AMERICAN NATIONAL RED CROSS

REPORT

OF

BOARD OF ENGINEERS

ON THE

HUAI RIVER CONSERVANCY PROJECT

IN THE PROVINCES OF

KIANGSU AND ANHUI, CHINA

WASHINGTON, D. C.
1914
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HUAI RIVER CONSERVANCY PROJECT.

The Board of Engineers appointed by the American National Red Cross in accordance with an arrangement with the Republic of China to make certain investigations connected with the Huai River Conservancy project submits the following report:

The Board was instructed to make:

(a) "A further survey and investigation of the physical conditions affecting the Huai River Conservancy that must govern the engineering question of feasibility of that project.

(b) "The determination with as close an approach to accuracy as may be practicable of the area of present waste and submerged public lands that through the regulation works will be reclaimed for agricultural, social, or industrial purposes, together with an estimation of their real and annual income value.

(c) "The determination of the approximate area of privately owned lands that will be improved in productiveness and value by means of the regulation works; also an estimation of the annual or income value per unit area of the benefited lands expected to result from these regulation works, etc.

(d) "An estimation of the tonnage and net revenue derivable therefrom on the traffic that should exist on that portion of the Grand Canal included within the area of this conservancy project.

(e) "An estimate of cost of the proposed regulation and reclamation works required to effect the Huai River Conservancy, the time required for construction and installation, and the annual cost of operation, renewals, and maintenance."

The Board was further instructed to submit its report on or before November 1, 1914.

The Huai River Conservancy area, as defined by agreement, comprises:
The drainage areas of the Huai River, the Inner Grand Canal, the Yi River, the Sze River, and the Shu River, situated in Honan, Anhwei, and Kiangsu provinces, China, shown on General Map, Plate I.

The object of the conservancy is:
To improve these watercourses, especially as to the physical conditions that affect flooding of arable lands, continual submergence of lands, or submergence to such an extent as to create swamps.

The Board sailed from Vancouver, B. C., on June 11, 1914, and landed at Shanghai June 28, accompanied by an engineering and clerical force:
First, to check the general elevations already obtained in the area in question by the Chinese Conservancy Bureau;
Second, to make such special additional surveys as thought necessary and as time would permit;
Third, to gage streams in the area in question.
HUAI RIVER CONSERVANCY PROJECT.

The field parties were organized, outfitted, and dispatched to the field by July 5.

One party was directed to check by actual survey the elevations, hydrography, and topography in and along the Grand Canal from the Yangtse River to Tsingkiangpu, including the lakes to the west; thence through the Hunktese Lake and up the Huai.

Another party was dispatched to Pengpu, where the Tientsin-Pukow Railway crosses the Huai River, to establish a permanent gaging station in that vicinity and connect same with the line of levels brought up the Huai.

Another party was directed to run a line of levels down the Yen Canal from Tsingkiangpu to the sea at Haichow, and to obtain certain specified physical data concerning that waterway.

Another party was directed to make two sections of the present Yellow River bed and one of the old bed near the point where that river changed to its present channel in 1853.

The object of the surveys was to find the slope of trunk streams in the area in question to the sea and to the Yangtse River, to determine the maximum amount of water that it was necessary to pass to one or both places during floods, to obtain detailed topographic information necessary for planning the project, and such data as would assist the Board in forming an opinion as to the probability of the Yellow River leaving its present course and usurping the bed of the Huai and as to any precautions necessary to prevent such an occurrence.

The Chinese Conservancy Bureau had made an outline map of the area in question and had determined the elevations of the streams and lake beds above sea, together with their approximate locations. Check lines of levels run by the Board's survey parties proved that the level work referred to above was well done. Practically nothing, however, was known as to the flood discharge of the streams involved in the project. The only rainfall data bearing upon the problem that the Board could obtain is shown on Plates Nos. II to VIII, inclusive.

The Board made the following inspection trips:

First. From Pukow, on the Yangtse River, by the Tientsin-Pukow Railway, to the point where this road crosses the Grand Canal.

Second. By house-boat on the Huai River from twelve miles above Pengpu to and across Hunktse Lake to the Grand Canal.

Third. By house-boat on the Grand Canal from Chinkiang to the mouth of the Yi River at Yaowan, thence on horseback up a branch of the Yi to the channel that runs into Loma Lake.

Fourth. By boat to the mouth of the Grand Canal. The Board inspected the Loma Lake country and all important channels leading from the Grand Canal.

Fifth. By steamer up the Yangtse to Hankow, thence by rail to Kai-
fengfu; crossing the western edge of the Huai basin, thence by horseback to
a point on the Yellow River north of Kaifengfu; thence by boat to a point
a short distance below the place where the river left its old channel in 1853.
Thence to Kaifengfu overland, crossing the old bed of the Yellow River;
thence to Peking by the Hankow-Peking Railroad, returning to Shanghai by
the Tientsin-Pokow Railway.

Mr. A. P. Davis made a special trip down the Yen Canal to its crossing
of the Liutang River.

Other trips through the mouths of the Grand Canal, across Hungtse Lake
and into the lakes to the west of the Grand Canal south of Tsingkiangpu were
also made. Travel over the greater part of the area was difficult and slow,
and the time available was not sufficient for a detailed examination of the
entire region.

HISTORY.

Geographically and topographically the conservancy area outlined in the
Board’s instructions is divided into two parts separated by the old channel
of the Yellow River, which that stream occupied from 1324 to 1853 (see
maps, plates I and IX).

First. The Sze, Yi and Shu areas. These streams, lying north and east
of the old river bed, drain the mountainous country of Shantung. Their flood
flow is torrential in character. Their lower course is quite flat and has been
somewhat obstructed by artificial works; hence, their drainage to the Yellow
Sea is imperfect.

Second. The Huai River area. This area, lying south and west of the
old Yellow River bed, has a low gradient, and its former outlet has been prac-
tically closed by the deposits of the Yellow River. It has since established an
outlet to the Yangtse through which the flood and low waters find imperfect
relief.

Under local flood conditions the water from each of these areas passes, to
a limited extent, by way of the Grand Canal, through the outlet of the other,
but these areas constitute essentially separate problems, and should be and
are herein treated separately except to the extent of their mutual inter-
ference.

THE YI, THE SHU AND THE SZE AREAS.

The construction of the Grand Canal modified the course of the flood waters
of the Yi and the Sze Rivers. All of such water, however, except a limited
amount that passes through the Hungtse Lake and the Grand Canal south
of Tsingkiangpu to the Yangtse River, finds its way, as formerly, to the sea
north of the old Yellow River bed. These flood waters, as well as those of the
Shu, submerge the low lands on both sides of the Yen Canal. Practically the
only important work done in this area was the construction of the Yen Canal,
directly across the natural drainage of the country. The operation of this canal involves the construction of temporary earthen dams across the branches of the Liutang River east to the Yen Canal. These dams are partially the cause of the smaller inundations west of the Yen Canal. The great inundations, however, would cover a large portion of this country irrespective of the Yen Canal.

THE HUAI RIVER AREA.

The history of the Huai River district is so interwoven with that of the Yellow River and the Grand Canal that one cannot separate work done to meet conditions in the Huai River alone from that done for the Huai combined with the Yellow.

It is probable that prior to the time that the Yellow River usurped that portion of the bed of the Huai between the Hungtse Lake and the China Sea that the Hungtse Lake had considerable depth and acted, as at present, as a great regulating reservoir for the Huai, and that that part of the channel of the Huai from this lake to the sea was simply an overflow channel from the lake.

After the Yellow River took possession of the lower part of the channel of the Huai and raised its flood surface and its bed, the flood level in Hungtse Lake was increased. This flood height was further increased and the lake bed raised by the Yellow River itself breaking into the Hungtse Lake during floods. This excessive height of Hungtse Lake due to the Huai and to the Yellow caused serious flooding of the country south of Hungtse Lake, both west and east of the Grand Canal, and the history of the country is full of descriptions of the loss of life and property resulting from these floods. To remedy this condition there was built during the Ming Dynasty a high earthen dike, presumably extending from the Grand Canal to high land west of Tsiaiangkiapa for the purpose of preventing the waters of Hungtse Lake and the Yellow River passing south and flooding the country to the southeast. During the reign of the third Emperor of the Manchu Dynasty a cut-stone retaining wall was built on the lake face of this earthen dike. Apparently some inadequate sluiceways were constructed originally through this dike.

The water being thus practically penned in as to a southern outlet, and having no other outlet than east to the sea through the Yellow River, excessive floods must undoubtedly have resulted in the country north of Hungtse Lake and the then course of the Yellow River. It apparently was then decided to make five large openings in this dike, such openings to be closed with removable dams, called by the Chinese “pas,” that is, with dams built of material that could be removed when the Hungtse Lake reached a certain stage; and detailed instructions were promulgated concerning the opening of each “pa.” This then gave a large outlet south as well as through the Yellow River bed itself. The result of the operation of these pas was serious
flooding almost annually of much of the country to the south on both sides of the Grand Canal.

The existing channels from the Ming Dike south to the lakes, including the San River, and from them to the Yangtse River, are evidently artificial and indicate the execution of an immense amount of work for the purpose of passing safely as much as possible of the combined floods of the Huai and Yellow Rivers south to the Yangtse River (see map, plate IX).

Removable dams or "pas" were built at the crossing of the Grand Canal and Yellow River to prevent the latter during high water connecting with the Hungtse Lake or the Grand Canal. During low water these dams were removed so that boats coming up the Grand Canal could cross the Yellow River and continue their journey north. It appears from history that these dams were often washed out by the Yellow River during floods. In order to protect the east bank of the Grand Canal during such floods, five pas were built in such bank. Opening these pas gave relief to the high waters in the canal, but flooded an extensive and thickly populated area to the east between the canal and the sea. An old Chinese map reproduced herewith shows the pas for controlling the Yellow River and the inundation of the country to the east of the canal (Plate X).

In 1853 the Yellow River abandoned the channel that crossed the Grand Canal near Tsingkiangpu and left altogether the country south of the Shantung Peninsula and took a new course into the Gulf of Chihli.

The original conditions that affected the flow of the Huai River were materially changed by this and other visits of the Yellow River. The bed of Hungtse Lake was raised to an elevation of from thirty to thirty-three feet above sea-level, and the bed of the Huai was materially raised from Tsingkiangpu to the sea. This raised bed of the river and the dikes of the Grand Canal deprived the Huai of easy access to the sea to the east. The flood waters of the Huai, therefore, since this date have passed almost entirely through the lakes to the west of the Grand Canal and into the Yangtse River.

While the floods and consequent famine and distress in the basin of the lower Huai River and Hungtse Lake are very serious, the conditions were indescribably worse when the Yellow River connected with this area prior to 1853. The possibility of a similar connection between the Yellow River and the Huai basin which might destroy the effect of any conservancy work caused the Board to conclude that this report would be markedly incomplete unless it included an investigation of the physical relations existing between the Huai and the Yellow River basins, with a view to forming an opinion as to the probability of the Yellow River again usurping the bed of the Huai.

**The Yellow River and the Huai Drainage Area.**

With the exception of the extreme western tributaries, the Huai River drainage basin lies in the southern half of the great plain of eastern China.
This plain occupies a roughly semicircular area approximately 600 miles in radius around the eastern end of the mountainous Shantung Peninsula as a center. This great plain is of delta origin, developed in a great bay or partially enclosed sea, which in prehistoric times formed a western extension and union of the present Gulf of Chihli and the Yellow Sea. This basin was gradually filled by the deposits brought down from the surrounding mountains by the numerous streams draining them, including the Yangtse Kiang, the Huang Ho (or Yellow River), and the western tributaries of the Huai.

The Yellow River has been more largely instrumental in the formation of the great plain of China and in the creation of the abnormal conditions that obtain in the plain than any other factor. These conditions are due to its comparatively recent occupation of its present lower course, to the unusual physical character of its sediment, and to the conditions that surround its flow from the mountains to the sea.

From the point where the Yellow River is deflected south by a spur of the Yinshan to the point where it debouches on the great plains of China the course of the river is comparatively modern. Of this part of the river Prof. Bailey Willis (see Researches in China, vol. I, p. 234) says:

"If we attempt to follow it from its delta on the great plain of eastern China, we have, indeed, a channel which marks a continuous river, but we have not a valley of erosion which we may attribute to the stream. As we saw it at the Tung-kuan, and as it is described in its course from that point eastward, it is a stream occupying a depression produced by normal faulting. It has taken possession of a channel, but has not made one. In its long course from north to south, above the great elbow between the provinces of Shan-si and Shen-si, it flows much of the way in a canyon, and where not bounded by cliffs of rock it is shut in by walls of loess. Some portions of its channel appear to be antecedent to upwarps in the surface, and we are thus thrown back to an earlier date than that of the warping for the beginning of the river's course. But it appears from descriptions given of the valley in works of travel or by the natives that nowhere in its lower section is the river accompanied by that wide channel of an older valley which we would expect if it had long flowed in its course across the surface. *

* * *

"These characteristics of the river valley point to unusual youth, and apparently indicate an absence of an earlier history."

Prior to the development of the modern river, the ancient Yellow River occupied its upper course as far as the western border of Shan-si. From this point it probably flowed through the present valley of the Heisen Ho into the chain of lakes which occupied the upper valleys of the Sankang Ho and the Yang Ho, and discharged through the present Yang Ho gorge, through the Hun Ho and the Pei Ho into the interior sea which has since become the great plain of China.

This is shown by the system of terraces of the upper Yellow River, which apparently extend from Ningsiafu in Kansu to Yenking Chow, north and west of Peking, and which occupied the valley of the chain of lakes mentioned. (See Plate I.)
“That this deposit was formed in fresh water is shown by the presence of the shells found in the terrace of the Te Hai. The uniform character of the loam in the different basins, and in all parts of the same basin, its great extent, and the fineness of the material of which it consists, are conditions which prove that it is not of local origin, or derived from the detritus of the neighboring shores, but that it was brought into the lakes by one or more large rivers which must have drained an area of great extent. Now throughout the region in question the only rivers are those of the Yang Ho and Sankang Ho basin, and, independently of the fact that these streams drain a very small area, the valley systems of these were almost entirely occupied by the lakes.

“Indeed the only direction from which a river of any importance could have come was from the west, in which case it could only have been the Hwang Ho (Yellow River).” (See Raphael Pumelly’s “Geological Researches in China, Mongolia, and Japan,” page 42.)

The later development of the great system of normal faults which extend through the mountains of Shansi for some 450 miles in a general northeasterly and southwesterly direction was accompanied by a general settlement toward the southern end of the fault block and a rising to the northern portion of Shansi near the Mongolian border. This movement either produced an upheaval and consequent obstruction in the eastern course of the ancient Yellow River near the western border of Shansi or accomplished the same result by opening a lower outlet channel to the south and east around the end of the fault block, and thus caused the Yellow River to radically change its point of entrance into the great plain of China.

Evidence shows that when the Yellow River first began to discharge its waters through the present outlet near Mengtsing the land stood at an elevation of several hundred feet below its present altitude, and the silt brought down by the river was deposited in deep water, forming a normal delta adjacent to the mountains, and at the same time with other streams building up, with lighter material, the general sea bottom where the great plain of China now exists. Later in geological times diastrophic movements raised this sea bottom to or above the water surface, thus forming the base at least of the great plain. This upward movement of the sea bottom and of the Yellow River delta caused the degradation of the bed and delta of that stream and others flowing into this sea, as evidenced by the terrace systems in the valleys of the Yangtse and Yellow rivers, where they debouch from the mountains, referred to by Willis and Pumelly. As this upward movement continued, the consequent degradation probably increased the deposits in the sea, thus increasing the slope of the sea bottom from the mountains to the present Gulf of Chihli and the Yellow Sea. When this upward movement caused the great plain of China to emerge from the sea, the length of the Yellow River was materially increased and its action was then reversed. Instead of cutting its own bed and delta, it commenced to build them up so as to form a normal gradient for its greatly increased length. Before this could be done, man interposed and began to confine the stream by dikes.

The great disasters caused by this river in the past, which have given it the name of “China’s Sorrow” and which are still a menace to the great plain
of China, are largely the result of the fight which has been going on for centuries between the Yellow River, which is carrying on the development of a normal delta plain under abnormal conditions, and the Chinese people, who have attempted for four thousand years or more to confine this stream within limited bounds in order that they may cultivate as much as possible of the great plain of eastern China and support thereby a comparatively dense population.

**Laws of Delta Growth.**

Normal deltas independently created by river systems are in general of a fan-shape and have sufficient gradient to assure the discharge of the load of silt carried by their waters at ordinary stages into the sea. Only after such a gradient is established in the normal delta plain is the delta normally further extended. The channels are, when normal, sufficient for low water conditions, but the flood waters commonly overflow the lower delta area, and the contained silt forms natural dikes along the channel and slowly builds the adjoining plain. The gradient being sufficient for the transportation of silt, is not increased by the silting of the channel excepting as the delta is extended and it becomes necessary to maintain the gradient as the length of the stream increases. A normal stream meanders across the flood plain, cuts and fills its concave and convex bends, and as its length increases raises its bed and occasionally makes radical relocations of its lower channel.

**The Normal Delta of the Yangtse.**

The Yangtse has largely created its own delta, which is normal and occupies the extreme southern portion of the great plain above described and the extension of such plains among the mountains and hills to the southward and eastward to the Bay of Hanchow. The Yangtse has at different times varied its course so as to occupy most of this delta plain, its course being to a considerable extent modified by its delta growth and the position of the intervening mountains.

Within historic times there has been a considerable extension of the Yangtse delta plain, and doubtless a corresponding rise in its upper delta bed, or at least in its water slope to overcome the losses of gradient caused by such extension.

The conditions of a normal delta are clearly shown in the delta of the Yangtse. Although its channel has been diked for centuries and in spite of a considerable extension of its mouth seaward, the river has not elevated its bed above the surrounding diked lands.
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MONTHLY RAINFALL AT HOKIAO SHOWING OCCURRENCE AND INTENSITY OF RAINSTORMS OF ONE INCH OR MORE
MONTHLY RAINFALL AT PENGPU AND TAMINGFU SHOWING OCCURRENCE AND INTENSITY OF RAINSTORMS OF ONE INCH OR MORE
DELTA GRADIENTS.

The low water elevation of the Yangtse at Hankow, 600 miles from the sea, is about 133 feet above mean sea-level, giving it a low-water slope of approximately .22 feet per mile. The silt carried by the water, while considerable is small as compared with the silt content of the Yellow River. The normal delta gradient of any stream is necessarily a function of the quantity and quality of the silt carried by the stream and of the nature of the bed over which the stream flows. In the Yellow River not only is the silt carried excessive in quantity, but it is pervious in character and is deposited on a pervious substratum that permits extensive losses in the river volume by seepage and hence produces an unusual cause for silt deposition. The Yellow River, in its effort to build up a normal delta plain, has already raised its bed at the bridge of the Hankow-Peking Railway, about 400 miles from its mouth, to an elevation above mean sea level of about 400 feet, giving it a gradient of about one foot per mile. Even this gradient, apparently excessive when compared with the gradient of the Yangtse, is totally insufficient for the normal purposes of silt transportation to the sea. A river flowing over a plain having insufficient or only sufficient gradient for silt transportation purposes has no general tendency to deepen its bed. The Yellow River, in accordance with this law, has never excavated a channel in the great plain of China, but has meandered over the plain in its effort to create normal delta conditions and has formed channels only by the building up of flood plains adjacent to its lines of flow.

THE CONDITION OF UNRESTRICTED FLOODS OF THE YELLOW RIVER.

The results from the unrestrained flow of the Yellow River may be understood and appreciated by its action during the times it has escaped from its diked captivity and wandered normally over the plains of China. About 1853 the river broke away from the bed that it occupied for over five hundred years, at a point about thirty miles northeast of Kaifengfu, and wandered unrestrained for many years to the northward of its former course, capturing the bed of the Ta-ch'ing ho and moving its mouth some 250 miles to the north of its former outlet and to the region to the north of the Shantung Mountains. About 1867 a portion of the area occupied by the unrestrained river was visited by Messrs. Ney Elias and H. G. Hollingworth.

Describing their impression of the Yellow River at the Nanshan, a small limestone hill forming the western extremity of the Tsinan Highlands, Mr. Elias says:

"The river at this point has no defined bed, but flows over a belt of country some ten or twelve miles in width, having merely the appearance of a flat, level district in a state of inundation; patches of ground, trees and even villages cropping up here and there; the Grand Canal traversing it in a general northwest direction until it reaches the northernmost channel of the river at Palimiso some fifteen miles west from the Nanshan. Along this fifteen miles of the canal the
banks have been carried away in a number of places by the Yellow River breaking across them. The gaps are sometimes half a mile or more wide, and the current rushing through them almost obliterates the course of the canal, and renders the navigation upon it difficult. For dreariness and desolation no scene can exceed that which the Yellow River presents here. Everything natural and artificial is at the mercy of the muddy dun-colored waters, as they sweep on their course to the sea; a flood not likely to subside and a doubly mischievous one from the fact of its ever moving onwards with a swift current."

The work of the Yellow River, due to one of its breaks through the artificial dikes by which its course has been temporarily restrained, is described by Tyler as follows (see notes on the Hwang Ho or Yellow River, by W. F. Tyler):

"Five years ago (1898) a breach occurred at Wang-chia-li-hang, some 40 li below Chi-nan, on the south bank, which devastated a large area of country and caused the terrible distress which resulted in the organization of relief work by foreigners. The effect of this flood I was able partly to examine while going down the Hsiao-ch'ing-ho, and afterwards by riding along the course of the torrent from where the breach occurred, I estimated that at least 100 square miles were turned into a sandy waste of almost absolute sterility, while over an area of 200 square miles a deposit of more or less sterility was laid. * * * At the few places where actual examination was possible the depth (of the deposit) was from 6 to 10 feet, and the statement of the natives was that it varied from 4 to 8 feet. The River Taotai (official in charge) concerned considers the average depth to have been about 5 feet. Now, if we adopt the depth of 5 feet, it is seen that the sand which was poured out of the river in a single flood was about 1/5 cubic mile (38,000,000,000 cubic feet)"

Describing the last great change in the course of the Yellow River, Tyler says:

"In 1853 the Hwangho broke its dike near K'ai-feng, and about 270 li to eastward of the breach the defluent waters found the bed of the Ta-ch'ing-ho, as if it had been specially prepared to conduct the Yellow waters for the remaining distance, of about 800 li, to the sea. The bed of the Ta-ch'ing-ho was at that time about 1 li wide, and was sunk in the plain to a depth of some 50 feet or so. This bed, to commence with, was more than sufficient to hold even the flood waters of the river; but the silting up must have commenced at once, and each year the flood waters must have come closer and closer to the top of the river bank.

"After a period of 30 years, i.e., in 1883, the flood waters began to overflow and gently flood the plain. In consequence of this, the Governor of Shantung constructed dikes on both sides of the river from Tun-hsien to the sea. These dikes are the present existing outer dikes of the river. Previous to this the dikes had gradually been continued down from Honan to Tun-hsien."

"In the meantime the Hwangho gradually raised the plain between its embankments, until now (1903) the flood level is about 15 Chinese feet above the level of the original plain—that is to say, the flood level has risen 15 feet in 20 years, i.e., ½ foot a year."

Historical evidence indicates that the Yellow River has been diked for about four thousand years and has in no case ever created on any course a gradient sufficient for normal silt transportation. This diking was therefore begun under conditions radically different from those of rivers flowing through deltas completed normally by their own silt deposits. On account of the necessities of a thickly populated country the wandering branches of the Yellow
River flowing unrestrained across the flat plain of China were early confined to a more narrow range by an extensive dike system. These dikes were built locally and insecurely at first, but were gradually strengthened, systematized and improved until they finally developed into an extensive dike system under the somewhat experienced and systematic care of the local and national authorities. In its confined channel, between primitive dikes, the Yellow River has been building up a restricted delta and endeavoring to create a gradient commensurate with its needs. This has involved the raising of both its bed and the limited flood plain within the restricted dikes until they are frequently high above the surrounding level of the great Chinese plain. (See Plate XI). As the heights of its bed and flood plain increased within the restricted area the river frequently broke through its confining dikes, and while sometimes recaptured and returned to its artificial limits, often permanently threw off its bonds, devastated the country and wandered uncontrolled over a new portion of the plain, carrying on its normal work of delta building in a wide track until again confined in a new and restricted course to enable the Chinese people to reclaim temporarily the lands necessary for their sustenance.

DANGER TO HUAI RIVER CONSERVANCY FROM YELLOW RIVER.

The only points at which a break in the Yellow River is likely to harm the Huai River improvements would be between the old river bed and the loess hills near the Hankow-Peking railway bridge. East of this the double-dike system of the old river bed lies between it and the district and is a fairly effective safeguard against such a disaster.

West of the old river bed there has evidently been a degredation of the bed of the present river, caused by an increased gradient in this part of the channel, due to the breaking of the channel through the north dike into the lower land at the time the river took its present course. This drop in the bed has not yet been recovered. This is shown by the facts that the surface of the river at ordinary stage is below the bed of its ancient channel and that the river above the break does not at present rise to its former flood plain even at times of maximum flood, and its safe control through this section, with reasonable care—which must for safety be fully assured—is not likely to become a serious problem within the time limits of any probable issue of bonds for conservancy purposes.

THE EFFECT OF IMPERFECT DRAINAGE AND RAINFALL.

Owing mainly to the flat topography, local drainage channels throughout the conservancy area are in general very poorly developed, and during dry weather are frequently hardly discernible, as they occupy depressions that in general are but a few feet below the level of the surrounding country and require but a few feet of water to bring about flood conditions over extensive
areas. The drainage is so defective as not to offer relief for even the average conditions of rainfall that occur in this region. The torrential character of the rainfall that frequently occurs in this area necessarily results in flood conditions which cause great losses and serious famines in the affected areas. Thousands of lives have been lost by drowning and much property has been destroyed. Even greater loss of life has ensued from starvation in the resulting famines, and millions have been spent even to partially mitigate the distress occasioned. While the average rainfall is about 36 inches per annum, the minimum rainfall locally is not more than one-third of this amount, and the maximum may be quite 80 inches. (See Plate II.) A local rainfall of 25 inches fell in 48 hours ten miles north of Pengpu in August, 1910. Fortunately such rainfalls are unusual, but rainfalls of from 4 to 8 inches in from one to three days are quite common (see Plates V, VI and VII), and result in floods more or less serious according to the condition and extent of area over which they occur.

In July, 1914, during the early part of the visit of the Board to this area, the country was suffering from a drought which had reduced the crop production from three-fourths to one-half the normal amount; in July and August vast numbers of grasshoppers, favored by the dry season, utterly destroyed certain crops; and in September late rains covered much of the country with overflow, destroyed much of the remainder of the crops, and afforded a most unfortunate climax to the afflictions of this hard-working community that even at the best is apparently unable to secure more than a bare living from the soil.

It is apparent from the imperfect drainage conditions throughout this country that any general system of main channel improvements can have but limited effect on the local drainage systems of the entire basin, but that any such system must be gradually extended and adapted to the local conditions. Such extensions, to be properly planned, require a vast amount of detailed information not now available regarding the local topographic and hydrographic conditions.

PROJECTS.

YI AND SHU AND SZE.

The Sze is an overflow channel from the Weishan Lake into the Grand Canal. Its discharge depends almost entirely upon the stage of that lake, concerning which the Board has no information. (See Plate IX.)

A high flood in the Yi was measured at Nanchingyih by one of the Board’s survey parties on September 4, 1914, and found to be 109,000 cubic feet per second. While the General Map does not show other channels, it was ascertained by this survey party that a material part of the flood waters of the Yi left the main channel at several points north of Nanchingyih, flowing southwest in channels and across country to the Grand Canal. Judging from the
survey party's description of the above situation, the flood discharge of the Yi may reach or exceed 140,000 cubic feet per second.

A large part of the flood water of the Yi follows the Grand Canal, finding outlets into the Liutang and the Yen Canal. Some passes into the Hungtse Lake and on to the Yangtse River. Some passes through the sluice locks at Tsingkiangpu and on to the Yangtse, producing floods in the Grand Canal.

No opportunity presented itself for measuring the flood discharge of the Shu. A comparison of its watershed with that of the Yi leads to the belief that its flood discharge may be approximately two-thirds that of the Yi, the physical conditions being quite similar, and that the total volume of flood waters that has no adequate channel to the sea and combines in the flat country west of the lower Yen Canal may be 225,000 cubic feet per second or more.

The problems involved in attempting to control the floods of the Yi, Shu and Sze are many, and the Board finds that the data available is not sufficient to enable it to formulate a project. Definite information is needed as to flood discharges. An accurate topographical map showing half-meter contours of all the country north of Tsingkiangpu between the Yen Canal and the Grand Canal is an essential. This map should extend north until it includes all connections between the branches of the Yi and the Grand Canal and until it develops all feasible routes by which the Yi River could be diverted into the Shu. In making this map accurate information should be obtained as to the extent of the flooded area and the benefits that would accrue from the control of the floods of these rivers.

In general it would seem advisable:

1st. To join the Yi and the Shu as far north as practicable in one capacious, strongly leved channel and to pass their combined floods to the sea by the shortest, most feasible route.

2d. That locks and dams be built in the Grand Canal and the flood waters of the Yi be completely diverted from such canal.

3d. The cost of such a project would be great and the benefits unascertainable with present information.

**HUAI RIVER PROJECT.**

The Huai River drains an area of about 50,000 square miles above Pengpu. The surveys show that its valley slopes very gently to the sea; that the average fall at high water from Pengpu to the sea via the Hungtse Lake through the bed of the old Yellow River (a distance of 256 miles) is 3.28 inches per mile.

Assuming the Huai River turned directly south at Tsangkiapa and separated from the bed of Hungtse Lake by a dam, the average slope from Pengpu to the Yangtse River when the latter is at extreme flood (a distance of 213 miles) is 2.98 inches per mile. The influence of the Paoying and
Kaoyu lakes is such, however, as to make the grade available for the narrower channels greater by this route than along the Yellow River route.

All of the heretofore proposed projects for improving the flood conditions in the Huai River, of which the Board has knowledge, contemplate either sending all the water east to the sea preferably by the bed of the old Yellow River or a portion of it to the sea by that route and the remainder south to the Yangtse through the lakes to the west of the canal. The location of outlet channels in these proposed projects is shown upon Plate IX.

While the Board has not had opportunity to make a direct measurement of the maximum flood discharge of the Huai River, it has had measured the discharge of that stream at Pengpu at stages between low water and an eighteen-foot stage. The low-water discharge was 4,000 cubic feet per second, and the discharge with a rise of eighteen feet was 84,815 cubic feet per second. (See Plate XVI.) The river sometimes rises ten feet above that stage, thus making variations between extreme high and low water about 28 feet. (See Plate XVII.) The maximum flood discharge of the Huai at Pengpu, estimated from measurements taken and from calculations based upon known high-water marks at Pengpu and a point eight miles up stream, plus the roughly estimated discharge of the small streams entering the Hungtse Lake and the Huai below Pengpu, leads the Board to conclude that the maximum amount of water entering the Hungtse Lake is at least 200,000 cubic feet per second. (See Plate XVIII.)

The following methods of so disposing of this water as to reduce floods have been proposed:

Project No. I.

For this project it has been proposed to send half the water down the old Yellow River bed to the sea and half south to the Yangtse. (See Plate IX.) To improve flood conditions around Hungtse Lake and up the Huai, it would be necessary to so arrange discharge capacities of outlet channels as to reduce flood heights in Hungtse Lake. This height, as determined by the Conservancy Bureau, is about fourteen and a half meters above sea-level. To materially improve flood conditions, Hungtse Lake should not be allowed to rise above a 13-meter stage.

With a lake-level at 13 meters, it is estimated that a channel crossing the Grand Canal and extending down the old Yellow River bed to the sea capable of discharging 100,000 cubic feet per second would have the following approximate dimensions:

1,000 feet wide, 23 feet deep, with side slopes $1\frac{1}{2}$ to 1, and would require the excavation of 920,000,000 cubic yards of material.

With Hungtse Lake at 13 meters and the Yangtse River at extreme flood stage (19 feet on the Chinkiang gage) (see hydrograph Plate XV), a channel from Tsiangkiapa to and through the lakes to the south and thence to the
PROJECTS PREVIOUSLY PROPOSED.

Yangtse River capable of discharging 100,000 cubic feet per second without increasing flood heights in the Paoying and Kaoyu lakes to the west of the Grand Canal would involve the excavation of 27,000,000 cubic yards of material, making the total yardage of this project 947,000,000.

The cheapest route to pass 100,000 cubic feet per second from Hungtse Lake east to the sea would be via the Yen Canal and the Liutang River, shown in location on Plate IX. Such a channel would involve the excavation of 589,000,000 cubic yards of material. Adding 27,000,000 cubic yards for the southern channel, there results a total of 616,000,000 cubic yards.

The results of this project would be as follows:

a. No appreciable decrease in the height of the sudden floods of the Huai River above Pengpu.

b. A decrease in the length of time that the river would remain in flood.

c. A lessening of the height of floods due to long-continued rains, when such conditions would, under present conditions, cause the Hungtse Lake to rise above the 13-meter stage.

d. No land reclaimed; benefits indefinite.

If this project be varied and the channel from Tsangkiapa to the Yangtse River be made by enlarging existing channels along the western edge of the lake region as shown on Plate IX, it would be practicable to drain the beds of Paoying and Kaoyu lakes during the winter and spring months, when the Yangtse is low, and such lands be made available for wheat. This would largely increase the total yardage of Project No. 1.

Project No. II.

This project proposed to send the flood waters to the same destinations: one-half to the east to the sea and one-half to the south to the Yangtse. That portion of the water destined for the sea to the east was to be confined to a channel across the bed of the Hungtse Lake, parallel and close to the Ming Dike. This channel was to be part in excavation and part formed by dikes. Imposing the same conditions as to height of Hungtse Lake, the yardage involved in making a channel capable of carrying 100,000 cubic feet per second to the sea would materially exceed the corresponding estimate in Project I. The cost of the other part of the project would be the same as in Project I; and the results would be essentially the same as in Project I, since the Hungtse Lake cannot be reclaimed by either.

Project No. III.

It has been proposed for this project to send all the water to the sea through the old Yellow River bed, reclaiming the beds of Paoying and Kaoyu lakes west of the Grand Canal.

With the Hungtse Lake at 13 meters, it is estimated that it would require a channel in the old Yellow River bed approximately 2,000 feet wide and 23
feet deep to carry 200,000 cubic feet per second to the sea, and would involve the excavation of 1,880,000,000 cubic yards of material, the channel slope from the Grand Canal to the sea being 3.17 inches per mile.

The beds of the lakes in question are below the extreme flood heights of the Yangtse. If such beds were thoroughly drained, a wheat crop could generally be grown on such lands. With dikes to hold back the flood waters of the River Yangtse during the summer months, there would be no drainage for this low, flat land, and with the excessive rains common during June, July, August, and September, it is not thought that crops could be grown during that part of the year.

If Project III be varied by sending all the water to the sea by the Yen Canal and Liutang River, it would involve the excavation of about 1,080,000,000 cubic yards of material.

None of the plans described above make the reclamation of the bed of Hungtse Lake practicable.

The Board after mature consideration finds itself unable to recommend any of these projects.

Project Recommended by the Board.

The Board is of the opinion that it is best not to attempt to divide the waters of the Huai, and that all such waters should go, as they have for the last sixty years, into the Yangtse River near Chinkiang; that such waters should be diverted into Paoying and Kaoyu lakes in such a way as to make entirely feasible the reclamation of the bed of Hungtse Lake. This reclamation of the Hungtse Lake bed makes it practicable to construct a channel across the same with high dikes, through which can be safely passed to Paoying Lake the waters of the Sui and the drainage water from a large part of the territory annually flooded, bounded by Hungtse Lake, the old Yellow River bed, the Tientsin-Pukow Railway, and the Huai River below Pengu.

The Board caused an investigation to be made of the feasibility and cost of diverting the Huai River to Paoying Lake on two alternative routes:

First, by building a dike across its mouth just below Kweishan, and cutting a channel across the peninsula from a point above Kweishan to Tsiangkiapa.

Second, by building a suitable dike from the left bank of the mouth of the Huai River opposite Kweishan to the village of Tsiangkiapa about three kilometers from the shore line.

It was disclosed by this investigation that the former plan would involve a far greater quantity of earth excavation than the latter, and in addition thereto a large quantity of rock excavation. The cost would be so great as to make that route practically prohibitive.

By the plan recommended it is proposed to build a suitable dike on the line indicated on the drawing and described above, from the left bank of the
CROSS SECTIONS OF YELLOW RIVER
Plate XII, A.—Loess Bluffs at Station of Huangho, Province of Honan

Plate XII, B.—Operating in east bank of Grand Canal to discharge flood waters; protected by revetment built of reeds and earth
Plate XIII, A.—Saving bean crop from flood, Yi River

Plate XIII, B.—Shipping at Yang Chwang on Grand Canal
mouth of the Huai River opposite Kweishan, to the village of Tsiangkiapa, roughly parallel to the shore of the Laotseshan Peninsula, and everywhere at least three kilometers therefrom. (See Plate XX.) This will form with the shore line a channel for the diversion of the Huai River from Hungtse Lake, which with the proposed excavation will be capable of carrying about 200,000 cubic feet of water per second at lake stage of 13 meters, and disposing of ordinary floods of 100,000 cubic feet per second without permitting the water at Kweishan to rise more than 12 meters above sea-level.

With a slope of .00005 between Laotseshan and Tsiangkiapa, the following table shows roughly the discharge capacity of this channel at various elevations of the Huai River at Kweishan:

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<tr>
<th>Stages of river</th>
<th>Discharge in cubic feet per second</th>
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<tbody>
<tr>
<td>11 meters above sea-level</td>
<td>30,000</td>
</tr>
<tr>
<td>12 meters above sea-level</td>
<td>100,000</td>
</tr>
<tr>
<td>13 meters above sea-level</td>
<td>200,000</td>
</tr>
<tr>
<td>14 meters above sea-level</td>
<td>340,000</td>
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</table>

It is proposed to build regulating works at the Tsiangkiapa outlet, with a capacity of 200,000 cubic feet per second, with water surface just above the works 12 meters above sea-level; to provide a channel below Tsiangkiapa with a discharge capacity of 200,000 cubic feet per second to Paoying Lake, with the lake at a stage 8 meters above sea-level; and channels from that lake to the Yangtse having the same capacity, with the river at 19 feet on the Chinkiang gage.

It is proposed to provide the unwatered bed of Hungtse Lake with an extensive network of canals and laterals, with beds about 3 meters below the surface of the ground. The outlets of the principal drains would be provided with controlling works, so that the channels would serve for drainage when left open, and by closing them the canals would be filled from the Huai River and used for irrigation by means of moderate lifts varying from 1 foot to 6 or 7 feet, according to their distance from the source of supply. This system would also be available for navigation, and would connect with the Grand Canal and thus make available the waters of the Huai River for navigation in that canal, and for irrigation east of it when needed. A diagram of the proposed system is shown on Plate XXI.

The enlarged channel capacity to be provided between the Kaoyu Lake and the Yangtse would in dry weather empty that lake, and, unless prevented, so deplete the waters of the Grand Canal as to destroy navigation and deprive the lands east of it of irrigation water. To prevent this, and to improve navigation it is proposed to build a lift lock in the Grand Canal near the town of Shaopo, with a total lift under extreme conditions of about 4 meters, and a channel with lock and regulating works connecting the Grand Canal above this lock with the channel leading to Sinnemiao, as shown on Plate XVI. This
will prevent waste of water in times of scarcity, insure a stable irrigation supply to the eastward, and greatly improve the navigation of the Grand Canal, which is now seriously interrupted in low-water periods. It is also proposed to dredge the Grand Canal from its lock southward to a bottom elevation of minus 4 feet on the Chinkiang gage.

Just above Tsingkiangpu it is also proposed to build a lift lock of 4 meters lift capacity, so located as to eliminate from the main canal all the sluice-locks above that town and also the great curves that occur in the canal in that vicinity. (See Plate XXII.) This will save distance, economize water, make navigation much safer and feasible at all stages of water, and improve the navigable capacity of the canal at that point and for some distance above. It is proposed to provide a regulated flood channel from the canal above this lock to Paoying Lake to care for the same proportion of the flood-waters from the upper Grand Canal as have formerly passed down the Grand Canal and into the Hungtse Lake. No water would be allowed to flow from this point down the Grand Canal except that used for lockage. This would thoroughly protect the country east of the Grand Canal and south of the old Yellow River bed from all floods except those due to local rainfall, providing the existing east dike of the Grand Canal be kept in good repair.

It is proposed also to connect the valley of the Sui with Paoying Lake by a large drainage channel with a normal capacity of 50,000 cubic feet per second. This channel would cross the reclaimed lands of Hungtse Lake and would be separated from them by high dikes. Branch dikes from these, connecting with high ground to the north and south, would be provided to protect from overflow the reclaimed lands of Hungtse Lake. (See Plate XX.) Various branches and laterals connecting with the main drain would be necessary to properly drain the lands, but the topographic information concerning the country affected is insufficient to permit the location of these drains at present, and detailed quantities and estimates must await the preparation of a good topographic map of the region. This system of drainage would be of great benefit in relieving at least the lands between the Sui and the Old Yellow River bed from flood conditions, and as it would be built for their benefit they would repay the cost. The area to be benefited is estimated at 10,200,000 mow, or 1,700,000 acres. To the cost of the main channel should be added the cost of the local connections, which could probably be provided by local effort, but should be constructed under competent direction and in accordance with approved plans.

It must not be expected, however, that these works will entirely prevent the flooding of the lands benefited. When 5 to 25 inches of rain fall in one storm upon plains as flat as these, no practicable works of man can prevent the submergence of the land. The most that can be done is to provide large and free outlets, so that the waters may run off quickly before they have killed growing crops. This will curtail both the magnitude and duration of the
DISTRIBUTION OF BENEFITS.

Floods, and, with reasonable local care in making connections with the drains and in protecting harvested crops, the damage would be largely avoided.

GENERAL BENEFITS FROM THE PROJECT.

The region to be chiefly benefited is the area bounded on the north by the old bed of the Yellow River, on the east by this old bed and the Ming Dike; on the south by the southern margin of Hungtse Lake and the Huai River; and on the west by the Tientsin-Pukow Railway. The upper Huai River and its tributary valleys will be but slightly affected by the proposed works.

Substantial benefits will also accrue to the agricultural land east of the Grand Canal, which was this year and is frequently inundated by the excess water from the Grand Canal, and is as often short of irrigation water. Both these conditions will be removed by the proposed works, and all the country served by the Grand Canal will benefit by the improved navigation.

The lands to be directly benefited by this project may be divided into 5 districts, on the basis of the character, amount and cost of the said benefits.

District No. 1.—Lands which will be reclaimed and irrigated. This includes the greater portion of the bed of Hungtse Lake, and comprises an area of about 350,000 acres, or 2,100,000 mow, valued at at least $75.00 per acre.

District No. 2.—Lands which will be reclaimed, but not irrigated. This includes the northeastern portion of Hungtse Lake, an area of about 36,000 acres, or 216,000 mow, valued at at least $50.00 per acre.

District No. 3.—Lands around Hungtse Lake which have been mostly cultivated but subject to frequent inundations, and which will be protected from overflow and provided with drainage channels. Estimated area 300,000 acres, or 1,800,000 mow; benefited at least to the extent of $15.00 per acre.

District No. 4.—Lands heretofore cultivated which will be provided with main drainage channels for the escape of all flood waters. This class includes the area bounded on the north by the old bed of the Yellow River, on the east by the old bed of the Yellow River, Hungtse Lake and District No. 3; on the south by the Huai River, and on the west by the Tientsin-Pukow Railway, with the exception of a portion of the southern part, which is too low to be relieved by these works. The benefited area in this district is estimated from the best available information at 1,700,000 acres, or 10,200,000 mow, and would be benefited at least to the extent of $4.00 per acre.

District No. 5.—Lands benefited by the regulation of the Grand Canal, preventing both overflow therefrom and water shortage therein for irrigation. This includes a large portion of the lands east of the Grand Canal and south of the old bed of the Yellow River. The area is roughly estimated at 5,000,000 acres, or 30,000,000 mow, and the entire area would be benefited to the extent of at least $10,000,000.

In addition to the direct benefits, there will be various indirect benefits, of which the most important is the improvement of navigation in the Grand
Canal, in consideration of which it is proposed to collect equitable charges for
the use of the locks to be provided.

Revenues from the Grand Canal.

In so far as the Board could determine, no record is kept of the tonnage
on the Grand Canal, and the revenues are so complicated by liken* charges as
to be indeterminate. This canal within the conservancy area is the principal
transportation route for a thickly-populated country about 150 miles wide and
200 miles long. The tonnage at present on this waterway is large, and with
the improvements contemplated could be transported with less than half the
boats at present employed, thus decreasing by at least half, the cost of such
transportation and leaving boats available for transporting the increased com-
merce that will result from the improved flood conditions and the cultivation
of reclaimed lands. This saving in transportation cost should be col-
lected in the form of tolls until the bonds issued are redeemed.

There should be in the agreement with China a definite statement as to
the maximum amount of liken or other charges the Chinese Government will
make on boats or cargo while in this canal or other canals built in the prosecu-
tion of this work. If the liken and other charges made do not exceed the cost
of the transit pass over other transportation routes the revenues that could
properly be collected for passage through the canals in question would be rela-
tively large. It is believed that the net income would not be less than $225,000
per annum. The contract should clearly state that the banking houses shall
have the right to collect tolls for the passage of boats through the canals and
locks built in the prosecution of this conservancy work until the bonds issued
for such work are redeemed.

Taxes on Reclaimed and Benefitted Lands.

The Chinese Government should agree to apply the entire tax on the re-
claimed land and any increase in taxation on the benefited land to the pay-
ment of the bond interest and principal. This should net not less than the
following amounts:

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
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<tbody>
<tr>
<td>Reclaimed land, 386,000 acres</td>
<td>$386,000</td>
</tr>
<tr>
<td>Benefited land, 7,000,000 acres</td>
<td>$1,720,000</td>
</tr>
<tr>
<td>Total</td>
<td>$2,136,000</td>
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</tbody>
</table>

Summary of Estimated Returns.

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value of reclaimed lands in Districts 1 and 2, page 30</td>
<td>$27,050,000</td>
</tr>
<tr>
<td>Value of benefits in District No. 3, page 30</td>
<td>$4,500,000</td>
</tr>
<tr>
<td>Value of benefits in District No. 4, page 30</td>
<td>$6,800,000</td>
</tr>
<tr>
<td>Value of benefits in District No. 5, page 30</td>
<td>$10,000,000</td>
</tr>
<tr>
<td>Total</td>
<td>$48,350,000</td>
</tr>
</tbody>
</table>

*"Likem" is an internal tax levied upon the transportation of goods.
COST OF PROJECT.

There should be received annually at the end of the six-year period of construction:

From the revenues of the Grand Canal and other canals in the area. ........................................... $225,000
From taxes on lands. ........................................ 2,136,000

$2,361,000

The above estimated prices for reclaimed land and values of benefits to be assessed are based on limited information both as to areas, which have been measured from the best available maps, and conditions which the Board has not had the opportunity to investigate in detail. The estimates are believed, however, to be conservative, and may on further investigation be increased. Further extensive surveys and investigation must be made to justly fix the areas which will be benefited and that should be assessed and the actual amount of benefits which will be derived. Unless essentially such benefits can be collected the project cannot be made to pay for itself. As a further preliminary to financing the project, the method of assessment and collection must be elaborated and the Chinese Government must agree to collect specific benefits at least equal to those estimated and to meet any deficiency which cannot be so collected.

The benefits will accrue on the completion of the work at the end of the six-year period; but the manner and terms on which the land will be sold and the disposition of the funds received, from such sale and those collected as benefits, in such a way that, with the fixed revenues, they will meet the interest on the bonds and pay them when due, are questions which the Board will not attempt to discuss. The term of the bonds should not be greater than the time required for construction, plus the period in which the reclaimed land will be paid for and the benefits collected.

COST OF PROJECT.

The works recommended are estimated to cost about $30,000,000, U. S. currency. (See Appendix.) They can be economically completed within about six years after the beginning of construction, provided funds are available as needed, and the work is vigorously prosecuted. If the bonds issued bear 5 per cent interest, and are sold at ninety cents on the dollar, and if 3 per cent can be secured on unexpended balances, the total issue to cover discount and interest during a six-year construction period will amount to $45,000,000.

On the basis of the benefits estimated above and the returns from canal tolls and the taxes suggested it is believed that a satisfactory method for financing the project can be devised.
 OPERATION AND MAINTENANCE.

The locks recommended will require attendants to operate them and will need care and occasional repairs, all of which can be paid for by a portion of the receipts derived from their use. The estimates of the net revenues therefrom are made with this policy in view.

The controlling works in the canals will also require similar attendants, but as these occur only at two points separate from locks, the extra cost will be small. The canals themselves, although of enormous length, do not have the complications often found in canal systems, such as side-hill locations, sharp curves or high velocities, and they are mostly too deep to permit aquatic plants to grow on their bottoms. The clearing of weeds from their banks, so expensive in America, is obviated by the practice of the Chinese people of gathering all such vegetation for forage or fuel as soon as it is available.

The dikes must be patrolled, especially just before and during the flood season, to guard against the attacks of burrowing animals and other dangers, since a break at flood time would be very serious.

Some provision for these expenses should be made in the contract with China. Probably the simple duties of caring for the small channels could be assumed by the riparian owners of land under contractual arrangement with them when the lands are sold, reserving suitable powers for the enforcement thereof, and the cost of the other work should be also provided for.

No precedents are available from which to estimate the cost of such work in China, but it is believed that an allowance of $200,000 per year would cover the necessary regular outlay and afford a surplus from which to accumulate a fund for repairing breaks.

CONTRACT.

The Board does not recommend a percentage contract. Much of the work can be more economically done by contracts for work of a specified character. There is no incentive for speed or economy when the contractor receives a specified per cent of the actual cost, and the Chief Engineer under such an arrangement is practically powerless to secure either. Should a contract be let for the entire work or a large part thereof, it should be let either on a unit price basis or for actual cost plus a specified amount. In the latter case the contract should also provide that if the contractor shall show inability or lack of due diligence in securing economy of construction or shall attempt to secure other than the specified profit the contract shall be nullified.

SUPERVISION.

The Board is of the opinion that the Chief Engineer should have complete authority as to plans of work and methods of doing same, but that after he
Plate XIV. A.—Pumping for irrigation east of Grand Canal

Plate XIV. B.—Flooded district along Tientsin-Pukow Railway, September, 1914
Plate XV, A.—Flood conditions along Tientsin-Pukow Railway, Kiangsu Province, September, 1914

Plate XV, B.—“Pa” or dike at Tsiangkiapa. This is the location of the dam and gates proposed for controlling the waters of the Huai River
Discharge in second feet

Base height in feet at Pengpu, base

Rating curve of Huai River at Pengpu.
SUPERVISION.

has completed plans in sufficient detail for work to actually commence such plans should be passed upon by a Board of Engineers, this board to be named by the banking houses which may finance the work. The work is too large and important and an error of judgment of too great consequence to be left entirely to the judgment of one man.

Thereafter an annual inspection and report should be made by an engineer or Board of Engineers acting in an advisory capacity to the Chief Engineer, the selection of such engineer or engineers to be made jointly by the banking houses and the Chief Engineer. In addition, the Chief Engineer should have the privilege at any time to ask the advice of one or more engineers expert in the particular problems when their importance seems to him to warrant such action.

WM. L. SIBERT.
DANIEL W. MEAD.
ARTHUR P. DAVIS.

Major General Geo. W. Davis, U. S. A., Ret.,
Chairman of the Central Committee,
American National Red Cross, Washington, D. C.
APPENDIX.

SUMMARY OF ESTIMATES.

<table>
<thead>
<tr>
<th>Description</th>
<th>Cubic yards</th>
<th>Gold dollars</th>
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<tbody>
<tr>
<td>Main outfall channel to Yangste</td>
<td>62,850,750</td>
<td>8,285,075</td>
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<tr>
<td>Excavation in San Ho Channel</td>
<td>30,000,000</td>
<td>2,400,000</td>
</tr>
<tr>
<td>Main diversion dike around Lao Tseuan</td>
<td>15,173,730</td>
<td>1,388,635</td>
</tr>
<tr>
<td>Excavation parallel to same, not used in dike</td>
<td>41,920,000</td>
<td>3,772,300</td>
</tr>
<tr>
<td>Dike parallel to Ming Dike</td>
<td>2,180,380</td>
<td>151,855</td>
</tr>
<tr>
<td>Dike across Pao Ying Lake</td>
<td>191,280</td>
<td>12,388</td>
</tr>
<tr>
<td>Rock riprap (square yards)</td>
<td>700,000</td>
<td>350,000</td>
</tr>
<tr>
<td>Canal from Pao Ying Lake to Grand Canal</td>
<td>2,567,800</td>
<td>154,066</td>
</tr>
<tr>
<td>Flood Channel from Grand Canal to Pao Ying Lake</td>
<td>8,182,610</td>
<td>571,383</td>
</tr>
<tr>
<td>Sul River Channel through lake to Ming Dike</td>
<td>38,800,000</td>
<td>3,380,000</td>
</tr>
<tr>
<td>Sul River Channel from Ming Dike to Pao Ying Lake</td>
<td>9,400,560</td>
<td>755,045</td>
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<tr>
<td>Sul River Channel feeder and guide dikes above</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hungtze Lake</td>
<td>21,500,500</td>
<td>1,380,069</td>
</tr>
<tr>
<td>Drainage for lake bed northeast of Sul Channel</td>
<td>7,708,040</td>
<td>462,482</td>
</tr>
<tr>
<td>Main drain of North System on irrigated land</td>
<td>10,218,000</td>
<td>715,260</td>
</tr>
<tr>
<td>North branch of South System</td>
<td>8,494,500</td>
<td>591,485</td>
</tr>
<tr>
<td>South branch of South System</td>
<td>13,706,800</td>
<td>1,306,478</td>
</tr>
<tr>
<td>Main trunk of South System above Kaoliang Kan.</td>
<td>13,534,920</td>
<td>1,082,703</td>
</tr>
<tr>
<td>Main trunk of South System below Kaoliang Kan.</td>
<td>4,258,810</td>
<td>298,116</td>
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<tr>
<td>Irrigation System:</td>
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<td></td>
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<tr>
<td>Eastern Irrigation Canal</td>
<td>1,730,510</td>
<td>103,830</td>
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<tr>
<td>Central Irrigation Canal</td>
<td>1,228,780</td>
<td>78,722</td>
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<tr>
<td>Western Irrigation Canal</td>
<td>625,000</td>
<td>39,290</td>
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<tr>
<td>Lateral System, 1,547 kilometers</td>
<td>35,570,000</td>
<td>1,591,630</td>
</tr>
<tr>
<td>Sub-laterals, 2,400 kilometers</td>
<td>28,300,000</td>
<td>1,048,000</td>
</tr>
<tr>
<td>Dredging in Grand Canal</td>
<td>665,400</td>
<td>46,540</td>
</tr>
<tr>
<td>Sinnemiao Channel</td>
<td>926,000</td>
<td>55,560</td>
</tr>
<tr>
<td>Control works and lock at Tsangkiapa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Irrigation headworks near Chuchwang</td>
<td></td>
<td>725,000</td>
</tr>
<tr>
<td>Control works at Kaoliang Kan</td>
<td></td>
<td>200,000</td>
</tr>
<tr>
<td>Lock and control works near Tsangkiangpu</td>
<td></td>
<td>240,000</td>
</tr>
<tr>
<td>Lock and control works near Shaope</td>
<td></td>
<td>250,000</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>$30,000,000</td>
</tr>
</tbody>
</table>

ANSWERS TO QUESTIONS PROPOUNDED BY THE BOARD ON HUAI RIVER CONSERVANCY.

BY HENRY M. WOODS, HUAIANFU, KIANGSU PROVINCE, CHINA.

1. Did the region with which you are acquainted suffer severely from drought in 1914?
   A. This region suffered severely with drought in 1914.

2. Give an estimate of the loss due to drought in percentage of crop reduction or otherwise.
   A. Loss to crops due to drought estimated approximately between 50 per cent and 60 per cent.

3. How often in a period of say ten years do such droughts occur?
   A. A severe drought like the one of this year occurs rarely—once in a lifetime, the Chinese say—but droughts of lesser severity occur about every four or five years.

4. Did the region mentioned suffer in 1914 from floods?
   A. This region suffered considerably from flood this year.

5. Were the floods due to local rainfall, to overflow from the Grand Canal, or other causes?
   A. These floods were due partly to an unusually heavy local rainfall in August and September, 1914, but more to overflow from the Grand Canal, most of the water coming from the Shantung province north; also from the Huai River west, through the Hungtze Lake.
APPENDIX.

6. Give an estimate of the damage caused by the floods, either in percentage of crops or otherwise.
   A. Damage to crops due to flood in this region is estimated approximately at from 20 per cent to 30 per cent.

7. What is the value of agricultural land in your vicinity?
   A. Land in this region, being suitable for the culture of rice, is generally valued at about $40 Mexican a. Chinese mow, there being about 6½ mow to the foreign acre—that is, roughly estimating in gold, about $110 to $120 per acre. The land in Pichow and Hachow north, being much poorer and not adapted to rice culture, is valued only at about $15 Mexican per mow, or $40 to $45 gold an acre.

8. What, in your opinion, would be the value of this land if the waters of the Grand Canal were so regulated as to never overflow except when needed, and to furnish a never-failing supply of water for irrigation when needed?
   A. With proper regulation of the waters of the Grand Canal and other adequate conservancy work, the value of land would probably be doubled, and a large tract northwest of this section adjacent to the Hongtze Lake, which is now useless marsh (perhaps a million acres or more), could be made excellent farming land.

9. Define approximately positions and extent of the lands to which the above answers refer.
   A. The above statements have special reference to the Hualin district in northern Kiangsu, adjacent to the city of Hualanfu, on the Grand Canal, 120 miles north of Yangtze River, covering a region about 80 miles long by 40 miles wide.
   (Signed)

HENRY M. WOODS,
Hualanfu, via Chinkiang, Kiangsu Province, China.

ANSWERS TO QUESTIONS PROFOUNDED BY THE BOARD ON HUAI RIVER CONSERVANCY.

BY HUGH W. WHITE, YENCHENG, KIANGSU PROVINCE, CHINA.

1. Did the region with which you are acquainted suffer severely from drought in 1914?
   A. Yes; very severely. The rice crop depends on irrigation from the canals, but in these canals and streams the fall is so slight that in this dry weather the tide water from the sea, 30 or 40 miles eastward, made all the water strongly brackish. Crops could not be planted, as the salt water would kill them. In the cities and towns a population of hundreds of thousands, or probably over a million, had no water to drink but this salt water, and much distress, sickness, and death resulted. This country depends on the Huai for fresh water.

2. Give an estimate of the loss due to drought in percentage of crop reduction or otherwise.
   A. See (8).

3. How often in a period of say ten years do such droughts occur?
   A. Will investigate further. In the four years I have known the place more than two years have been heavy drought.

4. Did the region mentioned suffer in 1914 from floods?
   A. Yes. When the early crops were already cut by drought, there came on a heavy late flood and ruined the fall crops.

5. Were the floods due to local rainfall, to overflow from the Grand Canal, or to other causes?
   A. Chiefly due to flood waters from the Huai and the Grand Canal. I will investigate further as to whether local rainfall had much to do with it.

6. Give an estimate of the damage caused by the floods, either in percentage of crops or otherwise.
   A. Common report says that between drought and flood the crops will not make more than 20 per cent. Others say it is a complete loss. On this point am seeking more accurate information.

7. What is the value of agricultural land in your vicinity?
   A. Seeking more accurate information.

8. What, in your opinion, would be the value of this land if the waters of the Grand Canal were so regulated as to never overflow except when needed, and to furnish a never-failing supply of water for irrigation when needed?
   A. Seeking more accurate information. Would certainly increase.

9. Define approximately positions and extent of the lands to which the above answers refer.
   A. I enclose hasty sketch-map. My answer refers particularly to the Yencheng province, lying eastward of the Grand Canal. The vast network of canals in this territory could not be put on the sketch. They are all supplied with water from the Huai River, coming through the Grand Canal. The greatest flow comes down through the Shapoh Lake, into the Grand Canal at Shapoh, thence out to Helen-mu-miao, and through the lock there. From this point the water all flows northeastward through innumerable canals to Yencheng and Funing. In addition to this flow, there are a number of streams from the Grand Canal from Tungkiangpu southward. The territory in the Funing and Antung counties is also in
flood times affected by the old Yellow River bed. It is now wheat land and settled with people, but is liable to flood. I am just starting to Fuming and will there meet men from the Antung county. I hope to get further information from them.

(Signed)

HUGH W. WHITE.

MEASUREMENTS OF HUAI RIVER, CHINA.

<table>
<thead>
<tr>
<th>Date, 1914.</th>
<th>Locality.</th>
<th>Gage height above sea.</th>
<th>Area cross-section, sq. meters.</th>
<th>Velocity, meters per sec.</th>
<th>Discharge, Cu. meters per section.</th>
<th>Discharge, Cu. feet per section.</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 11</td>
<td>3 miles west of Peng Po.</td>
<td>128.8</td>
<td>721</td>
<td>.24</td>
<td>178.7</td>
<td>6.300</td>
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<td>17</td>
<td>Huai Yuen...</td>
<td>139.5</td>
<td>745</td>
<td>.27</td>
<td>203.2</td>
<td>7.150</td>
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<tr>
<td>20</td>
<td>&quot; &quot;</td>
<td>140.5</td>
<td>571</td>
<td>.31</td>
<td>180.2</td>
<td>6.390</td>
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<td>23</td>
<td>&quot; &quot;</td>
<td>140.8</td>
<td>675.0</td>
<td>.31</td>
<td>210.2</td>
<td>7.418</td>
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<tr>
<td>26</td>
<td>&quot; &quot;</td>
<td>140.6</td>
<td>521.9</td>
<td>.28</td>
<td>147.8</td>
<td>5.217</td>
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<td>29</td>
<td>&quot; &quot;</td>
<td>139.5</td>
<td>582.0</td>
<td>.24</td>
<td>135.5</td>
<td>4.782</td>
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<tr>
<td>Aug. 15</td>
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<td>1110.4</td>
<td>.50</td>
<td>571.6</td>
<td>20.176</td>
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<td>888.0</td>
<td>.80</td>
<td>525.6</td>
<td>18.549</td>
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<td>22</td>
<td>&quot; &quot;</td>
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<td>614.5</td>
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<td>.66</td>
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<td>Peng Po...</td>
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<td>.89</td>
<td>2019.5</td>
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<td>.92</td>
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<td>2390.0</td>
<td>83.800</td>
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<td>2626.7</td>
<td>.96</td>
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STREAM MEASUREMENTS.—R. J. NEWELL.

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<td>1914.</td>
<td>Yen River...</td>
<td>Huang Chwong...</td>
<td>33.5</td>
<td>.43</td>
<td>14.28</td>
<td>504</td>
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<td>Aug. 4</td>
<td>Yen River...</td>
<td>Huang Ying...</td>
<td>33.1</td>
<td>.43</td>
<td>14.78</td>
<td>527</td>
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<td>13</td>
<td>Channel to east...</td>
<td>Steen Miao...</td>
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<td>.43</td>
<td>63.69</td>
<td>2248</td>
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<td>23</td>
<td>Hungtsze Feeder...</td>
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<td>.58</td>
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<td>3002</td>
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<tr>
<td>23</td>
<td>Grand Canal...</td>
<td>1/4 mile below Matow...</td>
<td>427.8</td>
<td>.62</td>
<td>263.65</td>
<td>9504</td>
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<td>28</td>
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<td>Total...</td>
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