1. Ch'ing-shui-ho	468		Ta-t'ung and Northern Shansi	T'ien-ching
2. Ho-ch'u	477			Pei-p'ing
3. T'ien-ch'iao	1,111			
4. Hei-yu-k'ou	567		T'ai-yuan	Shih-men [sic]
5. Chi-k'ou-chen	702			
6. Yen-shui-kuan	720		Lin-fen	Hsi-an
7. Hu-k'ou	647			Hsin-hsiang
8. Yu-men-k'ou	669			
9. San-men Gorge	1st Phase: 632 2d Phase: 1,123		Hsin-hsiang Cheng-chou	Chi-nan Hsu-chou Han-k'ou
10. Pa-li-hu-t'ung	1,878			
11. Hsiao-hen-ti	1st Phase: 163 2d Phase: 220			

The sequence for developing the other sites was based upon the probable demand for hydroelectric power. Chi-k'ou-chen was placed next, in view of the electric power demand expected from T'ai-yuan district in the development of Shansi. The development of the site farthest downstream was then planned, for irrigation and water transportation as well as flood control, in anticipation of the increased demand for electric power in the downstream area. It would be used to compensate for changes in the volume of water used at the upstream site by equalizing the flow farther downstream, and to supply water for irrigation and for the canals. It would have very little water for generation of electricity.

Since no detailed survey of the site has been made, this development may not materialize as planned. If feasible, it is both economical and reasonable to lead a canal from the Hsiao-hen-ti site to supply water for irrigation and canals. (This diversion canal would have sufficient fall.)

III. Basic Plan

The hydroelectric power plant sites are located in the 1000-kilometer stretch of the Yellow River between Pao-t'ou and Meng-ching. The special considerations which vary with locality complicated the calculation of the costs on a single hard and fast standard. General standards were therefore established from which the construction costs, etc., were calculated and then entered in general categories. This necessitated determination of a basic plan for construction methods and cost calculation. Since there is no limit to the elaborate computation of each item, these basic assumptions were made on the pattern of the large dam-type electric power plants in the United States, Manchuria and Korea.

A. All the dams are the concrete, gravity-overflow type. (It is assumed that the dam sites have suitable rock foundations.) The width of the river at each site is narrow for the flow, and flood water must be allowed to flow over the crest of the dam or through a by-pass tunnel to avoid overflowing the banks.* Detention reservoirs upstream should greatly decrease the volume of flood water. It may not be necessary to provide for passage of the maximum volume of flood water except at the San-men Gorge, but this should probably be done to gain the maximum fall.

A concrete gravity overflow dam would be the simplest suitable type. A rock-filled dam would require a discharge tunnel or other expensive facilities to handle the excess water, and the electric power plant would be further removed from the centerline of the dam. The cross-sections of the dams were drawn from the 1:500,000 aerial photograph maps. It was assumed for calculations that the height above the reservoir high-water level will be 2 to 3 meters; the depth from the mean river level to the foundation, 15 to 20 meters.

These figures are used in the following table.

* (TN: In a list of errata published subsequent to this document, this passage has been changed to read:
"The narrowness of the river is a peculiar characteristic. Special anti-flood precautions must therefore be taken.")

Dam Specifications

	Length of Crest (m)	Height above High-Water Level (m)	Depth from Mean River Level Foundation (m)	Total Height (m)	Concrete Required (1000 cu m)
1. Ch'ing-shui-ho	420	2	20*	80*	1,228
2. Ho-ch'u	325	2	15*	76*	827
3. T'ien-ch'iao	835	3	15	149	4,940
4. Hei-yu-k'ou	630	2	20	88	2,104
5. Chi-k'ou-chen	685	2	15	94	2,364
6. Yen-shui-kuan	585	2	20	97	2,141
7. Hu-k'ou	615	2	15	68	1,214
8. Yu-men-k'ou	460	2	20	89	1,531
9. San-men Gorge					
1st phase	395		15	61	685
2d phase	450	2	15	86	1,400
10. Pa-li-hu-t'ung	475	3	15	127	2,240
11. Hsiao-hen-ti	450	2	10*	40*	374

* (TN: Figures differ from those in table on preceding page.)

B. Electric Power Plants

Should the dam overflow, the narrowness of the river prevents placing the electric power plants parallel to the central axis of the dams. They must, therefore, be built on one or both sides of the river, below the dam and parallel to the river. The structures will be 40 meters wide and 20 meters long for each turbine. As a general rule, half the facilities will be set up on each bank. The unit generating capacity in round numbers will be 100,000 kilowatts per turbine.

Placing the electric power plants inside each dam and parallel to its axis for antiaircraft defense should be considered, as well as setting up strong antiaircraft defenses on both banks of the river. However, the present plan does not discuss these factors.

C. Conduits

Since the power plants are to be built parallel to the river, there must be outlets from the reservoir, with one conduit per turbine built in the river banks. The conduits will average 250 meters in length and will not require pressure-control tanks except at Hu-k'ou, where the conduits will average 3,000 meters.

D. Facilities for Discharging Excess Water

The Ch'ing-shui-ho site is not planned for regular flood control and will have as high a water level as possible. It will need facilities for directly discharging all flood water which reaches it, a total of 7,500 cubic meters per second, including the 5,000 cubic meters per second flood water at Pao-t'ou, plus that added below Pao-t'ou. The maximum possible flood at Hu-k'ou, calculated from the drainage area, is 15,000 cubic meters per second. The additional drainage area above San-men-hsia would make the maximum possible flood there 25,000 cubic meters per second. This figure can be reduced to 15,000 cubic meters per second by flood control in the reservoirs, reserving the upper portion to absorb floods.

The San-men Gorge site would then require facilities for direct discharge of only 15,000 cubic meters per second. The dams below the San-men Gorge will have this figure increased only by their additional drainage areas. It is difficult to know whether this additional flood water will occur at the same time as that from the San-men Gorge. If it should, the total flood volume at Pa-li-hu-t'ung and Hsiao-hen-ti would be only 20,000 cubic meters per second.

The table on the next page shows the concrete required for each dam, the planned flood volume, and the specifications for flood discharge gates.

(Table follows on next page)

Concrete Required and Number of Flood Gates on Each Dam

	Concrete Required (1000 cu m)	Planned Overflow (cu m/sec)	Height of Flood Gates (m)	Overflow Width (m)	No of Flood Gates
1. Ch'ing-shui-ho	1,228	7,500	10	120	15
2. Ho-ch'u	827	8,000	10	126	16
3. T'ien-ch'iao	4,940	8,500	10	135	17
4. Hei-yu-k'ou	2,104	9,500	10	150	19
5. Chi-k'ou-chen	2,364	11,000	10	175	21
6. Yen-shui-kuan	2,141	13,500	12	162	17
7. Hu-k'ou	1,214	14,500	12	174	17
8. Yu-men-k'ou	1,531	15,000	12	180	17
9. San-men Gorge (Phase 1 of Plan 2)	1,400 (685)	15,000	12	180	17
10. Pa-li-hu-t'ung	2,240	20,000	12	240	24
11. Hsiao-hen-ti	374	20,000	12	240	24

From Ch'ing-shui-ho to Chi-k'ou-chen, the flood gates will be 10 meters in height and width, while at Yen-shui-kuan and below they will be 12 meters in height and width. The number of gates is about 20 per cent more than the absolute minimum necessary. The required width of the overflow section will be the greatest - 240 meters - at Pa-li-hu-t'ung and Hsiao-hen-ti. The crest would also be able to accommodate the width of the causeway pillars.

E. Facilities for Water Transportation

Water transportation in the main channel of the Yellow River is not under consideration at present. Consequently, facilities are not being considered for elevators or locks. With the development of the Yellow River water power, and exploitation of the enormous coal and other resources along the river, a need will arise for water transportation. The maximum water level at each of the dams could then be raised slightly, to permit the backwater to reach the dam above and allow water transportation.

F. Facilities for Diverting Water for Irrigation and Canals

Since actual investigation was made at only one site, the other plans are purely theoretical and cannot be taken as definitive. It may be possible through irrigation to make arable the land of the Ordos Desert, but this plan considers water transportation and irrigation only in the downstream delta area. The dam farthest downstream is to be used to divert water into a separate canal for the North China area. Materials for this project have no bearing on hydroelectric power production and will not be discussed.

The diversion would reduce the volume of usable water. A suitable diversion canal, constructed after careful investigation, would probably eliminate this loss of generative power. (The fall of the diverted water would be sufficient.)

IV. Construction Materials

The acquisition of such construction material as iron, steel, cement, food, lumber, sand and gravel is a major problem. Cement, sand and gravel for the concrete are the most bulky, and the effect of their transportation on construction costs is very important.

Since actual investigations were made only at Ch'ing-shui-ho, it is not known where sand and gravel are available. Around Ch'ing-shui-ho and Hsia-ch'eng-wan there is no suitable sand, and the sand found along tributaries is too fine for concrete. What little gravel is found is not usable in its natural state. Sand and gravel must therefore be manufactured from local rock. Present knowledge of the local geology is also very limited. TAKATA, the engineer who surveyed the Ch'ing-shui-ho area in the 1940 investigation, found sandstone and limestone there. Other writers indicate that some granite is found at other sites. Sand and gravel can easily be produced from granite, and have been produced at many places in the United States from limestone.

All lumber and most food must be brought from elsewhere. The table on the next page shows the estimated amounts of the principal materials needed for the construction of each dam. This table is only a rough approximation but will serve our purpose. Specific assumptions are listed, but the calculations were largely based on actual figures from recently constructed large-capacity power plants.

(Table follows on next page)

RESTRICTED

MATERIALS NECESSARY FOR DEVELOPMENT OF YELLOW RIVER POWER PLANT SITES

Items		No 1 Ch'ing-shui-ho	No 2 Ho-ch'u	No 3 T'ien-ch'iao	No 4 Hei-yu-k'ou	No 5 Chi-k'ou-chen	No 6 Yen-shui-kuan	No 7 Hu-k'ou	No 8 Yu-men-k'ou	No 9 San-men-gorge	No 10 Pa-li-hu-t'ung	No 11 Hsiao-hen-ti	TOTAL	Specific Assumptions for these Calculations
Iron	(metric tons)	62,760	46,620	124,460	83,560	/88,320/ 88,220	85,290	77,080	75,530	100,380 (9,600)*	166,590	27,650	/938,140/ 938,190	
Permanent Engineering Installations	"	15,560	15,370	56,260	29,910 /20,910/	26,770	27,140	32,200	23,870	36,180	65,590	9,550	/338,400/ 338,440	
Iron Reinforcement Rods for Dams	"	1,770	1,180	7,120	3,020	3,400	3,080	1,750	2,200	2,000	3,220	540	/29,280/ 58,560	149 kg per cu m of concrete
Penstock	"	6,110	6,110	33,100	8,250	12,240	12,240	19,000	9,650	16,800	36,700	1,840	/162,040/ 152,040	All 5 m in diameter and of same thickness to withstand maximum pressure. Includes tunnel reinforcement rods.
Power Plant	"	3,000	3,000	7,200	3,600	4,200	4,800	4,200	4,200	7,200	11,400	1,800	54,600	600 tons per turbine
Wire	"	420	430	990	510	630	640	580	600	1,000	1,670	210	7,680	0.89 ton per kw of maximum output
Outdoor Installations	"	210	220	500	260	320	330	290	300	500	840	100	3,870	0.45 ton per kw of maximum output
Flood Gates	"	1,800	1,800	1,860	1,910	2,100	2,120	2,210	2,210	3,800	3,800	1,900	/25,510/ 25,420	1.8 tons per cu m of utilizable water
Overflow Gates	"	900	1,280	1,360	1,620	1,680	1,700	1,800	1,700	1,700	2,400	2,400	18,540	Calculated from volume of overflow
Temporary Reinforcement Rods	"	610	620	1,450	740	920	940	840	1,870 (*2)	1,460	2,440	300	12,190	1.3 tons per kw of maximum output
Other Uses	"	740	730	2,680	1,000	1,280	1,290	1,530	1,140 (*3)	1,720	3,120	460	15,690	5% of above 8 items
Turbo-Generator, Type I	"	16,000	16,000	38,400	19,200	22,400	25,600	22,400	22,400	38,400	60,800	9,600 (*4)	291,200	3,200 tons per 100,000 kw basic capacity (including primary transformer)
Temporary Engineering Installations	"	31,200	15,250	29,800	34,450	39,150	32,550	22,480	29,260	25,800 (9,600)*	40,200	8,500	308,640	
Work Railroad	"	22,200	6,850	10,200	24,450	26,050	19,800	11,000	17,400	5,400 (9,600)*	7,000	4,450	154,800	
Rails, etc	"	13,200	4,400	6,600	16,500	17,600	13,200	7,150	11,550	1,650 (6,600)*	4,400	2,750	99,000	110 tons per km (50-kg rails; width between rails 4' 8½")
Bridges, Stations, etc	"	6,000	2,000	3,000	7,500	8,000	6,000	3,250	5,250	750 (3,000)*	2,000	1,250	45,000	50 metric tons per km
Locomotives	"	1,500	150	300	150	150	300	300	300	1,500	300	150	5,100	150 tons per locomotive
Freight Cars	"	1,500	300	300	300	300	300	300	300	1,500	300	300	5,700	15 tons per freight car
Motive Power Installations	"	700				700				700			2,100	700 tons per steam-electric power plant with 7,000-kw maximum output
Principle Machinery	"	8,300	8,400	19,600	10,000	12,400	12,750	11,480	11,860	19,700	33,200	4,050	151,740	17.7 tons per 1,000-kw of maximum output (includes repair equipment)
Cement	"	380,000	260,000	1,500,000	640,000	720,000	660,000	650,000 (*1)	470,000	440,000	710,000	120,000	6,550,000	250 kg per cu m of concrete plus 20% excess allowance
Lumber	(cubic meters)	42,000	43,000	100,000	51,000	63,000	65,000	58,000	60,000	100,000	170,000	20,000	772,000	Approximately 0,09 cu m of unfinished lumber per kw of maximum output
Copper	(metric tons)	1,250	1,250	3,000	1,500	1,750	2,000	1,750	1,750	3,000	4,750	750	22,750	250 tons per generator or primary transformer (includes dam use)

* (Figures in parenthesis are for the re-routed railway line between San-men-gorge and Yun-ch'eng)

(TN: Most figures in this chart have an error within 5% according to the tables on pages

The following figures have an error exceeding 5%:

(*1) Should be 373,500
(*2) " " 870
(*3) " " 1,060
(*4) " " 7,330

RESTRICTED

25 94895

121AB

Notes on Preceding Table

1. The amount of iron for the dam was calculated from the concrete required and the volume of flood water.

2. Intake facilities and penstocks were calculated from the intake volume and the head, with the assumption that water would move directly from the reservoirs through penstocks to the power plants, except at Hu-k'ou. The penstocks will all be placed inside tunnels, with a clearance between the penstocks and the inside of the tunnels.

3. Railways will be discussed in detail later, but excluding bridges, etc., 110 metric tons per kilometer was estimated for the tracks. This is much more than that used on the Ta-t'ung to Feng-ling-tu railroad line. In some cases half this amount may suffice. Large numbers of locomotives and freight cars must be provided for the first construction site, but subsequent ones will need considerably less. This method is not necessarily the best. It might be better to assign a set number of the total to each site.

4. Steam-electric power generators for construction work may be treated similarly.

5. Cement factories will remain long after the construction work is finished, and if sufficient cement can be supplied in North China, this will involve no loss. This problem is not settled at present. Nevertheless, the factories will not be included in the cost of materials, except for some depreciation added to the construction cost. The cost could also be included in the unit price of the cement. The procedure will be the same in the case of steel mills.

6. It is difficult to calculate temporary construction facilities. Since there is no time for detailed study at present, it was calculated on the basis of the experience on the Yalu River. The actual costs will depend to a great extent upon the peculiarities of the site, the cement requirements, etc., and may not correspond precisely to calculations, but they will probably agree with them in general. It must be remembered that at San-men Gorge, where the first work will be done, all the equipment must be newly acquired. However, it can be moved to each succeeding site, with replacement only of that which has been worn out. The other sites will consequently require less new material. Nevertheless, the above table is calculated on the assumption that all facilities at each site will be new.

7. The amount of iron and copper for turbine-generators was calculated from the facilities installed for the flow of the Yalu River. It must be born in mind that the generators are treated as 100,000-kilowatt units, and fractions of the calculated power output are omitted.

8. Lumber requirements were based on those on the Yalu and Sungari Rivers, in proportion to the power output.

An average of 0.11 metric ton of iron is required per kilowatt of output (including turbines and generators), as shown in the following table. This figure is rather high, because it includes the large amount of iron needed for construction railroads, but it is considerably less than the amount used in power plants in Japan. Concrete requirements per kilowatt average 2.5 cubic meters, and vary between 1.3 and 4.5 cubic meters. Requirements at San-men Gorge and below are markedly less than for the other sites because the volume of water is twice that at the other sites, almost doubling the output, while the cross section of the river is practically the same.

Iron Required per Kilowatt of Output

		Maximum Output (1,000 kw)	Total Iron Required (metric tons)	Iron Required per Kilowatt Output (metric tons)	Concrete Required per Kilowatt (cu m)
1.	Ch'ing-shui-ho	468	63,000	0.11 [0.13]	2.7
2.	Ho-ch'u	477	47,000	0.10	1.8
3.	T'ien-ch'iao	1,111	124,000	0.11	4.5
4.	Hei-yu-k'ou	567	84,000	0.15	3.7
5.	Chi-k'ou-chen	702	88,000	0.12	3.4
6.	Yen-shui-kuan	720	85,000	0.12	3.0
7.	Hu-k'ou	647	77,000	0.12	3.3 [2.7]*
8.	Yu-men-k'ou	669	76,000	0.11	2.4
9.	San-men Gorge	1,123	100,000	0.07 [0.09]	1.3
10.	Pa-li-hu-t'ung	1,878	167,000	0.09	1.4 [1.2]
11.	Hsiao-hen-ti (including diversion dam for irrigation)	229	28,000	0.12	1.7
	Total	8,591	939,000	(Average) 0.11	(Average) 2.5

* (TN: See correction for total concrete on following page.)

A comparison of the maximum output, total concrete used and concrete per kilowatt of output of the world's principal dams is given in the table on the following page.

Concrete Used in Typical Dams in Manchuria, the United States and Japan

Dams	Maximum Output (kw)	Concrete Used (cu m)	Concrete per Kilowatt (cu m)
Suiho Dam on Yalu River	700,000	3,200,000,000	4.57
Ta-feng-men Dam on Sungari River	600,000	1,990,000,000	3.32
Boulder Dam	1,370,000	2,450,000,000*	1.79
Grand Coulee Dam	1,840,000	8,550,000,000*	4.65
Dam on Sho River (Komaki)	72,000	300,000,000	4.16
Dam on Sho River (Koyama)	47,000	143,000	4.04 [3.04]

* (TN: See Journal of Chinese and American Engineers, Vol 19, No 6, p 325.)

The preceding table shows that the water power sites on the Yellow River are as good as typical dam-type electric power sites if not superior to them. The concrete required per kilowatt varies with the load factor, but the minimum is 1.3 cubic meters at San-men Gorge and the average of 2.5 cubic meters is much less than that on the Yalu or Sungari Rivers. This is the main cause for the low construction cost even at isolated sites.

V. Construction Methods

A. Transportation of Construction Material

Several different methods of transportation could be adopted. The method should be adapted to the peculiarities of each site but, as explained above, apportioning the transportation to each site offers no advantage at present and would be complicated. Railway transportation was therefore adopted for all sites. Water and road transportation are of definite importance, and at some sites may be more useful than rail, but they are not as dependable or as satisfactory for the safety and control of the laborers.

Branch lines from the Ta-t'ung - Fen-ling-tu railroad line will supply Yu-men-k'ou and the sites above that point, while branches from the Lung-hai line will supply three downstream sites. Lack of any dependable maps of the railroad routes necessitated a rough calculation of the distances. A section of the Ta-t'ung - Feng-ling-tu line is narrow gauge and cannot carry much freight. This would make standard gauge heavy-rail branch lines pointless. However, in view of the plan, which will certainly materialize, to improve the main line in the near future, this heavy construction has been adopted. As pointed out in the preceding chapter, it may not be necessary to use 50-kilogram rails. In some cases rails of half this weight may be used. The following table shows the freight capacity, size of rails, and plans for improvement of the Ta-t'ung - Feng-ling-tu line.

Freight Capacity of the Ta-t'ung - Feng-ling-tu Railroad Line
(Track Improvement Expected About 1951)

Section	Present Freight Capacity (1,000 metric tons per year)	Present No of Rails (kg/m)	Freight Capacity after Improvement of Tracks (1,000 metric tons per year)
Yu-tz'u to T'ai-ku	ascent-1,510 descent-1,840	43 43	2,980
T'ai-ku to Lin-fen	ascent- 770 descent- 880	15.9	1,840
Lin-fen to Yun-ch'eng	ascent- 530 descent- 600	15.9	2,000
Yun-ch'eng to P'u-chou	ascent- 740 descent- 840	15.9	2,000
Ta-t'ung to Shuo	660	15.9	ascent- 950 descent- 950
Shuo to Ning-wu	780	15.9	ascent-1,070 descent- 950
Ning-wu to Yuan-p'ing-chen	133	15.9	230
Yuan-p'ing-chen to T'ai-yuan	432	15.9	560

The freight capacity is now sufficient for the construction of dam at a single site such as San-men Gorge. The planned railway routes are shown on the map on page following chart. These may not be the best routes and may not even be feasible.

The construction costs of the proposed railroads are shown in the following chart. The cost per kilometer varies with the terrain and is between 200,000 and 400,000 Yen.

RESTRICTED

CONSTRUCTION COSTS OF PROPOSED RAILROADS FOR THE DEVELOPMENT OF YELLOW RIVER SITES

Dam	Exact Location of Site	Construction Railroad	Extension (km)	Estimated Cost per Kilometer of Extensions* 200,000 ¥ per km	300,000 ¥ per km	400,000 ¥ per km	Estimated Total Cost (1,000 Yen)	Sequence of Construction
1. Ch'ing-shui-ho	6 km above Hsia-ch'eng-wan, Suiyuan	Branch from Ta-t'ung - Feng-ling-tu line at Shuo	120	30 km	-	90 km	42,000	2
2 Ho-ch'u	17 km above Ho-ch'u, Ho-ch'u District, Shansi	Branch from above line	40	-	-	40 km	16,000	4
3. T'ien-ch'iao	3 km below T'ien-ch'iao, Pao-te District, Shansi	Extension of above line from Ho-ch'u	60	-	-	60 km	24,000	7
4. Hei-yu-k'ou	20 km below Hei-yu-k'ou, Hsing District, Shansi	Extension from Chi-k'ou-chen	150	-	-	150 km	60,000	9
5. Chi-k'ou-chen	2 km below Chi-k'ou-chen, Lin District, Shansi	Branch from Ta-t'ung - Feng-ling ling-tu line at Fen-yang	160	-	-	160 km	64,000	3
6. Yen-shui-kuan	21 km above Yung-ho-kuan, Yung-ho District, Shansi	Extension from Fen-yang - Hu-k'ou line	120	-	-	120 km	48,000	9
7. Hu-k'ou	Lung-wang, Chi District, Shansi	Extension from Yu-men-k'ou line	65	-	-	65 km	26,000	8
8. Yu-men-k'ou	5 km above Yu-men-k'ou, Ho-ching District, Shansi	Branch from Ta-t'ung - Feng-ling-tu line near Wen-hsi	105	85 km	-	20 km	25,000	8
9. San-men-gorge	25 km below Shan, Honan	Branch from Lung-hai line at Hui-hsing-chen	15	-	15 km	-	4,500	1
10. Pa-li-hu-t'ung	30 km below Yuan-ch'u, Shansi	Branch from Lung-hai line at Hsin-an	40	-	40 km	-	12,000	7
11. Hsiao-hen-ti	28 km above Meng-ching, Honan	Branch from Lung-hai at I-ching-pu	25	-	25 km	-	7,500	5
Connecting line between San-men-gorge and Yun-cheng			60	60	-	-	12,000	
New Section of Lung-Hai Line to Replace That Flooded by San-men-gorge Reservoir			100	100	-	-	20,000	
TOTAL			2,500	275	80	705	361,000	
Ch'ing-shui-ho		Branch from Pei p'ing - Suiyuan Line at Pi-k'o-ch'i	130	105	-	25	31,000	

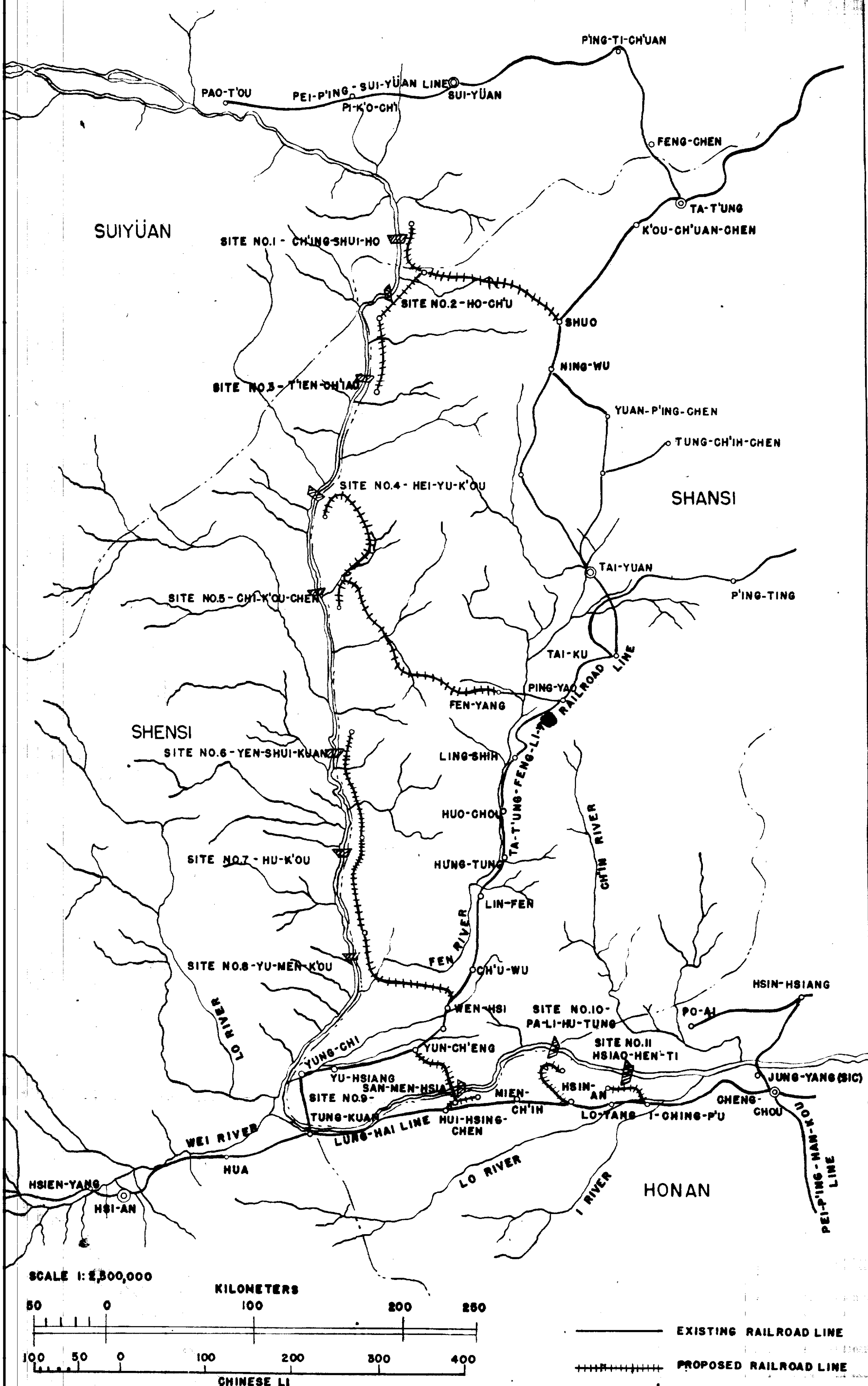
*(TN: Costs per kilometer vary with terrain.)

RESTRICTED

25 94896

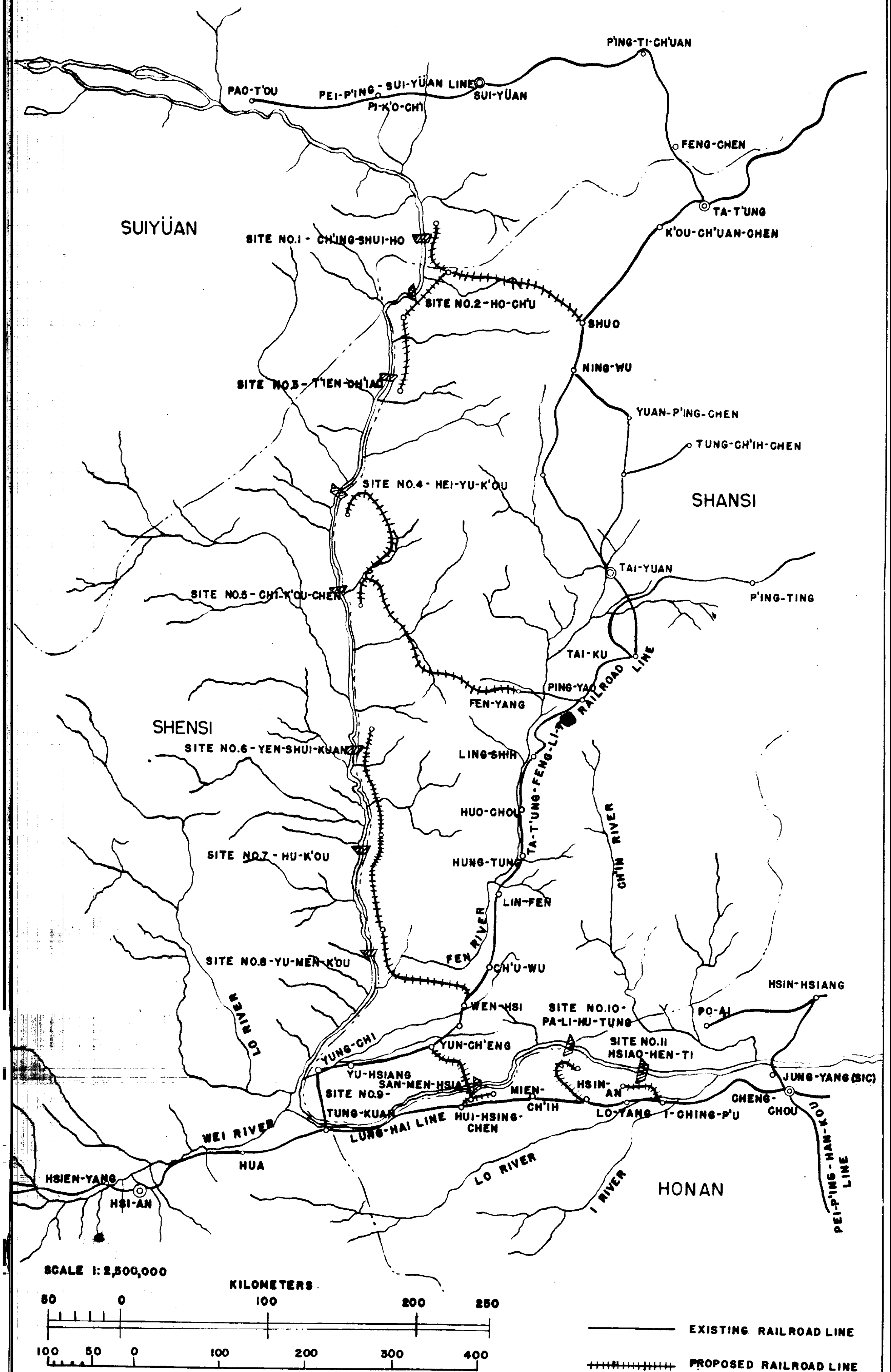
Approved For Release 1999/08/25 : CIA-RDP78-03109A000200010001-6

TRANSPORT RAILROAD LINES PROPOSED FOR YELLOW RIVER DEVELOPMENT



175 A C

TRANSPORT RAILROAD LINES PROPOSED FOR YELLOW RIVER DEVELOPMENT



The Yellow River has unusually fine sites for dam construction but, unfortunately, very poor communications except in the lower section. The construction of railroads will clearly take a large portion of the material and capital necessary for the development of these sites. This problem will require careful study. Although it is unorthodox to include these railroad construction costs in with the cost of developing the sites, it has been done here to give a general idea of costs.

B. Temporary Diversion of River

Temporary diversion of the river for dam construction demands individual consideration for each site. However, a theoretical discussion will serve as a basis for estimating construction costs. Since the Yellow River at the prospective water power sites is narrow in proportion to flood water and average flow, it cannot easily be decided whether to attempt to limit the flow to the center of the channel, as was done on the Sungari River and at the Sui-ho Dam on the Yalu River. If this proves unfeasible, the flow must temporarily be diverted around the sites, as was done at Boulder Dam. This latter method is very expensive. The flow could certainly be restricted to the middle half of the 250 to 300 meter width of the Yellow River at water level. At particularly difficult sites, a wider site could be selected. At present, the river depth or the nature of the bedrock is not definitely known, but the report assumes that the diversion method used at the Sui-ho Dam on the Yalu River is feasible.

C. Cement Factories and Iron Foundries

Development of the water-power of the Yellow River, requires a tremendous amount of cement, iron, lumber and other materials. It would be uneconomical to transport any of them from great distances. Lumber cannot be produced quickly, but cement, which is required in very great quantity, should be manufactured near the place where it will be used. Materials needed for the manufacture of cement are found in abundance throughout Shansi.

Coal, lime and gypsum deposits are practically inexhaustible. Cement factories producing approximately 150,000 metric tons per year can be established at Ta-t'ung, Tai-yuan and Lin-fen to supply the sites nearest to them. Another factory should be built along the Lung-hai railroad line for the sites at San-men Gorge and below. The needed raw materials are available in abundance along this line.

In view of the plan to establish large iron foundries, ordinary iron materials, excluding machinery, should be supplied in North China. Importing all the material from abroad would be very difficult and needlessly expensive. Since iron reinforcement rods and structural steel for building dams do not require much material, large iron foundries are not needed. Enough steel could be supplied by native methods. After the completion of the Yellow River development, the foundries could be employed for other uses to contribute to the expansion of productive power of the region. The cost of iron foundries is not included in the present construction cost estimate.

If iron foundries are established, iron will then be available much more cheaply.

VI. Estimated Construction Cost

No survey has been made of an actual dam site except at Ch'ing-shui-ho. It is almost impossible, therefore, to make an accurate estimate of the construction costs from the planned construction method, but since the sites are exceptionally favored, it is believed useful to consider the amount of capital and material necessary for their developmemt. The calculation of construction cost is based upon the preceding assumptions for material estimates and construction method. The following are the basic assumptions:

A. Re-routing the Railroad Line

This will be required when the San-men Gorge dam raises the water level to 350 meters above sea level. Building the construction railroad from the Lung-hai Line through San-men Gorge may eliminate the necessity of moving part of the Lung-hai line. However, the cost has nevertheless been calculated at 200,000 yen per kilometer.

B. Compensation for Flooded Land

The Ch'ing-shui-ho and San-men Gorge reservoirs will have the largest areas. All the other reservoirs will be much smaller. Compensation is estimated at 20,000 to 30,000 yen per square kilometer, or 12 to 18 yen per MOU /735.5 square yards/. The exact figure will depend on the quality of the land, the cost of moving houses, etc. (Ch'ing-shui-ho and San-men Gorge will cost 30,000 yen per square kilometer, the other sites 20,000.)

C. Cost of Diversion

The diversion of the river at Ch'ing-shui-ho and the San-men Gorge will be difficult, but regulation of the discharge from these dams will greatly simplify the problem at the other sites. It will take considerable study to decide the best method of diversion at these first two sites. Assuming that it can be done as suggested above, by restricting the river to the middle of its bed, it will cost 8 million yen for each site. The other sites will cost 5 million yen each.

D. Cost of Electric Works

Up to now, installations to generate electricity in the large quantities needed here have cost 50 yen or less per kilowatt, but the present inflation makes the estimate 100 yen.

E. Cost of Temporary Installations

It is difficult to estimate the cost of temporary installations. The construction railroad was estimated to cost 20,000 to 40,000 yen per kilometer depending on the terrain, with the entire cost to be charged to the water power sites. But the railroad between San-men Gorge and Yun-ch'eng was considered to require movement of the southern section of the Ta-t'ung Feng-ling-tu line. Since this railroad could be used to transport material to other sites as they are developed, the cost was distributed equally to Sites 3, 4, 6, 7, 8 and 9. There are various views on the allotment of railroad construction costs, but it was decided to follow the above plan and assign to each site the costs of any other lines directly required for its construction.

Steam-electric power plants for motive power will be established only at the first site developed. The other sites will receive electricity from the hydro-electric power plants already in operation. The steam-electric power plants for the one site will cost 500 yen per kilowatt for construction, operation and amortization. The cost of motive power is higher at sites not using steam-electric power plants. For each site, the total cost, including operation and depreciation, of a cement factory with an annual production of 150,000 metric tons, is 3 million yen. The cost of the new machinery, including amortization, operation and maintenance costs is estimated at about 50 per cent of the total cost at each site. These are only general estimates.

F. Interest on the Cost of Construction

Although there is some disagreement, a rate of 6 per cent compound interest per year was adopted, on the assumption that most of the capital will be used within four years regardless of the construction period. These calculations are shown in the table on the next page.

RESTRICTED

RESTRICTED

CONSTRUCTION COSTS OF YELLOW RIVER POWER PLANTS (IN 1,000 YEN)

	No 1 Ch'ing-shui-ho	No 2 Ho-ch'u	No 3 T'ien-ch'iao	No 4 Hei-yu-k'ou	No 5 Chi-k'ou-chen	No 6 Yen-shui-kuan	No 7 Hu-k'ou	No 8 Yu-men-k'ou	No 9 San-men-gorge	No 10 Pa-li-hu-t'ung	No 11 Hsiao-hen-ti	TOTAL	Percentage	If San-men-gorge is constructed in two phases San-men-gorge 1st Phase	San-men-gorge 2d Phase	Hsiao-hen-ti 1st Phase	Hsiao-hen-ti 2d Phase	Summary
Total Construction Cost	316,000	174,900	520,870	300,990	334,620	330,280	407,130	253,870	442,130	528,100	102,780	3,711,680 [3,711,670]		281,070	212,910	84,460	34,260	When construction is divided into two phases: San-men-gorge total cost 493,980,000 ¥ (44,310,000 ¥ more than one-phase construction); Hsiao-hen-ti total cost 118,720,000 ¥ (15,940,000 ¥ more than one-phase construction)
Compensation for land, etc	69,000	640	4,030	3,800	2,450	3,750	3,310	2,750	89,340	1,920	570	181,560	5	5,400	83,940	570		
Rerouting of railroad lines			2,000	2,000		2,000	2,000	2,000	22,000			32,000			22,000			200,000 per km. 20,000,000 ¥ to charge 100 km of Tung-hai line, charged to site No 9; 12,000,000 ¥ for 60 km of San-men-hsia to Yung-cheng line, charged in equal parts to sites No 3, 4, 6, 7, 8 and 9
Compensation for inundated land	69,000	640	2,030	1,800	2,450	1,750	1,310	750	67,340	1,920	570	149,560		5,400	61,940	570		20,000 to 30,000 yen per sq km depending on the nature of the soil
Engineering cost	61,290	48,390	195,980	83,760	92,410	94,210	170,560	74,590	96,700	154,810	31,110	1,103,810	30	56,510	50,340	28,270	12,630	
Dam	42,810	29,910	126,430	60,590	65,780	62,180	40,390	47,550	49,670	66,620	21,310	613,240		33,060	23,210	20,750	9,000	
Excavation	2,560	1,480	7,040	3,600	2,760	3,800	2,280	2,600	2,400	2,960	1,280	32,760		1,600	800	1,280		4 yen per cu m (allowing 25% more than actual volume)
Concrete	24,560	16,540	98,800	42,080	47,280	42,820	24,280	30,620	28,000	44,860	7,480	407,260		13,700	15,000	7,480		20 yen per cu m
Diversion of Water	8,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	8,000	5,000	5,000	61,000		8,000	2,000	5,000		
Overflow Gates	2,800 (*1)	1,920	2,040	2,280	2,530	2,550	2,700 (*2)	2,550	2,550	3,600	3,600	28,110 [29,110]		2,550	2,550	3,600		1,500 yen per ton 10m x 10m = 80 tons 12m x 12m = 100 tons
Intake Gates	2,000	2,000	2,060	2,120	2,240	2,360	2,460	2,460	4,200	4,200	2,010	28,110		4,200	1,840	1,500	9,000	2,000 yen per cu m/sec of maximum water volume used to generate electricity
Others	3,890 [3,992]*	2,970 [2,700]*	11,490	5,510	5,980	5,650	3,670	4,320	4,520	6,060	1,940	56,000		3,010	2,020	1,890		10% of total cost of above five items
Canal	18,480	18,480	69,550	23,170	26,630	32,030	130,170	27,040	47,030	88,190	9,800	490,570		23,450	27,130	7,520	3,630	
Intake	2,400	2,400	2,470	2,540	2,690	2,830	2,950	2,950	5,040	5,040	2,520	33,830		5,040	1,010	2,520	1,220	Total cost of intake installations, minus above intake gates: 2,400 yen per cu m/sec of maximum water used
Tunnel Excavation	1,730	1,730	4,140	2,070	2,420	2,760	48,000	2,420	4,140	7,860	1,040	78,310		2,420	1,720	690	350	30 yen per cu m
Concrete for Tunnel	1,180	1,180	2,840	1,420	1,660	1,890	6,300 25,520	1,660	2,840	5,400	710	52,600		1,660	1,180	470	240	45 yen per cu m
Penstock	9,160	9,160	49,700	12,400	14,500 (*3)	18,400	28,920	14,500	25,200	55,000	2,760	239,700		8,280	16,920	1,840	920	Diameter 5 meters. 1,500 yen per ton (includes reinforcement rods thick enough to withstand maximum pressure)
Water Flow Regulating Tank							3,600					3,600						
Power Plant Excavation	580	580	1,250	670	770	860	770	770	1,250	1,920	380	9,800		770	480	270	110	8 yen per cu m
Reinforcement Methods, Concrete, etc	750	750	1,800	900	1,050	1,200	1,050	1,050	1,800	2,850	450	13,650		1,050	750	300	160 [sic]	150,000 yen per generator
Drain	1,000	1,000	1,030	1,060	1,120*	1,180	1,230	1,230	2,100	2,100	1,050	14,100		2,100	1,000	750	300	1,000 yen per cu m/sec of maximum water used
Others	1,680	1,680	6,320	2,110	2,420	2,910	11,830	2,460	4,660 [4,240]	8,620	890	44,980		2,130	2,470	680	330	10% of total cost of above eight items
Electrical Construction Costs	50,000	50,000	120,000	60,000	70,000	80,000	70,000	70,000	120,000	190,000	30,000	910,000	24	120,000	24,000	20,000	10,000	100 yen per kw (includes all miscellaneous costs)
Temporary Installation Costs	83,280	44,500	98,690	99,240	109,630	92,380	81,470	60,190	60,980	85,100	22,190	837,650	23	52,160	17,730	19,620	4,950	
Cost of Construction Railroad	42,000	16,000	24,000	60,000	64,000	48,000	26,000	25,000	4,500	12,000	7,500	329,000		4,500		7,500		200,000 to 400,000 yen per km depending on terrain
Locomotives and Freight Cars	10,000	6,000	2,000	1,500	1,500	2,000	2,600	2,000	10,000	2,000	1,500	40,500		10,000	2,000	1,500	500	Allotment of purchase price
Steam-Electric Plant	3,500				3,500				3,500			10,500		3,500				Calculated according to time of commencement of construction, motive power required, and transportation facilities
Cement Factory	2,510	1,710	10,000	4,270	4,800	4,370	4,330	3,140	2,930	4,720	780	43,560		1,440	1,490	620	160	Factory to produce 150,000 tons per year; 2 yen per cu m of concrete for amortization of basic cost
Other Machines	11,130	9,840	31,600	14,380	16,240	17,420	24,560 [24,056]*	14,460	21,670	34,490	6,110	301,900		17,650	7,430	4,830	2,260	10% of electrical and engineering cost for amortization, repair and operation of machinery, excluding those listed above
Temporary Buildings	5,570	4,920	15,800	7,190	8,120	8,710	12,280 [12,028]*	7,230	10,840	17,250	3,060	100,970		8,830	3,720	2,420	1,130	3% of electrical and engineering costs
Motive Power	1,000	1,980	* 6,320	2,880	1,500	3,480	4,890	2,890	2,000	6,900	1,220	35,060		1,500	1,490	970	450	20% of machinery cost (excludes steam-electric plant)
Others	7,570	4,050	8,970	9,020	9,970	9,400	7,410	5,470	5,540	7,740	2,020	76,160		4,740	1,610	1,780	45	10% of above seven temporary installation costs
Related Costs	46,230	27,940	91,960	48,290	53,570	53,460	73,810	41,360	66,440	85,910	16,890	605,860	16	41,490	32,730	14,340	6,010	
Cost of Supervision and Survey	10,430	8,200	33,400	14,300	15,700	16,100	28,000 [29,100]*	12,700	16,400	26,400	5,300	187,030		9,620	8,550	4,820	2,150	17% of engineering cost
Interest on Construction Costs	31,600 [sic]	17,200 [sic]	50,200 [sic]	29,600 [sic]	33,000 [sic]	32,500 [sic]	39,000 [sic]	24,900 [sic]	44,000 [sic]	51,700 [sic]	10,050 [sic]	363,750		28,100 [sic]	21,200 [sic]	8,220 [sic]	3,310 [sic]	6% annual interest to run four years
Others	4,200	2,540	8,360	4,390	4,870	4,860	6,710	3,760	6,040	7,810	1,540	55,080		3,770	2,980	1,300	550	10% of above two items
Reserve Fund	6,200	3,430	10,210	5,900	6,560	6,480	7,980	4,380	8,670	10,360	2,020	72,790	2	5,510	4,170	1,660	670	2% of all above items
Cost per Kilowatt (in yen)	675	367	468	546	477	459	630	380	394	281	446			445	439	517	518	
Cost per Kilowatt Hour (in yen)	141	7.1	9.0	10.7	9.3	9.0	12.3	7.3	8.2	5.4	7.4			11.7	9.1	11.2	8.5	Cost per kw hr at Pa-li-hu-t'ung after completing 1st phase at San-men-gorge: 6.8 sen

[redacted]

The following figures have an error:
(*1) should be 1,800
(*2) " " 2,550
(*3) " " 18,400

RESTRICTED

RESTRICTED

129 AB

25 84897

Figures for dams and tunnels and the approximate unit prise are based upon the above plans. The figures are largely accurate for present high costs, but may in a very short time require correction because of the present rapid price fluctuations. A detailed examination of these estimates will be necessary from time to time, but water power from the Yellow River will be cheaper than that of any other site that could be developed in East Asia. If these sites had been developed six or seven years ago, power would have cost less than 200 yen per kilowatt.

VII. Basic Cost of Electric Power

The basic cost of electric power is calculated by the same method as that used in Japan. The interest rate is generally high in China, and poses a special problem. Japanese capital might be available at a low interest rate, but it would be difficult to secure sufficient capital in China without paying a high rate. In a few decades the interest rates in China may decrease, but at present they are high.

The construction cost should not be borne by electricity alone. A systematic, general development of the river will improve irrigation, water transport and flood control. Proper allotment of costs to these factors on the basis of direct monetary benefit from the project is impossible, and there was insufficient time to calculate it from their general benefits. The total cost was therefore assigned to electric power. Water transportation was not considered except locally, and any extensive development of it would require a major increase in the cost of the project, to raise the heights of the dams, etc. A new plan covering this development should be prepared.

Needless to say, the high output of electricity will make the cost of maintenance and operation of the electric power plants very low per unit of output, but precise figures cannot be given since there is no similar development in East Asia. Determination of the amount of dividends and interest is also difficult. For the present, annual interest is assumed to be 7 per cent. The amortization period for engineering developments is calculated 40 years; for electric engineering developments, 30 years at 4.5 per cent annual compound interest. These costs, plus maintenance and operation, will bring the basic cost of electricity just outside the mountain area to 12.5 per cent of the construction cost. The following table shows the estimated basic cost of electricity if electricity bears the entire burden.

(Table on the following page.)

Sale Cost of Yellow River Electric Power

Plan		Site	Total Engr Cost (yen)	Maximum Output (1,000 kw)	Annual Output (1,000,000 kw-hr)	Construction Cost per Kilowatt (yen)	Construction Cost per Kilowatt-Hour (sen)	Sale Cost of Electricity Outside Mountain Area (sen)
Plan No 1 or No 2		1. Ch'ing-shui-ho	316,000,000	468	2,240	675	14.1	1.8
		2. Ho-ch'u	174,900,000	477	2,480	367	7.1	0.9
		3. T'ien-ch'iao	520,870,000	1,111	5,780	468	9.0	1.1
		4. Hei-yu-k'ou	300,990,000	567	2,880	546	10.7	1.3
		5. Chi-k'ou-chen	334,620,000	702	3,590	477	9.3	1.2
		6. Yen-shui-kuan	330,280,000	720	3,660	459	9.0	1.1
		7. Hu-k'ou	407,130,000	647	3,300	630	12.3	1.5
		8. Yu-men-k'ou	253,870,000	669	3,480	380	7.3	0.9
Plan No 1	San-men Gorge completed in one operation	9. San-men Gorge (Assuming maximum output is immediately achieved)	442,130,000	1,123	5,410	394	8.2	1.0
		10. Pa-li-hu-t'ung	528,100,000	1,878	9,740	281	5.4	0.7
		11. Hsiao-hen-ti	102,780,000	229	1,390	446	7.4	0.9
Plan no 2	1st Phase at San-men Gorge completed	9. San-men Gorge	281,070,000	632	2,400	445	11.7	1.5
		10. Pa-li-hu-t'ung	528,100,000	1,878	7,750	281	6.8	0.9
		11. Hsiao-hen-ti	84,460,000	163	750	517	11.2	1.4
	2d Phase at San-men Gorge completed	9. San-men Gorge	493,980,000	1,123	5,410	439	9.1	1.1
		10. Pa-li-hu-t'ung	538,100,000	1,878	9,740	281	5.4	0.7
		11. Hsiao-hen-ti	118,720,000	229	1,390	518	8.5	1.1
		Total for Plan No 1	3,711,680,000 [sic]	8,591	43,950	432 (Average) [sic]	8.4 (Average) [sic]	1.1 (Average)

RESTRICTED

The average basic cost of electric power for all the sites is then 1.1 sen per kilowatt-hour, one of the cheapest electricity rates available among the river systems in East Asia which have been investigated. There are power plants with a lower basic rate, but this is because of the low prices when they were built. Their rates are therefore not comparable with those for the Yellow River project. As stated in Chapter IV of this part, considerably less construction material is required for the Yellow River power plant sites than for other sites, so that even after overcoming the transportation problems, the real construction cost will be cheaper. This is one of the main reasons for the low basic cost of electric power.

(Table follows on next page)

RESTRICTED

CONSTRUCTION PLANS FOR THE YELLOW RIVER POWER SITE DEVELOPMENT

	No 1 Ch'ing-shui-ho	No 2 Ho-ch'u	No 3 T'ien-ch'iao	No 4 Hei-yu-k'ou	No 5 Chi-k'ou-chen	No 6 Yen-shui-kuan	No 7 Hu-k'ou	No 8 Yu-men-k'ou	No 9 San-men-gorge (1st Phase)	No 9 San-men-gorge (2d Phase)	No 10 Pa-li-t'ung (1st Phase)	No 10 Pa-li-t'ung (2d Phase)	No 11 Hsiao-hen-ti (1st Phase)	No 11 Hsiao-hen-ti (2d Phase)	
Height of Dam (m)	80	76	149	88	94	97	68	89	61	86	127	127	40	40	
Length of Crest (m)	420	325	835	630	685	585	615	460	395	450	475	475	450	450	
Drainage Area (sq km)	425,150	428,850	433,800	442,350	458,950	488,450	508,550	514,800	721,500	721,500	725,250	725,250	728,000	728,000	
High-Water Level of Reservoir (m above sea level)	985	924	862	728	659	579	501	432	325	350	275	275	163	163	
Discharge Level (m above sea level)	928	866	732	663	583	505	435	366	282	282	167	167	136	136	
Head (m)	57	58	130	65	76	74	66	66	43	68	108	108	27	27	
Extension Stillwater (km)	143	48	63	91	117	163	118	66	132	200	98	98	24	24	
Stillwater Area (sq km)	2,300	31.9	101.3	89.6	122.5	87.5	65.4	37.5	180	2,244.5	95.8	95.8	28.3	28.3	
Total Reservoir Capacity (1,000,000,000 cu m)	24	0.53	4.43	1.97	3.46	2.17	1.12	0.84	6	40.07	2.37	2.37	0.283	0.283	
Maximum Water Depth (m)	58	59	131	66	77	75	51	67	45	70	109	109	28	28	
Planned Flood Volume (cu m/sec)		5,000					15,000		30,000	30,000					Reduced to 15,000 cu m/sec by San-men-gorge flood control
Maximum Utilizable Water (cu m/sec)	1,000	1,000	1,030	1,060	1,120	1,180	1,230	1,230	2,100	2,100	2,100	2,100	880/750/*1	1,050	
Maximum Effective Head (*2) (m)	56	57	129	64	74	73	65	65	33	64		107		26	
Maximum Theoretical Output (1,000 kw)	549	559	1,303	665	823	844	759	784	741	1,317	2,202	2,202	192	267	
Maximum Power Generated (1,000 kw)	468	477	1,111	567	702	720	647	669	632	1,123	1,878	1,878	163	229	
Average Utilizable Water (cu m/sec)	600	600	620	635	670	705	740	740	993	(1,250) 1,260	995	(1,250) 1,260	400	*(750) 760	60% of maximum water used, except at Dam No 9 (1st Phase) 10 and 11 (2d Phase)
Average Effective Head (m)	(56)*4 50*3	(57) 56.5	(129) 127	(64) 62	(75) 73	(73) 71	(63) 61	(65) 64.5	(36) 33	(64) 59	(107) 106.5	(107) 106	*(26) 25.5	*(26) 25.5	
Average Theoretical Output (1,000 kw)	300	332	772	386	480	490	442	467	322	(723) 692	1,039	(1,300) 1,315	100	*(187) 190	
Average Power Generated	256	283	660	329	410	418	377	398	274	(617) 590	886	(1,110 1,122	85	*(159) 162	
Annual Electric Power Output (1,000,000,000 kw-hr)	2.24	2.48	5.78	2.88	3.59	3.66	3.3	3.48	2.40	5.41	7.75	9.74	0.75	1.39	
Calculated Overflow (cu m/sec)	7,500	8,000	8,500	9,500	11,000	13,500	14,500	15,000	15,000	15,000	20,000	20,000	20,000	20,000	Allowing 20% for excess flow 10m x 10m cu m/sec 12m x 12m = 100 cu m/sec
Number of Overflow Gates	10m x 10m 15	10m x 10m 16	10m x 10m 17	10m x 10m 19	10m x 10m 21	12m x 12m 17	12m x 12m 18	12m x 12m 17	12m x 12m 17	12m x 12m 17	12m x 12m 24	12m x 12m 24	12m x 12m 24	12m x 12m 24	
Number of Turbo Generators	5	5	12	6	7	8	7	7	7	12	19	19	2	3	
Dam Excavation (cu m)	640,000	370,000	1,760,000	900,000	690,000	950,000	570,000	650,000	400,000	600,000	740,000		320,000		25% allowance[?]
Length of Tunnel (m)	5 @ 250	5 @ 250	12 @ 250	6 @ 250	7 @ 250	8 @ 250	7 @ 3,000	7 @ 250	7 @ 250	12 @ 250	19 @ 300		2 @ 250	3 @ 250	
Tunnel Excavation (cu m)	57,500	57,500	138,000	69,000	80,500	92,000	1,600,000	80,500	80,500	138,000	262,000		23,000	34,600	Cross-sectional area: 46 sq m (diameter 7.60 m) No 7 Hu-k'ou: 72 sq m (diameter 9.60 m)
Excavation for Power Plant Foundation (cu m)	72,000	72,000	156,000	84,000	96,000	108,000	96,000	96,000	96,000	156,000	240,000		32,000	48,000	B = 40m; L (per each generator) = 20m; D = 15m
Total Excavation (cu m)	769,500	499,500	2,054,000	1,053,000	866,500	1,150,000	2,266,000	826,500	576,500	894,000	1,242,000		359,400/375,000/sic	402,600	
Concrete for Dam (cu m)	1,228,000	827,000	4,940,000	2,104,000	2,364,000	2,141,000	1,214,000	1,531,000	685,000	1,400,000	2,240,000		374,000		
Concrete for Tunnel (cu m)	26,300	26,300	63,000	31,600	36,800	42,000	567,000	36,800	36,800	63,000	120,000		10,500	15,800	Cross-sectional area: 21 sq m (20% allowance for concrete of 0.8m thickness) No 7 Hu-k'ou: 27 sq m
Total Concrete (cu m)	1,254,300	853,300	5,003,000	2,135,600	2,400,800	2,183,000	2,167,000/sic/ (1,781,000)	1,567,800	721,800	1,463,000	2,360,000		384,500	389,800	
Number of Locomotives	10	1	2	1	1	2	2	2	10	10	2		1	1	150 tons each
Number of Freight Cars	100	20	20	20	20	20	20	20	100	100	20		20	20	
Number of Basic Motive Power Installations	7,000 kw				7,000 kw				7,000 kw	7,000 kw					Construction cost: 500 ¥ per kw. Sequence of construction and relation between motive power and transportation will determine locations

[redacted]

RESTRICTED

131 HB

Approved For Release 1999/08/25 : CIA-RDP78-03109A000200010001-6

RESTRICTED

A JAPANESE PLAN FOR HYDROELECTRIC DEVELOPMENT OF THE YELLOW RIVER IN CHINA
(Continued)

Far Eastern Research Section
Survey Committee No 2
North China Committee
Subcommittee No 4
May 1941

PART 5. RELATION OF THE HYDROELECTRIC PLAN TO FLOOD CONTROL AND WATER SUPPLY

AKIGUSA Isao and YANO Katsumasa

TABLE OF CONTENTS

RESTRICTED

I. Introduction

The Yellow River water-power development plan provides for several large dams and reservoirs to regulate the flow and concentrate the fall in the river. This will produce a great change in the flow of the river.

The general water-power development plan should include a water supply plan to utilize this change in flow.

The water supply plan calls for the diminution of flood water and the increase of low-water volume, while the water-power development plan requires only the increase in low-water volume. The benefits from using reservoirs for controlling floodwater and for equalizing the flow of water for electric power may not coincide.

Sites selected for reservoirs naturally have limited value for water supply. No matter how advantageous a site may be for water-power development, a part of the reservoir capacity must be used for flood control at the sacrifice of its water power potential.

By studying these mutually opposed interests in the reservoir, the optimum use of its capacity can be determined. This study will ascertain the character of the floods, and make possible accurate forecasting of them.

The exact volume and time of floods must be anticipated. The structure of the dams must meet these conditions. An overflow dam with large flood gates, or a dam with large release valves below the water surface, would increase the percentage of the reservoir capacity available for water power.

II. Relation of the Hydroelectric Plan to Flood Control

A. Flood Control at Ch'ing-shui-ho

According to hydrometric records, the maximum flood volume at Pao-t'ou never exceeds 4,000 cubic meters per second. Since there are no significant tributaries between Pao-t'ou and Ch'ing-shui-ho, there must be little difference in their flood volumes.

The drainage basin above Ch'ing-shui-ho is approximately 420,000 square kilometers, and although heavy flood-water occurs above this site, the gentle gradient and wide bed of the river between Ning-hsia and Sui-yuan largely equalize the flood volume without overflowing the banks. In 1933 and 1934 the maximum flood volume at Lan-chou was 5,400 and 7,000 cubic meters per second, respectively. These floods, without overflowing the banks, were down to 3,600 and 2,200 cubic meters respectively, when they reached Pao-t'ou.

The principle source of flood water in the downstream area is the drainage basin between Ch'ing-shui-ho and T'ung-kuan, and the basins of the Fen and Wei Rivers. Flood-water conditions above Ch'ing-shui-ho occur later than they do below that point. Probably less than 2,000 of the 23,000 to 25,000 cubic meters per second maximum flood water at Shan-chou originates above Ch'ing-shui-ho. The numerical accuracy of these figures must be verified, but they are supported by geography and hydrometry. Since flood water originating above Ch'ing-shui-ho constitutes only about 10 per cent of the flood water downstream, the Ch'ing-shui-ho reservoir can have little effect on the great floods in the downstream plains. The entire capacity of the Ch'ing-shui-ho reservoir may, therefore, be used for water power.

B. Relation to Flood Control of Dams between Ch'ing-shui-ho and Yu-men-k'ou

The eight upstream reservoirs, Ch'ing-shui-ho, Ho-ch'u, T'ien-ch'iao, Hei-yu-k'ou, Chi-k'ou-chen, Yen-shui-kuan, Hu-k'ou and Yu-men-k'ou would have a total capacity of 38,520,000,000 cubic meters. Excluding the Ch'ing-shui-ho reservoir the total would be 14,520,000,000 cubic meters.

The average annual flow at Shan is 43,000,000,000 cubic meters, and the flow at Yu-men-k'ou, excluding that from the Wei River, is approximately 26,000,000,000 cubic meters. Flood water from the drainage basin between Ch'ing-shui-ho and Yu-men-k'ou thus constitutes a considerable part of the downstream flood-water volume. Moderate flood water is insufficient to constitute a flood in the lower reaches of the river. In any case, these dams are not planned for flood control and even if they were, with the passage of years, the reservoirs will become filled with silt and lose their value. Moreover, these reservoirs will be developed over a long period and flood control cannot wait for them.

C. Relation of San-men Gorge Reservoir to Flood Control

San-men Gorge Reservoir was planned principally for flood control. The surplus capacity of the reservoir may temporarily be used to supplement the river flow at low water and for silt absorption, but in time silting will leave only enough capacity for flood control. The head of water at the dam could still be used for generating electricity, but there will be no capacity for equalizing the flow of usable water.

This reservoir must release the 25,000 cubic meters per second maximum flow of flood water it receives, at a rate not exceeding 15,000 cubic meters per second.

The line-graph of flood water which was prepared at Shan in August 1933 would, with a safety factor of 50 percent, require a capacity of 2,500,000,000 cubic meters to limit the flow below the reservoir to 15,000 cubic meters per second.

If the maximum water level of the San-men Gorge reservoir is to be 425 meters above sea level, its total capacity will be approximately 6,000,000,000 cubic meters. Of this, the 2,500,000,000 cubic meters capacity of the top 6 meters—from 419 to 425 meters above sea level—will be reserved for flood control.

The flood gates of the overflow dam will be large enough to allow a flow of 15,000 cubic meters per second at maximum water level. To allow as much flood water as possible to pass downstream before the reservoir fills to its maximum water level, the overflow crest of the dam below the gates must be as low as possible. It will be 413 meters above sea level—12 meters below the maximum water level. The 15 overflow gates must each have an effective width of 11 meters, making a total of 165 meters.

The important point in flood control is to maintain the water level during the flood season from 1 June to 15 September at 419 meters or lower. When the water level rises above this point, the gates will be opened to prevent the rise. If the water continues to rise with all the gates open, this rise will absorb the flood until the discharge rate reaches 15,000 cubic meters per second. If the water level begins to fall below 419 meters, the gates can be controlled to maintain that level.

D. <u>Effect of Soil Conservation on Reservoir Silting</u>

Soil conservation in the barren headwater areas, to prevent silt being washed downstream, should be made a separate project, but immediate results from such measures cannot be expected. The river will carry silt for some years to come. According to studies of the silt volume in the lower reaches, most of the silt originates in drainage areas of the Yellow River itself between Pao-tou and T'ung-kuan, and in drainage areas of the Wei River system, principally the Ching River. The volume of silt originating above the Ch'ing-shui-ho reservoir is very small, amounting to only 3 percent at the height of the flood season. Discussion of the effect of silting is therefore unnecessary.

The reservoirs below Ch'ing-shui-ho as far as Yu-men-k'ou will become largely filled with silt. Approximately 12,500,000,000 of the 14,520,000,000-cubic meter combined total capacity these dams will be filled by silt, preventing this volume of silt from flowing downstream.

The average annual flow of silt to the downstream area is 500,000,000 cubic meters. If half this volume originates in the drainage area between Ch'ing-shui-ho and Yu-men-k'ou, the reservoirs will reduce the flow of silt to the downstream area by 50 percent for approximately 50 years.

Although the greater portion of the 6,000,000,000-cubic meter San-men Gorge reservoir will, as stated above, eventually be filled by silt, the flow of silt to the downstream area will be decreased for a period corresponding to the silt absorption capacity of the upstream dams.

III. Relation of the Hydroelectric Plan to Water Supply

The construction of the San-men Gorge reservoir will be of great advantage to activities which require water, by increasing the flow of the Yellow River during its low water period from

200 to 650 cubic meters per second and, when the upstream dams are completed, to 800 cubic meters per second. This flow will be utilized in the following manner:

Irrigation	- 400 cubic meters per second
Industries	- 50 cubic meters per second
Water transportation	- 50 cubic meters per second
Total	- 500 cubic meters per second

The remaining 300 cubic meters per second will be allowed to flow downstream. The first 500 cubic meters per second will be diverted into the Wei River. The irrigation plan calls for the irrigation of approximately 1,000,000 CHOBU /2,450,000 acres/ around Lin-ch'ing. The water transportation plan calls for sufficient water to accommodate 500-ton boats from Hsin-hsiang or Hsiu-wu to T'ien-ching, or through Chi-nan and the Hsiao-ch'ing River to the sea.

Future railroad, water transportation, electric power, coal and water supply developments give the Hsin-hsiang area great possibilities as an industrial zone. It would require approximately 50 cubic meters of water per second for industrial uses.

Thus, the San-men Gorge reservoir will be of immense value for water transportation, irrigation, water for industrial use and hydroelectric power, as well as for flood control. Use of the 15,000-cubic meters per second flood water for irrigation and rejuvenation of the land on both sides of the Yellow River below the Pei-ping - Han-k'ou railroad bridge should receive extensive study.

/End of Volume I/

/Parts 6 to 10 continue in Volume II/