導淮工程計劃

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蔣中正

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NATIONAL GOVERNMENT OF THE REPUBLIC OF CHINA

The Huai River Commission

Bureau of Engineering

PROJECTS OF THE FLOOD CONTROL, NAVIGATION AND IRRIGATION FOR THE HUAI RIVER SYSTEM

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導淮工程計畫

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導淮工程計劃序

　　導淮之舉關係蘇魯皖豫四省亦影響蘇魯皖豫四省之民生自二中全會決議依已往十八年之調查成績實施濬治期以五年成功後國府即特設委員會並制定原則頒發訓令期於依限完成中央眷懷淮禍拯濟民生甚盛事也惟是發軔伊始一切施工程序計議不厭求詳雖前賢之遺規尚在而時過境遷實有重勘覆測之必要用是選任專門員司組成兩測量隊由總工程師督率分途進行遍歷淮河運河沂沭汶泗及黃河各處爲實地之查勘殫一年之力始擬定技術報告第一期並附以各種圖表用資佐證以茲事體大非集思廣益無以期精詳復由會召集導淮計劃討論會議集合淮河流域各省政府代表與導淮有關之中央水利機

關代表華洋義賑會代表及對於水利
素有研究之專家暨本會委員與工程
師會萃一堂博諮周議以爲最後之决
定今者此項工程計劃已經本會核議
認爲可行並已呈請國府備案工款有
着立可施行蓋淮河久爲災祲議治已
歷年所總以巨款無由立至爲實施之
難關論者更狃於言之匪艱行之維艱
之陳說而不達知難行易之旨未敢輕
於一試今幸計劃完成是難知者已求
得其知易行者當力踐其行吾人唯有
本　總理實業計劃之宏規念淮民不
食水利而受水災之困苦務於最短期
內籌撥巨款積極從事以完成此偉大
之建設玆以斯篇付梓特弁數語用資
共勉邦人君子以覽觀焉

中華民國二十年一月蔣中正

委員長副委員長暨各委員鈞鑒竊儀祉於民國十八年六月奉

國府令任本會工務處長受命之後深恐才絀任重竭蹶不前有負政府民生建設至意乃多方徵集專門人才以共仔肩旋於七月着手組織工務處八月成立總工程師辦公處設計組測繪組並組成兩測量隊一面偕同各工程師親歷江淮運沂沭汶泗及黃河各處查勘一面蒐集已有資料分途研究既悉淮域之形勢復明洪湖之水理乃以爲導淮入江入海各途計劃同時派隊測量入江入海各路十一月二十日本會所聘顧問工程師方修斯教授來京復與申勘要害詳究圖籍並與職處同人交換意見參互稽考乃擇其對於防洪灌溉交通三事最有利益工程最經濟者定爲計劃具爲報告而測量之事亦告成段落職處同人復據之以作更進之研究所得結果筆之爲此次之總報告其中各項設計大都根據於舊測圖表如經詳細之施工測量以後容有尙待修改之處至于治導綱要雖不敢謂萬無一失而本諸十餘年前賢之成績參之以中外水利工程師之經驗在導淮計劃中已定可循之軌理合具文詳陳敬乞

鑒核

工務處處長兼總工程師李儀祉謹呈

中華民國十九年五月三十一日

PREFACE

The project of the regulation of the Huai River, which embraces large parts of Kiangsu, Shantung, Anwhei and Honan, destined to exercise a profound effect upon the livelihood of millions of people. After the Central Executive Committee of the Kuomingtang passed, during the Second Plenary Session, the resolution to complete in five years the necessary work which is based on the data and maps procured in the past eighteen years, the National Government took to appoint the Huai River Commission and set forth basic principles and instruction with the purpose of carrying out the plan within the allotted time limit. The anxiety of the Central Government over the living conditions of the people dwelling in the Huai River valley should be honestly appreciated.

In order to make a good beginning no effort was spared in the elaboration of a working plan. With the general schemes as hitherto outlined by scholars and engineers becoming more or less out of date, resurveying work had to be undertaken. Specialists were therefore enlisted and in due course of time, two surveying parties were organized and sent out to the fields. Under the direction of the Chief Engineer, an inspection party traversed many localities in the valleys of the Huai River, the Grand Canal, Yi Ho, Shu Ho, Wen Ho, Sze Ho and the Yellow River. After one year's continuous effort and steady working, the Chief Engineer was eventually able to draw up the report No. 1 which gives projects of flood control, navigation, and irrigation for the Huai River System, and is illustrated profusely with diagrams and drawings. The Commission then decided to convene a special conference to give a final touch to the gigantic project and to this conference come representatives of the four Provincial Governments, the National Reconstruction Commission, the Yangtzekiang Commission, the Famine Relief Committee, and several specialists particularly interested in the conservancy problem of the Huai River, together with the members and engineers of the Commission. After a lengthy discussion the report was formally adopted whereupon the Commission submitted it to the National Government. As soon as necessary fund is raised, the work will be carried out.

To sum up, the flood problem of the Huai River Valley has long been a source of serious concern and much has been said to solve it, but due to financial difficulty solution work had to be postponed from time to time. Moreover, the "Easier said than done" attitude of certain people has always worked as a handicap. In this connection we believe in Dr. Sun Yat-sen's statement "Harder to know than to do". Now with the scheme having been duly prepared we shall endeavour to follow teachings in Dr. Sun's book on "International Development of China" and hope in the immediate future enough fund could be obtained to carry the great project to success, thus relieving forever the anxiety of the people in the Huai River Valley. On sending the report to press, I take the liberty to add these few paragraphs in the hope that my countrymen would give their hearty approval.

Chiang Kai-shek

Nanking, January, 1931.

Letter of Transmittal

Huai River Commission, Engineering Bureau,
Huaiyin, Province of Kiangsu,
May 31, 1930.

President Chiang Kai-shek, Chairman,
and the Honorable members of the Commission,
Nanking.

Sirs:

I have the honor to submit herewith the first number of official Technical Reports on the projects to effect the flood control and the improvement of navigation and irrigation of the whole Huai River system.

In last June, by the order of the National Government, I was appointed concurrently the Chief Engineer of this Commission and Commissioner of the Engineering Bureau. Seeing the heavy duties thus imposed on me, and the Government's anxiety in the Nation's Reconstruction, I made every effort to enlist the services of the engineering specialists from different parts of the country. The office of the Bureau was successfully established in July in the Capital. Then I proceeded to Huaiyin to organize there the Chief Engineer's Office with its two departments, engineering and surveying. Two surveying parties were also subsequently formed and sent to the field. Afterwards, I went on an inspection tour with several engineers to examine at closehand the different rivers, including the Yangtzekiang, Huai River, Yellow River, Grand Canal and the Yi, Shu, Wen, Sze rivers. In the meantime, the available topographical and hydrological data and records were carefully collected and analysed.

After grasping the general characteristics of the region under question, and the hydraulics of the Hungtze Lake, comparative estimates of different projects to send flood water of the Huai River either to the Yangtzekiang or the sea, were made. Surveying parties were also instructed to make surveys along the most possible routes contemplated.

On Nov. 20, 1929. Prof. Otto Franzius of Hannover University, the Consulting Engineer of the Commission, arrived at Nanking. I went with him to the important rivers and localities, and showed him all available maps and records. After holding conferences with our engineers, and carefully studied the problem, he was finally able to state his opinion as to the most economical and practical projects to effect the solution of the problem in his report. Based on his suggestions and the field data, the surveying work being finished in due course of time, and then further investigation and designs were made by my engineering staff. The result of the study is contained in the present report.

Part of the schemes are based upon the former records and maps, therefore they are subject to change when complete surveys are made. With the accomplishment of surveys and records of the far-sighted men in the past decade and the experiences of the foreign and native engineers, this report, it is hoped to set forth a right way to the solution of the problem on hand.

Respectfully submitted

H. Li (signed)

Chief Engineer and Commissioner.

總理遺囑

余致力國民革命、凡四十年、其目的在求中國之自由平等、積四十年之經驗、深知欲達到此目的，必須喚起民衆及聯合世界上以平等待我之民族，共同奮鬥！

現在革命尚未成功、凡我同志，務須依照余所著：建國方略、建國大綱，三民主義、及第一次全國代表大會宣言，繼續努力，以求貫澈。最近主張，開國民會議，及廢除不平等條約、尤須於最短期間，促其實現！是所至囑！

總理遺像

導淮工程計劃

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導淮工程計畫

第一章 總論

第一節 引言

淮河尾閭之失途,不自遜清咸豐五年銅瓦廂決口,黃河北徙始。而始於黃河奪淮故道,洪澤湖下至清口河床逐漸高仰之時。自明至清,河臣所亟急者,抬高洪澤湖面,蓄清以刷黃耳。洪湖不高,則清口故瀆有黃無淸可知。淮河之水早以出三河入江爲正軌。及黃河北徙,涓滴斷流,故道之弊乃顯然。於時山陽丁顯首倡導淮之論,有心之人和者羣起。清之垂末,張謇主持尤力。迨及民國,創設江淮水利測量局,後改爲導淮測量處。由民元起施測至民十五止,成績最多。其他淮域中測量工事,則有江北運河工程局,淮揚徐海平剖面測量局,安徽水利測量局及山東運河工程局,分別爲之。故關於淮河之圖載,在吾國中其詳備爲他河域冠。前賢之力不可泯也。至於治導方略,中外人士建議良多。其擬有具體計劃者在客卿方面則有美國紅十字會之報告(一九一四年)及美國工程師費禮門報告(一九二〇)。在本國方面則有江淮水利局計劃,安徽水利測量局計劃及全國水利局計劃。私家研究,以灌雲武同舉著述爲最多。其淮系年表一書,尤足珍貴。民國肇造十有餘年,軍閥橫肆,亂無寧日。導淮

之事,雖經有心人竭力提倡,迄未能見諸實施。民國十七年建設委員會設整理導淮圖案委員會,搜羅關乎導淮之計劃圖表及各方建議殆盡。整理之後,成整理導淮圖案報告一書。民國十八年一月,政府特設導淮委員會,先後特派委員二十人,而以黨國領袖爲之長,政府之注重導淮可知。繼卽總務處,工務處,財務處相繼成立,又聘德國漢諾勿工科大學方修斯教授爲顧問工程師,於是年十一月二十日抵京,合同以半年爲期。其間經變亂多端,跳梁至今未靖。而政府一面申討不軌,一面力圖建設,並不稍懈。同人均能仰體上意,勤奮工作,研究結果,著爲報告可以爲計劃依據者,有洪澤湖之水理灌漑需水量之研究,洪澤湖蓄水與減洪作用之研究,淮河洪水頻率之研究,導淮經三河高寶湖入江之初步計劃,導淮經廢黃河入海之初步計劃,導淮經張福河鹽河灌河入海之初步計劃,導淮經射陽湖入海之初步計劃,山東減除洪水之初步計劃,各計劃皆詳定其路綫,比較其土工,以資評斷。旣以比較結果趨重於三河入江及灌河入海二途,於是組隊實測二千五百分之一地圖。此外則三河壩,邵伯鎭,淮陰,擬設壩閘之址,亦皆實測詳圖,以供確實計畫。又復於閘壩之址,鑽驗土質,以明瞭其基址情形。凡此皆爲計畫根本之作。方氏亦殫心竭力,多方擘畫。與同人相處數月,意洽然也。雖以地方不靖,未能遍履淮域,而猶幸淮河之圖載尙富,加以同人中熟悉情形者知無不告,本其學識經驗,草成全體計畫,作爲報告,褎然巨册於淮河上

中游及其支流之防災工事,洪澤湖微山湖之利用,三河之出口,運河鹽河灌河之開通,汶泗沂沭之治導,交通及灌溉之籌劃,靡不詳盡。此外於黃河之治導,亦參考所有圖載,另成報告一册,其計畫皆經同人反覆推論,以求其工最省,效最宏。故此次報告中計畫,大體皆與方氏同致。惟計算之間,擬數稍有區別耳。凡可視爲終結之計畫,立卽爲工程設計,如瀉洪河床,蓄洩活壩,航行船閘等,並擬以各種式各種材料,參酌比較,以擇其最省工最合用者。故一經委員會審定,工費有着,立卽可以興工。至於治導計畫,將於下節述其綱要。

第二節　導淮治運綱要

導淮之目的,曰防洪災,便航運,裕農利,而發水電附之。防災爲目的之主要者,先祛害而後言利也。淮河全體以洪澤湖爲樞紐。運河全體以微山湖爲樞紐。蘇皖之爭在是。蘇魯之爭在彼。用之則防洪便航利農發電等事,全部靈活。涸之則全部困滯。故導淮治運盤根錯節,於斯乎解。灌溉之利,人知其重矣。交通之要,多或忽焉。吾國腹地之廣,淮域居民之繁,僅恃津浦一路,紆繞而委輸其貨物,工商之不振,民生之憔悴,匪盜之繁興,交通不便,爲其大原也。故謀國者首重民生。謀民生者於生衆食寡以外,在今日世界,宜益以不可少之二原則,曰運脚極省,能力極廉。以運脚相衡,陸道鐵道十至五而水道一。以能力相衡,

則水電相因而生,幾於不費之惠。此而不為,尚有可為者乎。以下關於防洪航運交通灌漑各節,當分章詳論,關於水電,正待繼續研究,容當另詳。玆先舉其綱要如下。

一,開闢淮河主要瀉洪河床,出三河穿高郵邵伯諸湖,於六閘以下循廖家溝等河注之江。入江水量,以不使揚子江超過民國十年最高水位為原則。於蔣壩洪澤湖口,設活動霸以調節入江之量,即江水若漲至民十高水位時,則減洩至每秒六千立方公尺,水落則逐漸增至每秒九千立方公尺。淮水入江之量一經活動壩之調節,不致盡量下洩入江,故於江為有利而無害。此項計畫,工程最省,大體經過低地,祇須建築雙堤,河流即有定槽,而高寶諸湖,可因以涸出之墾地凡一百餘萬畝。

二,修建蔣壩洪澤湖口活動壩,以調節洪澤湖之水面。平時在黃河零點上13.6公尺。最低時使不下11公尺,以便航運。而灌漑所需之水量及降度,亦由此支配。

三,以洪澤湖為停蓄之所。淮河尋常洪水,由三河支配使湖水面在洪水未至時,高無過廢黃河零點上12.5公尺。若遇江水低落而洪水來量在每秒九千立方公尺以內者,儘量瀉出。過於九千,則流出量以每秒九千立方公尺為止。洪水餘量,將儲之於湖。以所擬最大洪水量每秒一萬五千立方公尺計,則應停於湖中者,自每秒零立方公尺至六千立方公尺者,凡二十五日,計增高湖面至15.6公尺。若淮漲之期,亦值揚子江來

水最盛,則限制三河流量爲每秒六千立方公尺,增加停量.此爲非常之遇,千百年而一次,湖水面增高亦無過16.10公尺。將來經費充裕,再增淮洪入海之路,則可以減輕洪澤湖之負擔。

四,洪澤湖以上淮河及其最要支流,應設隄防。蓋淮河中游平淺,舍築隄防洪外無他法。淮河自洪河口下至雙溝,俱設堅固有律之隄。支流應設隄者。有洪河,潁河,淠河,史河,西淝河,茨河,渦河及北淝河一部,澮河及沱河。其河床淩亂有須改正者,如潁河及西淝河入淮一段。支流密近有宜合併者,如茨河北淝河併入渦河。淮河本身灣曲太甚,有應截直者,如郭台子,三河尖,趙家集及鳳臺縣治以北一段,雙溝集以西鑿山脊入溧河逵歸洪澤湖一段。淮河本身橫斷面太狹有須拓寬者,如洪河口以下,馮台子,鳳臺,蚌埠,沫河口,安淮集等處。蚌埠之北,津浦鐵路須添造橋孔,以利宣洩。

五,淮河中游,及各支河流域,當河槽高水位時,可藉現存各湖泊暫時瀦積過量之雨水。其無法宣洩之水,則開溝洫設滂浦以排入幹河。滂浦機器或用風力,或用其他原動力。

六,運河中設七船閘,初辦以通行九百噸船爲準。但留將來擴增至二千噸之餘地。七閘所在自揚子江起 一,邵伯鎭 二,淮陰 三,劉老澗 四河定閘 五,得勝閘 六,藚家口 七,蔣家溝 以達黃河。各閘之間,水深不足者挖深之。隄缺者完補之,增高之。邵伯鎭以下

至瓜洲及三江營,完全開放。其航水資藉江潮。水深不足處挖深之。淮陰閘爲中運裏運及張福河鹽河之交义點,以一閘當四河相互往來之用。舊閘一律廢除。

七,張福河上達洪澤湖及淮河中游,無需他閘。淮陰交义處,運河鹽河須改道一段。鹽河下游於蔡工渡及新浦各設一船閘,灌河上端設一船閘,起首亦以通行九百噸船爲準。留增加至二千噸船之餘地。各閘間水深不足者挖深之

八,劉老澗閘上東堤之內,設一減水活動壩,以瀉泗河洪水入沂。此閘以上各船閘,旁皆附活壩,以裕洪水之路。微山湖以上諸河洪水,以微山湖停蓄支配之。

九,以微山湖爲停蓄之所,使其水面在廢黃河零點上35.1至30.6公尺之間。限制洪水出湖之量,每秒不逾一千立方公尺。所蓄之水,以濟航槽及備旱年灌溉。

十,改建蘆口壩,導沂由周家口而南,穿駱馬湖至其南端。除留蘆口壩一路濟運有活動壩支配外,其他各口俱堵築之,使完全與運河隔離。至三岔渡與劉老澗旁減水壩所出之泗河水相會。出北六塘入灌河。

十一,導沭循其舊道至沭陽經前沭河,薔薇河入臨洪河。與沂河隔離。沂沭上游或可築水庫以節洪水量,尚待調查。

十二,三河壩旁,附設一小船閘,以便民船由三河上下。

十三,開潯河由洪澤高良澗出,穿運河涇河閘,經射陽湖達串場河。高良澗旁洪澤湖設一船閘。涇河閘旁運東堤

設一船閘。運河東西以至范公堤間灌溉之水,取給於是河。其分水由溼河閘處分歧爲三路。向南至邵伯鎭。向東與串場河相會。向北至淮陰。灌溉面積總計可達一千五百萬畝。又運河入洪澤湖之船舶,亦可取道於此,以達淮河上游。

古,由鹽河於蔡工渡閘上開新河向南,橫貫黃河舊床,至阜寧與串場河連通。其水供范公堤以東灌溉,並濟串場河航運之需。串場河及新洋港應設之閘,待測量後始可確定。

宝,淮河懷遠附近,擇地設一船閘,及活動壩,以濟洪澤湖以上之航運。

夫,灌河口設一海船港,以接內航水道,其計畫尙須繼續研究,始可決定。

七,三河壩擬設一座五萬匹馬力之大水電廠。浮山,洪河口間及微山湖,亦可設較小之水電廠。其詳細計劃正在繼續研究中。

以上工程,範圍甚廣,實施之時,當分先後,將於後章詳之。

第三節　施工程序及經費估計

淮河流域以內,排洪航運灌溉各工程,經緯萬端,需款孔多,勢難同時舉辦,施工須分先後。其程序,以全部論,先去害,繼興利,故排洪爲首,灌溉航運爲次。以局部論,害

表 1　第一期工程分年經費計算表

民國二十年開始至民國二十五年完成

工程類別 ＼ 年別	第一年	第二年	第三年	第四年	第五年	總計
禦洪工程	8,218,200元	8,218,200元	7,718,200元	7,818,200元	600,000元	32,572,800元
(1)建築蔣壩鎮洪澤湖口活動壩及船閘魚道	1,000,000	1,000,000				2,000,000
(2)開挖淮河入江水道	7,218,200	7,218,200	7,218,200	7,218,200		28,872,800
(3)修築洪澤湖圍堤及洩水閘				600,000	600,000	1,200,000
(4)建築中運河活動壩三座			500,000			500,000
灌溉工程	150,000元	750,000元	3,050,000元	2,300,000元	3,350,000元	9,600,000元
(1)添置裏運河各閘洞新式閘門	100,000					100,000
(2)改建通揚通運河口閘門	50,000					50,000
(3)開挖洪澤湖至涇河閘之幹渠及建築進水閘		750,000	750,000			1,500,000
(4)興辦高寶湖區墾闢工程			2,300,000	2,300,000		4,600,000
(5)開挖鹽河至串場河之渠					1,110,000	1,110,000
(6)開挖涇河閘至串場河之渠					2,240,000	2,240,000
航運工程	1,925,200元	1,630,900元	1,651,600元	2,000,000元	160,000元	7,367,700元
(1)建築淮陰邵伯二船閘	750,000					750,00
(2)自劉老澗至三江營及懷遠至蔡工閘航道浚深及築堤	875,200	800,000			160,000	1,835,200
(3)建築蔡工新浦龍溝三船閘	300,000	600,000				900,000
(4)建築龍溝活動壩及草壩共三座		200,000				200,00
(5)自蔡工閘至新浦閘航道浚深及築堤		30,900				30,900
(6)建築劉澗河定得勝三船閘			1,100,000			1,100,000
(7)自[illegible]窯口至劉澗閘航道浚深及築堤兼改建鐵路橋			551,600	2,000,000		2,551,600
總計	10,293,400元	10,599,100元	12,419,800元	12,118,200元	4,110,000元	49,510,500元

表 2　第二第三期工程一覽表

工程期次	工程項目	工程細目	工費估計
第二期工程	排洪工程	1. 沂河治導工程	$9,596,400
		2. 泗河治導工程	372,200
		3. 沭河治導工程	7,759,200
		4. 淮河上游幹河治導工程	70,000,000
	灌溉工程	1. 裏運河開浚汜水至高郵之河槽	
		及增高淮安至汜水之隄頂	$ 757,600
		2. 建造串場河通海及通揚運河通	
		江諸閘	待　估
		. 中運河不牢河兩岸建閘開渠	,,　,,
	航運工程	1. 疏濬山東南運河並建造船閘以	
		達黃河	待　估
		2. 淮河懷遠建造船閘及活動壩	,,　,,
		3. 臨洪口灌河口海橇工程及灌河	
		港埠工程	待　估
第三期工程	排洪工程	1. 淮河上游各支流治導工程	待　估
		2. 山東南運河湖上游治導工程	,,　,,
	灌溉工程	1. 山東南運河湖各區農田水利	待　估
		2. 淮河上游各區農田水利	,,　,,
	航運工程	1. 添築船閘連絡裏運河鹽河與串	
		場河之航道	待　估
		2. 濬深各河渠並添築船閘航行二	
		千噸之船隻	待　估
	水電工程	1. 蔣壩洪澤湖口水電工程	
		2. 微山湖口水電工程	,,　,,

先去其重者,利先興其大者。故於排洪工程,須先從下游着手,尾閭既暢,在下游固免泛濫之災,在上游亦減壅阻漫溢之害。於航運工程,先辦目前通航主要之道。於灌溉工程,首及農產重要之區及新涸之地。此外則擇需費少而成效速者,提前建設之。務就目前財力之能及,舉辦收效最宏之工程,而後逐漸以及其餘。本此原則,擬定施工之程序及經費估計,列如表 1 及表 2。

關於第二期第三期工程,如下列各章所述,尚須作詳細之研究規劃,以求工費之節省,表列各費,僅示概略。

第一期工程完成以後,可以直接免除洪水並同時得水灌溉者約二千萬畝,每年每畝平均徵收水捐一角,

年得二百萬元。航路可以通暢無阻者達九一三公里，在最初數年，每年來往貨物以二千五百兆噸公里計，每噸公里平均徵貨運捐三厘，年入七百五十萬元。而高寶湖新地之價值，約有四千萬元。又廢黃河已墾未墾之公地，約有九十五萬畝，淮水既不再經過斯河，該項公地，可清理放墾，其地價當在一千萬元以上。憑此各項產業及收獲，卽可繼續建設第二期第三期工程，以底於全部之完成，不必更籌巨款矣。

第四節　治導後之利益

一,可以避免洪水之地面

洪澤湖以上淮河流域	20,000,000	畝
裏運東西	18,000,000	畝
沂泗沭流域	12,000,000	畝
共計	50,000,000	畝

二,可以涸湖增墾之地面

盱眙五河之間	500,000	畝
廢黃河	950,000	畝
高寶邵伯等湖	1,000,000	畝
共計	2,450,000	畝

每畝平均價值以二十五元計約共 60,000,000 元

三,可以得水灌漑之面積

高寶湖區	2,250,000	畝
裏運以東范公堤以西	11,740,000	畝
沿通揚運河	2,500,000	畝
范公堤以東沿海	5,000,000	畝
微山湖以南	20,000,000	畝
共計	41,490,000	畝

每畝徵水捐每畝每年以一角計　每年共徵 4,149,000 元

四,開通航路共 913 公里。初辦數年,每年運輸貨物以二千五百兆噸公里計。每噸公里平均徵貨運捐三厘,每年可徵 7,500,000 元,關捐碼頭捐不在其內。

第二章　排洪工程計畫

第一節　淮河之洪水量及其周期

淮河之洪水量

淮河源出河南省桐柏山,東行會豫皖之洪,汝,灌,史,淠,潁,淝,渦,澮,池諸水,至龜山注洪澤湖。(見總圖)而後由張福河三河分途洩入江海。洪澤湖之進水總量,卽爲淮河之排水總量。惟歷年流量測量,因下游入湖口門,不便施測,其主要測站,設於蚌埠。按淮河流域面積,依據舊測各圖在洪湖以上約爲166,110方公里,蚌埠以上,約爲124,610方公里。蚌埠流量,以流域面積爲比。僅及全量百分之七五。其氣象,地質,地形等在流域內互相類似,若以蚌埠之流量爲主,以流域面積之比,推求其餘支河之流量,而得淮河之總流量,結果亦有足恃。準此以推求淮河逐年最大洪水量列如下表。

表 3　淮河逐年最大洪水量　(以每秒立方公尺數計)

年份	民國四年	民國五年	民國六年	民國七年	民國八年	民國九年	民國十年	民國十一年	民國十二年	民國十三年
洪水量立方公尺	2,100	12,900	3,300	2,400	3,350	1,600	6,200	1,570	4,250	3,900
備考							是年淮河蚌埠以上決口			

據上表所列,十年之中,洪水量在1000至2000立方公尺間者,兩年。2000至3000立方公尺間者,兩年。3000至4000立方公尺間者,三年。4000至5000立方公尺間者,一年。5000立方公尺以上者,兩年。內以五年洪水爲最巨。惟民國十年,淮河及其支流,相繼決口,水漫平地,經過測站之水量較小,其値乃不足恃。若以蚌埠之水位言,民十爲19.84公尺,民五爲19.825公尺,民十固較民五爲高。以淮河下游排水孔道三河之最大流量言,民十爲14,600立方公尺,民五爲8,400立方公尺,民十亦較民五爲大。故由過去之記載,知民五民十,爲淮河最大洪水之年,可無疑義。而民五之最大洪水量,依據上表,已知爲每秒12,900立方公尺。至於民十,以隄決故,表中之値,旣不足恃,應另行審定者也。

按各時期三河及張福河之洩水量與洪澤湖蓄水盈虧之和,得淮河之洩水總量。根據民國十年三河及張福河之流量記載,與相當時間之洪湖水位(蔣壩)記載,其受風之影響,而及於洩水量者,更正計算之,得是年之洪水量曲線,閱第一二圖。

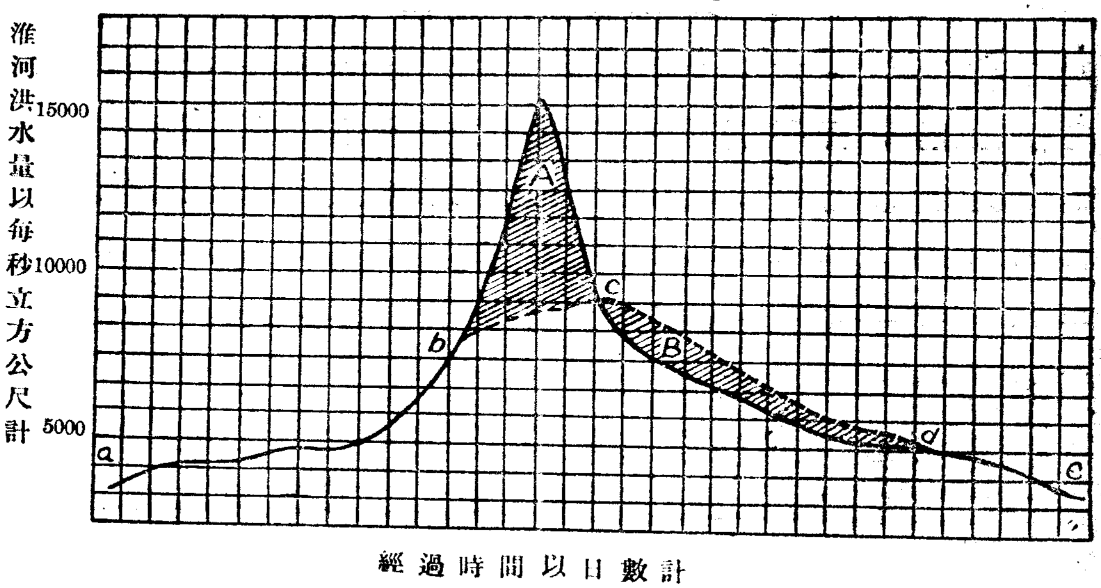
自圖得洪湖之最大進水量,卽淮河之最大洪水量,爲每秒15,000立方公尺比較民五,超出2,100立方公尺,實爲淮河洪水量之最高値也。(按此値經方修斯顧問批評以爲估算過高。但爲安全計,仍被採用。)

防洪工程若全恃排洩,則洪水之最高量,卽爲規劃唯一之根據。若兼恃攔蓄,有水庫爲之輔,則洪水量外,其

相當於各水量之時間長短,更有密切之關係。例如上圖所示,洪水量大於每秒 10,000 立方公尺者,歷時約三十日。大於 12,000 立方公尺者,歷時約二十八日。大於 14,000 立方公尺者,歷時約十八日。今若其量不變,而時間僅及上述之半,則攔蓄任何量以上之洪水,其應蓄之量,將僅及其半。而所需水庫之容量,亦僅有其半已足。

洪水量之大小及時間,欲同時表示,其最簡明者,卽爲洪水量曲線,如第二圖,其縱軸示水量之大小,其橫軸示相當於各量之時間,斯項曲線,如憑實測爲根據而繪成者,精確無疑。否則仍不免失之過大或過小。據本會顧問工程師方修斯之意見,上述民國十年之洪水量曲線,或係最非常之境況,證以經驗,不易遇到。蓋是年淮隄決口,水流失常,計算時視同其他各年,容或不確。而計算湖水盈虧,所憑恃之水尺,僅蔣壩一處,以洪湖之大,全湖面之變遷,及風浪之影響,必不爲小。以限於一地之水尺,爲全湖水位昇降之標準,更無法計算風浪之影嚮以改正蓄水量,其結果容亦不合實狀。上述曲線,若竟採用,固可應付最非常之洪水而有餘,然未免過屬安全,而因此所需工程較巨,工費較大,似可不必耳。

按民國十年,淮河上游,雖隄岸潰決,而根據實測之流量曲線尚存。此項曲線,較之無潰決時,其橫軸爲寬,(卽時日延長)因水之散漫於流域地面以上者,其流速較在河槽爲緩,故當洪水峯過後,溢水逐漸緩流歸槽時,河之中水量,及其經歷時間,大爲增加。若洪水量曲線,隄



第三圖 修改洪水峯方法圖

岸無潰決時，如第三圖實線所示。則隄岸潰決時，其相當之曲線，將如虛線之形。圖中A部所代表之水量，當較B部為大。蓋A部原有之水量，於到達B部以前，必有一部分由蒸發滲漏及流入他河而先行損失也。為安全計，假定斯項損耗總量，為決口溢水總量之半，並定洪水峯之最高值，為每秒15,000立方公尺。於是完成流量曲線abcde，令其最高點在15,000立方公尺，令B部之水量等於A部之半，是即較為切合於眞實狀況之流量曲線。包圍A部之邊線，應為鋸齒狀之灣曲線，但缺少記載不能杜撰，姑定為直線。良以直線所代表固偏於安全方面者也。如上所述，因以製定民十洪水曲線如第四圖，為淮河最大洪水之標準。

最大洪水量之周期

各河洪水，小者每隔一二年，發生一次，稍大者每隔

五年或十年一次,更大者二十年或五十年一次,至極大之洪水,則千百年間偶或遇之。欲求洪水之周期,須有長時期之流量記載,方能準確。淮河之流量記載僅及十年,自不敷應用。而如民十大水,是否即為每隔十年一次,二十年或五十年以後,是否將有更大之洪水,在規劃導治工程之前,不得不設法研究者也。

考河道洪水之發生,概由於暴雨。苟在全流域以內,同時平均承受最大之暴雨量,而其暴雨經歷之時日,適等於該流域最遠點之雨水流達所求洪水量處必需經歷之時日,且在逕流與雨量最大之比率時期,(即暴雨量之一部,不經滲漏,不經池湖之攔阻等等,而立時流入河道之百分率為最大時)則發生洪水峯之最高值。故苟知暴雨量之周期,可約略求得洪水之周期。奈淮河流域之雨量記載,一如流量記載,殘缺幾等於零,實不能採用。惟徐家匯天文臺,於長江流域,則有四五十年之雨量記載,江淮比鄰,氣候相似,七八月洪水時期之暴雨,其主原為東南來之颱風,經歷江淮流域復相同。長江流域之暴雨,亦可發生於淮河流域。長江流域之暴雨周期,容亦相當於淮河流域。故根據徐家匯天文臺公佈之鎮江,蕪湖,九江,漢口,宜昌各站之雨量記載,(民國紀元前三十二年至民國十三年)推算繪製為江淮流域最大月雨量及最大日雨量之周期曲線,如第五圖。採用圖中最大日雨量曲線所示各值,並搜集暴雨量與經歷時日及流域面積之關係推算之,估定淮河流域最遠點之水,流達

洪澤湖之時間爲五日,淮河流域逕流,與雨量之比,當平常洪水,爲百分之二十,非常洪水,爲百分之二十五,於是推算淮河洪水量與周期之關係如下表。

表 4　淮河流域之洪水周期（依暴雨量比率推算）

周期	最大日雨量（公釐）	全流域五日內平均最大雨量（公釐）	全流域每日平均最大雨量（公釐）	逕流與雨量之百分比	全流域每日逕流（公釐）	洪水量（每秒立方公尺）
十年	15)	172.0	34.4	20%	6.88	10,000
廿五年	200	187.5	37.6	20%	7.52	11,000
五十年	245	198.0	39.6	25%	9.90	14,400
一百年	300	214.5	43.0	25%	10.75	15,500

上表所示各值,得自所應用之各項記載及數值,而非得諸淮河本部直接的測驗,固不能盡恃。惟各步計算,皆偏於安全方面。而如民十大水,爲不易多遇,每百年或僅有一次,則可以預料者也。

美國傅爾歐氏 Fuller 曾本各河大水之記載,求得各河各次大水流量與各該河每年尋常大水流量之比例,列成一表,復以比例數之大小,依次編入,作爲同一流域之記載,共得一千六百七十二年之期間,由此求得洪水與周期之公式如下。

$$Q = Q_a(1+0.8\log T)$$

Q ＝洪水流量以每秒立方公尺計（一日二十四小時平均）

Q_a ＝每年尋常洪水流量以每秒立方公尺計

T ＝洪水周期之年數

由第三表,淮河洪水量之記載,知除民五民十外,以民十二爲最大,爲每秒 4,250 立方公尺,爲安全計以此數爲淮河每年尋常洪水量代入上式推算之,得下表。

表 5　淮河洪水之周期　(依傅爾歐氏公式計算)

周期	十年	二十五年	五十年	一百年	五百年
洪水量 以每秒立方尺公計	8,100	9,530	10,500	11,700	14,200

表中洪水量,爲一日二十四小時之平均值,在二十四小時以內,洪水量之增減,或可大至十分之一二。其值與第四表所列,相近而較小。前後所得之結果,其確實之數值,雖有參差,而民十洪水量,其周期必在百年以上,卽以後有更大之洪水,其量所增徼幾,則可逆料得之。

今試更以歷史記載證之。民十淮河洪水,漫溢之災,及於霍邱,潁上,鳳臺,壽縣,懷遠,宿縣,靈璧,五河,泗縣,盱眙等屬,約有 11,740 方公里。平地水深,自一公尺至四公尺。考諸已往,據武同舉氏所著淮系年表,在最近三百年中,淮河水災之廣大,類如民十者,可三次。一在順治六年,(民國紀元前二百六十三年)是年淮水溢,息縣,潁州,霍邱,五河,泗州,俱大水,泗城水逾丈,平地一望如海。一在乾隆六年,(民國紀元前一百七十一年)是年潁州,太和,潁上,霍邱,亳州,蒙城,宿州,靈璧,五河,泗州盱眙,均大水。一在同治五年,(民國紀元前三十三年)是年永城,宿州,泗州,鳳陽,五河,盱眙等大水,爲從來所罕有。此外則洪水之災,雖歷年不絕,而大概僅及三四縣屬,無如斯之烈

者。卽所舉三次,雖平地之水深不詳而範圍之廣,亦未能盡如民十。是以如民十之洪水,縱不爲空前絕後,而爲非常之水,非隔百年以上,所不輕見者,於此亦可決然無疑。

由上所述,如民十洪水量,可代表淮河之最大洪水量,以此作治導之標準,實可安全無慮。

第二節　淮河下游之治導

淮河上挾豫皖之水,匯注於洪澤湖,經三河張福河,由裏運河之歸海歸江各壩,分洩於江海。其入江之途,自三河穿高寶湖越六閘左近之歸江十壩,匯流至三江營入江。爲淮水宣洩最要之道。惟以江水之頂托,載量之不足,其洩量乃遠遜於來量。至歸海各壩,則下游地勢低窪,入海水道更狹淺,不能容巨量之水,於是各壩洩水,縱能減輕上游之沈災,亦勢須造成下游之氾濫。每次啓放歸海各壩時,運東運西人民,必各死命相爭持。因之歸海壩之啓放,時期必遲,而淮水之蓄積於洪澤高寶諸湖者,必達巨量,沿湖及上游。已罹災厄。故每次淮漲,運東運西,上游下游,必同罹其災,不可或免。而據民十實測,洪澤湖下洩之量,合三河張福河計之,最大時爲每秒 15,158 立方公尺,歸江歸海各途之洩量,合計爲每秒 13,700 立方公尺,仍有每秒達1,458 立方公尺之水量,壅積於高寶湖間。苟上游之來量不減高寶湖瀦蓄水量,依時增多,湖水水面,將繼漲增高,足使上游積水,壅阻不前,沉災彌

烈而湖至不能容時，萬一漫溢運堤，洪流東趨，裏下河區更將不堪設想。故就淮運現狀言，若遇民國十年大水，即歸海壩啓放得時，亦不能減免淮水之災。況以鄰爲壑，悖於政體乎。今入江一道，既不足應宣洩之需，洪澤諸湖，又難應蓄積之用，欲免沉災，自不得不另謀導治之策也。

導淮路綫之主張，亦已夥矣。本處逐一詳加估算比較，深知入江實較入海爲經濟。而入海之道，以經由張福河，鹽河，灌河一綫，較由廢黃河或其他爲省易。故從排洪着想，應以入江爲主，入海爲輔。惟洪澤諸湖，在今日爲天然之洪水庫儲，應盡量利用之，使排洪之尾閭工程，得以減省。又淮運枯水流量極小，沿運灌溉，不得不仰賴於蓄水。灌溉蓄水之庫，其位置愈高爲愈佳。惟在高處，庶其流可以及遠。洪澤湖水位又復高下得宜，實一極好之蓄水庫也。爲兼籌並顧計，不憚再四研求，爰敢決定導淮之技術上原則凡三。（一）排洪入江，而不令江受淮害。（二）利用洪澤湖攔洪，以減省尾閭工程。至來日國庫充裕，開闢入海之道，以減輕洪澤湖之負擔。（三）兼用洪澤湖蓄水，以發展灌溉。今試逐一詳論之。

入江水量之決定

民國十年九月十九日，據江淮水利局之推算，淮水入江，每秒約8,000立方公尺，爲入江量之最高値。是時長江水位，在鎮江爲22.90呎，（吳淞零點爲準下倣此）同年八月二十一日，値長江之最高水位24.50呎時淮水入江，約近6,000立方公尺。以此爲例，欲令長江洪

水期之水位,不受變更,淮水入江之量,當在6,000至8,000立方公尺之間。設淮水上游,無水庫爲洪水消長迴旋之地,而必全賴尾閭排洩者,則可恃入江之量,僅及6,000立方公尺而已。若在本計劃中,則有洪澤湖調節淮流。於是當江水位達最高時,可依舊宣洩6,000立方公尺,惟在江水位減低時,淮水洩量始可隨之增加。但無論如何。其增洩之量,必不使江水位高出於原來之最高水位24,50呎,更又必不使江水位最高時日,過分延長,庶於淮有利,於江則無害矣。

欲知長江在最大洪水時期,能承納淮水逐日最大之洩量,應先計算長江容量與水位之關係。更先略事研究南京江陰間長江水流狀況。

據浚浦局報告,民國四年七月十九日,長江在南京之洪水量,爲每秒72,000立方公尺。南京鎭江之間,無巨大支流,可增入巨量之水。鎭江之洪水量,可亦假定爲72,000立方公尺,無大錯誤。考民四鎭江之最高水位,在七月二十日,爲20,65呎,卽爲上述大水流達鎭江所產生之最高水位。在民國十年,鎭江水位,最高至24.50呎其相當流量,必較民四爲大。用傅希海滿氏 Forchheimer 公式求之。

$$Q = \frac{1}{n} At^{0.7} J^{0.5}$$

$$Q_1 = \frac{1}{n} A_1 t_1^{0.7} J_1^{0.5}$$

式中Q爲流量,以每秒立方公尺計,n爲河床糙度系數,t爲平均水深,以公尺計,J爲水面降度。流量稍有

變更。降度變更極小，若假定爲相同，於是

$$\frac{Q}{Q_1}=\frac{\frac{1}{n}At^{0.7}J^{0.5}}{\frac{1}{n}A_1t_1^{0.7}J_1^{0.5}}=\frac{At^{0.7}}{A_1t_1^{0.7}}$$

$$Q=\left(\frac{A}{A_1}\right)\left(\frac{t}{t_1}\right)^{0.7}Q_1=\left(\frac{A}{A_1}\right)^{1.7}\left(\frac{W_1}{W}\right)^{0.7}Q_1$$

設河槽之平均寬，當流量增大時，廣闊若長江，當變化極小而可不計，即設 W_1 等於 W。於是

$$Q=\left(\frac{A}{A_1}\right)^{1.7}Q_1 \cdots\cdots\cdots\cdots\cdots(1)$$

按民四長江在鎮江洩量 Q_1 爲 72,000 立方公尺時，其橫斷面積 A_1 爲 34,175 平方公尺。當民國十年八月二十一日水位最高之時，其相當之橫斷面積，爲 36,315 平方公尺，代入上式，得是日之長江流量。

$$Q=\left(\frac{36,315}{34,175}\right)^{1.7}\times 72,000=79,800$$

【註】當本報告撰擬時，揚子江水位均根據浚浦局所繪水位曲線，因輾轉傳鈔，路失眞相。玆已根據鎮江海關紀錄加以校正矣。

當民國十年九月十九日，淮水入江量最大之時，長江之橫斷面積，爲 35,413 平方公尺，同法得是日長江之流量，爲 76,500 立方公尺。長江在鎮江之流量與水位關係就上項推算，可列如下表以明之。

表 6 揚子江水位剖面積及流量表

日期	水位（浚浦局零點）	面積（平方公尺）	流量（每秒立方公尺）
民國十年八月廿一日	24.50呎 (7.47公尺)	36,315	79,800
民國十年九月十九日	22.90呎 (6.98公尺)	35,413	76,500
民國四年七月廿日	20.65呎 (6.29公尺)	34,175	72,000

平均統計,即流量每增加 1,000 立方公尺,水位昇高約0.15 公尺。玆更以另法求之以資參證。

依傅氏公式

$$Q = \frac{1}{n} A t^{0.7} J^{0.5}$$

式中 A = W（平均寬）× t（平均深）

故

$$Q = \frac{w}{n} t^{1.7} J^{0.5}$$

$$t^{1.7} = \frac{nQ}{wJ^{0.5}}$$

令 n 及 w 之値爲定數,應用微分法

$$dt = \frac{n}{1.7wt^{0.7}}\left(\frac{JdQ - 0.5QdJ}{J^{1.5}}\right)$$

但

$$\frac{1}{n} t^{0.7} J^{0.5} = V$$

故

$$dt = \frac{JdQ - 0.5PdJ}{1.7wVJ}$$

當流量增加 dQ 時,降度增加 dJ 之値爲極小,爲簡明計,令 dJ 爲零。於是

$$dt = \frac{dQ}{1.7WV} = \frac{AdQ}{1.7WQ} \cdots\cdots\cdots\cdots(2)$$

當鎭江水位最高在 24.50 呎時,上已算得流量爲 79,800 立方公尺,斷面面積爲 36,315 平方公尺,平均寬爲 18,00 公尺。今用公式（2）,流量增加,其影響於水位漲高者,試加推算,得結果如下:

$$dt = \frac{1000 \times 36315}{1.7 \times 1800 \times 79800} = 0.15$$ 公尺,　與前適相符合。

長江容量與水位之關係旣明,可進而研究淮水入江之安全洩量。考歷年鎭江之長江洪水位,以民十爲最高。將來洩淮入江,其影響於長江之最高水位爲若何應以是年爲準。

根據鎭江海關之水位記載,繪成鎭江民國十年八九月洪水量之水位曲線。復自江淮水利局之流量記載,估得是季逐日淮水排洩入江之量。於是由上述長江容量與水位之關係,細加推算,求得淮水入江之水量,隨江水位之高低,可自 6,000 至 9,000 立方公尺。(其値詳列於第六圖)卽當江水位最高之際,(如八月二十一日)仍如民十舊例,僅洩 6,000 立方公尺,當長江上游來水減小,水位低落時期,可依次漸增至 9,000 立方公尺於是長江承受淮水後之水位,將如第六圖所示,永不致高出長江之本來最高水位。若是非特無害於江,抑且有利於江。蓋江淮現狀,設如民十大水,九月十九日淮水入江 8,000 立方公尺,偶遇八月二十一日之最高江水則江水位更將昇高 0.3 公尺。長江水患,行將更烈。如斯現象,淮不導治,不敢必其無,淮旣導治,允可避免。謂之有利於江,誰曰不宜。

上項計算,乃根據江淮並漲至最高極度。若非同時並漲,或並漲而有一較遜於民十之量,則江水位之高度,並將更低。(低於第六圖中之細線)故淮水入江之量最大以每秒 9,000 立方公尺爲限,誠萬分安全也。

洪澤湖之攔洪效能

淮河最高洪水量,達每秒 15,000 立方公尺,入江之量,僅有每秒 6,000 至 9,000 立方公尺,來量與去量相較,相差懸殊。是不得不另求消納之道。淮運現狀,上已言之,上游之來量大而速,下游之洩量小而緩,中賴洪澤

高寶諸湖,爲暫時游波停蓄之所,因是得稍殺狂瀾之勢,稍減沉淪之災。今洪澤湖面積既大,容量既多,其自然攔洪之效亦甚著。故憑已往之經驗,知利用洪澤湖爲攔洪水庫,以盡量消納尾閭一時所不能排洩之洪水,乃治淮中最經濟之方策也。

今請先述攔洪水庫之原理,而後再及洪澤湖之運用。凡河道之洪水流量,如流量曲線所明示,其最高之值,歷時極短。卽其洪水峯自低而高,復自高而低,以至尋常洪水時期之流量,其歷時亦復數日至十數日而已。惟潰隄岸,毀廬舍,汜濫之災,則莫不肇於此時。是以治水者,恆以此爲治理之準則。普通言治水而僅以整理河槽爲能事,則非開浚一巨量之槽,必不足以消納此最高之洪水。例如洪水峯之最高值,爲每秒10,000立方公尺,則勢必令河槽有10,000立方公尺之洩量,洪水峯之最高值,爲20,000立方公尺。則必需20,000立方公尺之洩量,固不問此最大洪水之經歷,爲數十日,或數日,或數小時也。如此治水,其工程之巨,需費之繁,將不可僂指計。今若有攔洪水庫爲之調節,則當洪水之驟漲也,大於一定之流量,可暫時儲積之。當洪水之漸退也,向日儲積之水,可依時排洩之。於是洪水之來量,縱隨時不同,縱可增至極高值,然尾閭之洩量,仍可以遠遜於洪水峯之量。一轉移間,尾閭工程,節省不可勝計。故天然地勢上,苟有適當水庫。常採用爲助。洪澤湖之於淮河,卽其例也。

淮河最大流量,爲每秒 15,000 立方公尺。當長江

水位最高之際,僅能排洩 6,000 立方公尺。若無洪澤,勢須闢一巨道入海,排洩每秒 9,000 立方公尺之流量,就本處所估計,其需費至少二萬餘萬元。今有洪澤,以爲攔洪水庫,則非特可以調節入江之量,以適應長江之最高水位,且入江以外之洪水,亦可暫有停蓄之所,縱需入海之道,工將大省。

當長江最大洪水時期,淮水入江之量。已詳列於第六圖。假定淮水入江以外,過量之洪水,皆暫時儲蓄於洪澤湖,仍逐漸排洩入江。洪澤湖當洪水初期,湖水位在 12.5 公尺。(詳灌溉需水量節)爲求節省湖口操縱機關之蔣壩活動壩,及其下游入江水道之工程計,令湖水位至 13.5 公尺以上時,始能排洩每秒 9,000 立方公尺。並令淮河之洪水最高峯,與長江之洪水最高峯,同日相遇。蓋若是則江淮並漲,洪水之情形最稱惡劣耳。於是就逐日進水與洩水量計算之,進水逾於洩水之量,則積儲於湖中而加增湖水位之高度,進水量遜於洩水之量,則湖水排出而水位漸減。同時洩水之量,在湖水位不及 13.5 公尺時,則視水位而遞有增減,過於 13.5 公尺時則以入江 9,000 立方公尺爲限度。如是逐日鈎稽,以計算湖水位應有之變化。其結果詳見第七圖甲,乙。湖水位之最高點爲 16.1 公尺,與民國十年相等。若兩河之洪水最高峯,參差數日,洪水情形,無此險惡,而洪湖之最高水位亦因以減低。

今若入江以外,另洩每秒 1,000 立方公尺入海,即

令洪澤湖之最大洩量,至每秒 10,000 立方公尺。用同法推算之,則如第八圖,洪澤湖之最高水位,將僅達 15.3 公尺。若是則沿湖之地,在 14.5 公尺以上者,苟有小堤以備萬一,卽可安全耕種,而洪湖大堤,亦足以有恃無恐,實爲最安全之策。然入海一道土方工程較多,卽此 1,000 立方公尺,亦將費一千萬元以上。而一考洪澤湖最高水位 16.1 公尺之遭遇,須在江淮同時奇漲洪水峯同日相會之時,方能一遇,固不知相隔若干百年始有一次。卽或遇之,歷時復不久,固不慮其或釀奇災。故導治之方,首在入江。入江工程以外,爲安全計,兼及洪澤湖四邊隄岸之修葺,與建築,務令湖邊十四公尺半以上之地,仍得安全耕種。俟來日國庫充裕,民生富厚,農田水利,更求發展之時,始再闢入海之道,亦未爲晚。

排洪入江之路線

淮水自然入江之路線,係由洪澤湖經三河。高寶邵伯諸湖,至六閘,穿運河,出歸江十壩,取道董家溝,廖家溝,至三江營而達於江。今就此路線各段而詳察之,位於洪澤高寶湖間爲三河,自洪湖口至三河衛一段河床狹而深,三河衛至高寶湖一段則河床寬而較淺,計其最狹之處,僅有三百公尺,最寬之處,達二公里有餘,寬狹至不一律。民國五年當洪湖水位在 13.70 公尺時,三河流量爲每秒 8,400 立方公尺。民國十年,當洪湖水位在 15.77 公尺時,其流量達 14,600 立方公尺。惟水面降度損失較鉅,是其缺點。今欲令其在洪湖水位 13.5 公尺時,排洩

每秒 9,000 立方公尺之流量,所需疏浚及整理工程,比較甚微。三河以下爲高寶邵伯諸湖,舊時以入江諸壩之不能啓閉得時,各湖遂亦爲淮水停積之地。而湖與運河雖隔一線西堤,實則到處相通。湖水一漲,運水亦隨之以漲。運河東堤,舊有歸海壩助洩淮水,在湖河相連時代,爲保障運河東堤計,各壩之設實非得已。今後淮河氾濫之水,上有洪澤湖爲之停蓄,下有揚子江爲之輸洩,則歸海各壩可廢棄,而高寶邵伯諸湖,亦可涸出以興農墾。淮水之行經高寶湖也,可範圍之於固定河槽之內。更以湖區之地勢既低,地價復小,祇築雙堤,卽成深廣之河槽,所費亦甚少。其經行路線,則擇其徑捷而地勢低下者,所以省工費,並省水位降度之損失。當排洪道之穿越運河也,位在邵伯船閘之下(詳航運工程)不論洪水或枯水時期,有船閘爲之操縱,排洪通航,仍可兩無妨礙。通揚運河之舊口,可堵塞之,由六閘以達運河,另設閘壩,以利航運灌溉,而免洪水之侵襲。排洪道穿越運河而後,將分出金灣,東灣,鳳凰,新河,壁虎,諸引河,下經董家溝,廖家溝,而至三江營以入江。所有舊日各引河口之土壩,可一律撤除之,令成自由排水之口。當民國十年,六閘水位在 8.41 公尺時,上述五河之洩量,達每秒 7,841 立方公尺。今欲增其洩量至每秒 9,000 立方公尺,縱令水位稍低,所需之土工亦屬有限。而閘壩之建築,可全部免除,所省實甚巨。綜上所述,知整理淮水入江之舊道,如現所規畫者,實爲最安全,最經濟之排洪水道也。排洪道之路線,玆更附圖

以明之。（第九圖甲,乙）

入江水道之設計

平面　自蔣壩鎮之南,導淮水循三河東下,因該段河槽狹小,水位降度損失過鉅,故擬於蔣壩鎮之北,自洪澤湖起,另闢長 5.8 公里之新引河,至三河衞附近與舊三河相會合。（閱第九圖甲,乙,）將來之洪水操縱機關,北部活動壩卽築於新引河之最上端,南部活動壩則築於原有之三河中。淮水循三河至金溝鎮西之柏家灣後,乃導之入柏家澗,復向東南蜿蜒以達新河（河名）。柏家澗至新河間,地勢較高,但淮水入江,以此路爲最捷,若改趨寶應湖,則路線加長甚多,故寧取此路。爲減少村舍田畝之犧牲計,斯段路線,畧多灣曲,但與流水仍無影響也。自新河而下,趨東南入高郵湖,直達唐家湖,復遇較高之地,致淮水行經談家尖與胡莊圩之間,路線又稍曲折。過胡莊圩以後,乃由南湖達邵伯湖至六閘。自六閘以下,原有歸江各壩之引河數道,自東至西順序數之,曰金灣引河,曰太平河,（卽東灣引河）曰鳳凰河,曰新河,及瓜州運河,（下達壁虎引河）淮水卽由此五道南行,至古運河以南,併爲二流,曰芒稻河,（卽董家溝）曰廖家溝河,至八江口復合爲沙頭河,東南至三江營入揚子江。總計自洪澤湖至三江營全線長 153 公里弱。

流量　入江水道之流量以最多宣洩每秒 9,000 立方公尺爲度。各段河槽均以此數爲設計之根據。自洪澤湖至三河衞附近並行二河,一爲原有三河,一爲新開

引河各令排洩淮河洪水每秒 4,500 立方公尺。以下各段至六閘止均無分流,故河槽流量即為每秒 9,000 立方公尺。六閘以下至古運河口,平行河道共計為五,其流量之分配如下。

金灣引河	每秒	1,500	立方公尺
太平河	每秒	2,500	立方公尺
鳳凰河	每秒	2,000	立方公尺
新河	每秒	2,000	立方公尺
裏運河	每秒	1,000	立方公尺

總計仍合每秒 9,000 立方公尺之數。

古運河至八江口間合為二流,一為芒稻河,洩每秒 1,500 立方公尺,一為廖家溝河,洩每秒 7,500 立方公尺。自八江口以下,由沙頭河排洩全量以入江。其由瓜洲口出者為數甚微,遂略而不計焉。

水面降度　導淮入江水道,計長 153 公里弱,當湖水位 13.5 公尺時,在活動壩下游之水位定為 13 公尺,(閱第十圖)揚子江最高水位為 4.3 公尺,首尾兩點較差為 8.7 公尺,即總降度也。各段水位降度損失各不相同。計自蔣壩之活動壩至柏家澗,長 34.89 公里,損失 1.6 公尺。柏家澗至六閘長 77.51 公里,損失 3.9 公尺。六閘至三江營長 40.27 公里,損失 3.2 公尺。各段以內水位降度之分配,具見第十圖中。大致原有河道深闊合度者則仍其自然降落之形狀。高地而需開挖者,則使其降度較大。經過低地或湖泊者,則降度之分配較小。其目

的均在求浚渫工程之極端節省而已。

活動壩　活動壩在洪澤湖水位13.5公尺時,其洩量定為每秒9,000立方公尺。壩底之高度設定為8.00公尺。水流經過壩門之降度損失為0.5公尺,則依次式約略估計,活動壩之長應為600公尺。

$$Q = 0.96L(H-h)\sqrt{2gn}$$

$$Q = 9,000m^3/Sec$$

$$H = 5.5m$$

$$h = 0.5m$$

$$\therefore L=600m$$

活動壩已經設計者有板牐(Stop Logs),針牐(Needles),輻形牐(Tainter Gates),懸門牐(Sliding Gates)各種。因壩址之土質承重能力,尚待實地試驗,故尚難確定孰為最合宜之式樣。惟各種活動壩每公尺長之單價,均不甚相遠,大致在三千元左右,故估計此壩所需經費約為2,000,000元。

隄防　隄防之標準形式,暫定為頂闊4公尺,側坡各為3:1,將來俟實驗竣事,再作相當之改正。隄頂之高,擬為洪水位以上1.5公尺。凡河道須加開浚之處,浚出之土方,如出土距離非遠,即利用以築隄防。否則必須挑土築隄,其工費因以較昂。自蔣壩至柏家澗,計需挑土築隄之土方為5,554,570立方公尺,可以利用挖出之土而加以硪工者凡2,024,500立方公尺。自柏家澗至六閘間挑土築隄之土方計17,020,500立方公尺,僅需

磩工者 7,381,500 立方公尺。自六閘至古運河口,兩岸咸屬高地,或舊有土隄,僅需略事培修,且全段均有浚出土方可以利用,計需磩工者僅241,600立方公尺。自古運河至八江口,計需挑土築隄之土方凡 1,591,000 立方公尺。又自八江口至入江處計需挑土築隄之土方 1,143,000 立方公尺。總計全河兩岸共需挑土築隄之土方約 25,309,070 立方公尺,又利用浚出之土加以磩工者共 9,647,600 立方公尺。(閱第十圖)

浚河工程　凡就平地開浚河槽部分,其岸坡均定爲 2:1。蔣壩北部引河最高水面闊度定爲450公尺,平均深度凡 6.4 公尺,水面比降爲 0.000098,計須挖土 10,225,000 立方公尺。自洪澤湖口至柏家灃之三河應加開浚之處,最高水面闊度自520公尺至 1,400公尺不等,平均深度亦自 5.9 公尺至8.22公尺不等,水面比降自 0.00005 至0.000072不等,共應挖土 17,851,000 立方公尺。自柏家灃至六閘河面闊度自1,488公尺至 2,186公尺不等,平深均度自 4.5 公尺至6公尺不等,水面比降自 0.00003至 0.00009不等,計應挖土 31,330,000 立方公尺。自六閘至古運河口,五河分流,各就原河浚深,不加闊度,平均深度自5.7公尺至12.2公尺不等。水面比降自 0.0000816 至0.000094不等,浚河土方共計 13,378,000 立方公尺。自古運河以下至入江之處,原有河道已敷排洪之用,故無須開浚矣。計算土方,一部分根據前淮揚徐海平剖面圖,將來施工測

量完成後,當再爲相當之修正。

經費概算　導淮入江所需工程費概算如下

甲,活動壩建築費	$ 2,000,000
乙,浚河工程費	22,960,345
丙,築隄工程費	4,295,592
丁,收用土地費	1,566,800
戊,自活動壩至洪澤湖切灘費	50,000
己,意外費及監督管理費	3,000,000
共計	$ 33,872,737

洪澤湖圍隄之修築

入海水道未闢以前,洪澤湖之最高水位,或恐氾濫周圍之農田,擬沿湖造圍隄以障之。其東南隅之洪湖大隄,高厚堅實,足資屏障,惟舊隄石砌擋牆,間有崩離之處,應從事修砌,以保安全。新造圍隄,擬自洪湖東角之仁和集起,接聯於舊隄,循14.5公尺之同高線,向北繞成子窪至安河窪西之高地。其南隅之三河口以西,自馬狼岡至三官集,亦擬同樣建隄以防之。統計圍隄全長約180公里。隄之斷面形擬項寬爲3公尺,側坡爲3:1,隄頂高出洪水位1.5公尺,約需土方6,500,000立方公尺,需費約一百萬元。舊時沿湖排水河道之口。應築水閘以操縱之。約另需工費二十萬元。

第三節　淮河中上游及其支流之治導

淮河自三河尖以下,支流衆多,來量巨大,本身河槽旣已不能容納,而鳳臺,懷遠,浮山之山峽,復一再束縛洪流,於是上壅下阻,橫流旁溢,潰決隄防,洪流所被,胥成澤國。至於各支流下游,亦皆淺狹不勝,漫溢之災,因之更烈。據安徽水利局所製平剖面總圖及其洪水泛濫之界,民國五年,被水區域,約爲 8,000 平方公里,民國十年,達 13,700 平方公里,亦云廣矣。

洪水量之估計

淮河各支流及幹河各處之洪水量,無確實之記載。前江淮水利局於淮河之洪河口,三河尖,及史河,潁河,曾有流量之實測,此外則全付闕如。玆就所有實測記載及應用各河舊測諸圖,估計各支流之洪水量如下。

淮河(洪河口)	每秒	3,000	立方公尺	十年七月十一日實測
淮河(三河尖)	每秒	3,310	立方公尺	十年七月十三日實測
洪河(合汝河)	每秒	1,000	立方公尺	
史河(合灌河)	每秒	3,200	立方公尺	十年七月十三日實測
潁河	每秒	3,100	立方公尺	十年七月二十日實測
淠河	每秒	1,600	立方公尺	
西肥河	每秒	300	立方公尺	
渦河	每秒	1·250	立方公尺	
芡河	每秒	210	立方公尺	
北肥河	每秒	330	立方公尺	
澮河	每秒	600	立方公尺	
沱河	秒每	250	立方公尺	

池河	每秒 350	立方公尺
睢河	每秒 1,400	立方公尺

以上所列爲各支流單獨或遇之洪水量,未必各河同年皆達此量,卽或同年盛漲,而其流達淮河也,或前或後。淮河在各支河口以下之流量,決非爲各支流最大洪水量之和,乃顯著之事實。故淮河幹流各段之洪水量,究爲若干,仍待估算。

爲安全計,以淮河之最大洪水總量每秒 15,000 立方公尺,由洪澤湖向上推算之。睢河及其他之直接流入洪澤湖者,約爲每秒 1,500 立方公尺,淮河幹流在洪澤湖口之最大洪水量,爰爲每秒 13,500 立方公尺,由斯向上遞減,逾每一支流之口,卽相比少去一部之水量。因估得淮河幹流各段之最大洪水量如下:

浮山以下	池河口以下	每秒 13,500	立方公尺
浮山至五河	澮河口以下	每秒 13,000	立方公尺
五河至懷遠	澮河口以上渦河口以下	每秒 12,000	立方公尺
懷遠至鳳臺	渦河口以上西肥河口以下	每秒 10,000	立方公尺
鳳臺至正陽關	西肥河口以上淠河口以下	每秒 9,500	立方公尺
正陽關至垂岡集	淠河口以上潁河新口以下	每秒 8,500	立方公尺
垂岡集至三河尖	潁河口以上史河口以下	每秒 6,000	立方公尺
三河尖至決河口	史河口以上洪河口以下	每秒 4,500	立方公尺

民國十年淮河之最大流量,在三河尖僅爲每秒 3,310 立方公尺,在正陽關以下之魯口,僅爲每秒 6,000 立方公尺。各河導治以後,洪水不再漫溢,流入幹河之量,

容或較大。而各支河及幹流上游之洪波,亦將或先或後,與舊相異。將來之洪水量,究達若干,無確實資料,可作依據。惟上估之值,較之各該段舊日所遇之最大洪水量,均大過五分之一至三分之一,憑以規劃,當可無虞。

幹流導治計劃

淮河自洪河口以下,河底降度極平,斷面復狹小,其載量幾不及最大洪水量之半。而現有河堤,卑矮不足防範,以致偶遇洪水,如民國十年,四散泛流,廣可十五公里。此種廣寬之最大洪水床,必須加以範束。若欲開浚現今河槽,納全部洪水於其中,需費之巨,幾無可能,惟有兩岸建築長堤一策。顧問工程師方修斯之規劃,亦同此旨。但專賴築堤。尙不能使最大洪水床之均深完滿。河身灣曲太甚者,應截灣取直之,橫斷面太狹者,應開浚拓寬之。兩堤之距,毋使驟寬驟狹。兩堤之高,務令其工費及留於河床中被災之地爲最省。本此原則,規劃淮河幹流之治導。玆擇要述之。

淮河洪河口以下,郭台子,三河尖,趙家集,及鳳台四處,應逐漸施以截灣取直之工。合計其總長約爲18公里。挖開之斷面,令與各該地附近之舊槽面積,約略相等,以保河流之均勻穩定。平均挖土面積約爲 2,800 平方公尺,共計土工約五千萬立方公尺。舊槽斷面狹小,應事開浚放大者,計有洪河口至張八坎子,牌坊台子至馮台子,鳳台截直段以下至鹽窩子,蚌埠附近,龍河集至沫河口,安淮集至溪集,卜家渡至浮山等處,挖土面積自五百至

二千五百平方公尺不等,共計挖土約有九千萬立方公尺。統計浮山以上,洪河口以下,淮河幹流之開挖土工,約爲一萬四千萬立方公尺,約共需經費三千萬元。蚌埠鐵路橋,應增添橋孔,以利宣洩,而免壅阻。

浮山以下,擬開闢新槽,逕直穿過雙溝東南之高崗至漂河窪入洪澤湖。在施工之初,爲節省經費計,可先闢一小槽,賦以較大之降度,利用水流之巨大速率,以冲刷放大之。至於舊河槽則暫維現狀,俟新槽冲大敷用後,兩旁再築堤範之,以圖附近窪地之墾殖。斯處鑿直完成以後,淮流可縮短60公里,對於排洪航運,皆有莫大利益。新槽全長,自浮山至漂河窪約爲18公里,其中15公里爲灘地,3公里爲高岡。令初開之溝之底寬爲100公尺,兩岸坡度爲1:1平均水深爲10公尺。約計灘地段之挖土爲11,500,000立方公尺,高岡段之挖土爲6,800,000立方公尺,在漂河窪中或亦須先開一狹渠爲助,共約需費五百萬元。斯項規劃,能否實施完成,俟雙溝東南之高岡之地質測驗後決之。

淮河幹流應築堤防,自雙溝至洪河口,全長約410公里。據顧問工程師方修斯之規劃,兩堤相距,平均在3.5公里,堤高在5公尺至6公尺之間,全部工程,最爲經濟。嗣經本處根據江淮水利局所測之橫斷面,與上節所述各處應洩之洪水量,逐個推算之,得兩堤相距,自雙溝至懷遠爲4公里,自懷遠至正陽關上游8公里之溜子口爲3公里,自溜子口至三河尖爲2公里,自三河尖

至洪河口爲3公里。堤高概在4.5至6.5公尺之間。中有特殊地形極短距離中,堤之最高者達7公尺。最高洪水位,概令在堤頂以下1公尺。新堤可同時用爲汽車道,頂寬擬爲6公尺,堤坡擬爲3:1。堤高5公尺以上者,頂下2公尺始,擬加戧堤,其寬爲10公尺。共計淮河幹流兩堤土方約爲一萬萬立方公尺。約需費一千八百萬元。堤身挖土坑,及其間灘地所佔面積,約計共需164方公里,即266,000畝,以每畝四十元計之,須償地價爲一千零六十四萬元。此外又有涵洞水閘抽水機等設置費,須行加入。計堤防之全部工程費,約需三千五百萬元。

兩堤間所夾之面積,用作最大洪水河床者,估計有二百萬畝。此項田地,仍可任人耕種,其受水災,不較頻於舊時,僅水較深耳,然導治以後,洪水之排洩較速,其被淹之時期,可以較短,利害參半,或免其捐稅,或稍給一次之貼費。固無需巨款收買也

淮河幹流,傾斜極小,能利用之最大降度,爲五萬分之一。採用此值,及最大洪水床所需之平均水深推算之。洪河口之最高水位,將爲28公尺。浮山爲20公尺。浮山以下至洪澤湖,經雙溝截直段18公里中有3.5公尺左右之降度,足生充分之流速,冲刷助成新河槽。浮山以上之最大洪水位,在初似覺過高,但因浚深河底之需費不貲,幾無法避免。然導治以後,水流集中,藉其冲刷之力,舊槽中泓將逐漸低降而洪水線亦可年低一年也。統計淮河幹流之全部治導工費約爲七千萬元。

各支流之治導

淮河支流,性質各異,治導之策,勢難完全一致。惟各支下游情形,大都與幹河相似,而幹河洪流,既用堤防約束,水位高於兩旁之地,支流受其反漾,建築堤防亦為主要之工。為節省堤工計,支河之小而鄰近大河者,將合併之。舊槽之蜿蜒平行於幹河者,將改闢其口門而縮短之。此外則將各就其特殊情狀,或在上游施以荒溪工事,或在沿線施以截灣取直,務令需費省而收效宏,方盡治導之能事。

淠河及史河與灌河之流域,多為山地,治導之策,宜在上游及其支流山谷中,建造防堰等工。但資料不足,尚待研究。若無上游工事,史河應築堤自三河尖至灌河口上游之新渡口附近,約長 70 公里。灌河應築堤自河口至柳樹棚附近,約長 40 公里。淠河應築堤自河口至小李集,約長 95 公里。洪河自與汝河相會之三岔口以下所有巨灣,擬一律截直之,另於兩旁培築堤防,計截灣取直共九處,全長約 14 公里,堤防長約140公里。潁河自洄溜集以下,修築堤防至入淮口止,其入淮口門,舊在正陽關,茲擬在垂岡集以北,改道入淮。計開挖新道長約 6 公里,築提長約 70 公里。西肥河及其支流黑河,港河應築堤共長約 70 公里。北肥河擬在高嘴子附近,闢新河 4 公里,南至殷小集入渦河。芡河則擬在棗林集改道至沙溝集入渦河。渦河卽自沙溝集起,改道直趨懷遠下游之張莊入淮。渦河築堤上至移村集,北肥河至項橋集,芡

河至萬福集,合計堤長共約 90 公里。沱河及北沱河擬與澮河在五河縣相合而疏浚新道入淮,所有該數河下游之香澗湖及沱湖等,擬保持其湖身,不令涸墾,沿湖修堤,上溯澮河至忠義集,沱河至清忠集,北沱河至羅橋集,堤長共約200 公里。泗縣靈璧宿縣以北之諸小水,擬概令流入汴河睢河逕入洪澤湖。睢河河床較高,須加浚深度,培築堤岸,施工區域長約 90 公里。此外諸小支流,亦有應築堤疏浚者,工程無多,暫置不論。幹支堤防建築以後,當洪水之季,流域以內之過量雨水,應建設閘洞及抽水機以排洩之。所有各地大小湖泊,擬保留之以瀦積內地之水而減少抽水機之工費。統計各支流之治導工費,約需三千萬元。

合計皖境淮河及其各支流之全部工費,約為一萬萬元。受益田畝約有二千萬畝,平均每畝僅負擔工費五元,即可永免水災。

以上所述,不過略示治導之概要,至於詳細規劃,則資料不足,尚有所待,即就所列各部規劃論,詳細測勘以後,仍當繼續研究,以求工費之更為節省而易於興辦。

第四節 沭河之治導

沭河源出山東蒙沂山,經紅花埠流入蘇境,名大沙河。至沭陽之新河鎮,分為兩支。其幹流直趨青伊湖,經薔薇河至臨洪口入海。支流分為前後沭河,又分為官田河

及柴米河。後沭河亦入青伊湖,前沭河及官田河均由港河入薔薇河,而柴米河則東南行經由北六塘河入海。沭河上游,降度大而少有停蓄之地,冬春之季,常乾涸無水。夏令山洪暴發,來勢洶湧,排洩不及,則橫流旁溢而無所歸束。在昔猶恃下游有碩項青伊桑墟諸湖,以爲瀦蓄區域,今各湖皆已淤墊,甚或高出上游河槽,不獨全無容量,抑且阻遏去路。自新安鎭以下,凡沭水所經之地,皆成災區。而在泛漲至極高度時,且往往與沂水連成一片,如沙礓河柴米河等處,皆爲沂沭交侵之地。沂漲則犯沭,沭漲則犯沂,沂沭並漲而成相持之局,則積水不退,災情愈重,故爲沂爲沭,令其各有定槽,不相互侵,乃首要之圖也。

洪水量之估計

沭河之洪水。據前江淮水利測量局之記載,以民十及民十三爲最大。民國十年七月十五日,在茅茨莊實測最大流量每秒 2,555 立方公尺。民國十三年七月十五日,在興安鎭測得最大流量每秒 4,470 立方公尺。民十三之洪水量,爲十數年來記載中之最高者。更據該局報告,是年洪水,沿河居民稱爲數十年來所未嘗遇者。而以流域情形及面積大小相近之河流比較之,如斯洪水量亦不多覯,故沭河之最大洪水量,估爲每秒 4,500 立方公尺。

導治計劃

沭河下游之排水量,缺乏記載。然據江淮水利測量局實測沭河之平面及斷面圖而作一近似之估計,則大

沙河在顏家集附近,僅能容每秒880立方公尺之流量,薔薇河在卸甲坊,僅能容每秒180立方公尺之流量。準是而言,在沭河來量最大時期,其流經顏家集循槽而下者,不足五分之一,其流經卸甲坊循槽而下者,僅二十五分之一。尾閭之狹小難容,而致漫溢爲灾,乃顯著之事實。然沭河平時來源,既不巨旺,卽在山洪暴發之際,亦驟漲驟落,歷時極暫。例如民國十年七月十二日,每秒流量祇39立方公尺,十五日驟漲至2,555立方公尺,過此卽降落甚速,至十九日僅有505立方公尺。又民國十三年七月十三日,每秒流量祇20立方公尺,十五日驟增至4,470立方公尺,翌日卽降至2,470立方公尺,而至十七日則僅有247立方公尺矣。據此以觀,治導沭河,上游苟有攔蓄之工,必事半而功倍。且沭河現狀,洪水一過,幾卽乾枯,交通灌溉,兩無所裨。而洪水暴流,挾沙以下,海口沉淤,尾閭更難通暢。除害興利,允宜上游建造攔洪水庫。並於幹支逐段建造滾水底堰,(Ground Sill)以平其降度,減其流速。阻其泥沙,兼以攔蓄洪水,斯乃治沭之上策也。但沭河上游,舊時測繪未詳,本處則限於經費時間,及地方不靖,迄未得派員實測,有無適當地址,以築水庫,尙不敢必。底堰應有若干,應若何建造,爰亦不能詳細規劃,祇得俟諸來日。

至於沭河尾閭,固不論上游之有無工事,皆當疏浚以利排洩者也。其主要目標,則在沂沭分導,上已言之。故沭河排洪主道,擬自紅花埠起循大沙河穿青伊湖經薔

薇河至臨洪口入海。（如第十一圖）路線徑捷,降度充足,排洪甚爲便易。沂沭間現有河道,擬築閘於其口,引水以應灌溉交通之需。所有詳細設計,須俟將來測勘以後,方可着手。茲先就前江淮水利局所測地形圖及縱剖面圖。設計排洩每秒 4,500 立方公尺水量之水道。以估計導治沭河工程費之最大限度。蓋導治洪水,卽以洪水峯之最高值,爲洪水道之容量,工程費爲最鉅。前於討論入江水道時已詳言之矣。今就此以估工程費之最高限度。他時上游,攔洪水庫,苟能確定建造,則全部工程,所需工費,當可小於此項範圍也。

沭河最高限度之排洪道計劃:　　此項計劃以排洩沭河之洪水峯最高值每秒 4,500 立方公尺爲原則。其路線爲取徑直計,當如第十一圖所示。其比降自臨洪口至青伊湖長 65.2 公里,取 1 比 10880 自青伊湖至沭河口,長 39.46 公里,取 1 比 7,900。自沭河口至紅花埠長 62.66 公里,取 1 比 3,200。按實地之需要,配置其剖面形式。共計工程費及土地給價如下:

堤工土方	36112400 立方公尺	出土距平均一百公尺 每立方公尺價一角六分	$ 5,777,984
堵塞支河土方	70000 立方公尺	出土距及單價同	$ 11,200
支河閘洞大小七處			$ 200 000
貼用土地	177,000畝	給價每畝十元	$ 1,770,000
		共計	$ 7,759,184

第五節　沂河之治導

沂河發源於山東蒙沂諸山。經郯城總入蘇境，至溝上集分爲二支。其正幹南行至周家口，復東南行經駱馬湖折東行至大石渡，分經南北六塘河，越鹽河經武障龍溝，由灌河入海。支流口門，舊有蘆口壩爲之操縱，西流之水，分爲三股，由瞿塘口沙家口及二道口注中運河。而幹流之經由周家口者，除直趨駱馬湖外，亦分流由磘灣之竹絡壩入運。與運河上游來源，匯合南趨，容量不勝，復由九龍廟五花橋及劉老澗等處，分入六塘，東注於海。餘水仍由運河南行以入江。但遇淮河泛漲，則與張福河之水俱入鹽河，鹽河水勢盛漲時，又或旁溢以入六塘。

溝上集之蘆口壩，原以節制注運水量。其後正幹河槽，逐漸淤墊，宣洩不暢，蘆口壩亦隨之圮壞。沂河來水，全部洩入支流，其正幹非至盛漲不能洩水，磘灣之竹絡壩舊亦爲節制西趨水量而設，今亦已傾圮僅存遺跡。竹絡壩上約一公里餘，有一支流由錢家口東行，分洩盛漲之水，入沂河南行正幹，匯注駱馬湖。但湖身今已淤成平陸，無復停蓄之功，惟有逕直南趨以至六塘河。遇沂水盛漲，水面極高時，有一部水量入砂礓河以注沭河。沭河異漲之際，亦或由砂礓河西流，而成沂沭交侵之局。劉老澗爲中運沂泗合流分注六塘以出海之最大口門，舊有閘壩爲之操縱，今亦廢壞無存矣。

洪水量之估計

沂河洪水，據江淮水利局之實測記載，亦以民十年

及民十三年爲最大。民十最大流量，在李莊測得每秒 2,310 立方公尺，民十三則在蘆口壩測得每秒 2,130 立方公尺。故就實測之記載言，該河之最大洪水量爲每秒 2,310 立方公尺。惟沂河與沭河，上游之地形相似，據徐家匯天文台之雨量記載觀之，兩河上游流域之受雨量，亦復相似，而兩河之性質亦頗相同，沂河之洪水逕流，當與沭河相近。沂河之流域面積，較沭河爲稍大，惟沂河之降度較之沭河則稍小，故沂河之最大洪水量，當與沭河不相上下，因照兩河流域面積之比例，估爲每秒 4,500 立方公尺。以期計畫上之安全。

治導計劃

沂水幹河，河床淤塞，齊村以下，大部洪流，皆假道於運。例如民國十年，上游來水每秒 2,310 立方公尺，其經由蘆口壩西行入運者，有 1,900 立方公尺之多，即餘水循幹南下者，至竹絡壩亦復注運。而入運口門，亦皆淤淺不能盡洩來水，沂河本身之災，於以釀成。中運上承泗水，容量有限，而分沂東流之口門，若九龍廟五花橋及劉老澗等處，亦同病淤塞，不敷排洩，中運災區，亦因之而成。排沂水以入海之道，如總六塘河，如南北六塘河，如龍溝河，武障河，其容量更愈趨愈小，根據舊測縱橫斷面而估計之，在總六塘河之三岔渡，最大流量約爲每秒 1,300 立方公尺，至南北六塘分流處之上游，僅爲每秒 750 立方公尺，合計龍溝武障之最大流量，亦復相等。尾閭不暢，六塘災區，乃由斯以成。若夫洪流經砂礓河東行者，更助

沭爲虐。沂以缺乏尾閭,東侵西襲,致成舊黃以北之大害,欲謀治導,須有適當入海之道,固不待復言矣。

按中運河上承微山湖,舊爲山東南流諸水之唯一孔道。魯西魯南之水舍此更無其他出路可循。沂河洪水,尤宜斷絕入運,俾得承納魯南之水,以袪該地之災,兼輕中運區域之患。沂河排洪之道,爰擬自溝上集起,循舊日正幹至周家口,南行穿駱馬湖至三岔渡,會劉老澗旁洩之泗水(詳泗水治導)東行經總六塘河至錢家集,而後由北六塘河龍溝河下注灌河以入海。所有舊日西流入運支口,除留一路濟運外,擬一律堵塞之。排洪道除其尾閭灌河外,容量均遠遜於洪水量,概應疏浚或築堤以增加之。

沂河之最大洪水,如上所述,或達每秒 4500 立方公尺,即民十實測,亦有每秒 2310 立方公尺之多。惟沂河一如沭河,因上游降度過大,復無停蓄之地,其洪水之量縱大,其歷時則極短。例如民國十年八月二日每秒流量祇 65 立方公尺,八月七日驟增至 2,310 立方公尺,過此卽降,至八月十日乃減至860立方公尺。又十三年七月二十四日,每秒流量194立方公尺,七月二十六日驟增至 2,130 立方公尺,過此亦卽低降,至七月三十日,乃減至977立方公尺。是故治沂之道。與沭河同,固須下游有通暢之尾閭,尤須在上游建造攔洪水庫,並逐段建造底堰以平其比降,緩其流速,攔蓄其洪水量,既可省尾閭之工,兼可圖農田水利之發展。惟因上游之測繪未詳,

（情形同沭河）攔洪水庫之有無適當地址，底堰之若何建造，尾閭之若何寬深，尙難卽行統籌決定。爲估計治導工程經費之最高限度起見。亦仿沭河之例。就前江淮水利局所測圖表，加以計畫。

沂河最高限度之排洪道計畫：本計畫所取之導治路線詳見第十二圖以排洩洪水峯最高值每秒4,500立方公尺爲標準。自齊村經周家口耀徐廠至三岔渡，均排洩每秒4,500立方公尺，比降自三千七百餘分之一至七千三百餘分之一不等，兩堤距離自600公尺至790公尺不等，堤高平均0.4公尺，河深五公尺至六公尺不等，自三岔渡經小房渡至龍溝，加入中運河自劉老㵎來之洪水量每秒1,000立方公尺，（見本章第六節）故以排洩每秒5,500立方公尺爲度，比降爲一萬五百餘分之一，兩堤平均距離爲916公尺，堤高自三公尺半至六公尺不等，河深中間自五公尺半至八公尺不等，兩旁自二公尺至四公尺半不等。龍溝以下經灌河入海，灌河本極深廣，故工程費較少，計兩堤平均距離爲一千四百餘公尺，堤高自一公尺半至五公尺三不等，河深中間自七公尺至十一公尺不等，兩旁自半公尺至三公尺八不等。總計工程及土地給價如下：

堤工土方共計	43,540,000立方公尺	平均出土距一百公尺單價 一角六分	$6,966,400
各段支河堵工土方	500,000立方公尺	出土距及單價同	$ 80,000
下游支河需閘四座約計			$ 200,000
貼用土地	235,000畝	給價每畝十元	$2,350 000

共計 $9,5 6,400

第六節 泗河及山東南運湖河之治導

山東黃河以南。泰山山脉所出諸水,若汶若泗以及鄒滕諸小水,皆西歸於運河。曹州舊屬諸水,若洙若萬福若順堤等,亦皆東匯於運河。此衆流之所歸所恃以入海者,北爲黃河之口,南爲灌河瓜州三江營諸口,而黃河河床淤高,堤頂已高出地面四公尺以上,於是運河以西,合新舊黃堤與運堤形成一三角式水盤,所恃以爲水之出路者,僅微山湖一雙閘耳。於是運西九縣,平時亦苦水患,大水之年,更昏墊不堪。其在運河以東者,以地勢較高,爲患較輕。而東平一縣則爲汶水所浸,永爲巨泊。其他諸水皆經運南流,而蘇人則舊以沂淮爲害,已深苦水患,時時以山東湖河之浚通爲慮。今則淮沂旣各謀導治,中運載量,專以承輸山東之水。沂河下游,亦兼顧此水之消納,山東水患,亦得從此免除矣。

山東南流諸水,概以微山湖爲歸宿。湖之全面積,約近一千方公里,根據十萬分一之平面圖,約略推算,則在同高線 31 公尺時,面積約爲 370 方公里,在 35 公尺時,面積約爲 870 方公里。湖底高度約在 30.6 公尺。湖之容量,在水位 31 至 35 公尺間,約爲 2480 兆立方公尺。故微山湖亦可利用之以攔洪防潦,蓄水防旱,一如洪澤湖之於淮水也。

洪水量之估計

汶河洪流,現由戴村壩經清河坡河以入黃,將一仍其舊。東平災區之救濟,可另圖之。微山湖之受水量,爰亦不再計及該河之最大洪流。汶河以外,流入微山湖之最大洪水量,究有若干,以缺乏記載,不能詳確規定。據山東南運河工程局民二至民五之流量測量,泗河本幹之最大洪水爲每秒748立方公尺。而微山湖之受水流域總面積約爲30,000方公里,按泗河本幹之流域面積,依據舊測各圖,僅有4,060方公里。若以面積爲比例,則最大洪水流量,將達每秒5,500立方公尺。惟泗河本幹之流域,地屬山麓,逕流較大,憑以計算,結果亦大。且此最大洪水,歷時極短,據該年記載,此最高値僅歷一日之久。微山湖既有巨量之容積,足以調節洪水,苟求其洪水總量或其平均流量,卽可爲下游治導之根據。

據徐家匯天文台之報告,微山湖受水流域以內在夏季洪水期之雨量,與青島相近。由青島歷年之記載,知每年雨量,以七月八月爲最大,而歷年該兩月之最大雨量,爲295.3加280.5等於576公厘。雨量與逕流之關係,在此區域,亦無記載,可供研究。惟據普通經驗,其最大比例,或不能超過百分之四十,今爲安全計,姑以此爲準,則當流域面積爲30,000方公里時,兩月之洪水總量將爲$30,000\times0.576\times0.4=6,900$兆立方公尺。卽平均每秒1,330立方公尺。至洪水流量之最高値,究爲若干,仍難臆定。惟微山湖可攔蓄定量以上之洪水,而令其下游之排水量,

不受上游來水量變遷之影響。微山湖之容量,若規定其最高水位爲 35 公尺,(民十最高水位爲35.56 公尺)則在低水位與高水位間有 2,480 兆立方公尺。於是七八兩月應事排洩之總量爲 4,420 兆立方公尺,即每秒853立方公尺。爲安全計,微山湖之洩量,估爲每秒一千立方公尺當敷所需。

排洪計劃

微山湖洩水口門有二,一由韓莊之湖口閘經中運爲入蘇,一由張谷山之藺家壩經不牢河以達蘇之瞿塘集,復入於中運。不牢河河底既高,河床復狹小,當民國十年,湖水位在 35 公尺時,最大流量僅及每秒135立方公尺。而自湖達瞿塘集之距離,不牢河復較中運河爲長,其降度因之比較爲小。故不牢河不適於排洪之用,擬仍用中運河。惟中運河爲蘇魯航運要道,謀枯水時之航行無阻,微山湖以下,將設船閘於得勝閘河定閘劉老澗等處(詳航運工程篇)規劃排洪時對於水位及流量之計算,應兼顧及之。

微山湖水,當在韓莊附近,歸入中運,下匯沂水,出灌河以入海。研究中運河與沂河之高度,此下行洪水,其出運之口。應在劉老澗。玆擬於劉老澗船閘之上游。運河東岸,建一活動壩,足以排洩每秒 1,000 立方公尺之流量,下循舊道至三岔渡,會沂以入六塘河而出海。韓莊之湖口閘及中運河內舊有之閘,一律拆除之,以暢洪流,兼便航行。得勝閘河定閘兩處船閘之旁,應各建活動壩一座,

爲洩洪下行之操縱。

沂河排洪道在三岔渡之最高水位爲18公尺,令劉老澗活動壩及劉老澗至三岔渡一段之降度總損失爲一公尺,於是劉老澗活動壩前之水位,當排洩洪水每秒 1,000 立方公尺時,應在19公尺。自劉老澗至河定閘,運河長度爲97公里,爲減少工費及儘量利用舊河床之橫斷面積起見,斯段比降定爲 13,300 分之一。於是河定閘活動壩之下游,水位爲26.28公尺。令經過活動壩之降度損失爲一公尺。壩上水位應爲27.28公尺河定閘至得勝閘相距爲45.5公里,同理令斯段之比降爲 9,000 分之一,並令經過活動壩之降度損失爲一公尺。算得壩下之水位爲32.33公尺,壩上之水位爲33.33公尺。自得勝閘至湖水入運之湖口閘,相距爲11.63公里,令其比降亦爲 9,000 分之一,於是湖口閘之水位,爲34.62公尺。即在此水位時,可排洩每秒 1,000 立方公尺之流量。斯乃安全之計,蓋若至湖水位已達最高之時,始能排洩全量,勢將令湖中積水過多,水位更高,而上游將少受排洪之利矣。

根據上述比降,令最大流速,爲航行安全計,不得超過每秒二公尺,如湖口閘至河定閘間,爲排洩每秒 1,000 立方公尺之流量,採用傅希海滿氏公式,其最小之橫斷面形,應爲:

底寬	50	公尺
水面寬	82	公尺

水深　　8公尺

岸坡　　2比1

自河定閘至劉老澗,最小斷面,應爲:

底寬　　64公尺

水面寬　　96公尺

水深　　8公尺

岸坡　　2比1

按運河現有橫斷面,除自湖口閘至得勝閘寬度不足,得勝閘及河定閘之下游附近,深度不符,應事開浚外,挖土之工極少。惟各地最高水位,高於地平,無堤者應增築,有堤者應按照最高水位(如第十四圖)加高培厚之。堤頂高度,規定高出最高水位1.5公尺。堤之橫斷面形,擬定其頂寬爲4公尺,兩坡爲三比一。

自劉老澗至三岔渡爲節省經費計,亦擬就現有河槽整理之,以洩每秒1,000立方公尺之水量,計斯段距離爲11公里。令其比降爲二萬分之一,用傳希海滿氏公式計算,其橫斷面形應爲:

底寬　　80公尺

水面寬　　112公尺

水深　　8公尺

岸坡　　2比1

就現有河床,整理之道,自劉老澗至阮渡凡4.37公里以內,應事開浚,兼築堤防。自阮渡至三岔渡,凡6.63公里,僅需增築堤岸。堤之橫斷面形,將一如中運河。

不牢河擬不堵塞,惟建閘洞於其口,以操縱水流,專爲該河兩岸給水之用。劉老澗船閘之旁,中運河中,亦應另築水閘一座,操縱下游所需之灌溉水量,估計需費共約十五萬元。

得勝閘河定閘及劉老澗東岸之排洪活動壩,統計需費約五十萬元。

所有泗河及山東南運湖河之排洪工程經費,統計如下:

(中運河各段開挖土方工程列入中運河航運工程經費項下茲不贅列)

劉老澗至三岔渡開挖土方	973,600 立方公尺	單價	0.135	$	131,436
又築堤土方	526,200 立方公尺	單價	0.16	$	84,192
利用挖土以築堤之土方	261,300 立方公尺	單價	0.025	$	6,533
不牢河及劉老澗灌溉用水閘洞二座				$	150,000
得勝閘河定閘及劉老澗活動壩三座				$	500,000
	共計			$	872,161

本計畫所及,祇使魯南諸水有一通暢之尾閭,足敷排洪,實爲解除魯南水災之根本要圖。至於南運湖河之若何疏通,若何調節,以興農田水利,則有俟於測量調查者正多,暫不具論。

第三章　航運工程計劃

第一節　總論

河流之航渠化

淮運區域內,水道縱橫,小規模之水運事業,本甚普遍。其著者如中運河裏運河鹽河張福河洪澤高寶邵伯諸湖以及淮河之本幹,均風帆相接,爲商貨往來之孔道然各湖河均爲天然水道。雨季來源暢盛,則水深廣,較大之船舶。均能行駛自如。一遇乾旱,來源枯涸,僅存之水量仍日夜奔赴江海,斯時卽淺灘畢露,而航運爲之阻斷。水運事業之不能進步,卽由於是。

低水位時,節制水量之工事,國人亦早有行之者。在昔漕運時代,運河中間段設閘,若滎流閘河定閘惠濟三閘等今猶存在,惟閘板久佚,終年開放,有閘亦與無閘等耳。此外若扼水入運則有洪澤湖口之三河壩,限制入江入海之水,則有歸江歸海諸壩,均於洪水經過之後趕謀堵閉。鹽河在時碼頭附近枯水期內亦臨時攔河築壩,凡此均爲節制水量,以接濟航運而設。惜工程粗陋。或竟阻斷航道,貨物至此必須換船而行,或束狹河槽過甚,使水流迅疾萬分,船隻必須牽挽上下,不便殊甚。

爲航運計,河道必須常年有相當之深度,與船舶吃水深度相稱,否則卽有停頓之虞。然天然水道,一年中水位漲落每每甚鉅,卽一年中可供航行之水深度,至不整

一。以中運河礠灣爲例（閱第十七圖）各種水位一年中之持續期間相去懸殊。此處河床最深點爲十五公尺，因是水深在三公尺以上者，一年中僅有 77 日，佔全年百分之二十一。水深在二公尺半以上者，全年僅118日，佔全年百分之三十二。水深在二公尺者，一年中亦祇186 日，佔全年百分之五十一。若水位在19.7者全年僅五十七日，佔全年百分之15.5而已。如此水道，其不能供巨大貨船終年航行之用，可不問而知。至云濬深河床，可以增加水深，實不盡然，蓋枯水期內，上游來源甚小者，若將河床開挖極深，使其通暢逾恆，勢必至去流加速而水位亦隨之低落。若浚深河底，以翕引江海潮汐，則在濱江近海之地，尙可行之，數百里長流而欲盡令浚至江海低潮位以下，則盡人知其爲不可能者。故欲謀常年保持河流之相當深度，惟有設置船閘與活動壩以節制其水量，名之爲河流之航渠化。

例如中運河之船閘及活動壩建築以後，礠灣最低水位卽可增至19.7 公尺。當未整理以前，一年中在此水位之日數，僅佔全年百分之15.5者，今可終年如一，此其便利航運爲何如耶。又如第二十三圖，在未整理以前，各段之最低水位線，有多處與河底相切，此卽河床全部涸出之現象，整理以後，則到處水深至少爲三公尺，載重九百噸之巨船，可終年往來無阻，一轉移間，中運河卽可成爲交通之要道。

活動壩能隨意啟閉，低水期內，將其關閉，河流中逐

段水量,即爲所節制,而水位保持。活動壩之側,則建船閘。閘有門二重,啟閉甚易,兩門之間爲閘室。船自上游來,先放水入閘,使與上塘之水平,然後啓上塘閘門,放船入室。乃閉上塘閘門,再放水入下塘,使閘室之水位與下塘齊於是啓下塘閘門,放船至下游。船舶由下游上溯者,其法亦同。階梯上下,無盤駁牽挽之煩。若遇洪水盛至,則活動壩與船閘閘門一律開放,使洪水仍得暢流而下,恢復天然水道之原狀。

今欲發展淮運區域內航運之利,惟有將主要航道設置活動壩及船閘,以使其航渠化而已。

航運路線網

各部之航運工程計劃,將於下文分節論列,玆先一述各路線互相聯絡之狀況。(閱第十九圖)

斜貫西北至東南通江者爲運河,第一期建設時自微山湖之藺家口閘起南經淮陰邵伯至三江營以達於揚子江。設船閘凡五。

將來黃河治理後,於黃河濱藺家口各設一船閘,即可拓展之使北達於河。更於串場河與通揚運河相交之處,及鹽城至涇河閘所闢之灌溉渠道之上口,各設一船閘,即可使通揚運河串場河與運河成爲互相溝通之航道。

斜貫西南亘東北通海者爲淮河洪澤湖張福河鹽河及灌河之聯絡線,藉運河之淮陰一閘,並於鹽河蔡工渡灌河上段及新浦鎮各設一閘,即可通航。將來於懷遠

附近增設一閘.交通卽可及於淮河上游。又於高良澗至涇河閘之灌溉渠道上,建設一船閘,則淮河通江之航道,卽可以此爲捷徑。至洪水期內,則船舶仍可由三河而下,以達於江。

將來交通狀況之預測

各航道建設以後,交通自必雄飛突進。據方顧問工程師之推測,運河開通五年以後,每年可有 5,000,000 噸之運輸,二十五年以後,可增至 20,000,000 噸,蓋以其包括生計區域之廣,航道路線之適宜,工資之廉省,其發展之速,必遠過於他國也。依此而推,則淮鹽河聯絡以後,亦必有同樣之發展,故可於淮運區域內航道建設完成五年以後,貨運額可達 10,000,000 噸。現今之貨運額,無確切之統計,至多恐不及 1,000,000 噸,卽五年以後可以多十倍。

航渠之橫剖面

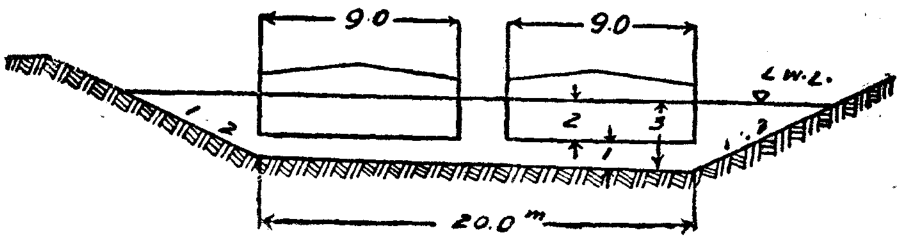
航渠橫剖面之大小,應以所經過之船舶爲準。在昔運河行漕時代,因節節設閘蓄水濟運之故,所用船舶制度較鉅。自漕運旣廢,運河失治,而大號糧船,已不多見。裏運河之下段,因水較深廣,故船舶有達 150 噸者,然僅及邵伯爲止,更上則難以行駛矣。

現今規畫運渠,應以切於最近的將來之需要爲原則。若此時遽以數千噸之船爲準,則未免失之過鉅。蓋欲使大貨船能見諸實用,必須於每一交通起卸地點,有輻輳之公路鐵路及水道綫網,使腹地貨物能有巨量之集

中,庶可以賴以輸運。今淮運區域內,各項道路,雖皆在建設之際,然俟其完成需時尙久耳。

此次規畫航渠時,其最大通行之船爲長 72 公尺,寬 9 公尺吃水 2 公尺。命完滿度爲 0.88,載重係數爲 0.8 則此船之載量爲 72×9×2×0.88×08.=910 公噸,卽 900 英噸。航渠之橫剖面,卽以能容此項大船兩艘並列爲度(第十八圖)故所需河底寬爲 20 公尺,最低水位時深 3 公尺。使船底與河底間留空隙 1 公尺。

在船閘附近之上下,必須放闊水面以備船舶停艤。此部份並應取直線形以令前後可以瞭見,在第一期建設中擬定此部份爲 1 公里河底寬度增至 40 公尺。



第十八圖　航道最小橫剖面圖

船閘之寬深度

第一期建設之船閘,不必過求偉大,俟將來水運發展,大船逐漸加多至數百艘以上,再謀增設較大之船閘亦未爲晚。現定船閘之長自上塘門限至下塘門之退堂爲 85 公尺。閘寬爲 12 公尺,檻上最小水深度 $2\frac{1}{2}$ 公尺。卽最大之船每次可通過一艘。寬 5 公尺,長 32 公尺,吃水 2 公尺,載量 225 公噸者,同時可通過四艘。寬 3

公尺長20公尺吃水 1 ½ 公尺載量60公噸者,同時可通過六艘。至普通小民船,則同時可通過十艘以上。將來增建較大之船閘後,此項船閘仍可專充載客汽輪及公事船之用,因爲耗水較少而開閉輕便,故可以歷久而不廢。

此項船閘,以每小時開啟一次計,耗水量連渠段中滲漏蒸發合計之,每一航渠不及每秒 20 立方公尺,在洪水期內,此可以不計,即在灌漑與枯水期內,亦所耗水源無多,可以設法接濟無疑也。

洪水及灌漑期之航運

淮河洪水之排洩,自洪澤湖以下,雖與現所規畫之航道相隔絕,然運河劉老澗上游之於泗,灌河之於沂,鹽河在新浦以下之於沭,及淮河在洪澤湖上之本幹,則均以同一河床兼供排洪之用,在最大洪水時期。航運受其妨碍,容或難免。故在此時期以內,宜將一切閘壩開放,以洩出最大之洪水量。航運幸能維持,固屬幸事,否則亦並無大害,蓋最大洪水,多年始來一次,而爲期又暫而非久也。

當灌漑時,張福河中運河劉老澗以下一段,暨裏運全部,均兼作輸運灌漑水量之用,在此時期以內,因輸運水量之突增,一部份之水位雖將昇高,而其餘部份,必將低落。爲避免航道之阻斷計,一部份之河底必須加浚至最低水位以下三公尺。

河床灣曲之修整

天然河道,恆多灣曲過甚之處,雖自航渠化以後,流

速減小,然終不便於航行,應於第一期建設工程完竣後,擇其灣曲最甚者,加以修改,使其曲綫半徑最小爲1公里。

船閘與活動壩之構造

各航道所用之船閘制度,均大同小異,其建築地點將於下文詳述之,今因閘壩地址詳細地圖尙未測成,未能爲逐箇之設計,僅列水位差度 9.2,6.7 公尺兩種於第二十圖與第二十一圖,以見一斑。

建閘基址,大率爲砂土與粘土所構成。其承重能力,尙待實地試驗,今姑以每平方英尺四千磅爲限。據以設計,則閘身必須充分減輕重量,方可免基礎工程之繁費爰採用鋼筋混凝土之建築。閘牆之背,均用背撐 Counter fort 閘底用肋狀橫樑,以期節省鋼筋混凝土之分量。爲堅固起見,更於背撐及肋狀樑間加設與之直交之横骨,使縱横如棋盤形。平時水土壓力,旣可得均勻之分佈,偶遇意外撞擊,亦得迅速傳達於各背撐及肋樑。

船閘牆面,受意外之撞擊機會較多,故計算應力時,加增水壓力之三分之一,以資應付。又於鋼筋之外,厚附混凝土,偶被擊破,較易修補。

閘門均作雙扇對開式,以建築鋼構造之,閘門及洩水門開關機械,均以人工運用爲主。

運渠兼作排洪之用者,其船閘之旁,應建較大之活動壩。若僅爲排洩渠段內之雨水,並調勻渠段內之水位起見,則建一較小之閘洞或活動壩已足。

第二節　運河之航運工程

第一期所建設之運河航運工程,起自山東省境微山湖上之叢家口,至三江營入揚子江爲止。共長430公里。設船閘凡五,卽得勝閘,河定閘,劉澗閘,淮陰閘,邵伯閘是也。自叢家口至劉澗閘,其水源取諸微山湖,自劉澗閘以至邵伯閘,則並用微山湖與洪澤湖之蓄水量。

自叢家口以北至黃河之濱,爲程約150公里,以測繪未詳,未能爲之計畫。然大致在叢家口及黃河濱建造兩船閘,已足使航道推展達於黃河,而揚子江與黃河之航運,卽可互相聯絡矣。此當列爲第一期以後之工程。

自邵伯鎭以下,通江之孔道有二,一遵排洪計劃中三河入江之路,由六閘下太平河廖家溝沙頭河而至三江營。一經揚州至瓜洲達於江。在排洪工程完竣以後,三河入江之路,在六閘以下,深通逾恆,已可無須額外疏浚工程,揚子江之船舶,可於低水期內,駛入運河。若瓜洲一路,則淤淺較甚,果能加以疏浚,使終年通江,固屬最佳,否則亦僅江水低落時期,航道稍形淺澀而已。以其交通關係,僅係地方局部問題,故未列入計畫之內。

今以每一船閘以下,作爲一渠段,而詳述其工程計畫。

第一渠段　自叢口閘至得勝閘

爲航運計,自叢家口至微山湖之湖口閘一段,須加

以開浚。自湖口閘以下,則爲排洪計,需開浚土方較多。

將來於叢家口應建船閘,暫定其名爲叢口閘。

此段運河,與津浦鐵路交义於韓莊,可使韓莊成爲商貨之一集中點。鐵路橋須改建,抬高約五公尺。

自叢家口至得勝閘爲程37.5公里,所需工程費總計如下。(大部分挖土工程,實爲排洪所需,茲均列入於此,以免劃分)

挖深排洪及航運河床土工	7,168,188	立方公尺	$ 967,705
築堤硪工(卽利用挖出之土)	1,102,046	立方公尺	$ 27,551
築堤取土及硪工	57,551	立方公尺	$ 9,209
改建鐵路橋費約計			$ 50,000
共計			$1,054,465

第二渠段　自得勝閘至河定閘

中興煤礦有鐵路達此渠段左岸之台莊鎮。將來山東之煤,卽可全年由運河輸運。北可至濟寧及黃河沿岸,南可接濟淮運全域,並達於揚子江各埠,洵於運河航運前途有莫大之關繫。得勝閘之下塘水位變化,定爲0.5公尺。最高28.9公尺。最低28.4公尺。上下塘水位最大差度爲6.7公尺,最小爲1.7公尺。洪水期內減至1.0公尺。渠段全長45.5公里。所需工程費總計如下。

得勝閘一座			$ 300,000
挖深排洪及航運河床	3,300,262	立方公尺	$ 445,535
築堤硪工(卽利用挖出之土)	555,844	立方公尺	$ 13,896
築堤取土及硪工	2,015,856	立方公尺	$ 322, 37

共計		$1,081,968

第三渠段 河定閘至劉涸閘

此段河道,在低水期內,最稱淺澀。一年中可以通行較鉅之船舶者,幾無幾日。觀第二十三圖中所繪未整理以前之最低水位線,卽第十七圖碯灣水位持續期間曲綫,卽可知其困苦之狀况矣。

此段上游,灘上集之南爲不牢河口,迂繞曲折以通微山湖之西岸。不牢河淤墊雖甚,但運河水位抬高以後,將來祇須略加整理,或由地方加以局部工程,卽可通航。而本渠段適承其下游,故其交通利益,可以伸及腹地。不僅運河兩岸而已。

隴海鐵路在不牢河口之南,橫跨運河。目前雖無重要集鎭,然將來運河之航運發達,則水陸交通,以此爲啣接之點,乃意中事也。惟鐵路橋須重建抬高約六公尺。

本渠段水位變化定爲 0.5 公尺,卽最高爲 20.2 公尺,最低爲 19.7 公尺.河定閘上下塘水位差最大爲 9.2 公尺,最小爲 8.2 公尺,洪水期內減至 1 公尺,工段長約 104 公里,所需工程費總計如下。

河定閘一座			$ 400,000
挖深排洪及航運河床	2,476,974	立方公尺	$ 334,391
築堤硪工(卽利用挖出之土)	569,950	立方公尺	$ 14,249
築堤取土及硪工	1,978,120	立方公尺	$ 316,499
改建鐵路橋費約計			$ 50,000
共計			$1,115,139

第四渠段　劉澗閘至淮陰閘

此段與洪湖相通。故水位變化較鉅，共計五公尺。卽最高爲 16 公尺，最低爲 11 公尺。劉澗閘上下塘水位差最大 9.2 公尺，最小爲 3.7 公尺。自閘以下至衆興之閘，河底略須浚深。雙金閘以下，則舊河槽曲折太甚，另闢新河，以與裏運相接。（見第二十六圖）西由張福河通洪湖，可直達淮河上游，而往來船舶，亦可免惠濟等三閘之困難矣。工段全長約 57.5 公里，所需工程費總計如下。

劉澗閘一座			$ 400,000
挖深航運河床	2,207,082	立方公尺	$ 297 956
築堤礎工（卽利用挖出之土）	170,020	立方公尺	$ 4,250
築堤取土及礎工	80,764	立方公尺	$ 12,908
共計			$ 715,114

第五渠段　淮陰閘至邵伯閘

此渠段在運河中爲最長。其北端淮陰附近，尤爲交通網絡之樞紐。南由本渠段通揚子江，北由中運通山東，且與津浦隴海等路相接。東由鹽河出鹽灌各海口。西接洪澤湖可達淮河上游。將來萬商雲集，檣帆林立，可以預料。交通旣便，文化日進，將來路線所及，人民之生計當不難日臻充裕矣。

淮陰鎭江間，本有輪船可通。但除高郵以南，尙可勉强終年通行外，高郵以北之一段，往往一年中祇可通行數月。交通之不便，旅行多視爲畏途。施工以後，此弊當可革除。

本渠段水位變化爲 0.5 公尺。即最高爲 7.3 公尺，最低爲 6.8 公尺。在灌漑期內，水面略呈傾斜。惟淮陰閘之下塘水位增至 10.00 公尺，故閘之上下塘水位差度最大爲 9.2 公尺。最小爲 1 公尺。淮陰淮安間河床略須挖深，工段長約 145 公里。所需工程費總計如下。

淮陰閘一座			$	400,000
挖深航運河床	666,074	立方公尺	$	89,920
西堤缺口堵塞土方	80,000	立方公尺	$	12,800
共計			$	502,720

第六渠段　邵伯閘至揚子江

此渠段在六閘與淮水排洪入江水道相交，故即在邵伯至六閘間闢新道與入江水道相接，乃由太平河廖家溝沙頭河至三江營入江。其原有運河河槽則作爲通揚運河之引水渠。

邵伯閘之上塘平時水位爲 6.8 至 7.3 公尺。水位變化爲 0.5 公尺。在灌漑期內上塘水位減至 5.8 公尺。下塘水位視揚子江潮位及淮水入江水道之水位而定。揚子江水位最低時，下塘水位爲 —0.4 公尺。故上下塘水位相差最大爲 7.7 公尺。淮水盛漲時，下塘水位爲 7.5 公尺。較高於上塘水位 0.2 公尺。此時可將船閘低門開啓成爲自然河流，於交通並無妨礙。

太平河爲排洩淮洪起見，本須浚深至零點以下，約 4 公尺。廖家溝及沙頭河則原有河槽甚深，故在揚子江低水時期水深均已達 3 公尺有餘。普通水位時水深可

六七公尺。江輪可以直達六閘,不須因航運而另加工程也。

通瓜洲之運河,河槽在普通揚子江水位時亦有三公尺左右之水深。餘一二淤淺之處應加以疏濬外,卽可無須極鉅之工程。而鎭揚間運客之船舶可以往來無阻矣。茲將邵伯至入江水道間之工程總費列下。

邵伯船閘一座			$ 350,000
挖深航運河床	888,790	立方公尺	$ 119,986
築堤磩工(卽利用開挖之土)	1,990	立方公尺	$ 50
築堤取土及磩工	39,020	立方公尺	$ 9,243
共計			$ 476,279

工程費總計

本工程總計經費如下

渠　段	建閘經費	挖深河床	築堤取土	築堤加磩	改建鐵路橋	共　計
第一段		$ 967,705	$ 9,209	$ 27,551	$ 50,000	$ 1,054,465
第二段	$ 300,000	$ 445,535	$ 322,537	$ 13,896		$ 1,081,968
第三段	$ 400,000	$ 334,391	$ 316,499	$ 14,249	$ 50,000	$ 1,115,139
第四段	$ 400,000	$ 297,956	$ 12,908	$ 4,250		$ 715,114
第五段	$ 400,000	$ 89,920	$ 12,800			$ 502,720
第六段	$ 350,000	$ 119,986	$ 6,243	$ 50		$ 476,279
總　計	$ 1,850,000	$ 2,255,493	$ 680,196	$ 59,99[illegible]	$ 100,000	$ 4,945,685

第三節　淮河至海口航運工程

此項工程之目的,在使淮河中上游及洪澤湖張福河鹽河灌河成爲一連貫之航道。第一期建設之工程,係自懷遠起經蚌埠盱眙高良澗碼頭鎮穿淮陰閘至西壩入鹽河再經蔡工閘至龍溝鎮,分爲二路,一路由龍溝河過龍溝船閘入灌河以達於海,一路北行經新浦船閘至臨洪口以達於海。航道全長凡483公里。其中淮陰船閘卽利用運河航運工程所建築者。此外應新建之船閘凡三,卽蔡工閘龍溝閘,與新浦閘是也。

灌河深廣逾恆,自响水口以下吃水五公尺之海輪,可以行駛。將來加以約束及治導工程,並於開山附近之海口建築海堤,攔截北洪子,使南洪子刷成深泓,則外海船舶可以駛入灌河,而响水口卽可成爲外海內河轉船之港埠。

龍溝附近鹽河中應建活動壩二座,以免沂河洪水之倒灌,將來如加築蔡工閘至新浦閘間之河堤則此二活動壩亦可撤廢。在第一期工程完竣時,如遇沂河洪水,則暫閉此壩。因沂河洪水漲落甚速,故阻礙航運,並不甚鉅。龍溝閘旁爲平時蓄水計應建大活動壩一座,橫亘灌河上段之內。沂河治導工程計畫今尙未確定,苟於上游覓得攔洪水庫地址,則沂河洩量尙可減少,而此活動壩工程亦可同樣減縮。故在第一期建設工程中,此壩可如歸江歸海各壩形式,以柴土爲之。洪水一至,卽行撤除,水去則復行堵築之。

南六塘河河底較深,故於新浦龍溝兩閘造成後船

舶亦可暢行至高溝鎭以上。

高良澗至涇河閘爲灌溉計,應築引水之渠,將來於進水牐旁另築船閘,則淮河上游之船欲赴裏運河者,可由此轉道,路程較近。

淮河各源流,將來或加疏浚,或於河口築閘,則航道更可延展。

洪澤湖在將來灌溉期水位需低降至十一公尺,但在灌溉尚未充分發展之時,最低水位必較是爲高,故洪澤湖底暫時亦可不加浚深也。

關於本項工程之平面圖及剖面圖,觀第廿四圖與第廿五圖。與運河之聯絡方法,觀第十九圖與第廿六圖。

第一渠段　自懷遠至淮陰閘

此渠段溝通懷遠蚌埠五河盱眙淮陰諸大城市。其交通之重要,利益之廣溥。當可不言而喻,其上部爲淮河之中游,河底平坦,故費較少之浚河工程。卽可通行所規定之最大船舶。又淮河于蚌埠穿津浦鐵路而過,該處鐵橋橋墩在規定高水位以上約十公尺,故鐵橋不必改建。龜山以下至高良澗,爲洪澤湖,水深稍覺不足,須闢航綫一道。高良澗以下至碼頭鎭爲張福河,浚深之工,亦屬不多。碼頭以下開闢新河,分曲線二股(見第二十六圖)以與中運相接,而連通於淮陰閘。渠段全長凡265公里。所有工程費總計如下。

闢洪澤湖航線	1,000,000	立方公尺	$ 100,000
開挖航運河床	3,394,602	立方公尺	$ 458,271

築堤硪工（即利用開挖之土）	993,310	立方公尺	$ 24,833
築堤取土及硪工	2,255,950	立方公尺	$ 360,056
共計			$1,004,056

第二渠段　淮陰閘至蔡工閘

舊時鹽河與運河之間,航運不能相通。所有自鹽河而來之貨物,均須在西壩起岸,駁運至淮陰或楊莊入運。而運河貨物則由淮陰或楊莊起岸,駁運至西壩入鹽。西壩與淮陰楊莊各距十數里,貨物裝卸往來,搬駁既費時日,又增運費,不便已極。茲由淮陰以西之運河起,至西壩以東之鹽河止,闢一新河,長約5.34公里以貫通鹽運二河,其裨益於航運,實非淺鮮。

自西壩以下,仍用鹽河舊槽,無須疏浚工程。惟蔡工閘以上一段,因灌溉時期水位頗高,略須修堤。其費用已歸入灌溉工程淮陰閘歸入運河工程,玆均不列入。

此段最低水位爲 6.8 公尺,最高爲 7.3 公尺。灌溉期內水位略有傾斜,在淮陰閘下塘爲 10.00 公尺。蔡工閘下塘水位爲 3.0 公尺及 3.5 公尺。上塘爲 6.8 公尺及 7.3 公尺。灌溉期內爲 9.9 公尺。故上下塘水位差最大爲 6.9 公尺,最小爲 3.3 公尺。

渠段全長約 61.00 公里,所需工費總計如下。

蔡工閘一座			$ 300,000
開挖新河土方	2,125,680	立方公尺	$ 286,967
築堤硪工（即利用開挖之土）	4,130	立方公尺	$ 103
共計			$ 587,070

第三渠段　蔡工閘至新浦閘

此段水位變化爲 0.5 公尺,即最高 3.5 公尺,最低 3.0 公尺。惟在龍溝與沂河相交處,沂河最高水位至 8.0 公尺,而最低水位又不敷航運之用,故須建活動壩三座。其中二座較小,在鹽河入沂口,以防沂水倒灌。一座較大,在龍溝以下沂河中。爲節省經費計,可暫用舊式草壩,待將來沂水整理以後,再行改建活動壩。壩旁建船閘一,以通灌河之船。

新浦閘上塘水位爲 3.0 及 3.5 公尺。下塘潮位爲 —2.2 及十 3.35 公尺。故上下塘水位差最大爲 5.7 公尺。惟沭河盛漲時期下塘達 3.8 公尺,高於本段高水位 0.3 公尺,此時可將閘門開啟,無礙交通。

按上述辦理,則灌河臨洪兩海口之貨物船舶可以直入內地,而內地貨物亦可直接運至兩海口。

此段全長約 77 公里,所需工費總計如下。又自龍溝至灌河口凡長 73 公里。

新浦閘一座			$ 300,000
龍溝沂河閘一座			$ 300,000
龍溝沂河壩一座			$ 100 000
龍溝鹽河壩二座			$ 100,000
開挖航運河床	189,042	立方公尺	$ 25,521
築堤硪工(即利用開挖之土)	20,205	立方公尺	$ 505
築堤取土及硪工	30,469	立方公尺	$ 4,875
共計			$ 830,901

工程費總計

聯絡淮海航道工程所有工程費總計如下

渠段	船閘	活動壩	挖深河床	取土築隄	築隄硪工	共計
第一渠段			$ 618,271★	$ 360,952	$ 24,833	$ 1,004,056
第二渠段	$ 300,000		$ 286,967		$ 103	$ 587,070
第三渠段	$ 600,000	$ 200,000	$ 25,521	$ 4,875	$ 505	$ 830,901
總計	$ 900,000	$ 200,000	$ 930,759	$ 365,827	$ 25,441	$ 2,422,027

★其中因挖深洪澤湖中河槽計$160,000可於將來灌溉需用水量增加,洪澤湖最低水位降至12,00公尺以下時再行動工。

第四章 灌溉工程計劃

第一節 灌溉需水量之估計

舊黃河之南北，今運河之東西，土地肥沃，氣候溫和，乃吾國重要農區之一。惟以淮沂泗沭之失治，非潦卽旱，災荒頻乘，民不聊生。今各河洪水，已有治導之規劃，對於農田灌溉，允宜統籌兼顧。庶害除而利亦隨之以興矣。

舊黃南北，因土質氣候習俗之不同，農產種類，亦顯相異。舊黃以北，概植旱季作物，灌溉之需求較遜。然偶遇大旱，災象立見，苟施灌溉，利且無窮。舊黃以南，則水田甚廣，如裏下河區，幾全部植稻。舊時每當春夏之交，雨水缺乏之時，卽羣賴運河之水，以資灌溉，惟因淮運之有失調節，往往水源有限，不敷分給，其有望於灌溉之發展，固一如望洪水之祛除也。

農作物　舊黃河以南，其主要農產，爲稻棉豆麥芝蔴花生蕃薯及其他値物。當春夏乾旱之季，最要農產，厥爲稻與棉。

雨量　灌溉區域之雨量，無詳細之長期記載。就各地歷年所有之短期記載，研究其逐月之最大平均及最小雨量，知當平均雨量之年份，可恃雨水以防止旱荒。當乾旱之年份，在四月中至七月中之耕植時季，最小雨量，祗約四英寸（十一公分）實不足以資農作物之生長，而必需灌溉。

需水淨量　冬季及其他附屬農作不計，主要農產，必須施以灌溉者，為稻與棉。稻之需水時期，約自四月中旬至七月中旬。棉則於栽植之季，四月五月之間最為亟需。稻之產額，欲得豐收，需水極多。但求免除災荒，維持尋常產額。則需水之量，當可減少。按民國十一年，裏下河區稻田產額，平均每畝逾二石。地形較低之區，曾由運河閘洞給水灌溉之，餘則全恃雨水。是年四月中至七月中，降雨量約為八英寸。同時運河閘洞給水量，據本處推算，約為每秒 95 立方公尺，合共735兆立方公尺。裏下河區之稻田，據運河工程處估算，約共有一千萬畝。設其三分之一，為河水灌溉所及之地。則平均各地所得之水深，包含一切損耗在內，為 14 英寸。故是年稻田所受之總水量，為8英寸至 22 英寸。每畝產額，則在一石五斗與三石五斗之間。於此可見，苟有一英尺左右之淨實水深，以供灌溉，雖遇極旱之年，已可免除災旱，若遇雨水較稍充足之年，則更可豐收。依此為準，估計稻田之需水量為18英寸。至於棉及其他雜粮，有其半數，即 9 英寸已足。而當灌溉時季，至少有 4 英寸之雨水，可資挹注，於是仰給於灌溉之淨水量，稻為 14 英寸，棉及其他雜糧為 5 英寸。根據斯値，即可作需水總量之估計。

輸水損耗　溝渠輸水，有一部水量，損耗於滲漏及蒸發。損耗水量隨當地情形，及渠床性質而異。蒸發損耗，恆較滲漏為小。而舊渠之滲漏又較新渠為小。此區河渠，皆由來已久，輸水損耗，可估為總水量百分之十五。若遇

新闢之渠,則可估爲百分之三十。

灌漑面積　舊黃以南,灌漑之地,可概分爲四區。卽裏下河區,高寶湖區,通揚運河區,及沿海墾植區。裏下河區包含江都高郵寶應興化東台泰縣鹽城各屬耕稼之地。據江北運河工程局之估計,除范公堤以東之地不計外,面積約爲11,740000畝,其中百分之八十六爲稻田,百分之十四爲其他雜糧地。高寶湖區包含洪湖東南,運河以西之低地,卽白馬寶應高郵汜水界首等湖之週圍及其湖底涸出之田地是也。據運河工程局之估計,諸湖高水位與尋常水位之間,約有1,840,000畝,各湖湖底,涸出面積,可有1,000,000畝。導淮以後,若總面積之十分之二,爲村鎭道路溝渠之地,則當有二百二十五萬畝。可成農田。(已詳排洪工程章)惟欲圖斯區之墾植,固應灌漑以防旱,並須排水以防潦。蓋湖區低窪,舊無河渠過量之雨水,非另闢溝渠,及設置抽水機以排洩之不可也。(詳第29圖)斯新闢農區,由當地習慣暨現今耕殖狀況察之,或有百分之八十爲稻田,餘爲耕種雜糧之地。通揚運河區,除有一部面積已包含於裏下河區及沿海墾植區,又濱江之地,可藉江水灌漑不計外,其餘灌漑面積,或有二百五十萬畝,其中稻田約佔百分之三十,棉及雜糧約佔百分之七十。沿海墾植區,約共有五百萬畝,在逐漸經營發展之中。該區幾皆種棉,需水之量比較爲少,但四月五月耕種之時,偶遇乾旱,亦將有賴於灌漑。

需水總量　根據上述之需水量輸水損耗量,灌溉面積,及其農作類別,可估計各分區之需水總量,計裏下河區需水2,670兆立方公尺,高寶湖區561兆立方公尺,通揚運河區351兆立方公尺,沿海墾植區512兆立方公尺。共計舊黃河以南各地之需水總量爲4,094兆立方公尺。

第二節　洪澤湖之蓄水量及其水位

舊黃以南各地之灌溉水源,惟淮河是賴,而淮河旱年流量,當春夏之交,小至每秒數十立方公尺,且如民國六年五六月間幾完全斷流。灌溉水源,尤非賴洪澤湖之瀦蓄不可。

考淮河以民國六年爲最旱,(如第27圖)然其總流量,仍遠過於灌溉需水量,故洪澤湖祇須攔蓄每年潦期之水,卽足供旱季之需。而如民六最旱之年,當灌溉之季,尙有一部水量,可直接取給於當時之天然水流,瀦蓄總量,可相當縮減。惟湖面廣大,所蓄之水,消耗於蒸發者,亦不爲少,應增加蓄水量以補充之。如上所述,需水量爲4,094兆立方公尺,灌溉時季,淮河天然水流能供給之水量約爲1,370兆立方公尺。故應蓄水量爲4,094－1,370＝2,724兆立方公尺。合蒸發損耗爲1,000兆立方公尺。洪澤水庫應蓄之總水量,爲3,724兆立方公尺。若洪澤湖最低水位爲11公尺,更低卽不能照常給

水,則從容量曲線(第一圖)知洪湖水位,應在13.2公尺。即每年洪水之後,應保持此水位,始可供給灌漑所需之全部水量。更爲安全計,令洪湖蓄水水位在13.6公尺。

惟洪澤湖同時爲攔洪水庫,欲洪水之儲量瀦積,尾閭工程之盡量節省,當洪水時期,湖水位以愈低爲愈佳。惟其最低限度,應令洪水之後,儲積其餘各月之水流仍能達其應有之蓄水總量。設以民六旱年爲準,洪水之後,灌漑之前,淮河水量,能供蓄積者,在2,500兆立方公尺以上。故在洪水之季,其水位可低至12.5公尺。蓋洪湖容量,在13.6與12.5公尺之間,爲2,200兆立方公尺。固必能於洪水以後,儲滿有餘,不妨灌漑。而對於攔洪,則功效倍增,所補不鮮。

故洪澤湖之水位,歷洪水期之始終,最低應在12.5公尺。洪水之後,灌漑之前,應在13.6公尺。於是攔洪與給水,兼顧而無一失矣。

第三節　灌漑水量之分配

灌漑區域之地勢,北高而南低,裏運河串場河概自北而南,且其位置復較兩旁之地爲高。爲灌漑分水計,利用上述二河爲幹渠,最爲適宜。惟自洪澤水庫,東達茲二渠之總幹,應採取何道,乃亟應規劃者也。

今由洪澤湖輸水以濟運者,爲張福河。張福河下達

裏運河之最北一端,形勢居高。用爲總幹,固甚合宜。惟該河河身狹小,兩岸復高。淮運導治,淮陰築閘以後,其載量當洪湖水位 12 公尺時,約有每秒 50 立方公尺。當洪湖水位13.6公尺時,亦僅約有 140 立方公尺。灌溉需水總量,平均計之,須達每秒475立方公尺,不敷過甚。若欲增加其載量,須全賴於開挖。而兩岸地高,挖土之工非輕。爲工程經濟計,勢難用作總幹。據顧問工程師方修斯之意見,灌溉水量之大部,可由洪澤湖之高良澗循舊潯河以達涇河閘入運。舊潯河原亦狹小,惟兩岸較低,可同時疏浚及築堤以增其載量,工費將較張福河爲省。至於張福河,則利用其現有載量,以分輸小部水量。是誠最經濟之規劃也。

各分區之需水量,設其灌溉時期爲一百日,平均計之,則裏下河區爲每秒310立方公尺,高寶湖區爲每秒 65 立方公尺,通揚運河區爲每秒 40 立方公尺,沿海墾植區爲每秒 60 立方公尺。共爲每秒475 立方公尺。當各區農田全數施行灌溉以後,在需水量最多之一月,所需水量,勢須大於上述之平均數,惟爲期當在十年或二十年以後。在此規劃,各幹渠之載量,暫以平均數爲準,至全部開發以後,再設法增加其載量,尙未爲晚。

玆擬由洪澤湖至涇河閘之總幹渠,輸每秒425 立方公尺之水量入運河,另以每秒 50 立方公尺由張福河輸之鹽河,而後輸出於蔡工渡附近,穿黃河而南,以達串場河。由涇河閘入運之水,以每秒 25 立方公尺輸之

向北灌溉沿運北部之地,100立方公尺,輸之向東,取道溼河穿射陽湖以至串場河,灌溉沿線兩旁之地,兼作串場河之水源。300立方公尺輸之向南,灌溉高寶湖區及裏下河區之射陽湖以南各地,並輸40立方公尺至邵伯入通揚運河以應該區之需。假道鹽河而達串場河之50立方公尺,除灌溉舊黃以南阜寧以北之地外,餘水入串場河。合溼河來水,由串場河分給於沿海墾植區。此乃分佈灌溉水量之大綱也。

第四節　灌溉幹渠

灌溉時期洪澤湖之水位,將自13.6公尺逐漸低降至11.0公尺。此最低水位,僅於最旱之年,偶一遇之。其時必在灌溉季之末期,且爲時則甚短灌溉渠之流量,當此最低水位惟有聽其降至極小或竟暫時斷流。不然,渠及閘之工費將極大,而如裏運河同時爲航運之渠,欲雙方兼顧,開挖之費,更將不貲。且水位既低,縱有水量,分佈灌溉,事實亦屬不易。

現擬幹渠載量。當洪澤湖水位12公尺時,輸送灌溉所需之最大水量,至水位降低時,聽其逐漸減小。溼河閘處之運河水位,尋常在6.8公尺,當灌溉時期可令昇高至10公尺。自洪澤湖至溼河閘之幹渠,約長40公里,平均爲1:20,000之降度,當流量爲每秒425立方公尺時,用傳希海滿氏公式,採用渠床糙度係數00225

計算之,渠之最大斷面形可如下:

水面寬	75	公尺
渠底寬	45	公尺
水深	8	公尺
岸坡	2	比 1

幹渠之橫斷面,將半由開挖,半由築堤成之。並令挖土之量適敷築堤之需,乃最經濟之規劃也。挖土與築堤,共計土方約 7,500,000 立方公尺,需費約1,200,000元。

自涇河閘北流之水,僅每秒 25 立方公尺,運河河槽,輸送裕如,無需施工。涇河閘南向之運河,其流量應自每秒300立方公尺遞減至 40 立方公尺以達邵伯。邵伯船閘之水面可落至6公尺,不致妨礙運河之航行。計斯100公里中得 4.0 公尺之降度,平均計之,爲 1:25000。惟流量既逐段不同,各處寬深,復不一律。爲省工計,可令現今斷面較小之處,降度稍大,反之,則降度稍小。全段配置,務令開挖之工,小至最低限度。根據江淮水利局所測裏運河之縱橫斷面,逐段推算,知除汜水至高郵,斷面過小,須略施開浚外,其餘皆能輸送必需之水量。惟淮安至汜水之間,則以水位增高,堤頂應加高一公尺左右。計培堤之土工,共472,500 立方公尺,每方以一角六分計共計洋 75,600 元。挖土之工 2,527,600 立方公尺每方以二角七分計。共須洋682,000元,兩共757,600元。

涇河閘東流至串場河之渠,在其終點,水位應在若何高度,視串場河南流水量之若干及其需要之水面高

而定。茲擬爲五公尺。涇河閘處以新渠之地勢甚低，令運河新渠水位跌降三公尺。於是新渠最大流量時之水位差爲 7.0－5.0＝2.0 公尺。渠長約 84 公里。降度約爲 1:42,000。其最大斷面形可如下:

水面寬	40 公尺
渠底寬	12 公尺
水深	7 公尺
岸坡	2 比 1

估計全堤土工，約爲 14,000,000 立方公尺，需費約二百二十四萬元。

張福河及鹽河，擬不加開浚。就其現有載量，當洪湖水位在 12 公尺時可輸送約每秒 50 立方公尺至鹽河之蔡工口船閘之上游。淮陰船閘處，可保持其最低水位 11 公尺，蔡工口船閘處，水位將降低至 9.93 公尺，惟仍可不妨航行。自鹽河闢渠穿舊黃河以達阜甯之串場河，長約 48 公里。令阜甯之水位爲 6.00 公尺。其降度爲 1:12,200。所需橫斷面可擬定如下:

水面寬	25 公尺
渠底寬	5 公尺
水深	5 公尺
岸坡	2 比 1

挖土築堤，約計土工爲 6,720,000 立方公尺。需費約一百十一萬元。

運河流量，至邵伯尙餘 40 立方公尺，輸至六閘轉

入通揚運河。惟六閘舊閘應重行修建,方可作為節制口門。茲估計該閘修繕費約需洋 50,000 元。

各渠規劃,大都以江淮水利局所測各圖為根據,間有欠詳確之處,尚須複測校核。所有各渠之設計容有稍事變更之處。

灌溉工程中,引水分水,應有閘壩涵洞,為之操縱。分水閘洞,視各區分水溝渠之規劃而定,但分水溝渠,經緯萬端,一時尚難全部決定。又串場河通海諸港,通揚運河通江各河,亦應相度地勢,分別緩急,逐漸建築閘壩,以資蓄洩。此亦有待於測勘規劃,均暫置不論。至於灌溉幹渠之口,各須建造進水閘或活動壩,共需五座,約共需洋六十萬元。

第五節　中運河區之灌溉

舊黃河以北中運河東西,概植旱地作物,如麥類豈類高粱蕃薯及其他雜糧。灌溉之術,民所不諳,推求其源,則水源無着,河渠缺乏,亦一因也。

淮沂泗沭導治以後,微山湖操縱成為水庫,每年存水可供灌溉之用者,約有 2400 兆立方公尺,以之灌溉旱地作物,可達二千萬畝,徐海舊屬,悉蒙其利。中運河及不牢河可利用為輸水幹渠。不牢河,就其現有載量,當微山湖水位高時,可輸送每秒一百立方公尺左右。其餘則純由中運河輸之。中運河既兼顧排洪,載量固甚充足也。

中運南輸水量在得勝閘河定閘二處,已有排洪之活動壩,爲之啓閉操縱。惟劉老澗船閘之旁,則應增築活動壩一座,爲排洩下游必需之灌溉水量。估計需費約近二萬五千元。

第六節　初步工程規劃

灌溉區域面積廣大,勢難同時興辦,而排洪航運灌溉息息相關,復不能不有所期待。惟導淮入江進行期中,舊黃以南各區之灌溉,應改進現狀,作初步之發展。其最要者,則爲裏運河區。該區閘洞河渠之設置,現已極多。惟操縱失宜,水量之耗費極大。所有閘洞,應一律添置緊密之閘門。其啓閉之時日,水量之分配。應調查測勘,根據所領農田面積,農作種類,土壤性質等,分別規定,並特設專員以監督管理之。至於農民欲新闢閘渠,發展灌溉者,應予以充分之指導必要之監督,不數年間,當可藉民衆之力完成其分水工程。至於裏運河河槽,因在開發之初,流量可小於上所估計之需水總量。高郵氾水間之開挖工程,儘可從緩。故裏運河僅置閘門五十座,約洋十萬元,卽可應初步灌溉之需矣。

高寶湖區,淮水導治以後,施以灌溉及排水之工,將有一百萬畝之新地可成良田,每畝價值,最低以四十元計,卽有四千萬元,幾可償導淮初步工程之全部工費,應及早興辦之。該區之排水渠及灌溉渠同時建造,排水渠

之挖土，卽塡灌漑渠之堤岸，事半而功倍。所有幹支河渠之規劃，如第 29 圖。其載量，洩量，斷面，土方等，亦經詳細設計估算，計培堤土工共 3,341,000 立方公尺，每立方公尺以一角六分計，需費洋535,000 元，開挖土工共17,863,000立方公尺，每立方公尺以一角三分五厘計，共需費洋 2,412,000 元，兩共 2,947,000 元，渠埝占地共19,000畝，百分之五十爲民地，每畝以二十元計，須費190,000元，水閘涵洞等建築需費 460,000元，抽水機場共五座，須費 1,000,000 元，共計高寶湖區全部水利工程需費爲4,597,000元。

自洪澤湖輸水至裏運河之幹渠，爲灌漑給水之最要工程，應及早興築。爲一勞永逸計，其載量卽爲每秒425立方公尺。通揚運河之新口門，亦應先行開闢，庶不致妨阻其水源。規劃估計，已詳上節。

統計初步灌漑工程急需之費可如下表（第7表）

表 7　初步灌漑工程經費估計

工程類別	工費估計				
	土方	閘門涵洞	收用民地	其他	總費
幹渠工程（洪湖至涇河閘）	$ 1,200,000	$ 300,000	——	——	$ 1,500,000
裏運河初步工程（添設新閘門）	——	$ 100,000	——	——	$ 100,000
高寶湖區全部工程（灌漑及排水）	$ 2,947,000	$ 460,000	$ 190,000	抽水機場 $ 1,000,000	$ 4,597,000
通揚運河新口門工程	——	$ 50,000	——	——	$ 50,000
					$ 6,247,000

受益田畝除高寶區之新地地值約有四千萬元左右,逐年農產收穫約有千萬元外,其他灌溉所及之面積,若僅以裏下河區之半數計,有五百萬畝以上,每年因灌溉而增加之農產價值,平均最低以每畝二元計之,亦達一千萬元之上,故初步工程之完成,其有裨於國計民生,已非淺鮮,安能不急起圖之哉。

第五章　繼續進行之測量設計工作

各河之排洪航運與墾工程,除第一期第一步之工程業已規劃就緒卽可實施外,其餘工程,有待於測量研究者,不勝枚舉,本處一方逐漸作第一期工程之實施,一方亟應繼續進行斯項基本工作,爲其他各部施工之標準。而在第一期工程中,如航運灌溉,欲得最經濟之細部規劃,有需於測驗研究者亦不爲少。茲特根據以上各章之規劃綱要,將所需之測驗設計工作,擇要條列於下:

關於測量者:—

(1)測勘沂河沭河上游

(2)測量微山湖及山東南運河湖平剖面圖

(3)測量淮河上游各湖平剖面圖

(4)測量沿淮之精密水準綫

(5)測量淮河上中游及支流之改定河道綫

(6)測量自洪澤湖高良澗至裏運河涇河閘之渠道線

(7)測量鹽河串場河間之渠道線

(8)測量自裏運河涇河閘東至串場河之渠道線

(9)測勘串場河通海諸港通揚運河通江諸河之閘壩地址

(10)測量中運河及山東運河各閘壩地址之詳細地形

(11)測量雙溝集淮河截灣取直段及溧河之詳細

地形

(12)測量淮河懷遠附近閘壩地址之詳細地形

(13 繼續並增加各河系水文測驗站

(14)聯接揚子江南北岸水準線

關於探驗及實驗者:—

(1)探驗擬造各閘壩地址之地質

(2)實驗擬造各閘壩地址之土質承重能力

(3)建立河工試驗室購置儀器用模型實驗擬建各閘壩之效用而爲計畫修正之根據

(4)用模型實驗已計畫各河流河床之線路及剖面是否穩定

(5)用模型實驗隄防之禦水能力

(6)建築材料之檢驗

(7)洪水期內各河流糙率之實地測驗

關於設計者—

(1)工用機械之選擇及設計

(2)規擬各工段施工之佈置及程序

(3)規訂施工細則

(4)規劃各工段員工之食宿交通等事宜

(5)設計閘壩各建築物之細部結構

(6)設計沂沭河上游攔洪庫

(7)設計自微山湖至黃河之航道

(8)設計通揚運河之航運工程

(9)設計淮河各源流之治導工程

(10)設計各地局部排水及灌漑及墾闢工程

(11)設計新闢河道後所需橋梁及道路

(12)設計清江浦响水口灌河口三汛營等新城市及港口

(13)設計施工時之機械修理廠

(14)繼續研究減低洪澤湖最高水位方法

(15)規訂各閘壩及一切建築物之維護方法與管理規則

Chapter I. General Statement

Article I, Introduction

The deterioration of the natural lower course of the Huai River was not begun as commonly believed with the year 1852 when the Yellow River broke through its bank at Tung-wa-shian in the Province of Honan and migrated to the north. It was really due to, the gradual silting-up of its bed from the Hungtze Lake down to the sea and the admission of the Yellow River into it long ago. During the Ming and Ching Dynasties, nearly all the river authorities were busily engaged in elevating the water surface of the lake in order to reserve enough water to help the dilution of silt-burden water of the Yellow River, for if the lake were not elevated no water of the Huai River could enter the Yellow River at its outlet near Huaiyin. In the meantime the Huai River had, however, already made the San Ho down to the Yangtzekiang its main course of flood escapeway. The abandoned bed proved to be useless as soon as the migration of the Yellow River happened, as no single drop of water could ever pass through it at that time.

The first man called to public attention to regulate the Huai River was Mr. Ting-hsien of Sanyang. He did not succeed to get any support. The late Mr. Chang Chien was the most outstanding man to pay attention to the question. He established the Kiang Huai Conservancy Board, which was subsequently reorganized into the Huai River Surveying Board. This board lasted from 1912 to 1926, and had accomplished most of the surveying work. Besides this, the Huai Region has been surveyed to certain limit by the different organizations, such as Kiangsu Grand Canal Board, Huai-Yang-Hsu-Hai

Topographic Surveying Board, Anhwei Conservancy Board and Shantung Grand Canal Board. For these reasons, the number of maps and records in this region is most abundant in comparison with other rivers of the country. It is the result of the continuous effort of the late far-sighted men, to whom we should not pass without mentioning a word.

Many schemes have been drawn up by the engineers either in this country or abroad, such as the Red Cross Engineers' Report of 1914, John R. Freeman's Report of 1920, Kiang Huai Conservancy Board's Report, Anhwei Conservancy Board's Report and the former National Conservancy Bureau's Report. Mr. Wu Tung-chu of Kwanyung District wrote a great deal about the problem. His "Table of Annual Events of the Huai River Systems" is a piece of very laborious work.

It is due to the continuous fightings of the notorious generals in the country since the establishment of the Republic that the construction works of the regulation of the Huai River has not been able to carry out, inspite of the attention has paid to it. In 1928, the National Reconstruction Commission appointed a committee to make a collection of the literature and records of the Huai Regulation problem. A pamphlet called "Report on the Records and Maps in Connection with the Huai River Problem" was issued afterwards. The National Government finally paid its attention to this matter, and appointed in succession, in January, 1929 twenty members, to organize the Huai River Commission, with the President as the chairman. The three bureaus under the Commission, that is, the Bureau of General Affairs, the Bureau of Finance and the Bureau of Engineering, were established successively. Prof. Otto Franzius of Hannover University was invited to act as the consulting engineer, with a six month contract, and he arrived at Nanking on 20th, November of that year. Although rebellions have been broken out from time to time since the organization of the Commission, the Government has meanwhile spared no effort to the Nation's reconstruction work. The Commission was encouraged to push on its work for the Nation's benefit.

Tentative technical reports have been drawn up dealing with certain aspects of the problem, such as:

The Hydraulics of the Hungtze Lake,

Water Requirements below the Hungtze Lake,

Hungtze Lake as a storage and also a Flood Detention Reservoir.

Frequency of Floods of the Huai River,

Project of Escapeway through the Kao Pao Lakes for the Huai River,

Estimate of Excavation for a Channel in the old Old Yellow River Bed,

Preliminary Estimates of Excavation of the Outlet to the Sea for the Huai River,

Project of Diverting Flood Water through the Sheyang Hu to the Sea,

Memorandum on Shantung Grand Canal Project.

In each tentative project, paper location of different routes was made in order to compare the quantity of earthwork for the final selection. On seeing that the most possible routes to divert the flood water of the Huai River are those by way of the Kao Pao Lakes and Kwan Ho, surveying parties were sent to those places. Topographic maps of 1:2,500 and 1:10,000 scales were made. Beside these, detail surveys of the sites for regulators and locks at Chiangpa, Shaopai, Yangchuang, etc., were also made. Borings were taken at each site of the contemplated structures to reveal the underground conditions. All those matters are connected to the final make-up of the scheme.

Prof. Franzius has also exerted all his effort and time in working up different projects, going along harmoniously with our engineers for the whole period of his staying in China. Even though he was prevented from visiting all the places in the Huai River territory on account of the disturbance of the rebellion, nevertheless, with the aid of the abundant maps and records of the region under question, and also the explainations of some of our engineering staff who are quite familiar with the local conditions, he was able to draw up a lengthy report, which is very complete in its nature. In his report, the flood control measures of the upper and middle Huai River together with the tributaries, the utilizations of the Hungtze and the Wishan Lakes, the construction of the outlet channel of the San Ho, the regulation of the Grand Canal, Salt Canal and Kwan Ho, the improvement of the Wen, Sze, Yi and Shu Rivers, and the schemes of navigation and irrigation, are all deliberately dealt with. Moreover he also wrote another report on the regulation of the Yellow River from all available data and records.

The principal part of the schemes in this report is the same as in his, since in working up the plan, much investigation and deliberation were exercised by our engineers in reaching the most economical and effective solution for both purposes. The only difference in the two reports consists in some numerical assumptions in calculations. As soon as the principle of the scheme is worked out, designing work begins accordingly, such as designs for the flood channel, movable dams, shiplocks, etc., each being designed in different types and materials for comparison. For these reasons, as soon as this report is approved and adopted by the Commission, and fund available, construction work can start without delay. The main points of the schemes will be summarized in next article.

Article 2. Outlines of the Project.

The main purposes of the regulation of the Huai River systems are for flood control and improvement of navigation and irrigation, while the development of water-power is a secondary one. Flood problem should be solved, before utilization of the water resource is possible. Here we should pay attention to the value of two lakes, the Hungtze and Wishan, on the Huai River and Grand Canal respectively. The same lakes that have roused continuous conflicts between the people living on the opposite shores should also be duly considered in this connection. Any one is concerned with the problems of flood detention, navigation, irrigation and water-power, should at first think of the possible reservoir sites. Only through existence of them their solution becomes possible. Hence the key of solving the problem of Huai River regulation lies in the well utilization of these natural reservoirs.

The benefit of water in irrigating land to increase its productive power is well-known to all, another important factor in its power of production is often neglected, that is transportation. In the Huai region, the only thoroughfare existed is the Tientsin-pukow Railroad, which is naturally insufficient in serving such a vast area and population. The under-development of industry and commerce, the poverty of the general public, and the bandit disturbance are all due to the sad conditions of communication. It is only through the regulation of the Huai River system that all these reverse conditions can be mended. With the supply of cheap water power and low rate of water freight, which is counted to be only from one-fifth to one-tenth of that of railroad transportation, industry can be flourished. The projects contained in this report include the flood control, the improvement of navigation and irrigation, each being dealt with somewhat in detail, while water power being left for further investigation. The main items are summarized as follows:—

1.) It is to provide for the Huai River a principal flood channel through the San Ho, Kao-yu Lake, Shaopai Lake, Liochiakou River to the Yangtzekiang. The flood discharge through this channel is regulated so that it will not make the water surface of the latter river higher than the H. H. W. L. of 1921. At its head, near Chiangpa, movable dams will be constructed as the regulator. As soon as the water level of the Yangtze increases to the H. W. stage as in 1921, part of the gates will be closed so as to limit the discharge down to 6,000 m^3/sec. and as soon as the Yangtze river receeds, the discharge can be increased up to 9,000 m^3/sec. which is the highest limit the regulator and flood channel are designed for. By this means, the discharge of the Huai to the Yangtzekiang will be regulated at will and will not endanger the latter by discharging as much as possible, which is the condition existed at present. Hence the flood condition of the Yangtze will be reduced too. The cost of construction for this channel is very low, since most part of it lies in the lakes and low land, and it requires only two dikes on both sides to create the needed channel. Land amount to more than 1,000,000 mou in the region of Kao Pao Lakes (Kao Yu and Pao Ying) can be reclaimed after the dikes are built.

2.) After the Chiangpa regulator is constructed, the water surface in the Hungtze Lake can be maintained at 13.60m in the ordinary time, and not lower than 11.00m when extremely drawing down for the sake of maintaining navigation. The lake in this way can furnish enough water for irrigation use, with sufficient slope.

3.) The Hungtze Lake will be used as detention basin for flood water. Before a flood is set in, the lake will be emptied to the elevation 12.50m. If by that time the Yangtzekiang is not at a danger stage and the Huai River flood is moderate, the inflow to the lake being less than 9,000 m^3/sec., then the regulator will be opened to discharge as much as possible. As soon as the inflow is increased to and over 9,000 m^3/sec., then part of the gate will be shut down to limit the outflow to 9,000 m^3/sec., while the excess quantity of inflow will be retained in the lake. Based on the standard flood peak of 15,000 m^3/sec., the necessary time of retaining the inflow water is about 25 days with an amount varies from zero up to 6,000 m^3/sec. The lake surface will be increased to 15.60m. If the H. H. W. of the Huai River and the Yangtzekiang meet together, then the discharge of the flood channel to the latter will be limited to 6,000 m^3/sec. in the critical moment, and the lake surface will be likewise higher, that is

16.10m. This will be the rarest happening, and will not be met with oftener than once in 1,000 years. If another outlet to the sea is provided in the future for the Huai when fund is available, this condition will still be improved.

4.) It is necessary to dike the Huai River above the Hungtze Lake, and its principal tributaries, since with the flat topographic feature of those rivers, no other method than the dikes will be practical for controlling the flood water. The Huai river proper will be strongly diked from Hunghokow to Shuangkou while the tributaries, such as Hung Ho, Yin Ho, Pei Ho, Shih Ho, Hsifei Ho, Chien Ho, Kwo Ho, Kwei Ho, To Ho, and part of Peifei Ho should also be diked. Channel correction will be effected at such places as the points of confluence of the Huai with Yin Ho and Hsifei Ho. Several tributaries such as Chien Ho, Peifei Ho will be combined into the Kwo Ho before they join with the Huai River. Several cutoffs are also necessary at Kotaitze, Sanhochien, Chaochiachih and Fengtai city. Near Shuangkou, the Huai River will be conducted to the Hungtze Lake at Lihowa through a short cut in the hills. Several places, where the cross-section of the Huai River is not broad enough will be widened, such as Hunghokow, Fengtaitze, Fengtai, Pengpu, Meihokow, Anhuaichi, etc. The bridge of T. P. R. R. at Pengpu will be provided with additional openings.

5.) Many lakes and swamps are existed near the banks of the Middle Huai River and its tributaries. They can be used to retain temporarily the excessive rainfall. Those places where no drainage work by gravity is possible, are to be drained by means of pumping. Either wind power or other source of energy can be used for pumping.

6.) It is to provide seven locks in the Grand Canal from its junction with the Yangtzekiang up to that with the Yellow River. The locks in the order will be Shaopai, Huaiyin, Liulauchien, Wutingchai, Teshenhai, Chunchiakow and Chiangchiakou on the Yellow River. The locks for immediate use will be designed for ships of 900 tons, but spaces will be reserved for future extension for ships up to 2,000 tons. The shallow places between each pair of locks will be dredged, and some repair work is necessary for the dikes. The portion of the Canal below Shaopai locks will be open, and connected with the Yangtzekiang by ways of Kuachow and Sankiangying. The lock at Huaiyin will be used for the inter-communication of ships from four directions, that is the Changfu Ho, the Salt Canal and both directions of the Grand Canal. The old Chai's at Huaiyin will be abandoned.

7.) From the Changfu Ho up to the middle portion of the Huai River, no more lock is necessary. A new channel to connect with the Salt Canal for the Changfu Ho will be constructed near Huaiyin. In the Salt Canal, two locks, one at Tsaikungtu, and another at Hsinpu will be provided, while in the Kwan Ho, one lock is also necessary. They are all to be designed to accommodate ships of 900 tons, and spaces reserved for future extension. The shallow places will be dredged.

8. In the eastern bank of the Grand Canal at Liulauchien, a spillway will be provided to discharge the flood water of the Sze River into the Yi River. At the sides of locks above Liulauchien, movable dams will be attached for passing flood water. The Wishan Lake will be used to retard the flood water coming from its upstream.

9.) The Wishan Lake will be used as a reservoir. Its W. L. will be maintained between 35.1 and 30.6m. In this way the maximum outflow from the lake will be limited to 1,000 m^3/sec. The storage will be used for navigation and irrigation.

10.) The closing dam at Lukowpa on the Yi River will be rebuilt into a movable structure so as to confine the flood water of the Yi River running southward across the Loma Lake, and at the sametime part of the water can be diverted into the Grand Canal in case of need. Other branches are to be closed, so the Yi River can be separated with the Grand Canal. It runs down to Sanchatu where it joins with the Sze Ho coming from Liulauchien on the Grand Canal, and thence to Kwan Ho by way of the Peiliutang Ho.

11.) The Shu Ho will be conducted in the original channel to Shuyang, and entering the sea at Linhungkow, by way of Chienshu Ho, and Rose River. It is to be separated with the Yi River. The sites for detention basins on the Yi and Shu for retarding the flood peak are to be investigated further on.

12.) A small lock is to be built at the side of the Chiangpa movable dam for the convenience of small junks running up and down the San Ho.

13.) The Hsun Ho will be used as a canal for conducting water in the Hungtze Lake from Kaoliangchien to the Grand Canal, Ching Ho, Sheyang Hu and Chuangchang Ho. A lock will be put on the Ming Dike at Kaoliangchien, another be put at the junction of the Grand Canal and Ching Ho. The irrigation water required by the land on both sides of the Grand Canal and up to the Fankung Dike will be supplied by this canal. The flow at Ching Ho will be diverted into three directions, north to Huaiyin, south to Shaopai, and east to the Chuangchang Ho. The total area irrigated will be 15,000,000 mou. This canal will also be used for the junks in the Grand Canal to go through the lake to the upstream of the Huai River.

14.) A new canal will be built from a place at the upstream side of Tsaikung Lock on the Salt Canal southward to join the Chuangchang Ho, so as to supply irrigation water to the land at the east of the Fankung Dike, and also for navigation. The sites of locks in the Chuangchang Ho and Hsinyangchiang will be settled after detail survey is made.

15.) A lock and movable dam will be provided on the Huai River between Fushanhsia and Hunghokow for extending the navigation route for upstream.

16.) A sea harbour will be placed at the mouth of the Kwan Ho as the terminal for inland and outbound ships. It is pending for further investigation.

17.) A water-power station of some 50,000 H. P. capacity will be built near the Chiangpa movable dam. Fushanhsia on the Huai River and Wishan Hu on the Grand Canal have also possibilities for developing water power, though at a smaller scale. Further investigation is under way.

The order of carrying on all the works stated above will be discussed in next section.

Article 3. Construction Program and Costs.

The order of carrying out all the projects of flood control, irrigation and navigation in the valleys of the Huai River system is worthy for consideration. The construction program should be so arranged that it will be consistent with the present financial condition, the importance of work and the benefit resulted. Take the whole into consideration, the project of flood control must be executed before the irrigation and navigation works, because the harmful elements should be removed at the very start. As to the individual projects, the regulation of rivers should be started from downstream side up so as to serve the purpose of a general relief to the whole river. The canalization of waterways must be started in those rivers where the improvement for water transportation is urgently needed. The irrigation water must first be applied to the most important agricultural district, and then to the newly reclaimed area in turn. With these points in view, the construction program and the yearly budget are set forth as follows:

Table 1. Construction Program and Budget for Project of Primary Importance

The First Stage of Development.

1931—1936

Division of Works	Year					
	1st. year	2nd. year	3rd. year	4th. year	5th. year	Total Cost
Flood Control Projects	8,218,200	8,218,200	7,718,200	7,818,200	600,000	$32,572,800
(1) Construction of the Chiangpa Movable dams and lock	1,000,000	1,000,000				2,000,000
(2) Construction of the Flood Channel thrugh the Kao-Pao Lakes	7,218,200	7,218,200	7,218,200	7,218,200		28,872,800
(3) Reparation of the dikes around the Hungtze Lake and providing drainage outlets				600,000	600,000	1,200,000
(4) Construction of 3 movable dams in the Middle Grand Canal			500,000			500,000
Irrigation Projects	150,000	750,000	3,050,000	2,300,000	3,350,000	9,600,000
(1) Installation of New head gates in the dikes of Inner Grand Canal for the irrigation laterals	100,000					100,000
(2) Reconstruction of the head work at the west end of the Tungyang Canal	50,000					50,000
(3) Construction of the Irrigation Main Canal between the Hungtze Lake and Chinghochai		750,000	750,000			1,500,000
(4) Reclamation of the Kao Pao Lakes			2,300,000	2,300,000		4,600,000
(5) Construction of the Irrig. Main Canal between the Salt Canal and Chuangchang Ho					1,110,000	1,110,000
(6) Construction of the Irrig. Main Canal between Chinghochai and the Chuangchang Ho					2,240,000	2,240,000
Navigation Projects	1,925,200	1,630,900	1,651,600	2,000,000	160,000	7,367,700
(1) Construction of Huai Yin and Shaopai locks	750,000					750,000
(2) Improvement of the Channels from Liulauchien to Sankiangying, and Hualyuan to Tsaikungtu	875,200	800,000			160,000	1,835,200
(3) Construction of 3 locks at Tsaikungtu, Hsinpu and Lungkou	300,000	600,000				900,000
(4) Construction of the strawdam and movable dams at Lungkou		200,000				200,000
(5) Improvement of the channel between Tsaikungtu and Hsinpu		30,900				30,900
(6) Construction of 3 locks at Liulauchien, Hotingchai and Teshengchai			1,100,000			1,100,000
(7) Improvement of the channel from Chunchiakow to Liulauchien, and reconstruction of the railway bridges and tracks			551,600	2,000,000		2,551,600
Total for each year	10,293,400	10,599,100	12,419,800	12,118,200	4,110,000	$49,540,500

Table 2 Construction Program and Estimates for Projects of Secondary Importance.

Second and Third Stages of Development.

To be Executed after the Completion of the Works shown in Table 1.

Period	Items	Division of Works	Cost
First Period	Flood Control Projects	(1) Regulation of the Yi Ho	$9,596,400
		(2) Regulation of the Sze Ho	372,200
		(3) Regulation of the Shu Ho	7,759,200
		(4) Regulation of the Upper Huai River	70,000,000
	Irrigation Projects	(1) Deepening the channel of the Inner Grand Canal between Fan-shui and Kao-yu, and raising the dikes of the same between Huai-an and Fan-shui	757,600
		(2) Construction of the locks of the outlets of the Chuangchang Ho to the sea and the Tungyang Canal to the Yangtzekiang	to be estimated
		(3) Construction of the locks and canals along the Middle Grand Canal and Pelao Ho	,,
	Navigation Projects	(1) Canalization of the Southern Grand Canal in Shantung	,,
		(2) Construction of the lock and movable dam at Huai-yuan for the canalization of the upper Huai River	,,
		(3) Construction of the jetties at Linhungkow and Kwanhokow	,,
Second Period	Flood Control Projects	(1) Regulation of the tributaries of the Upper Huai River	,,
		(2) Regulation of the upper portions of the Southern Shantung rivers	,,
	Irrigation Projects	(1) Irrigation and Drainage along the Southern Shantung rivers	,,
		(2) Irrigation and Drainage along the Upper Huai River	,,
	Navigation Projects	(1) Construction of the locks for intercommunication of the Salt Canal, Chuangchang Ho, and Inner Grand Canal	,,
		(2) Deepening all the channels and adding new navigable locks for ships up to 2,000 tons	,,
	Water Power development	(1) Construction of the power plant at Chiangpa, on the Hungtze Lake	,,
		(2) Construction of the power plant at the outlet of the Wishan Lake	,,

The projects contained in Table 2. will be further investigated in order to reduce their costs to a minimum.

After the completion of the primary works, the land which is relieved from floods and well irrigated will amount to 20,000,000 mou (one mou is equal to 6.67 are or 0.132 acre). If an annual water tax of $0.10 per mou be imposed, we can have $2,000,000 per year. The navigable distance throughout the year will be 913 km. If it is assumed that the yearly transportation for the first few years be 2,500,000,000, ton-km., and a tax of $0.003 per ton-km. be imposed, we can have a total annual income of $7,500,000. The reclaimed lands, in the Kao Pao Lakes will be 1,000,000 mou, while the public land within the dikes of the Old Yellow River will be 950,000 mou. After improvement of the Huai River, since no flood water would pass through the Old Yellow River bed, it can be offered for cultivation. Suppose the price of new land in the lakes to be $40 per mou, and that in the Old Yellow River bed to be $10 per mou, the total price of land will worth more than $50,000,000. With these sums of money, the secondary works can be carried out without any financial trouble.

Article 4. Benefits

1.) Land Protected from flood:

In the Huai River valley above the Hungtze Lake	20,000,000 mou
On both sides of the Inner Grand Canal	18,000,000 mou
In the drainage areas of the Yi, Sze and Shu Rivers	12,000,000 mou
Total	50,000,000 mou

2.) **Land to be reclaimed:**

Between Shuyi and Wuho on the Huai River	500,000 mou
In the Old Yellow River bed	950,000 mou
In the Kao-Pao Lakes	1,000,000 mou
Total	2,450,000 mou

At the average price of $25/mou, it will worth approx. $60,000,000.

3.) **Land to be irrigated with sufficient water:**

Around the Kao-Pao Lakes	2,250,000 mou
Between the Inner Grand Canal and Fankung Dyke	11,740,000 mou
Along the Tung-yang Canal	2,500,000 mou
Along the sea coast at the east of Fankung Dyke	5,000,000 mou
At the South of the Wishan Lake	20,000,000 mou
Total	41,490,000 mou

Annual tax upon lands @ $0.1/mou, it is $4,149,000 per year.

4.) Total navigable distance will be 913 km. Assume yearly transportation to be 2,500,000,000 ton-km. within the first few years, and a tax upon merchandise to be $0.003/ton-km., it will give a total sum of $7,500,000 per year, charges of lockage and wharfage being not included.

Chapter II. Projects of Flood Control

Article 1, Flood Magnitude and Frequency of the Huai River.

The Flood Magnitude

The Huai River takes its rise in the Tungpai mountains in the Province of Honan, collects the waters of its many tributaries, as the Hung, Ju, Kuan, Shih, Pei, Ying, Fei, Kwo, Kwei and Tse of the Provinces of Honan and Anhwei and empties to the east into the Hungtze Lake at Kwei-shan. After issuing from the lake, it divides into two courses, the San Ho and the Changfu Ho, and dissipates its water into the Yangtzekiang and the sea through different channels. The total quantity of inflow of the Hungtze Lake therefore represents the total quantity drained by the Huai River. But owing to the difficulties of making stream gaging near the junction of the Huai River and the Lake, the principal gaging station has been established at Pengpu. From the authentic maps, the drainage area of the Huai River above the Hungtze Lake and Pengpu was found to be 166,110 and 124,610 sq. km. respectively. If the flood discharge is proportioned to the drainage area, then the discharge at Pengpu represents only 75% of the total. It is approximately correct to count for the flood discharge of each tributary by the rate of run-off per unit area based upon the data obtained at Pengpu gaging station, as the meteorological, geological, and topographical characteristics of those tributaries are much the same. By this means, the maximum rates of discharge for successive years are computed as follows:-

Table III. Max. Discharges of the Huai River

Year	m^3/sec.	Year	m^3/sec.
1915	2,100	1920	1,600
1916	12,900	1921	6,200*
1917	3,300	1922	1,570
1918	2,400	1923	4,250
1919	3,350	1924	3,900

*Part of the flood flow escaped through the dike-breaks above Pengpu in that year.

From the above table, we can see that in two years, the flood flow happens between 1,000 and 2,000 m^3/sec.; another two years, between 2,000 and 3,000 m^3/sec.; three years, between 3,000 and 4,000 m^3/sec.: one year between 4,000 and 5,000 m^3/sec.: and two years, above 5,000 m^3/sec. Among them, the flood of 1916 is the maximum. But as part of the flood flow was escaped through the dike-breaks in 1921, the record of that year is not reliable. As to the gage readings at Pengpu it reached 19.84m in 1921, and 19.825m in 1916, that of 1921 was actually higher. In comparing the maximum discharges of the San Ho, the main outlet of the Hungtze Lake, we find 14,600 m^3/sec. in 1921 and 8,400 m^3/sec. in 1916, and it again gave a higher figure in 1921. It is not disputed that the floods of 1916 and 1921 both show a high record. The maximum discharge of 1916 is 12,900 m^3/sec. as stated above, while that of 1921 is to be found out by other means.

The total discharge of the Huai River can be reckoned as the sum of discharges of the San Ho and Changfu Ho, plus or minus the depletion or storage of the Hungtze Lake at any time. The records for discharge of the above two rivers in 1921 are available, while the storage or depletion of the lake for that year can only be approximately known from the gage readings at Chiangpa. After removing the irregularities on the resulted curve, the flood peak of that year is obtained as shown in Figure 2. (The storage capacity curve of the Hungtze Lake is shown in Figure 1.)

From this figure, we can see that the maximum inflow of the Hungtze Lake, or the discharge of the Huai River for that year, was 15,000 m^3/sec. It exceeded that of 1916 by 2,100 m^3/sec. Hence it can be assumed as the highest magnitude of flood discharge for the Huai River. (This value, in the opinion of Prof. Otto Franzius, is rather too high, but for safety it is still to be adopted.)

If channel improvement be used as the sole means of flood control, the highest flood peak of the river is the important basis for designing. But when retarding or storage reservoir be also used, then the duration of different rates of the flood discharge should also be taken into consideration. As in the above figure (Fig. 2) the discharge above 10,000 m^3/sec. lasted about 30 days; above 12,000 m^3/sec., 28 days; above 14,000 m^3/sec. 18 days. It is quite different from another flood peak with the same quantities of discharges but with one half of their duration, since the storage required for above any quantity of discharge will be only one half of the former one. The required capacity of storage reservoir will be correspondingly reduced.

The simplest way to show the magnitude and duration of different stage of flood discharge at the same time is by means of flood hydrograph, as shown in Fig. 2, in which the ordinates represent the quantity of discharge, while the abscissa, the corresponding time of occurrance. This kind of hydrograph, while constructed directly from field data, will represent actually the condition of flood flow, otherwise, it will be only an approximation. In the opinion of Prof. Franzius, this constructed hydrograph of 1921 will not be a normal case, and would hardly be taken place ever since according to his experience. His reasoning is that due to the dike-breaks, and as the flood flow was not in the ordinary form, therefore the derivation of such a curve with the ordinary method will not be correct. Also the computation of depletion and storage of the Hungtze Lake was based only upon a single gage at Chiangpa it is likely in error in considering the bigness of such a lake which is subject to winds and seiches. Hence the resulted hydrograph, when adopted, will be safe enough for flood of any magnitude, but will require too big an engineering work and expense which are really unnecessary.

The hydrograph at Pengpu in 1921, though it was modified by the result of dike-breaks, still represents the actual condition of stream flow, except that the duration or time scale of the curve is somewhat lengthened. This is because the flow running out from the dike-breaks is usually slower than that in the river channel, and lags behind the flood peak. This condition is best represented in Fig. 3.

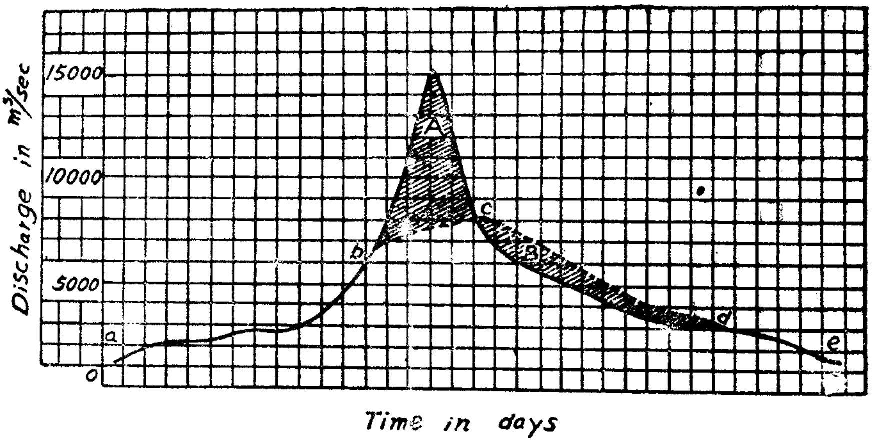


Fig 3

The full line represents the hydrograph when the dike were not broken, and the dotted line, the same hydrograph resulted by the dike-breaks. The quantity of water represented by shaded portion A in the figure must be larger than that of B, for a part of it must have lost due to evaporation, percolation, or escaping into other rivers, before coming back to the original channel. Fors afety, when we assume the total losses numerated above to be one-half of the quantity of water escaped through dike-breaks, and also the highest rate of flood flow to be 15,000, we can construct the probable hydrograph of the Huai River for 1921 without dike-breaks by making the area A equal to twice B. The bounded line around A should be irregular instead of a smooth one, but owing to lack of record, a straight bounded line is used. A flood peak with straight bounded line is of course one of the worst. With this method the standard flood peak of the Huai River, as shown in Fig. 4, is constructed.

Frequency of Floods

It is evident that the average flood to be expected every year is exceeded by floods of less frequency that may occur at intervals of 5 and 10 years and that these will be considerably exceeded by greater floods which may occur at intervals of from 20 to 50 years, and that still greater flood will be expected even in thousand years. In order to predicate the frequency of floods of any stream, it is a matter of certainty that the longer the records, the more accurate the predication. But within the drainage area of the Huai River system, only a few gaging stations with records of one half a decade are available. It is far from being sufficient. Yet the frequeucy of a flood like that of 1921 which is adopted as the standard maximum flood for all designs of flood control works must be investigated by all means before going on further.

As flood originates in excessive precipitation, its amount and distribution are of primary importance. If when the rain-storm cover the whole area of river valley, and the duration of storm is just as long as the time required by the remotest rain drop reaching the gaging station, and also when the ratio of run-off to rainfall is a maximum, (that is when the evaporation, percolation, natural storage in the lakes and ponds, etc. are reduced to minimum) then the maximum quantity of flood peak is originated. Hence if the frequency of rain-storm can be known, the frequency of flood can be approximately known too. It is unfortunate that the rainfall records within the valleys of the Huai River are as short and incomplete as the discharge records, so they cannot be used for our purpose. But on the other hand we can obtain rainfall records lasting more than 40 years of the places in the neighboring valley of the Yangtzekiang as kept by the Ze-Ka-Wei Observatory, Shanghai. The adjacent valley of the Yangtzekiang has much the same meteorological conditions as that of the Huai River. Besides, when the typhoons, which are always accompanied with excessive rainfall, as occurred in the months of July and August, strike across the lower Yangtze Valley, it will also hit the Huai River basin. Hence the great rain-storm that occurred in the Yangtze Valley would also have occurred in the Huai River Valley. By the rainfall data of Ze-Ka-Wei Observatory at Chinkiang, Wuhu, Kiukiang, Hankow, and Ichang, all being lasted from 1880 to 1924, more than 40 years, the frequencies of maximum monthly and maximum daily precipitation are computed and plotted in Fig. 5. By assuming that five days be needed for the remotest rain drop to reach the Hungtze Lake, and also the ratio of run-off to rainfall during the ordinary flood period to be 20%, and during extraordinary one, 25%, the frequencies of floods can be determined with the aid of values obtained from the curve of maximum daily precipitation in Fig. 5, as following:

Table IV. The Frequencies of Floods for the Huai River.

Based on rain-storm records.

Frequency	Max. one day precipitation	Averg 5 day precipitation on whole area	Mean daily precipitation	Ratio of Run-off to Rainfall	Run-off Per 24 hours	Flood discharge m³/sec.
Once in 10 yrs.	150 mm	172mm	34.4mm	20%	6.88mm	10,000
Once in 25 yrs.	200	187.5	37.6	20%	7.52	11,000
Once in 50 yrs.	245	198	39.6	25%	9.90	14,400
Once in 100 yrs.	300	214.5	43.0	25%	10.75	15,500

Although the values in the above table are indirectly computed, but they offer a safe basis of comparison since all the steps of computation are very conservative. It is no doubt that the flood of 1921 will not occur more often than once in 100 years.

Mr. Weston E. Fuller has tabulated the ratios of different maximum flood flow of various streams to their average annual flood in the order of magnitude, and obtained the relation between floods to be expected in a series of years and the average yearly flood in the formula:

$$Q = Q_{av}(1 + 0.8 \log T)$$

Where

Q = maximum (24 hours average) flood in m^3/sec.

Q_{av} = average yearly flood in m^3/sec.

T = number of years in which the maximum flood is likely to occur.

From Table III. (P. 16) of the maximum yearly flood discharges of the Huai River, we see that the flood of 1923, 4250 m^3/sec. is the third largest one besides those of 1916 and 1921. For safety, we substitute this value into the above formula as the average yearly flood, the following table is resulted:

Table V. Frequencies of Floods of the Huai River.

Based of Fuller's formula.

Frequency (once in years)	10	25	50	100	500
Flood discharge m^3/sec.	8,100	9,530	10,500	11,700	14,200

The values of flood discharge are the average in 24 hours, while for the maximum flood discharge they may be increased by 10 to 20%.

The results obtained are similar but a little smaller than those given in Table IV. Anyhow the flood as that in 1921 must have a frequency of more than once in 100 years. Even the greater floods may be expeceted in the future, the rate of increasing must be very small.

Furthermore, it can be proved by the historical records. In the 1921, inundation covered an area of 11,740 sq. km., to a depth of 1 to 4 meters, including the following cities: Houchiu, Yingshang, Fengtai, Shouhsien, Huaiyuan, Hsuhsien, Lingpi, Wuho, Szehsien and Shuyi. From Mr. Wu Tung-chu's "Table of Annual Events of the Huai River System", we find that there were three great floods which were comparable to that in 1921 during the last 300 years: One of them occurred in 1649, and covered the districts Sihsien, Yingchow, Houchiu, Wuho and Szechow with a depth of more than 3 meters; another one occurred in 1741, and covered the districts Yingchow, Taiho, Yingshang, Houchiu, Pochow, Mengchen, Hsuhsien, Lingpi, Wuho, Szechow and Shuyi; still another one occurred in 1879, and covered the districts Yungchen, Hsuhsien, Szechow, Fengyang, Wuho and Shuyi. Besides those floods, the usual inundation only covered from 3 to 4 districts and certainly not to be compared with that in 1921. Even for the above said floods, the innundation areas were not so broad as that in 1921. Therefore it can be concluded that the frequency of the 1921 flood, even it may happen, must be more than once in 100 years. From above discussions, it is doubtless with great safety to adopt the 1921 flood as the standard basis for designing the regulation works of the Huai River.

Article II. Regulation of the lower Huai River.

The Hungtze Lake, being a natural detention reservoir receives all the flood water of the Huai River which drains most part of the provinces of Honan and Anhwei. After issuing from the lake, the flood water runs through the Changfu Ho and San Ho and finds its way either into the Yangtze River or directly to the sea by passing through the flood escapes built in the eastern dike of the Grand Canal. The way leading the flood water from the Hungtze Lake to the Yangtze River passes through the San Ho and Kao-Pao Lakes, and the flood escapes near Liuchai thence discharging into the Yangtze River at Sankiangying. It is the principal outlet of the Huai River. Owing to the high stage of the Yangtze River, and the insufficient capacity of the outlet the discharge of the flood water of the Huai is usually limited in quantity and in consequence the outflow of the lake is always much less than the inflow. As to the channels leading to the sea from the so-called five flood escapes in the eastern bank of the Inner Grand Canal, they are usually too small in capacity that no great amount of flood water can ever be expected to discharge through them. Moreover, since the land level at the east of the Grand Canal is very low, so even it is possible to open these escapes in time in order to protect the valuable land up-stream or west of the Grand Canal, severe damages will surely be resulted. According to the past experience, whenever there is an extraordinary flood, the people on both sides of the Grand Canal will struggle hard for decision whether the flood escapes are going to be taken away or not. In consequence it is usually too late for the urgently needed protection. Enormous quantity of flood water must have already accumulated in the Hungtze and Kao-Pao Lakes so that the regions adjacent to the lakes and the upper Huai River are almost always subject to inundation. At the last moment, when the escapes are finally opened the inundation spreads out all over the country no matter where it is. Thus whenever a great flood happens, it makes no exception on both upstream and downstream lands in suffering flood losses. According to the actual measurement of 1921 flood, the total maximum discharge from the Hungtze Lake in the Changfu Ho and San Ho was 15,158 cubic meters per second and the maximum total discharge both leading to the Yangtze and directly to the sea was 13,700 cubic meters per second. The difference of the above two values gave a quantity of flood water 1,458 cubic meters per second to be reserved in the Kao-Pao Lakes. If the condition like that keeps on for a certain period, the water surface of the lakes will increase higher and higher so as to make the land upstream and near the lakes suffering much in flood damage. In case the capacity of the lakes reaches its maximum limit for reserving flood water, over-flowing over the eastern dike of the Grand Canal is then apt to happen. It will be more dangerous to the land east of the canal. Therefore with the present condition of the lakes and Grand Canal, even the flood escapes leading to the sea are removed at the proper time in case of flood as in the year 1921, it will give no appreciable benefit in relieving from flood. Furthermore by this way it is simply to transfer the harmful flood water from the upstream land to the region east of Grand Canal. This is certainly not a good and proper policy. Now we meet with the difficulties that on one hand the present passages leading to the Yangtze can not carry an enormous quantity of the flood water of the Huai and on the other hand the capacity of the Hungtze and Kao-Pao Lakes has its limitation for reserving the flood water. A better solution of the problem for dissipating the flood water of the Huai must be made.

Many projects for the flood channels of the Huai River have been proposed by different authorities in the past decade. After having taken all the proposals into consideration and compared their relative economy by our engineering staff, it is concluded that the scheme of leading the flood water of the Huai to the Yangtze River is comparatively much more economical than any other channel leading directly to the sea. Also in the many schemes of leading the Huai directly to the sea, the way through the Changfu Ho, Yen Ho and Kwan Ho will cost least. Hence so far as flood control is concerned it is advisable to make the way leading to the Yangtze River as the principal outlet for the Huai River while a part of flood water may be discharged directly to the sea if preferred. The Hungtze Lake is a natural reservoir, the detention capacity of which must be fully utilized so that the construction cost of the outlet channel can be economized. During the dry seasons the discharge of the Huai and that in the Grand Canal are very small in quantity, hence a storage reservoir is also needed to meet the demand of irrigation water to the land on both sides of the Grand Canal. Owing to its elevated position, the Hungtze Lake can serve very well for the purpose.

After a thorough investigation of the question, and with due balancing of the flood control, irrigation and navigation problems, three general principles are formulated as the basis for the solution, and they are as follows:

1.) The flood water of the Huai River is to be conducted into the Yangtze River within a safety limit so as to make no appreciable effect on the latter.

2.) The Hungtze Lake is to be utilized as a flood detention reservoir to retard the flood peak so as to minimize the cost of outlet channel.

3.) The Hungtze Lake is also to be used as a storage reservoir for the development of irrigation.

These will be fully discussed in the following pages.

Determination of the Amount of Flood Water to be Discharged into the Yangtze River.

According to the record of the former Kiang Huai Conservancy Board, the greatest amount of flood water of the Huai River discharged into the Yangtze River was 8,000 m^3/sec., as occurred on September 19, 1921. On that date, the gage reading at Chinkiang was 22.90 ft. above W. H. Z. On August 21 of the same year, when the Yangtze River attained its highest stage of 24.50 ft. above W. H. Z. at Chinkiang, the amount of flood water of the Huai River received was about 6,000 m^3/sec. Therefore the amount of flood water of the Huai River that can be discharged into the Yangtze River without appreciably affecting the latter during the flood season ought to be from 6,000 to 8,000 m^3/sec. Suppose there are no lakes serving as detention reservoir for the Huai River, then the safe amount of flood water flowing into the Yangtze River will be limited to 6,000 cubic meters per second. But in our case, with the Hungtze Lake as an equalizer, it is possible to cut down the amount of flow to 6,000 m^3/sec. when the Yangtze River is at a dangerous stage but gradually increase as the Yangtze River receeds. In this way, the Yangtze River stage can be maintained not over the H. H. W. L. of 24.50 ft. above W. H. Z. The duration of H. W. is also not to be too much prolonged. It is the best solution of the problem that not only the flood of the Huai can be relieved, but also that of the Yangtze River is greatly lessened. In order to find out the maximum daily flow of the Huai which can be safely discharged into the Yangtze without doing any harm during the highest flood period of the latter, we have first of all, to investigate the relation of the water stage and its discharge, and also the present condition of flow of the Yangtze River from Nanking to Kiangyin.

According to "The Report on Hydrography of the Yangtze Estuary" by the Whangpoo Conservancy Board, the maximum discharge of the Yangtze at Nanking on July 19, 1915 was 72,000 cubic meters per second. Since there are no great tributaries emptying into the Yangtze River between Nanking and Chinkiang, it will be approximately correct to assume that the same amount of discharge would have passed through Chinkiang the next day. The gage reading corresponding to this discharge was found to be 20.65 ft. at Chinkiang. But we have already stated that the H. H. W. L. at Chinkiang to be 24.50 ft. in 1921, the discharge corresponding to this stage must be much greater than that in the year 1915. Since we have no record of the actual measurement for this maximum discharge at Chinkiang, it can only be roughly estimated by the following method:

By Forchheimer's Formula,

$$Q = \frac{1}{n} A t^{0.7} J^{0.5}$$

$$Q_1 = \frac{1}{n} A_1 t_1^{0.7} J_1^{0.5}$$

In which, Q is the discharge in cubic meters per second; n, the Kutter's coefficient of roughness of the river; t, the average depth of water in meters; J, the slope of water surface of the river. Since the variation of the slope is very small with respect to the change of discharge, we can assume "J" to be constant. Then

$$\frac{Q}{Q_1} = \frac{\frac{1}{n} A t^{0.7} J^{0.5}}{\frac{1}{n} A_1 t_1^{0.7} J_1^{0.5}} = \frac{A t^{0.7}}{A_1 t_1^{0.7}}$$

$$Q = \left(\frac{A}{A_1}\right) \cdot \left(\frac{t}{t_1}\right)^{0.7} \cdot Q^1 = \left(\frac{A}{A_1}\right)^{1.7} \cdot \left(\frac{W_1}{W}\right)^{0.7} \cdot Q_1$$

where W being the average width of the river in meters. In case of a wide river as the Yangtze, the change of average width will be comparativelys mall during the rising river. Assuming $W = W_1$, we have

$$Q = \left(\frac{A}{A_1}\right)^{1.7} \cdot Q_1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Now since we know the cross sectional area A_1 of the Yangtze River b ing 34,175 square meters corresponding to the discharge 72,000 cubic meters per second in the year 1915 at Chinkiang, and its cross sectional area A being 36,315 square meters corresponding to the highest stage on Aug. 21 in the year 1921, the maximum discharge on the latter date can be found by applying the above formula.

$$Q = \left(\frac{36,315}{34,175}\right)^{1.7} \times 72,000 = 79,800 \text{ m}^3/\text{sec.}$$

At the time when the maximum flow of the Huai discharged into the Yangtze on Sept. 19, 1921, the cross sectional area of the Yangtze is found to be 35,413 square meters. In like manner we find the discharge of the Yangtze at Chinkiang on that date being 76,500 c ibic meters per second. Based upon the above calculations, the relation of the water stage and the discharge at Chinkiang can be shown in the following table:

Table VI. The Relation of Water Stage and its Discharge of the Yangtze River at Chinkiang

Date	W. L. (W.H.Z)	Cross Sectional Area (m^2)	Discharge $m^3/sec.$
Aug. 21, 1921	24.50 ft. (7.47m)	36,315	79,800
Sept. 19, 1921	22.90 ft. (6.98m)	35,313	76,500
July 20, 1915	20.65 ft. (6.29m)	34,175	72,000

From the above table, we can see that generally, every increase of 1,000 cubic meters per second in discharge, corresponds to a rise of 0.15m of the water surface elevation. This can be proved in another way.

By Forchheimer's formula.

$$Q = \frac{1}{n} A t^{0.7} . J^{0.5}$$

Since $\quad A = W \cdot t$

therefore $\quad Q = \frac{W}{n} t^{1.7} . \; J^{0.5}$

or $\quad t^{1.7} = \frac{n \; Q}{W \cdot J^{0.5}}$

By differentiation, and treating n and W as constant,

$$dt = \frac{n}{1.7 W t^{0.7}} \left(\frac{JdQ - 0.5QdJ}{J^{1.5}} \right)$$

But $\quad \frac{1}{n} t^{0.7} . J^{0.5} = V$ (V being the mean velocity)

$$\therefore \quad dt = \frac{JdQ - 0.5QdJ}{1.7WVJ}$$

When the discharge is increased by dQ, the value of the increment of the slope dJ is very small. For simplicity let $dJ = 0$, then

$$dt = \frac{dQ}{1.7WV} = \frac{AdQ}{1.7WQ} \cdots\cdots\cdots\cdots\cdots\cdots(2)$$

We have already found that during the highest stage of the Yangtze River or 24.50 feet above W. H. Z. at Chinkiang, the corresponding maximum discharge was 79,800 cubic meters per second. Also the cross sectional area at that time was 36,315 square meters and its average width was 1,800 meters. Substituting these values in formula (2), the rise of W. L. for every increase of 1,000 cubic meters per second of discharge will be

$$dt = \frac{1,000 \times 36,315}{1.7 \times 1,800 \times 79,800} = 0.15 \text{ meter}$$

This checks with what we have found before.

After having determined the relation of the increment of water stage of the Yangtze River due to the additional discharge of the Huai River, we can next come to the problem of how much of the flood water of the Huai can safely be conducted to the Yangtze without serious effect on the flood condition of the latter. From the gage records of the Yangtze River at Chinkiang, we find that the flood condition of 1921 is the highest one on record. It can be used as the basis of our investigation. An hydrograph of the Yangtze River at Chinkiang for the months of August and September is first made as shown by the heavy line in Fig. 6. The corresponding daily discharges of the Huai River into the Yangtze River are obtained approximately from the record kept by the former Kiang Huai Conservancy Board, and are recorded at the lower portion of the hydrograph. The safe amount of discharge of the Huai River into the Yangtze is then determined day by day, and the probable hydrograph in the future is constructed by the already established relation, as shown by the light line in the same figure. The safe amount thus found varies from 6,000 m^3/sec. during the highest flood crest of the Yangtze River, as in 1921, up-to 9,000 m^3/sec. when the flood of the Yangtze River is receeding. By this way, the future W. L. of the Yangtze River, after the Huai River is regulated, will never rise above the original H. H. W. L. Hence so far the Yangtze River is concerned, this method of regulation of the Huai River will not only be of no harm, but also beneficial. Since if the Huai River is left as it is, it will naturally endanger the Yangtze River by the uncontrolled flood water. Were the stage of the Yangtze River at its highest as Aug. 21, 1921, the discharge of 8,000 m^3/sec. of the Huai into it would raise the Yangtze River 0.3m higher, the flood condition will be much more considerable. No body can assure that this worst condition will never happen if the Huai River is not regulated; but on the other hand, as soon as the Huai River is under control, this condition can be completely eliminated. That is why we say it is beneficial to the Yangtze River too.

The foregoing computations are based on the worst condition, that is, when both the maximum flood peaks of the Huai and Yangtze occurring at the same time. If they do not occur simultaneously or one of the flood peaks has less magnitude than that of 1921, the resulted hydrograph showing the variation of water surface elevation of the Yangtze after the admission of the Huai River will be still much lower. Therefore it is safe to take the amount of 9,000 cubic meters per second as the limiting value for sending the flood water of the Huai into the Yangtze River.

The Detention Capacity of the Hungtze Lake.

The maximum flood discharge of the Huai River is found to be 15,000 m^3/sec., while the safe amount which can be emptied into the Yangtze River is only from 6,000 to 9,000 m^3/sec. Their difference is great, and so it is necessary to find some method to provide for. As stated above, through past experience, we have already known that the flood condition of the Huai River, which has insufficient channel capacity at its lower course, has been greatly reduced by the presence of the Hungtze and Kao Pao Lakes. With the vast area and capacity of the Hungtze Lake, it can serve for our purpose as a detention reservoir to hold the excessive discharge of flood water that can not be sent down to the Yangtze River in a short time. This is considered as the most economical arrangement in the scheme for the regulation of the Huai River.

Before taking up the method of how to operate the Hungtze Lake for flood control, let us briefly consider the principle of a detention reservoir in general. The flood flow of a river as shown by its hydrograph takes usually a sudden rise and fall in certain short period. It forms a flood peak. Its duration is usually not over a score of days. However, most of its flood damages, such as washing away dikes and homesteads, and overflowing over fields, are made in this short period.

Therefore one who is concerned with the regulation of a river must pay attention on this fact. Now if only the channel improvement is depended upon for flood control, it will be necessary to provide a channel of very big cross-section to cope with the highest flood discharge of the flow. For instance, the channel must have a capacity of 10,000 cubic meters per second if the highest value of the flood peak is 10,000 cubic meters per second, while the channel must be capable to discharge 20,000 cubic meters per second in case its maximum flood peak reaches such a high value, and so on, notwithstanding whether the duration of the flood peak lasting several weeks or few days or even only a few hours. In this way the cost of the regulation work must be very expensive on account of the tremendous quantity of earthwork. If, on the other hand, reservoirs are available for the purpose of detention, the case will be changed. Once the flood flow is above a certain limit of the channel capacity, a portion of it can be temporarily reserved in the reservoir and gradually discharged at future time when the flood getting lower down. In this manner, although the inflow may vary to a great extent or attain to its highest peak, the discharge of the outlet channel will nevertheless be much smaller than the maximum value. This will render great economy in the expenditure for improvement of the outlet channel. Hence whenever there is a reservoir site which can be economically developed, one does not hesitate to use it for the regulation of a river. The Hungtze Lake is a good example for this case.

The maximum discharge of the Huai is 15,000 cubic meters per second, of which only 6,000 cubic meters per second can be discharged into the Yangtze when the latter is in its highest stage. If the Hungtze Lake is not existed, it will be further necessary to provide a large channel leading to the sea for the excessive capacity of 9,000 cubic meters per second. This will cost roughly not less than two hundred million dollars. On the other hand, if we use the Hungtze Lake as a detention reservoir not only the outflow into

Yangtze can be regulated consistent with the water stages of the latter, but also the surplus water which cannot be discharged in the same time can be temporarily stored in the lake. Even another channel leading water to the sea is preferred its expenditure would be reduced on account of the detention ability of the Hungtze Lake.

The operation of the Hungtze Lake as a detention reservoir will be like this. Before the flood season, the lake surface will be lowered down from its ordinary stage (see Chapter on irrigation) to 12.5m suppose a flood like that in 1921 is set in, the regulator at Chiangpa will be opened to discharge as much as the stage of the Yangtze River is not endangered. For the sake of reducing the cost of construction of the regulator and the flood channel, they are designed to discharge and carry the maximum flow of 9,000 until the elevation of the W. L. in the lake becomes 13.50m. Hence during the first stage of operation, the discharge through the regulator is less than 9,000 as fully illustrated in Fig. 7a and 7b. As soon as the flood inflow to the lake exceeds its outflow, the lake surface will raise, and its outflow is correspondingly increased due to the increasing of head of water. In case of the worst condition of flood that the flood peaks of the Yangtze and the Huai Rivers meeting at the same time, the regulator should be partly closed so as to insure that it would not do any harm to the former, as shown in Fig. 7a. If the flood peak of the Yangtze does not meet with that of the Huai, the condition will be better as shown in Fig. 7b. In either case the maximum outflow will be limited to 9,000 m^3/sec. Through the computation of the effect of the W. L. in the lake by the step method for routing flood, the resulted hydrograph of the Lake surface are shown in Figures 7a and 7b. The highest W. L. attained will be 16.10m and 15.65m in both cases respectively.

Suppose it is designed to discharge another 1,000 cubic meters per second directly to the sea, the maximum allowable outflow of the Hungtze Lake is then 10,000 cubic meters per second. Treating in the same manner as before, the highest water level of the lake will be only 15.3 meters (see Fig. 8a, 8b). With the building of small levees surrounding the lake, then all the land above the level 14.5 meters can be protected from flood. Also the Ming Dike of the Hungtze Lake can be safety depended for protection. This is, of course, the best and safest measure for flood control. However the channel leading to the sea will involve a big quantity of earth excavation, that at least ten million dollars will be necessary. Besides, the maximum water level of the lake of 16.10 meters can only be occurred when both the maximum floods of the Huai and Yangtze occur at the same date. The probability of such an occurence will be very rare. Even it happens, the duration of the high water stage is not very long. Hence it is not necessary to care for any great loss due to inundation. In conclusion, the primary important step to be taken for regulation of the Huai is to provide a channel to the Yangtze. And levees surrounding the lake must be also repaired and added for additional safety, so as to make the land above 14.5 meters in elevation around the lake good for agricultural use. The work for the channel to the sea may be postponed to the future time when there is a better financial and social condition and also in pressed requirement for further development of that country.

The Course of the Flood Channel From the Hungtze Lake to the Yangtze River.

The present course of flood water of the Huai River follows naturally the San Ho and the chain of lakes such as Kaoyu Paoying, etc., and merges into the Grand Canal at Liuchai. By passing through the flood escapes in the dikes of the Grand Canal, it follows the Tongchiakou, and Liochiakou to join the Yangtzekiang at Sankiangying. Let us first examine briefly the local conditions of the different sections of the course. The San Ho is the first section of this natural course, lying between the Hungtze and Kao-Pao Lakes. It has a narrow channel but of great depth at its upper portion from the Hungtze Lake to Sanhowei and a shallow channel but broad one at its lower portion from Sanhowei to Kao-Pao Lakes. Its channel is so irregular that it has a minimum breadth of three hundred meters only up to more than two kilometers in some other places. The channel capacity of the San Ho is comparatively high; it discharged 8,400 m^3/sec. in 1916 when the lake W. L. was at 13.70m, and 14,600 m^3/sec. in 1921, when the lake was at 15.77m. Due to its high velocity, the loss of head in the short distance was considerable. But in our case, we are going to let this section of the course to convey 9,000 m^3/sec. only when lake W. L. is at 13.50m, very little enlargement of its river bed is necessary. The next section is in the chain of lakes. Because the flood escapes in the eastern dike of the Grand Canal can not be put into operation on the right time, those lakes have been called for reserving a part of the flood flow. On the other hand, even those lakes are separated from the Grand Canal by the western dike, yet they are actually not by the existence of many breaks in the dike. Once the W. L. in the lake rises, that of the Grand Canal follows too. This condition calls for more flood escapes leading water to the sea for the safeguard of the eastern dikes of the Grand Canal. In the present scheme, however, since part of the flood flow of the Huai River can be detained in the

Hungtze Lake, and else can be sent down to the Yangtze, those lakes and flood escapes are no more needed. Only two parallel dikes are to be built in the chain of lakes to serve as a definite channel for flood water, while the remaining area can be used for reclamation. But utilizing the depth of the lake and the cheapness of the bottom land, a deep and wide channel can be economically constructed. At the same time, by selecting the shortest and deepest route, not only construction cost can be greatly reduced, but also it is possible to save for the loss of head. The proposed channel is to meet with the Grand Canal at the downstream side of the proposed Shaopai Lock (see Chapter on Navigation Projects), it does not interfere with the navigation of the Grand Canal during the flood season. The Tungyang Canal will be separated from the flood channel by closing dams built in the original head bay at Liuchai and connected with the upper pool of the Shaopai Lock. New lock and sluice will be provided for at the head of the Tungyang Canal for navigation and irrigation. To the south of Liuchai the flood channel will be led through the five existed channels, namely Kingwan, Tungwan, Fenghwang, Sin Ho, Pihu and then combined into two main courses, Tongchiakou and Liochiakou and finally discharging into the Yangtze River at Sankiangying. The existed flood escapes in the five channels will be entirely taken away. When the gage reading at Liuchai was 8.41m in 1921, the discharge through the five channels was found to be 7,841 m^3/sec. In order to increase its capacity to 9,000 m^3/sec., even with a lower stage, it will not involve too much earthwork. The annual cost for operating these flood escapes can also be saved forever. The proposed course of the flood channel is fully illustrated in Figures 9a and 9b.

General Remarks on the Design of the Flood Channel.

1.) ALIGNMENT The general course of the flood way has been described in the last article. Since the cross-section of the San Ho adjacent to the Hungtze Lake is not sufficient to discharge the whole quantity of water without too much loss of head, a new channel of 5.8 kilometers long must be excavated to the north of Chiangpa and joining the San Ho near Sanhowei (See Fig. 9b).

The flood flow from the Hungtze Lake will be regulated by means of two movable dams to be constructed in the San Ho and the new channel. The combined flow follows the original course of the San Ho till Paichiawan, east of Kingkouchen, where it is to be deviated southward to Paichiachien and then southeasterly to join the river Hsin Ho. Although the land travelled is generally high from Paichiachien to Hsin Ho, yet it is taken because it is the shortest way for the Huai getting to the Yangtze. At this place, for the sake of seeking a minimum sacrifice of the small villages and farm lands its course is made in a reversed curve. Yet it will make no obstruction to the flood discharge. Starting from this cut it runs in a southeastern direction through the Kaoyu Lake directly to the Tangchia Lake. It meets with another high land in the region between Tanchiachien and Huchuangwei where the channel is also located with several short turns in its way. After passing Huchuangwei, it runs through the Nanhu to Shaopai Lake and thence to Liuchai where it joins with the five channels to the Ancient Canal, and combines into two main courses to the Yangtze River. The total length of the whole course is about 153 kilometers.

2.) DISCHARGE The channels at different sections along the course are designed for the maximum discharge of 9,000 m^3/sec. The two courses leading water from the Hungtze Lake are designed to pass 4,500 cubic meters per second in each. From their junction to Liuchai, there is only one main channel, which is hence designed for 9,000 cubic meters per second. From Liuchai to the Ancient Canal, the flow is again divided into five paralled channels. Its distribution is as follows:

the Kingwan Ho	1,500 m^3/sec.
the Taiping Ho	2,500 ,,
the Fenghwan Ho	2,000 ,,
the Sin Ho	2,000 ,,
the Inner Grand Canal	1,000 ,,

The sum of the discharge in the above five canals is still 9,000 cubic meters per second.

From the Ancient Canal to Pakiangkow, the flow is divided into two passages. One is Montao Ho to discharge 1,500 cubic meters per second, and the other is Liochiakou to discharge 7,500 cubic meters per second. Below Pakiangkow, it is designed to pass the total maximum discharge through Shatou Ho into the Yangtze. That the quantity discharged from Kuachowkow into the Yangtze being very small is not taken into consideration for safety.

3.) GRADIENT The entire course of the flood channel from the Hungtze Lake to the Yangtze River is about 153 kilometers. The water level just below the movable dam is at 13 meters when lake elevation is at 13.50 meters, while the H. H. W. L. of the Yangtze is 4.3 meters. The total available drop along the course is therefore found to be 8.7 meters (See Fig. 10). Different drops in water level are assumed for different sections along the course. From the place just below the movable dam at Chiangpa to Paichiachien being 34.89 kilometers in length, its drop is 1.6 meters. From Paichiachien to Liuchai, the distance is 77.51 kilometers while its drop is assumed to be 3.9 meters. The section from Liuchai to Sankiangying being 40.27 kilometers long is designed with a drop of 3.2 meters. The variation of the slopes of the water surface for different sections is clearly shown in Fig. 10. In general, it is so arranged that in case the original channel is large enough to pass the flood, its natural slope of flow is taken; that when the channel must be excavated through high land, the drop in water level is assumed comparatively greater; and that when the channel passes through low land or lakes, it is then designed to consume a smaller drop. This will render the cost of excavation and dredging to be most economical.

4.) THE REGULATORS The regulators to be constructed at Chiangpa are designed to pass 9,000 cubic meters per second when the lake elevation is at 13.5 meters. The floor of the movable dam is averaged at 8 meters in elevation, and the drop of head in passing the dam is assumed to be 0.5 meter. By the following approximate estimation, the length of the clear opening of the movable dam must be 600 meters.

$$Q = 0.96\,L\,(H - h)\sqrt{2gh}$$

$$Q = 9{,}000\ m^3/sec.$$

$$H = 5.5m$$

$$h = 0.5m$$

$$\therefore\ L = 600m$$

Many types of movable dams such as stop logs, needles, Tainter gates and Stoney gates have been investigated and designed. But which one is the best to be adopted can only be decided after the actual test of the soil condition at the site of construction is made. So far as the cost is concerned, it will make no great difference in the choice of types. Approximately it will cost about three thousand dollars for every meter in length of the movable dam. Therefore the estimation for the movable dam is about $2,000,000.

5. DIKES As for the standard section of the dike, the top width is assumed to be four meters and slopes on both sides, 1:3. This may subject to correction when model experiment on dikes is performed. The top of the dike must be 1.5 meters higher than the highest water level to be expected. In those places where excavation is necessary, the excavated material will be used for dike construction. In this case it needs only to pay the additional cost for tamping. In case no excavated material can be utilized, it is then necessary to pay for both hauling and tamping. For dikes along the flood channel from Chiangpa to Paichiachien the earthwork which needs to pay for both hauling and tamping amounts to 5,554,570 cubic meters, and that portion where excavated material is available and only tamping is required is 2,024,500 cubic meters. From Paichiachien to Liuchai, the earthwork for dike construction which needs both hauling and tamping is about 17,020,500 cubic meters and that which needs tamping only is about 7,381,500 cubic meters. From Liuchai to the Ancient Canal due to high lands on both banks, only repairing work for the existing dikes is needed. Moreover excavated material is obtainable for dike construction everywhere along this section. The earthwork in this section which needs tamping only

is about 241,600 cubic meters. Below the Ancient Canal no excavation or dredging is to be performed. The earthwork for dikes from the Ancient Canal to Pakiangkow is 1,591,000 cubic meters and that from Pakiangkow to Sankiangying where the channel joins with the Yangtze is 1,143,000 cubic meters. As to the whole system of the flood channel, for dikes along both banks, the total earthwork which needs both hauling and tamping is approximately 25,309,070 cubic meters and that needs tamping only amounts to 9,647,600 cubic meters (See Fig. 10).

6.) EXCAVATION OR DREDGING Side slopes of 1:2 will be adopted for the excavated portion of the channel. For the new excavated channel at Chiangpa, the width of its highest water surface is 450 meters, and it has an average depth of 6.4 meters and a slope of water surface of 0.000098. The excavation needed for this canal is 10,225,000 cubic meters. From the Hungtze Lake to Paichiachien along the San Ho the width of the channel at its maximum stage is from 520 to 1,400 meters; its average depth is from 5.9 to 8.22 meters and the slope of water surface is from 0.00005 to 0.000072. The earthwork of excavation for this section is 17,851,000 cubic meters. From Paichiachien to Liuchai the width of the channel at the highest water level is from 1,488 to 2,186 meters, its average depth from 4.5 to 6 meters, its slopes from 0.00003 to 0.00009 and the earthwork of excavation is 31,330,000 cubic meters. From Liuchai to the Ancient Canal there are five channels in parallel which will maintain their original width and will be deepened only by dredging. The average depth is from 5.7 to 12.2 meters, and the slope from 0.0000816 to 0.000094. The earthwork for dredging is 13,378,000 cubic meters. From the Ancient Canal to Sankiangying whence the flood water flows into the Yangtze, the original channel is enough for discharging the maximum flood. Hence no dredging work is needed for this last section. The computation is partly based on the topographical maps surveyed by the Huai-Yang-Hsu-Hai Topographic Surveying Board. Proper corrections will be made after the final survey is completed.

7.) ESTIMATES The approximate estimate for the cost of the flood channel of the Huai is summarized as follows:-

(a)	Movable dams	$ 2,000,000
(b)	Excavation and dredging	22,960,345
(c)	Dike construction	4,295,592
(d)	Land compensation	1,566,800
(e)	Clearing the head bay above the movable dams	50,000
(f)	Other miscellaneous and administrative expense	3,000,000
	Total	$33,872,727

Dike Construction Surrounding the Hungtze Lake.

Before another flood channel is provided to discharge the water into the sea, the land surrounding the Hungtze Lake will suffer the danger of inundation because of the high surface elevation maintained in the lake. For this reason, dike construction is then necessary. The old dike with stone facing on the southeastern shore of the lake known as "Ming Dike of the Hungtze", if duly repaired, can be well used for protection of the land. Construction of new dikes will be conducted in both directions to connect with the two extremities of the old dike. On the eastern side of the lake, it starts from Jenhochih to go around the Chentzewa along the contour line of elevation 14.5 meters and terminates at the high land west of the Anhowa. On the west of Sanhokow, in the same manner, a dike from Malangkang to Sankangchih is to be constructed. The total length of the dike to be built amounts to 180 kilometers. As to the section of the dike, the width on the top will be 3 meters and slopes on both sides will be 1:3, and it will be built 1.5 meters higher than the highest water level. The earthwork amounts to 6,500,000 cubic meters, while its cost will be approximately $1,000,000. Sluice gates along the dike must be provided, when necessary, for the drainage of the land at different places adjacent to the lake. They will cost about $200,000.

Article 3. Regulation of the Upper and Middle Huai River and its tributaries.

Much of the flood damages on the upper and middle Huai River have been caused by the insufficient capacity of the river channel which is called upon to pass an enormous quantity of water collected by the many tributaries below Sanhochien. Besides that, the narrow canyon-like gorges at Fengtai, Huaiyuan and Fushan play a great deal of obstruction for the discharge of flood water. Most of the tributaries are as a rule shallow and narrow that local overflow is a common occurrance. According to the topographic map published by the Anhwei Conservancy Board, the inundated area in 1916 was 8,000 sq. km., while in 1921, was 13,700 sq. km. The extensiveness of the flooded area is worthy of our notice.

Flood Flow

There is no actual record about the intensity of floods of the upper Huai River and its tributaries. Rough estimates can be made by referring to the broken records of former Kiang Huai Conservancy Board of the gaging stations, established at Hunghokow, Sanhochien, of the Huai River and also on the Shih Ho and Yih Ho. It is tabulated as follows:

River	Flood Flow in m^3/sec.	Remarks
Huai River (Hunghokow)	3,000	Surveyed at July 11, 1921
,, ,, (Sanhochien)	3,310	,, ,, ,, 13, ,,
Hung Ho (Ju Ho included)	1,000	
Shih Ho (Kuan Ho included)	3,200	,, ,, ,, 13, ,,
Yin Ho	3,100	,, ,, ,, 20, ,,
Pei Ho	1,600	
Hsifei Ho	300	
Kwo Ho	1,250	
Chien Ho	210	
Peifei Ho	330	
Kwei Ho	600	
To Ho	250	
Tse Ho	350	
Shui Ho	1,400	

The above tabulated values are only the probable maximum discharges of the various tributaries, but not necessary occur in the same year, or even so, they must not be discharged to the main river simultaneously. Therefore it is obviously that the discharge of the Huai River at any point should be smaller than the sum of the max. discharges of all its tributaries above that point. The probable flood flows of the main Huai River below the mouth of any tributary are left to be determined.

It is assumed that the max. inflow of the Hungtze Lake, for safety, being 15,000 m^3/sec., while the corresponding discharges of Shui Ho and others which are to be discharged directly to the Hungtze Lake being 1,500 m^3/sec. Hence the maximum flood flow of the main Huai River just above the Hungtze Lake can be assumed as 13,500 m^3/sec. That above every tributary upward should be deducted a certain amount of discharge due to that tributary. From this, we estimate the maximum discharge of each section of the main Huai River as the following table:

Sections				Flood Flow
Localities		Mouthes of tributaries		
From	To	From	To	in m^3/sec.
Kweishan	Fushan	Hungtze Lake	Tse Ho	13,500
Fushan	Wu Ho	Tse Ho	Kwei Ho	13,000
Wu Ho	Huaiyuan	Kwei Ho	Kwo Ho	12,000
Huaiyuan	Fengtai	Kwo Ho	Hsifei Ho	10,000
Fengtai	Chenyangkwan	Hsifei Ho	Pei Ho	9,500
Chenyangkwan	Shuikangchih	Pei Ho	Yin Ho	8,500
Shuikangchih	Sanhochien	Yin Ho	Shih Ho	6,000
Sanhochien	Hunghokow	Shih Ho	Hung Ho	4,500

The actual record in the year 1921 tells us that the flood flow of the Huai River at Sanhochien only reached 3,310 m^3/sec., while at Lukow, a short distance below Chenyangkwan, it reached 6,000 m^3/sec. only. The reduction of overflow after regulation will increase the flood flow of the main while the separation of the occurrances of the flood peaks of various tributaries will decrease it. Owing to the lack of complete records, the probable future flood is still uncertain. But at any rate the above tabulated values can safely be used since they are one-fifth to one-third greater than the recorded maxima.

Regulation of the Main River

The present main channel of the Huai River below Hunghokow can carry only one-half the amount of maximum discharge due to its contracted and small cross-sections and flat slope. The dikes, also, are so low and incomplete that no protection from overflowing can be offered by them. Thus inundation must happen as soon as there is a flood of considerable magnitude, and in 1921, it was seen that the flood channel became as wide as 15 km. The cost of earthwork makes it impossible to excavate a large channel that will discharge all the amount of flood flow which may occur. The only way we can do is to construct two long levees along the course of the main channel. Prof. O. Franzius, has the same idea too. In some localities, nevertheless, channel improvement should also be executed in order to arrive at a satisfactory solution. Hence several sharp bends of the channel should be eliminated by cut-offs, and insufficient cross-sections should be enlarged by resorting to dredging. The distance between levees is to be kept as uniform as possible, sudden changes are to be avoided. The height of levees should be such that the sum of the construction cost and value of flooded area included within the levees is a minimum. Upon the foregoing principles the regulation work of the main Huai River is designed and will be briefly described in the following paragraphs.

Cut-offs are to be executed at Kotaitze, Sanhochien, Chaochiachih and Fengtai with an aggregate length of 18 km. For keeping the current in equilibrium, the new cross-sectional areas along each cut-off should be as near the original ones as possible. The average value of these areas is computed to be 2,800 sq. m. approximately, making total earthwork of 50,000,000 cu. m. for the whole. At the following localities the channels are to be enlarged by excavation: from Hunghokow to Changpakaintze, from Paifangtaitze to Fengtaitze, from Fengtai cut-off to Yenwotze, from Lunghochih to Meihokow, from Anhuaichih to Chichih, and from Pouchiatu to Fushan. The sectional areas to be cut are from 500 to 2,500 sq. m. Total earthwork will be 90,000,000 cu. m. It may be concluded that the total quantity of excavation work of the main Huai River between Hunghokow and Fushan amounts to 140,000,000 cu. m. The cost of doing this will be about $30,000,000. Besides this new openings must be added to the railway bridge at Pengpu since the water passage under that bridge seems too small.

A new channel is desired to be excavated from Fushan passing directly through the high land at the southeast of Shuangkou and the Lihowa, to the Hungtze Lake. A small steep-sloped channel will be cut through at the starting. By means of the strong current it will be enlarged naturally to the desired capacity. By that time the dikes should be constructed so that reclamation of surrounding lands can be carried out. It is advantageous both to flood control and navigation since the length of the channel will be shortened by about 60 km. In the new cut-off, which has a total length of 18 km., 15 km. will be marshy land and 3 km. will be high land. Let the base width of the artificial channel be 100 m., side slope 1:1, mean depth 10 meters, then the excavation along marshy land will be 11,500,000 cu. m., and that along high land will be 6,800,000 cu. m. The cost of excavation, including a narrow channel in the Lihowa, will be about $5,000,000. The possibility of this kind of work may be determined after the soil investigation of the high land southeast of Shuangkou is made.

The total length of the levee of the main Huai River, from Hunghokow to Shuangkou, will be 410 km. According to our consulting engineer, Prof. O. Franzius's study, the most economical type of levee will be 5 to 6 m. in height, and average 3.5 km. apart. From the cross-sections taken by the former Kiang Huai Conservancy Board and the discharges at various sections as above computed, it is found that the required distance between levees at the portion from Shuangkou to Huaiyuan will be 4 km., that from Huaiyuan to Liutzekow, 8 km. upstream of Chenyangkwan, will be 3 km., that from Liutzekow to Sanhochien will be 2 km., and that from Sanhochien to Hunghokow will be 3 km. The height of levees will be between 4.5 m. to 6.5 m., only at certain place with very short distance the height reaches to 7m. The freeboard is taken as 1m. and side slopes at both sides 1:3. The top width of levee is taken as 6m. so as to serve as a public highway at the same time. Banquette is to be constructed at the place where the height of levee is more than 5m. The top of a banquette is 2m. below the top of the levee, and is 10m. wide. The total quantity of embankment amounts to 100,000,000 cu. m. and it costs about $18,000,000. The private land are occupied by the levees, the borrow-pits, and the berms between amounts to 164 sq. km., or 266,000 mou. At an average price of $40, per mou, it costs $10,640,000. Besides the above, the costs for sluices, pumping stations, etc. should also be added in. The total cost of levee construction, therefore, will be $35,000,000.

The land area of the proposed flood channel is estimated at 2,000,000 mou. It is still able to be used for cultivation, as its subjection to flood will not be oftener than before, except that if it does occur, the depth of water on it will be deeper. On the other hand, after the improvement is completed, the duration of inundation on the above mentioned land will be shorter for flood water of the Huai River can quickly be discharged. Hence the benefit and disadvantage are still balanced. It is only necessary to exempt the land tax or giving a small sum of money as compensation, without amounting to a big expenditure.

The valley of the main Huai River is usually flat, its steepest slope is not more than 1:50,000. With this value and the mean depth of water of the flood channel, we found that the W. L. elevation at Hunghokow will be 28m., at Fushan, will be 20m. Below Fushan down to the Hungtze Lake by way of the proposed 18 km. short cut at Shuangkou the available drop of head is 3.5m., enough to create sufficient velocity to help the formation of the channel by natural erosion. The flood W. L. above Fushan was thought rather too high, but on account of the great expenditure involved in the enlargement of channel by dredging, there could be no other alternative than what proposed. The H. W. L. will be lowered naturally year after year as the erosion of the channel bed progresses. The total cost of the whole project for the main Huai River is estimated at $70,000,000.

Regulation of the Tributaries

Different methods of flood cantrol should be applied to the tributaries of the Huai River of different characteristics. But for their lower courses, the backwater effect of the flood flows of the diked main river will be higher than their bottom lands, so the construction of levees is also necessary. For economical reasons the small tributaries should be combined with the larger one. Also if the tortuous channels of the tributaries be found near to the main river, they can be shortened by providing cut-offs to the main river. Besides these, hill-side terracing at their head waters and cut-off along the channels may be provided if found economical and effective.

The Pei Ho, Shih Ho and Kuan Ho are all of mountainous streams, so retarding basins may be built to control the flood. But owing to the lack of actual data, this is left for further investigation. If it is found necessary to provide levee system, then the required length of levees for the Shih Ho, from Sanhochien to Hsintukow, just above the mouth of the Kuan Ho, is about 70 km., that for the Kuan Ho, from the river mouth to Liushupang, is about 40 km., and that for the Pei Ho, from the river mouth to Siaoleechih, is about 95 km. Nine cut-offs will be required to eliminate the sharp bends of the Hung Ho below Sanchakow, the junction with the Ju Ho, at a total length of about 14 km. The required length of levees for the Hung Ho is about 140 km. A new channel will be excavated for shifting the river mouth of the Yin Ho from Chenyangkwan to Shuikangchih of a total length of about 6 km. The length of levees for the Yin Ho, from the new river mouth to Huiliuchih is about 70 km. The length of levees for the Hsifei Ho, Hei Ho and Chiang Ho, is about 70 km. New channels will be excavated for the Peifei Ho from Kaotzutze to Yinsiaochih and then combine with the Kwo Ho, same for the Chien Ho from Tsaolingchih to Shakouchih and them combine with the Kwo Ho, and also for the Kwo Ho, from Shakouchih to Changchuang downstream of Huaiyuan, and combine with the main

Huai River. The levees for the above rivers, the Kwo Ho up to I-tsenchih, the Peifei Ho up to Hsiangchiaochih, and the Chien Ho up to Wanfuchih have a total length of about 90 km. The To Ho and Peito Ho will combine with the Kwei Ho at Wuhohsien and discharge into the Huai River. The lakes along their lower courses, like the Hsiangchien Hu, To Hu, etc., will be preserved as the storage reservoirs. Around the lakes, levees will be constructed and extended up to Chungyichih for the Kwei Ho to Tsingchungchih for the To Ho, and to Lochiaochih for the Peito Ho. The total length of levees of these three rivers will be about 200 km. The small streams at the northern part of Szehsien, Lingpi and Hsuhsien will be conducted to the Hungtze Lake by way of the Pien Ho and Shui Ho. The channel bed of the Shui Ho seems too high, hence dredging as well as levee construction are necessary. The total length of this river to be regulated is about 90 km. Other than these, the excavation and embankment of the various small streams will not be considered here for they would not involve large sum of expenditure. Drainage structures such as culverts and pumps, should also be provided for draining away rain water collected on the bank sides of the levees during the H. W. period of the Huai River. Numerous lakes and swamps should be preserved as valley storages and at the same time to reduce the cost of drainage structures. The total cost of the whole project for the tributaries of the Huai River is estimated at $30,000,000.

It is found that the total area which will be protected under the present scheme amounting to 20,000,000 mou. While the total cost of the project is estimated to be about $100,000,000, it shows that it averages only $5.00 per mou.

The foregoing tells only the general feature of the scheme. Detail study will be made only after sufficient data are at hand.

Article 4. Regulation of the Shu Ho.

The Shu Ho takes its rise in the Mengyi mountains in the province of Shantung. It has different local names along its course. It is called the Tasha Ho or Great Sandy River after it passes the town of Hunghwapu down to the border of the province of Kiangsu. Its course is divided into two branches at Hsinhochen in the district of Shuyang. The main course runs eastward, through the Tsingyi Lake (dried) and Rose River to the sea at Linhungkow. The other branch divides itself into two, called the Front and Rear Shu Ho, and again divides into Kwantien Ho and Chaimee Ho. The Rear Shu Ho empties into the Tsingyi Lake too, while the Front Shu Ho and Kwantien Ho combine into one course, called Chiang Ho, and empty into the Rose River. The Chaimee Ho runs southeastward into the Yi River, and then finds its way to the sea. Since the valley of the upper Shu Ho is very steep that no natural storage can be offered by it. During the winter and spring seasons, the river bed is usually dried out, but in the summer season, the flood comes with such rapidity that the channel is unable to hold, and overflowing is usually occured. In the former days such swamps as the Shuhsiang, Tsingyi, Sangchu, etc., at its downstream side were still in existence, and could have offered as detention basins for the flood, but they are now all silted up, somewhere is even higher than the river bed, they can do more evils than good. This tells why the land traveled by the Shu Ho is always subject to flood, and many times, the flooded area merges into that of the Yi River to form a sea-like water body. The rivers, such as the Chaimee Ho and Shakiang Ho, etc., are always subject to the flood of both rivers and the condition of flood becomes worst if both rivers have an enormous flood meeting at the same time. It is plainly, therefore, in order to reduce the flood damage it is necessary to provide definite channels for the Shu Ho and Yi Ho separately going to the sea.

The Flood Magnitude.

According to the record of the former Kiang Huai Conservancy Board, great floods of the Shu happened both in the year 1921 and 1924. On July 15, 1921, the maximum flood discharge was found to be 2,555 cubic meters per second at Maotsechuang, while on July 15, 1924, measurement at Shinanchen indicated the maximum value to be 4,470 cubic meters per second, which is the highest record for recent years. It was confirmed by the people in the valley of the Shu Ho, that such a great flood had never been met with during the last several decades. By comparison with other rivers which have similar topographical canditions and nearly equal drainage areas, it is also shown to be a rare flood. Therefore the maximum flood discharge of the Shu Ho by which the schemes for flood control will base upon, is assumed to be 4,500 cubic meters per second.

General Scheme

Owing to incompleteness of the record of discharge measurement, no definite information can be obtained on the capacity of the channel of the Shu Ho at its lower course. By means of the maps and cross sections of the river, surveyed by the former Kiang Huai Conservancy Board, an approximate estimation was made, showing that the channel of the Tasha River near Yenchiachih to be capable to discharge 880 cubic meters per second and that of the Rose River at Shachiafong being capable to discharge 180 cubic meters per second only. The capacity of the channel at the former place is only one fifth, and that at the latter place, being still smaller, even not more than one twenty-fifth of the total maximum discharge of high flood. It is evident that the channel along its lower course is quite inadequate to carry the maximum flow and certainly inundation of the lands can by no means be avoided. But it is the fact that the rise and fall of the flow even during a high flood, are so sudden that its duration of flood peak lasts only a short period. Taking the high flood of 1921 for instanse, on July 12, the discharge was found to be 36 cubic meters per second only, but three days after, that is, on July 15, it increased suddenly to 2,555 cubic meters per second. After that date it dropped very quickly to 505 cubic meters per second on July 19. Aagain in the year 1924, on July 13, the discharge was 20 cubic meters per second; on July 15, it increased to 4,470 cubic meters per second; and decreased again to a value of 2,470 cubic meters per second on the next day. And it was found to be only 247 cubic meters per second on July 17. After its high flood of short duration passes away, the channel often immediately reduces its flow to its minimum quantity or even wholly drying. In spite of the flood damage, it is equally not advantageous for both navigation and irrigation purposes. Moreover, whenever the terrible flood comes, it always carries down with it from the mountainous valleys much quantity of sedimentary materials which will silt up the channel at its lower course, causing the condition from bad to worse. In order to solve the problem of flood prevention of the Shu Ho satisfactorily, it is necessary to provide detention basins and a system of ground sills at its head waters. In this way its flood peak can be depressed, velocity be checked and quantity of silt be reduced. But the region at the head waters of the Shu Ho has never been carefully surveyed. Financial difficulty and time limitation together with disturbance due to bandits at that region had prevented us to carry on the survey. Therefore no definite scheme for the detention basins or system of ground sills can be made for the time being.

As to the lower course of the Shu Ho, the channel must nevertheless be improved for flood discharge whether regulation work is provided on its upper part, or not. The best way, as already stated before, is to separate the Shu Ho from the Yi Ho. The main channel of the Shu Ho is proposed to go along the Tasha Ho from Hunghwapu through the Tsingyi Lake and Rose River to the sea at Linhungkow. (See Fig. 11) It is the shortest way with sufficient slope for discharging the flood. At its junctions with other existing rivers, sluice gates will be provided to facilitate drainge and also to divert water for irrigation and navigation. As it has already been explained that the detail design can only be made after the survey is completed, hence for the present, based on the maps of the former Kiang Huai Conservancy Board we can only estimate the cost of channel improvement with the assumption that it is required to discharge the maximum flow of 4,500 cubic meters per second. This will give the maximum limit of the cost for regulation of the Shu Ho. It is known that the cost will be expensive if the channel is designed to discharge the maximum value of the flood peak without any means for detaining the flood. This has been fully discussed in the foregoing section in connection with the flood control of the Huai River. The cost of the final project, which is to be proposed after completion of the survey, must be far within the maximum limit.

The Cost of Channel Improvement for Discharging the Max. Flood Flow.

The present estimation is based on the assumption that the channel is called to discharge the maximum flood flow of 4,500 cubic meters per second. Its alignment is shown in Fig. 11. From Linhungkow up to the Tsingyi Lake the channel is 65.2 kilometers long, while its slope of water level is designed to be 1:10,880. From the Tsingyi Lake to Shuhokow it is 39.46 kilometers long and its slope is designed to be 1:7,900. From Shuhokow to Hunghwapu, its distance is 62.66 kilometers and its slope is 1:3,200. The channel at different section is designed accordingly. The cost of this project is summarized as follows:

Item	Quantity	Unit Cost $	Cost $	Remarks
Earthwork for dikes	36,112,400 m^3	0.16	5,777,984	Hauling Distance 100 m.
Earthwork for closing branches	70,000 m^3	0.16	11,200	,,
Sluices			200,000	
Land compensation	177,000 mou	10.00	1,770,000	

Total..............$7,759,184

Article 5. Regulation of the Yi Ho

The Yi Ho, being also taken its rise in the Mengyi mountains in the province of Shantung, enters the boundary of Kiangsu Province at Tanchen. After it passes Koushangchih, it divides into two courses. The main course runs southward to Chowchiakow, turns in the south-eastern direction to the Loma Lake, and then flows eastward to Tashihtu to join the southern and nortern Liutang Ho up to the towns, Wuchang and Lungkou, where it goes across the Salt Canal and finds its way to the sea through the Kwan Ho. The branch course was formerly regulated at its head by a movable dam called Lukowpa. Its water runs westward to the Middle Grand Canal in three different channels, their junctions with the Grand Canal being Shutangchih, Shachiakow and Ertaokow. Small part of the flow in the main course is also diverted to the Grand Canal by way of the channels at Yaowan. Owing to the limited capacity of the channel of the Grand Canal, only a small part of the combined flow does run to the Inner Grand Canal. Main part of water returns again to the Liutang Ho through several cuts in the eastern bank of the Grand Canal, namely, Chiulungmiao, Wuhwachiao, Liulauchien, etc. During the high flood of the Huai River, part of the flood flow also finds its way to the Liutang Ho by way of the Changfu Ho and Salt Canal.

Formerly, regulators were constructed at Lukowpa and Yaowan. They were all destroyed. The former was used to regulate the flow in the branch course and as a safeguard to the Grand Canal. But after it was destroyed, the main current has found its way through the branch instead of the main course. Same is at Yaowan, where there was a regulator called Chulopa. After its destruction, the flow of the Yi runs freely into the Grand Canal. About one km. upstream of Chulopa, an escapeway of the Grand Canal was constructed to discharge surplus water into the Loma Lake. As the lake is entirely silted up, the flow from the escapeway runs at present directly southward to the Liutang River. During the high flood of the Yi Ho, a part of flood water finds its way through Shakiang Ho to the Shu Ho. The regulator at Liulauchien, which acted formerly as an escapeway for the Grand Canal, is also not existed.

Flood Discharge

According to the record of the former Kiang Huai Conservancy Board, great floods of the Yi, have been also found in the year 1921 and 1924. In the year 1921, the maximum discharge was found at Lichuang to be 2,310 cubic meters per second, while in 1924 it was found at Lukowpa to be 2,130 cubic meters per second. So far as the result obtained by actual measurement is concerned, the maximum flood discharge of the Yi Ho may be assumed at 2,310 cubic meters per second. But in comparing the valley of the Yi Ho with that of the Shu Ho which resemble almost in every respect to each other, this assumption seems to be a little bit too low to be adopted for design. Their topographical conditions are similar, and the rainfall in the two valleys are also not much in difference. Moreover they have the same torrential nature of the flood flow. Although the drainage area of the Yi Ho is comparatively larger, but its slope of the flow is less than that of the Shu Ho. Judging by these facts the probable maximum discharge of the Yi Ho can be by no reason less than that of the Shu Ho. Therefore for the sake of safety, it is assumed that the maximum discharge of the Yi Ho is also 4,500 cubic meters per second.

General Scheme

Since the main course of the Yi has been silted up, a large portion of the flood water below Chitseng has to find its way to flow into the Middle Grand Canal. As in the year 1921 the discharge at its upstream was found to be 2,310 cubic meters per second, while that portion which discharged to the Grand Canal by passing through Lukowpa amounted at 1,900 cubic meters per second. The other portion which went southward along its main route was still partly diverted to the Grand Canal from Chulopa. But owing to the limited capacity of the silted channels leading to the Grand Canal and the worse condition of the main course, the flood water usually causes the inundation of the Yi Ho valley. As to the Middle Grand Canal which is also limited in capacity, the outlets at Chiulungmiao, Wuhwachiao and Liulauchien can not divert all surplus water eastward to the Liutang Ho on account of its silted condition. The combined flow of the Sze Ho and the Yi Ho usually has to overflow on both banks and causes the flood damage in the region of the Middle Grand Canal. Again the channel which discharges the flood water of the Yi Ho to the sea from the Main Liutang Ho along the northern and southern Liutang Ho to the Wuchang Ho and Lungkou Ho has its capacity gradually diminished as it flows toward downstream. That is a very bad condition for flood discharge. At Sanchatu on the Main Liutang Ho the capacity of the channel is about 1,300 cubic meters per second, while at the place near the upstream of the junction of northern and southern Liutang Ho, it is only 750 cubic meters per second approximately, and the total discharge in Wuchang Ho and Lungkou Ho is also only that much. Since the flood flow can not entirely pass away to the sea at its downstream, the land in the valley of the Liutang Ho is surely subject to inundation. In case a part of the flow passes eastward to Shakiang Ho, that will make the case more severe in the flood area of the Shu Ho valley. In a word, since there is not a proper channel of adequate capacity to pass flood water of the Yi Ho to the sea, it often causes great damage in case of flood to the region north of the Old Yellow River. The first thing to be done for the regulation of the Yi Ho is then to provide a channel to the sea.

The Middle Grand Canal, led water from the Wishan Lake, is the only waterway for the drainage of water in the southwestern part of the province of Shantung. For the sake of flood control in Shantung and also the valley of the Middle Grand Canal, only the Sze Ho will be permitted to flow through the Grand Canal. Flood water of the Yi Ho must be separated from it. The course of the flood channel of the Yi Ho is proposed to pass along its original main course from Koushangchih to Chowchiakow and then to flow southward through the Loma Lake to Sanchatu, whence by combining with the portion of flood water of the Sze Ho which is to be diverted from Liulauchien (See next Section on Regulation of the Sze Ho) it runs eastward along the Main Liutang Ho to Chienchiachih. Then by the passage through the Northern Liutang Ho, Lungkou Ho, and Kwan Ho, it discharges into the sea. All the channels which lead its flood water to the Grand Canal, are to be closed except one which is to be retained for supplying of the Grand Canal in case of drought. Since the discharge capacity of the flood channel except the Kwan Ho section is everywhere much less than the maximum value to be provided, its channel section must be increased either by excavation or by construction of dikes.

The probable maximum discharge of the Yi Ho is 4,500 cubic meters per second and that actually measured in the year 1921 amounted to not less than 2,310 cubic meters per second. But the condition of the Yi Ho is just the same as that of the Shu Ho that it has a steep valley at its upstream without a place for detention. Although its flood peak is high, but its duration is rather short. For instance in the year 1921, on Aug. 2, its discharge was found to be 65 cubic meters per second only, on Aug. 7, it suddenly increased to 2,310 cubic meters per second. But on Aug. 10, it decreased again to the amount of 860 cubic meters per second. Also in the year 1924, the discharge amounted to 194 cubic meters per second only on July 24, but it raised to its maximum 2,130 cubic meters per second on July 26. Then the flood lowered again to the amount of 977 cubic meters per second on July 30. Therefore for the regulation of Yi Ho, same as in the case of the Shu Ho, not only it is necessary to improve its channel at the downstream side, but also it is required to provide detention reservoirs and ground sills at its upstream side. By this way flood water will be partly stored up and its velocity, checked. The cost of the channel improvement will be minimized and at the same time, irrigation can be developed. But the survey at its head water is not yet completed. No definite scheme can be laid down for the location of detention basins and system of ground sills at present. For estimating the maximum limit of the cost of regulation work, as in the case of the Shu Ho, it is designed to pass the maximum discharge for the channel improvement. For this computation, the togographical maps and cross sections of the channel and its downstream side surveyed by the former Kiang Huai Conservancy Board are used.

The Cost of Channel Improvement
For discharging the Maximum Flood Flow.

The course of the flood channel for this estimation is shown in Fig. 12. It is designed to pass the maximum flood peak value of 4,500 cubic meters per second. For simplicity of description, we may divide it into three sections. The first section is from Chitseng to Sanchatu. Its discharge capacity is designed for 4,500 cubic meters per second, its slope of flow is from about 1:3,700 to 1:7,300 the width of the channel between dikes is from 600 to 790 meters, the height of dikes is increased on the average 0.4m., and its depth of flow is from 5 to 6 meters. The second section is from Sanchatu to Lungkou. With the additional flow of 1,000 cubic meters per second from Liulauchien (See next section), the maximum discharge for this section and its downstream amounts to 5,500 cubic meters per second. The slope of flow for this section is about 1:10,500, its average width between dikes is 916 meters, the height of dikes is from $3^1/_2$ to 6 meters, and the depth of water is from $5^1/_2$ to 8 meters at its middle portion of the channel and from 2 to $4^1/_2$ meters near the banks. The last section is from Lungkou along the Kwan Ho to the sea. Since the existing channel of the Kwan Ho is large enough, not much money will be spent for this section. The average width of the channel in this section is about 1,400 meters; the height of dikes, from 1 to 5.3 meters, and its depth is from 7 to 11 meters at the middle and from 0.5 to 3.8 meters near the banks. The total cost is summarized as follows:

Item	Quantity	Unit Cost $	Cost $	Remarks
Earthwork for dikes	43,540,000 m³	0.16	6,966,400	Hauling distance 100 m.
Earthwork for closing branches	500,000 m³	0.16	80,000	,,
4 sluices			200,000	
Land compensation	235,000 mou	10.00	2,350,000	

Total..................$9,596,400

Article 6. Regulation of the Sze Ho and the Rivers and Lakes in the Southern Shantung Province

The Southern Grand Canal in the Province of Shantung receives all the streams from the mountain ranges of Tai Shan, such as the Wen, Sze and other small streams in the districts of Teng and Chow. The Chu, Wanfu and Shungti rivers in the district of Tsaochow also drain into it. The outlets for the Grand Canal are the Yellow River in the north and Yangtze River in the south. Its northern outlet is not an efficient one for the Yellow River bed is silted up higher and higher that its dike is at present four meters higher than the bottom land. In consequence, the triangular shaped region enclosed by dikes of the Grand Canal, old and new Yellow Rivers resembles a water basin, with only one outlet through the Wishan Lake. Nine districts in the west of the Grand Canal are always subjects to inundation, and much more severely damaged in the year of bigger flood. The land on the east of the Grand Canal, on account of its higher topography, is in a better condition except the district of Tungping, which is permanently inundated by the Wen Ho. The people of the province of Kiangsu, being on the downstream side, are constantly in fear of the rivers and lakes in the province of Shantung being improved and drained into their region. In the present scheme, it is proposed to regulate the Huai and Yi Rivers separately, the Middle Grand Canal will only be used to discharge flood water from the Shantung province till Liulauchien where it finds its way to the sea by the Yi Ho. By this means, the flood problem in the province of Shantung can be hopefully solved.

All the streams running southward from the province of Shantung are all temporarily detained in the Wishan Lake. According to the topographic map of 1:100,000 scale, it is roughly estimated that the lake area is 370 sq. km., enclosed by the 31m. contour line, and is 870 sq. km., enclosed by the 35m. contour line. The general elevation of the lake bottom is about 30.6m. Hence the capacity of the lake between 31 to 35m. is approximately 2,480 mill. cu. m., which is quite sufficient to be utilized for flood control and storage purposes, as in the case of the Hungtze Lake.

The Flood Magnitude

The present channel leading to the Yellow River for the Wen Ho will be maintained. The inundation of the district of Tungping will be relieved by another way. Hence the flood quantity of the Wen Ho is not included in the estimation of flood magnitude for the Southern Grand Canal in Shantung. The exact value of inflow to the Wishan Lake is not known for lack of data. The stream measurement made by the Shantung Grand Canal Board shows that the largest discharge of the Sze Ho in the period from 1913 to 1916 was 748 cu. m. per sec. Since the drainage area of the Wishan Lake is approximately 30,000 sq. km., while that of the Sze Ho is about 4,060 sq. km., so if the same rate of flood flow as that of the Sze Ho be applied to the whole area then the maximum flood inflow of the lake would be 5,500 cu. m. per sec. However, because of the hilly topography of the Sze Ho valley, the discharge on unit area must be high, so a general application of its rate to the whole area will give a value too large for use. Moreover, this maximum flood of the Sze Ho is of short duration lasting only one day. Now, with the big storage capacity of the Wishan Lake, it is enough to detain the flood flow. Only the total inflow or the average outflow of the lake during the flood period will be taken into calculation for regulation work.

According to the report of Ze-Ka-Wei Observatory, the precipitation of the drainage area of the Wishan Lake during flood season is nearly the same as that of Tsingtao. From the records of that station, the maximum precipitation occurred always in the months of July and August. The maximum values recorded were 295.3 mm. and 280.5 mm. respectively, hence the total value of these two months was 576 mm. Also there is no record upon the relation between rainfall and run-off in this drainage area to be studied, we can estimate the ratio only by experience. For safety, this is assumed to be equal to 40%, as that is the maximum ratio ever occurred. Since the drainage area of the Wishan Lake is about 30,000 sq. km., the total discharges during these two months will be $30,000,000,000 \times 0.576 \times 0.4 = 6,900,000,000$ cu. m. or in average 1,330 m^3/sec. The flood peak of maximum discharge is still unknown, but we can make that the outflow of the lake will not be affected by the inflow directly since the Wishan Lake can detain a certain amount of flood discharge. Suppose we fix the highest lake level at 35m., that in 1921 being

35.56m. then we have a storage capacity of 2,480 million cu. m. between the lowest and highest lake levels. The total outflow discharge during July and August will be 4,420 million cu. m. or 843 m^3/sec. For safety, we take 1,000 m^3/sec. as the outflow discharge of the Wishan Lake.

Flood Control Project

There are two outlets for the Wishan Lake. One is at Changkoshan, where it is controlled by a dam called Lingchiapa. Below that, the Pelau Ho conveys water to the Middle Grand Canal in Kiangsu at Shutangchih. The other outlet is at Hanchuang, where there is a regulating structure of 14 openings for regulating the inflow and also as a check dam in the main canal below the regulator. The former channel has been very much silted up, the maximum discharge in the year 1921 was only 135 m^3/sec. while the lake level reached to 35m. Also its distance between the lake and Shutangchin is longer than that of the Middle Grand Canal, hence it has a flatter slope. The latter channel, from Hanchuang down through the Middle Grand Canal, therefore, is selected as the flood channel for the Wishan Lake. But as the Middle Grand Canal will also be used as a navigable waterway, the navigable depth and discharge should also be considered in the flood control project. For the navigation in dry seasons, we shall construct locks at Teshenchai, Hotingchai, Liulauchien, etc. as will be described in the chapter on navigation projects.

The flood flow of the Wishan Lake will be discharged from Hanchuang through the Middle Grand Canal, Yi Ho. Liutang Ho, Kwan Ho, and then to the sea. From a study of the topography of the

Yi Ho and Grand Canal, the best way is to divert flood water from the Grand Canal at Liulauchien. A movable dam to discharge 1,000 m^3/sec. is proposed to be constructed on the eastern dike of the Grand Canal just upstream of Liulauchien Lock. Below that dam, the flood flow will follow the old channel eastward and meet with the Yi Ho at Sanchatu. The regulator and other Chai's at Hanchuang and along the Middle Grand Canal should all be demolished as to be convenient both for flood flow and navigation. Movable dams should be constructed at the sides of the locks at Teshenchai and Hotingchai as to regulate the flood flow.

Tbe highest water level of the flood channel of the Yi Ho at Sanchatu will be 18m. Let the total loss of head due to the movable dam at Liulauchien and in the channel between Liulauchien and Sanchatu to be 1m, then the water level just above that dam will be 19m. The distance between Liulauchien and Hotingchai is 97 km. The slope in this portion is used as 1 in 13,300, which is the most economical slope obtained as it will utilize most of the existing channels. Then the water level just below the movable dam at Hotingchai will be 26.28m. Let the loss of head due to this dam be 1m, the water level just above the dam will be 27.28m. The distance between Hotingchai and Teshenchai is 45.5 km. By the same reason let the slope in this portion be 1 in 9,000 and loss of head over the dam be 1m, then the water level below that dam will be 32.33m and that above the dam will be 33.33m. The distance between the Teshenchai and old sluice gate at the lake mouth is 11.63 km. Let the slope in this portion also be 1 in 9,000, then the water level at the lake mouth will be 34.62m. This means that when the lake level reaches the above value, its outflow discharged will be 1,000

m^3/sec. This is on the safe side, otherwise if the outflow reaches its maximum value until the lake level has raised to the highest gage, then the great amount of storage water in the lake will cause inundation in its upstream side.

For safety to navigation, the velocity of flow should not be more than 2 m/sec. with the maximum discharge of 1,000 m^3/sec. With the above mentioned slopes being used, then the minimum cross-section for the portion between the lake mouth and Hotingchai according to Prof. Forchheimer's formula, will be:

bottom width	50m
top width	82m
mean depth	8m
side slopes	1:2

That from Hotingchai to Liulauchien will be:

bottom width	64m
top width	96m
mean depth	8m
side slopes	1:2

According to the existing cross-sections of the Grand Canal, not much dredging work is required except the width of the portion between the lake mouth and Teshenchai and the depth of the portions just below Teshenchai and Hotingchai should be increased. Since the highest water level will be higher than the ground surface, then the height of levees should be increased according to the highest water level along the Grand Canal as shown in Fig. 14. Let the top width of the levee be 4m., its freeboard be 1.5m., and its side slopes be 1 to 3.

From Liulauchien to Sanchatu, for economical reasons, the old channel should be fully utilized. The distance in this portion is 11 km., max. discharge will be 1,000 m^3/sec., and let its slope be 1 in 20,000. According to Forchheimer's formula, its standard cross-section will be:

bottom width	80m
top width	112m
mean depth	8m
side slopes	1:2

In this portion, excavation and embankment should to provided from Liulauchien to Yuantu of a length 4.37 km., and only embankment should be provided from Yuantu to Sanchatu of a length 6.63 km. The levee section will be the same as that for the Middle Grand Canal.

The Pelau Ho will not be closed. It will be used for water supply purpose along its course. We shall construct a sluice gate at its mouth for regulating its flow. Also a sluice gate in the Middle Grand Canal should be constructed adjoining the lock at Liulauchien for regulating the irrigation water downstream. These two sluice gates cost about $150,000.

The total cost for three movable dams at Teshenchai, Hotingchai, and at the eastern dike at Liulauchien is estimated to be about $500,000.

The costs of the flood control project on the Sze Ho and Southern Shantung rivers are summarized as follows:

Excavation between Liulauchien	
and Sanchatu	973,600 m^3 @ $0.135 = $131,436
Embankment on the same	526,200 m^3 @ $0.16 = $ 84,192
Excavated material used for	
embankment on the same	261,300 m^3 @ $0.025 = $ 6,533
2 sluice gates at the mouth of the	
Pelau Ho and Liulauchien	$150,000
3 movable dams at Teshenchai,	
Hotingchai and Liulauchien	$500,000
	Total.....................$872,161

This project is mainly for providing the flood outlet of the Southern Shantung rivers. Other schemes as to improve the rivers for drainage and irrigation are not included for lack of data.

Chapter. III. Navigation Projects.

Article 1. Introduction

Canalization of Rivers.

Within the district of the Huai River and Grand Canal, streams and water bodies are so numerous that navigation by small junks are very much generalized. The well-known rivers and lakes are the Grand Canal, Salt Canal or Yen Ho, Changfu Ho, Hungtze Lake. Kao Pao Lakes and the Huai River proper. They are the important waterways for the transportation of native goods, and small boats are to be seen everywhere. But they are all of natural water courses, so that their navigable depths are subject to the fluctuations of the water surface. In the wet season they are of course deep enough for the comparatively big boats; but during the dry season, since the source of water supply is greatly limited, and at the same time the flow is not in any way checked from running into the Yangtzekiang or the sea, they soon become too shallow for navigation. This is the reason why navigation in this district is scarcely developed to a great extent.

In the former days when the Grand Canal was called upon to transport the rice tribute for the Royal family, it was built many Chai's (movable dams of the stop log type) in the canal to raise the water surface in the different pools, such as Yunliu, Hoting and Weichi, etc. Up to the present, even such Chai's are still in existence, but they are nearly all out of repair that the stop logs are not to be put down even in the dry season. They can serve no purpose. Besides those Chai's we have the Sanhopa at the southern end of the Ming Dike on the Hungtze Lake. It is built every year as soon as the flood season is over in order to compel water of the Huai River to flow into the Grand Canal by way of the Chang-fu Ho. At the lower end of the Grand Canal, there are several flood escapes with flash boards made of weeds and earth to check the flow of the Grand Canal from being lost into the Yangtzekiang or the sea after a flood season is over. Temporary earth dams are also to be found in the rivers to check the flow during dry season, such as near Tsematou on the Salt Canal. All these means are for the conservation of water quantity for the use of navigation. Nevertheless, they are all crude in form and sometimes contracting the channel so much as to cause tumultuous flow at the opening that boats are to be towed up and down with great difficulty. In many cases the navigation routes are entirely cut away, that trans-shipping is necessary at these places.

For navigation purpose, in order to prevent the interruption of traffic a river should have a sufficient depth of water for the whole year to be consistent with the draft of the biggest boats. But for the natural water courses, the variation of water level is very great, and it is quite uncertain as to the duration of time when there is a sufficient depth of water for navigation. For example on the Middle Grand Canal at Yaowan (see Fig. 17) the duration of time for the continuance of water level is different throughout the year. On this portion of the canal the deepest part is 15m. in elevation. In average there are 77 days (21% of the year) when it is three meters in depth; 118 days (32% of the year), when it is $2^1/_2$ meters in depth; 186 days (51% of the year) when it is 2 meters in depth; and 57 days ($15^1/_2$% of the year) when the water level ever reaches the record of 19.7 meters. Hence it is quite clear that water is deficient for the navigation of big boats throughout the year. But the way to increase the depth of water by deepening the channel is not possible, because during the dry season, the water source is quite limited, and if the channel is excavated to a steep slope, the velocity thus acquired will soon cause the water level to be quickly lowered. It is true that a river can be excavated to increase its tidal effect, but it should be quite near to a tidal river or the sea, and it is an impossibility to excavate a river of several hundred miles long such as the Granal Canal to such a depth that the channel will be below the mean water level of the sea to fetch the tidal effect. Hence the way to preserve sufficient depth of water for navigation is to canalize the river by building locks and movable dams along its course to regulate its flow.

For example, if a lock and a movable dam are constructed on the Middle Grand Canal at Yaowan, what is formerly considered as the highest water level to be occurred only 57 days of the year can easily be changed to be the lowest water level. According to the past records (see Fig. 23) the lowest water level at some parts of the Middle Grand Canal nearly coincides with the canal bed, that is at those parts the canal is wholly dried up during the dry season. But after proper improvement is given, the minimum depth of water will reach 3 meters, so that boats with 900 tons of freight can easily navigate throughout the year.

A movable dam is so constructed that it can be opened and shut at will. When a river is controlled by movable dams, sufficient depth of water can easily be preserved for navigation during the dry season. By the side of the movable dam, a lock is built. It has two sets of gates at the upper and lower ends of the lock chamber. When a boat is descending from the upstream, water is first conducted into the chamber till the water surface is even with that of upstream. Then the gates at the upstream side is opened for the boat and shut as soon as it has reached the chamber. The water in the chamber is then led out to the downstream, so that the water surface in the chamber and that of the downstream will be on the same level. The gates at the downstream end is now opened for the boat to pass. The process will be similar when a boat is ascending from the downstream. During the flood season, both the movable dam and the lock are opened for flood discharge, so the condition of the natural water course is resumed.

The Navigation System

Before dealing with the individual navigation projects, let us describe the navigation system at first. (see Fig. 19)

The Grand Canal running from the northwest to southeast and terminating at the Yangtze River forms one of the main navigation routes of the system. In the first period of construction, five locks are to be built along the course from Chunchiakow on the Wishan Lake down to Huaiyin, Shaopai and Sankiangying which is on the Yangtze. In future, when the Yellow River in the Province of Shantung is improved, two more locks, one at Chunchiakow and another at Chiangchiakou on the Yellow River, will be constructed to extend the navigation up to the Yellow River. Moreover, after a lock is constructed at the junction of the Chuangchang Ho and Tungyang Canal, and another on the proposed irrigation canal between

Yenchen city and Chinghochai, the boats on the Grand Canal and those latter streams can be made intercommunicable.

Another main navigation route will run from the southwest to northeast and terminate at the sea. It consists of a series of rivers and lakes, namely, the Huai River, Hungtze Lake, Changfu Ho, Salt Canal and Kwan Ho. Besides the Huaiyin lock, which is used for the both main routes of navigation, three more locks will be built during the first period of construction, one is at Tsaikungtu and Hsinpuchen, on the Salt Canal and at Lungkou on the Kwan Ho. In future, if another lock be built at Fushan or Huaiyuan on the Huai River, the navigation route can still be extended further upstream. At Kaoliangchien, the proposed irrigation canal from the Hungtze Lake to Chinghochai, one lock is needed in order to shorten the navigation routes from the upper Huai River to the Yangtze River. During the flood season, boats can directly pass through the San Ho to the Yangtze by means of the lock at th proposed regulator at Chiangpa.

The Predication of Future Transportation

When the navigation system is well developed, transportation and commerce are sure to prosper. According to Prof. Franzius' estimation, the Grand Canal after improvement for 5 years, will have an annual freight of 5,000,000 tons, and after 25 years, will increase to 20,000,000 tons, because its vast collecting and distributing area, the suitability of the location, and cheapness of labor will make the development quicker than usual. If the navigation between the Huai River and Salt Canal is to be connected, same development will be occurred. Hence we can expect that after the 5 years since the completion of the work, annual freight of 10,000,000 tons will be reached. There is no accurate statistics of the present transportation on those rivers, but from a conservative estimate, it is about 1,000,000 tons. That means, after 5 years, the transportation will increase ten-folds.

The Minimum Cross-section for the Canalized Rivers.

The size of a navigation canal should base on the size of boats. During the Ching Dynasty, when rice tribute were transported on the Grand Canal for the Imperial family, Chai's were constructed to preserve a sufficient depth of water for the navigation of large boats. But with the suspension of imperial service the Grand Canal is lack of care, so very few big boats are now to be seen. As the Inner Grand Canal is comparatively much deeper, boats with 150 tons are still in use, but they can only reach Shaopai because beyond that place, the canal becomes shallower.

Now the design of a navigation canal should base on the necessities of the immediate future, and should not be over-sized. Since the big freight ships can not be introduced until there are dense net-works of railroads, highways and waterways at the principal centers of freight. By this way, the freight can be greatly centralized, and the use of big ships can be found profitable. But for the present, even the milage of public roads is rapidly increased, yet still there is time before the completion.

In the present scheme, the largest ship we assume for future use is 72 meters long, 9 meters wide and 2 meters of draft. Assuming the ratio of fineness (Voelligkeitsgrad) to be 0.88 and ratio of tonnage (Tragfachigkeits ziffer) to be 0.80, then its tonnage will be $72 \times 9 \times 2 \times 0.88 \times 0.80 = 910$ metric tons or 900 long tons. The design of the channel for such a canal is to admit two boats to pass side by side. Hence the width of the canal bed should be 20 meters, and the minimum depth of water, 3 meters, with one meter clearance between the bottom of the canal and that of the ship. The typical cross-section is shown in the following figure (Fig. 18).

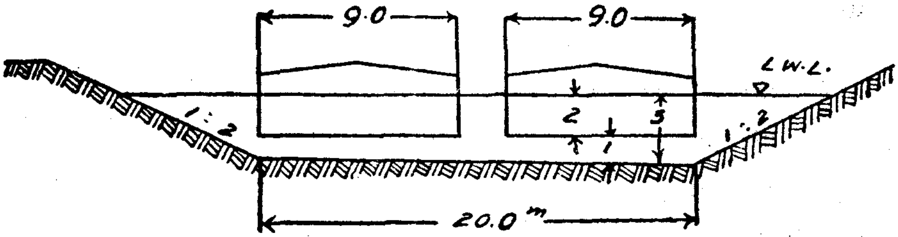


Fig. 18

Near the entrance and exist of a lock, the canal should be widened for the anchorage of ships, and also these must be a straight stretch as to give a clear view for the shippers. In the first period of development, we adopt the length of the stretch to be one kilometer, and the width of the canal bed, 40 meters.

The Dimensions of Locks

The lock of the first period of development will be designed for the necessities of the immediate future. In future with the increase of size of ships and freight it will naturally call for locks of larger size to be installed. Here we adopt the length of the lock chamber to be 85 meters, the width of the lock chamber, 12 meters and the minimum depth of water at the sill, $2^1/_2$ meters. One of the largest boats can pass through it at one time; for boats of 5 meters wide, 32 meters long and 2 meters of draft with a tonnage of 225 metric tons, four of them can pass at one time; for boats of 3 meters wide, 20 meters long, and $1^1/_2$ meters of draft with a tonnage of 60 metric tons, six of them can pass at one time; and for the common sized and small boats, more than ten of them can pass at one time. After the introduction of larger sized locks in future, they can still be in use for small steam-boats and passenger boats, because at each operation they require very little volume of water, and are easy to be manipulated.

Locks are to be opened once each hour. For a navigation canal, the water for lockage at each operation of the locks including the seepage and evaporation of the canal is estimated to be 20 cubic meters per second. This volume of water is neglected during the flood season, but even during the dry and irrigation season it can easily be supplied.

Navigation during the Flood and Irrigation Season

Although the flood channel of the Huai Ho below Hungtze Lake is separate from the navigation channels, yet all other principal rivers within the district of the Huai Ho and the Grand Canal are so regulated that the flood of one river is conducted to the other during the flood season. Thus the flood of Sze Ho is conducted to flow down the Grand Canal as far as Liulauchien; the flood of Yi Ho, to Kwan Ho; the flood of Shu Ho, to Yen Ho below Hsinpu; and the flood of the Huai Ho to its main channel above the Hungtze Lake. Hence during the flood season all locks and movable dams should be opened to discharge the maximum volume of water, and at the same time to maintain a favorable condition for navigation. Even if navigation is suspended by floods, little harm is done, because the duration of flood season is rather short.

During the irrigation season, the Changfu Ho, the Middle Grand Canal below Liulauchien and the Inner Grand Canal are used both for irrigation and navigation purposes. At that time with the sudden increase of water, the water level at some portion of the river will rise, while that at the other portion will fall. Hence in order to avoid inconvenience to navigation, the shallow portion should be excavated so that the minimum depth of water will be three meters.

The Correction of Curvature.

For a natural water course, there are usually some sharp bends. Even if the river has been canalized and the velocity of current controlled, they will still give much inconvenience to navigation, so they should be corrected, and the radius of curvature should not be less than one kilometer.

The General Design of Lock and Movable Dam

Locks adopted for the navigation canals and rivers are similar with each other, and the sites selected for their installment will be discussed later on. Now since the topographical features of those sites have not yet been carefully surveyed, detail plans of each lock for the particular site cannot be made, so only two typical designs are shown in Figures 20 and 21. The maximum lift for one lock is 9.2 meters, and for the other, 6.7 meters.

The lock foundation is for the most part of sand and clay. Its bearing power is to be investigated at the site of construction. Now assuming the bearing power to be 4,000 pounds per square foot, the dead load of the lock should be reduced so as to decrease the expense of the foundation construction. So reinforced concrete is used, the lock walls have been designed with counterforts on the back, and its floor reinforced with rib beams in one case. In order to increase the safety of the structure, cross beams are added between the counterforts and rib beams perpendicular with each other, so that the earth and water pressure can be equally distributed among the beams, and if there is any accidental collision due to ships, the force can be speedily transmitted to all parts of the structure.

As the lock walls are easily subject to impact, so in the calculation of stress the water pressure is increased by one third. The protection of the reinforcement is made with extra thickness, so that any breakage caused by accident can be easily repaired.

The lock has two pairs of miter gates made with structural steel. Hand manipulated machines are used for the operation of lock gates and water passages.

When a navigation canal is used to discharge the flood of another river, the movable dam which is installed by the side of the lock should be larger than usual. But if it is only used to discharge rain water or to control water for navigation, a sluice or a dam smaller in size will equally serve the purpose.

Article 2. The Navigation Project of the Grand Canal

In our first period of navigation development for the Grand Canal, works of improvement will be done beginning from Chunchiakow on the Wishan Lake of the Shantung Province to Sankiangying on the Yangtze River for a total length of 430 km. Along its course five locks are to be constructed, namely Teshen Lock, Hoting Lock, Liuchien Lock, Huaiyin Lock and Shaopai Lock. From Chungchiakow to Liuchien Lock, water is supplied by the Wishan Lake, and from Liuchien Lock to Shaopai Lock, water is supplied both by the Wishan Lake and Hungtze Lake.

As the Grand Canal from Chunchiakow to Chiangchiakou on the Yellow River for a length of over 150 kilometers has not yet been carefully surveyed, no scheme of improvement can be made, but generally the construction of two locks at the two places above mentioned will sufficiently accommodate the navigation between these two rivers. After the completion of these two locks the intercommunication between the Yangtze River and the Yellow River will be possible. It will be done after the first period of navigation development.

Below Shaopai there are two water channels flowing towards the Yangtze River: one is used for the proposed flood channels of the Huai River beginning from Liuchai, and passing through the Taiping Ho, Liochiakou and Shatou Ho to Sankiangying, while the other passing through Yangchow to Kuachow to join the Yangtze River. After the completion of the flood channel, the water depth below Liuchai will be enough for the navigation of large boats and further excavation is unnecessary. The other channel to Kuachow may be too shallow to accommodate the navigation between the Grand Canal and the Yangtze River during the dry season, yet it is of minor importance, so the scheme for its excavation is omitted.

In describing the proposed schemes, the portion of the canal below each lock is considered to be a section, and the engineering works of the six sections will be discussed in detail in the following pages.

The First Section: from Chunchiakow to Teshen Lock

For navigation purpose the portion of the canal from Chunchiakow to the outlet of the Wishan Lake should be excavated, while below the outlet excavation is also in need, as the canal is used for flood discharge. A lock will be constructed at Chunchiakow in future to be named Chungkow Lock.

As the Grand Canal meets the Tientsin-Pukow Railway line at Hanchuang, this town will be expected to become a commercial centre. The bridge and rails at the crossing should be reconstructed and raised five meters higher in order to make room for the canal boats.

The length of the canal from Chunchiakow to Teshen Lock is 37.5 kilometers. The estimate of the total expenses including the excavation of the channel for flood discharge is given in the following:—

Excavation of the channel	7,168,188 cu. m.	$967,705
Dike construction with excavated earth, ramming only	1,102,046 cu. m.	27,551
Dike construction with borrowed earth ramming included.	57,554 cu. m.	9,209
Reconstruction of rails and bridges		50,000
Total		$1,054,465

The Second Section: from Teshen Lock to Hoting Lock.

The railway constructed by the Chung Shing Coal Mining Company meets the Grand Canal at Taichuang. After the canalization of the Grand Canal is completed, Shantung coal will find the markets in all the towns and cities in the regions of the Huai Ho, the Grand Canal and the Yangtze River. This portion of the canal should be so regulated that the variation of water level for the whole year will be 0.5 meter, that is, the highest water level will be 28.9 meters and the lowest water level, 28.4 meters. The maximum lift of the lock will be 6.7 meters and the minimum lift, 1.7 meters. During the flood season, the difference of water level is to be reduced to one meter. The length of the canal from Teshen Lock to Hoting Lock is 45.5 km., and the estimate of the total expenses including the construction of Teshen Lock is given in the following:—

Construction of Teshen Lock		$300,000
Excavation of the channel	3,300,262 cu. m.	445,535
Dike construction with excavated earth, ramming only	555,844 cu. m.	13,896
Dike construction with borrowed earth, ramming included	2,015,856 cu. m.	322,537
	Total	$1,081,968

The Third Section: from Hoting Lock to Liuchien Lock

At this portion of the canal much difficulty is felt for navigation during the dry season, because for the whole year there are only a few days when there is a sufficient depth of water for the navigation of large boats. Figures 17 and 23 will clearly show these difficult features.

The Pelau Ho which joins the Grand Canal at Taichuang also unites with the Wishan Lake at its west bank. Though this river is now quite shallow, yet when the water level of the Grand Canal has been raised, it is easy to be improved for navigation, so as to accommodate the communication with interior towns and cities.

The Lung Hai Railway line crosses the Grand Canal at the south of the Pelau Ho. Though there are now no important towns in the neighborhood, yet when the navigation system of the Grand Canal has been developed, it will be the linking place for communications by land and by water, and the bridge and rails at the junction of the canal with the railway line should be raised six meters higher in order that ships may be able to pass.

The portion of the canal should be so regulated that the variation of water level for the whole year will be 0.5 meter, that is, the highest water level will be 20.2 meters and the lowest water level, 19.7 meters. The maximum lift of the lock will be 9.2 meters, and the minimum lift, 8.2 meters. During the flood season, the difference of water level is to be reduced to one meter. The length of the canal from Hoting Lock to Liuchien Lock is 104 kilometers, and the estimate of the total expenses including the construction of Hoting Lock is given in the following:—

Construction of Hoting Lock		$400,000
Excavation of the channel	2,476,974 cu. m.	334,391
Dike construction with excavated earth, ramming only	569,950 cu. m.	14,249
Dike construction with borrowed earth, ramming included.	1,978,120 cu. m.	316,499

Reconstruction of a bridge and rails	50,000
Total..............	$1,115,139

The Fourth Section: from Liuchien Lock to Huaiyin Lock.

Since the water of the Hungtze Lake flows to the Grand Canal through the Changfu Ho, so for this portion of the canal the variation of water level is very great, the highest water level being 16 meters and the lowest water level, 11 meters. The maximum lift will be 9.2 meters and the minimum 3.7 meters. From Liuchien Lock to Chungshin the channel needs little excavation, but below Chungshin the existing channel of the canal is so crooked that a new channel to connect with the Inner Grand Canal is necessary (See Fig. 26). With the completion of this new channel and the improvement of the Changfu Ho, boats from the Grand Canal can easily navigate to the upper part of the Huai Ho and one of the three Chai's near Matou, namely Weichi, Tungchi and Fushing Chai's can be reconstructed and used as a sluice during the flood season. The length of the canal from Liuchien Lock to Huaiyin Lock is 57.5 kilometers, and the estimate of the total expenses including the construction of Liuchien Lock is given in the following:—

Construction of Liuchien Lock		$400,000
Excavation of the channel	2,207,082 cu. m.	297,956
Dike construction with excavated earth, ramming only	170,020 cu. m.	4,250
Dike construction with borrowed earth, ramming included	80,674 cu. m.	12,908
	Total...........	$715,114

The Fifth Section: from Huaiyin Lock to Shaopai Lock

This portion of the canal is the longest among the six sections. At its north extremity is Huaiyin, which will be the communication centre for the surrounding towns and cities. The Grand Canal communicates with the Yangtze River in the south, and the Shantung Province in the north connects with the Tientsin-Pukow and Lunghai Railroad lines, flows to the sea through the Yen Ho and Kwan Ho at the east, and joins with the Hungtze Lake through the Changfu Ho at the west. Along its course there are many important towns and cities. Hence after it has been regulated and improved, the development of commerce and communication and also the improvement of living conditions of the surrounding towns and cities can be predicated.

There are now small steam-boats running between Huaiyin and Chinkiang. The portion of the canal below Kaoyu is quite deep for navigation throughout the year, but from Kaoyu to Huaiyin there are only a few months out of the whole year when there is sufficient depth of water for navigation. But after the improvement, there will be no more of such inconvenience.

The variation of water level for this portion of the canal is 0.5 meter, that is, the highest water level will be 7.3 meters and the lowest water level, 6.8 meters. During the irrigation season, the water surface will acquire a natural slope as the water level near Huaiyin Lock will be 10 meters, while that near Shaopai Lock 5.87 meters. The maximum lift of the Huaiyin Lock will be 9.2 meters, and the minimum, one meter. The channel between Huaiyin and Huai-an is to be enlarged. The length of the canal between Huaiyin Lock and Shaopai Lock is 145 kilometers, and the estimate of the total expenses including the construction of Huaiyin Lock is given in the following:—

Construction of Huaiyin Lock		$400,000
Excavation of the channel	666,074 cu. m.	89,920
Earth filling on the western Dike	80,000 cu. m.	12,800
	Total	$502,720

The Sixth Section: from Shaopai Lock to the Yangtze River.

Between Shaopai and Liuchai a new channel is excavated to join with the flood channel of the Huai Ho at Liuchai and to flow through the Taiping Ho, Liochiakou and Shatou Ho to Sankiangying on the Yangtze River. The old channel will be used as the headbay for the Tungyang Canal.

At the upstream of Shaopai Lock, the water level at normal times is from 7.3 to 6.8 meters, the variation of water level being 0.5 meter. But during the irrigation season it will be reduced to 5.8 meters. As to the water level at the downstream of the lock, it cannot be ascertained, because the rise and fall of water level has an intimate relation with the tidal effect of the Yangtze River and the volume of water coming from the flood discharge channel of the Huai Ho. But when the water level of the Yangtze River is at its lowest, the water level of this section will be -0.4 meter. The maximum lift of the lock is then 7.7 meters, and during the maximum discharge of the Huai Ho, the highest water level at the downstream of the lock will be 7.5 meters, being 0.2 meter higher than that of the upstream. At that time the lock should be opened so as to give a free passage for boats.

Taiping Ho when used for flood discharge should be so excavated that the elevation of the canal bed will be -4.0 meters. Liochiakou and Shatou Ho are very deep that at the lowest water level of the Yangtze River, the depth of water is over three meters, and at normal times it may be six to seven meters, so steam-boats coming from the Yangtze River can directly reach Liuchai. So no dredging works for its improvement is necessary.

The portion of the canal which passes through Kuachow is at normal times about 3 meters in depth. With a little dredging work to remove the shoals it will facilitate the navigation between Chinkiang and Yangchow. The estimate of the total expenses for this section of the canal including the construction of Shaopai Lock is given in the following:—

Construction of Shaopai Lock,		$350,000
Excavation of the channel	888,790 cu. m.	119,986
Dike construction with excavated earth, ramming only	1,990 cu. m.	50
Dike construction with borrowed earth, ramming included	39,020 cu. m.	6,243
	Total	$476,279

Total Cost of Navigation Project for the Grand Canal

The total cost for the first period of development are:

Section	Lock Construction $	Excavation of the channel $	Dike Construction with excavated earth, ramming only $	Dike Construction with borrowed earth, ramming included $	Reconstruction of rails and bridges. $	Total $
1st		967,705	27,551	9,209	50,000	1,054,465
2nd	300,000	445,535	13,896	322,537		1,081,968
3rd	400,000	334,391	14,249	316,499	50,000	1,115,139
4th	400,000	297,956	4,250	12,908		715,114
5th	400,000	89,920		12,800		502,720
6th	350,000	119,986	50	6,243		476,279
Grand Total	1,850,000	2,255,493	59,996	680,196	100,000	4,945,685

Article 3. Canalization of Rivers from Huaiyuan to the Sea.

The object of this project is to have direct navigation from the Upper Huai River to the Yellow Sea, by way of the Huai River, Hungtze Lake, Changfu Ho, Yen Ho and Kwan Ho. In the first period of development, it is proposed to start from Huaiyuan down the Huai River, passing the towns and cities such as Pengpu, Shuyi, Kaoliangchien, Matou, to Huaiyin, where it passes through the lock and through a new cut to Hsipa to join the Yen Ho. Another lock will be situated at Tsaikung on the Yen Ho. At Lungkou not far downstream of Tsaikung the navigation route divided itself into two courses, one passes over the Lungkou Lock to the Kwan Ho and finds its way to the sea; another goes along the Yen Ho in the northern direction to the Hsinpu Lock and then joins with the sea estuary of the Shu Ho. The total length of the navigable rivers will be 483 km. Besides the Huaiyin Lock, which will serve both the navigation of the Grand Canal and that of the present river system, three more locks will be constructed, i.e., Tsaikung, Lungkou and Hsinpu Locks.

The Kwan Ho is exceptionally deep and wide, able to be directly navigated by coastal steamers of five-meter draft, up to Shiangshuikow. In future, if improvement work be executed, and jetties be constructed at the estuary to deepen the southern pass near Kaishan, it is possible to be navigated by ocean ships, and Shiangshuikow will be developed as a seaport.

In the Yen Ho near Lungkou, two movable dams will be constructed to prevent flood water of the Yi Ho from entering into it. These dams can be taken away after the levees along the portion of the Yen Ho from Tsaikung to Hsinpu being raised to the required height. But for the time-being these dams will be closed when there is a high flood of the Yi Ho. Since the flood of the Yi Ho is short-durated, it would not be a tedious obstruction to navigation. At the side of the Lungkou Lock on the Kwan Ho, a larger movable dam is needed for preventing water of the Yi Ho from escaping into the Kwan Ho during the dry season. Owing to the project for improvement of the Yi Ho is not definitely determined, it is not wise to construct a permanent structure for this dam, because, in case detention basin can be economically constructed at its headwaters, the flood flow passed through this dam will be greatly reduced. Hence in the first stage of development, only earth-weed dam of the types commonly used as the flood escapes on the Inner Grand Canal will be built there.

The southern Liutang Ho is comparatively deeper than the Yen Ho, and with the completion of the Hsinpu and Lungkou Locks, navigation will extend to the town of Kaokou on it.

For irrigation purpose a canal should be constructed between Kaoliangchien and Ching Ho Chai with a sluice at the mouth of the outlet, and in future a lock is to be built by the side of the sluice gate, so that boats coming from the upstream of the Huai River can sail to the Inner Grand Canal through this new course.

As to the tributaries of the Huai River excavation and installation of locks will further facilitate the navigation.

In future during the irrigation season the elevation of water surface of the Hungtze Lake may be reduced to 11 meters, but before the time when the consumption of water for irrigation purpose is at the highest degree, the lowest water level may be higher than 11 meters, so the excavation of the Hungtze Lake can be temporarily left undone.

Figures 24 and 25 clearly show the plan and profile of the scheme to be done during the first period of improvement for the Huai River and Figures 19 and 26 show the way of connection of the Huai River with the Grand Canal.

First Section: from Huaiyuan to Huaiyin Lock.

Along this section of the Huai River there are many large cities such as Huaiyuan, Pengpu, Wuho, Shuyi and Huaiyin. Its importance of communication and benefit to traffic is known to all. At the upper part of this section, which is the middle part of the Huai River, the channel is both deep and wide, so a little excavation work will sufficiently accommodate the navigation of the biggest standard-sized boats. At the railway bridge of Pengpu where the Tientsin-Pukow Railway line runs across the Huai River, the elevation of the abutments is much higher than the assigned high water level, so no reconstruction is necessary. From Kweishan to Kaoliangchien is the Hungtze Lake. It is quite shallow; so a new navigation course should be excavated. From Kaoliangchien to Matou is the Changfu Ho, where works of excavation are quite limited, and below Matou there will be two new courses to join the Changfu Ho with the Huaiyin Lock and Middle Grand Canal (See Fig. 26). The length of river for this section is 265 kilometers and the estimate of the total expense is given in the following:—

Excavation of a new channel in the Hungtze Lake	1,000,000 cu. m.	$160,000
Excavation of the channel	3,394,602 cu. m.	458,271
Dike reparation with excavated earth, ramming only	993,310 cu. m.	24,833
Dike reparation with borrowed earth, ramming included	2,255,950 cu. m.	360,952
	Total	$1,004,056

The Second Section: from Huaiyin Lock to Tsaikung Lock

There is no means of direct communication between the Grand

Canal and the Yen Ho at present. Any cargo coming from the Yen Ho are to be unloaded at Hsipa and transported to Huaiyin or Yangchuang for further conveyance on the Grand Canal, and any cargo coming from the Grand Canal are to be unloaded to Huaiyin or Yangchuang and transported to Hsipa for further conveyance on the Yen Ho. But Hsipa, Huaiyin and Yangchuang are several miles away from each other, so the unnecessary removal of cargo among those places not only wastes money and time but also causes much inconvenience. Now from the west of Huaiyin to the east of Hsipa, a new navigation channel for a length of 5.34 km. is proposed to be excavated to connect the Grand Canal with the Yen Ho.

Since the old channel of Yen Ho below Hsipa is quite deep, it is still adopted for navigation and no more excavation is needed, but during the irrigation season, the water surface of the Yen Ho between Huaiyin Lock and Tsaikung Lock will be raised higher than usual, so the dikes along this portion of the river should be strengthened and repaired. The expense for dike reparation which is to be included in the cost of irrigation project and the construction of Huaiyin Lock on the Grand Canal is also excluded from the present estimate.

The lowest water level at this section is 6.8 meters and the highest water level, 7.3 meters, and during the irrigation season the water surface below Huaiyin Lock will be raised to 10 meters and above Tsaikung Lock, to 9.9 meters. Below Tsaikung Lock the water level will be from 3.0 to 3.5 meters, so the maximum lift at Tsaikung Lock is 6.9 meters and the minimum, 3.3 meters. The length of river for this section is 61 kilometers and the estimate of the total expense is given in the following:—

Construction of Tsaikung Lock		$300,000
Excavation of new channel	2,125,680 cu. m.	286,967
Dike construction with excavated earth, ramming only	4,130 cu. m.	103
	Total	$587,070

The Third Section: from Tsaikung Lock to Hsinpu Lock

The variation of water level for this section of the river is 0.5 meter, that is, the highest water level is 3.5 meters and the lowest water level, 3.0 meters, but at Lungkou where Yi Ho flows to the Yen Ho through the Northern Liutang Ho, the highest water level of the Yi Ho is 8.0 meters, and the lowest water level gives an insufficient depth of water for navigation. At Lungkou, two small movable dams should be built across the Yen Ho to keep out the flood water of Yi Ho and on the Kwan Ho a large movable dam made of weeds and earth should be constructed. At normal times this movable dam is closed to prevent the Yen Ho from flowing out, and during the flood season it is opened to discharge flood water of the Yi Ho. In future when Yi Ho is under improvement, a permanent movable dam is to be constructed to replace this temporary structure.

The water level above Hsinpu Lock is from 3.0 to 3.5 meters and below it is from -2.2 to 3.35 meters, so the maximum lift at Hsinpu Lock is 5.7 meters, but during the flood period of the Shu Ho, the water level below Hsinpu Lock will be raised to 3.8 meters, being 0.3 meter higher than the high water level of this section. At that time Hsinpu Lock is to be opened to give a free passage of the flow.

With the completion of the navigation works for the Huai River, Kwanhokow and Linhungkow will become the important sea ports both for the ocean steamers and for the transportation of freight to inland towns and cities. As to seaward bound cargo coming from those inland towns and cities, they can also be directly conveyed to either Kwanhokow or Linhungkow.

The length of river for this section is about 77 km. and the length of Kwan Ho from Lungkou to Kwanhokow is about 73 kilometers. The estimate of the total expense is given in the following:—

Construction of the Hsinpu Lock		$300,000
Construction of lock on Yi Ho at Lungkou		300,000
Construction of a movable dam on Yi Ho at Lungkou		100,000
Construction of two movable dams on Yen Ho at Lungkou		100,000
Excavation of the channel	189,042 cu. m.	25,521
Dike reparation with excavated earth, ramming only	20,205 cu. m.	505
Dike reparation with borrowed earth, ramming included	30,469 cu. m.	4,875
Total		$830,901

Total Cost

The total expenses of navigation projects for the Huai River to the sea are given in the following:—

Number of section	Construction of lock	Construction of movable dam	Improvement of channel	Dike Reparation and construction with borrowed earth ramming included	Dike Reparation and construction with excavated earth ramming only	Total
	$	$	$	$	$	$
1st			618,271	360,952	24,833	1,004,056
2nd	300,000		286,967		103	587,070
3rd	600,000	200,000	25,521	4,875	505	830,901
Grand Total	900,000	200,000	930,759	365,827	25,441	2,422,027

The excavation of a new navigation channel in the Hungtze Lake is to be postponed until the time when the consumption of water for irrigation purpose is increased and the lowest water level of Hungtze Lake is reduced to less than 12 meters. The expense of excavation which amounts to $160,000 should be reserved for this item.

Chapter IV. Irrigation Project

The region on both sides of the Old Yellow River and the Grand Canal comprises a large area of fertile land with temperate climate quite suitable for cultivation. It is really one of the important sections for agricultural production in our country. But so long as the flood problem of the rivers, such as the Huai, Yi, Shu and Sze which drain in that region, remains not solved, the inundation and drought will constantly occur that famine can never be prevented. Hence as soon as we have proposed the projects for flood control in order to remove the harmful elements of that region, we are able to propose the projects for irrigation.

Article 1. Estimation on Requirement of Water

On account of the difference in soil characteristics, climatic conditions and customs of the people, the crops raised on both sides of the Old Yellow River are not identical. On the northern side the common crops raised are those which need less quantity of water for their production. In case of an extraordinary drought, it will nevertheless still subject to famine. Hence irrigation is also indispensable. On the southern side, rice is probably the only principal kind of crop to be raised, especially in the district east of the Inner Grand Canal. It needs much water for the production. During the irrigation season from later spring to summer, when the precipitation is small in magnitude, it depends wholly upon the Grand Canal for the supply of water. In case the supply of water in the Grand Canal from the Huai fails, it is usually not sufficient for supplying the whole district. Hence the development of irrigation system is cryingly needed especially in this part of the country.

CROPS RAISED In the region at the south of the Old Yellow River the principal crops raised are rice, cotton, bean, wheat, sesame, pea-nut, potato, etc. The first mentioned two are the principal crops which need irrigation during the dry season from later spring to summer.

PRECIPITATION Long record of precipitation in the irrigation district is not available. Based upon investigations on monthly maximum, average and minimum precipitation from the record of short period at different places, it is indicated that in the year of average precipitation the water is just sufficient for crops, and that in dry year the precipitation amounts only to 4 inches (or 10 cm) from the middle of April to that of July. In the latter case, rain water is not sufficient for production of crops and hence irrigation is necessary.

NET QUANTITY OF IRRIGATION WATER NEEDED In spite of the minor products in the winter, the only principal crops which need irrigation are rice and cotton. The irrigation season for rice is generally from the middle of April to that of July, while cotton needs much water in the months of April and May. In order to obtain the maximum yield of rice, it will consume enormous quantity of water. But for average production, the amount of water needed for irrigation will not be much. Now let us take the case of 1922 for instance. The yield of rice in the Eastern District of the Inner Grand Canal in that year was on the average more than two piculs per mou (20 kg. per are or 1,750 lbs per acre). A portion of land which is comparatively low in elevation was irrigated by the supply of water from the sluices located in the eastern dike of the Grand Canal, while the remaining portion in this region had its supply of natural precipitation only. During the period from the middle of April to that of July, the precipitation amounted to 8 inches (20 cm) approximately, and the water supplied by the Grand Canal according to our investigation was about 95 cubic meters per second, amounting to a total quantity of 735,000,000 cu. m. The acreage of rice field in this district according to the Kiangsu Grand Canal Board is about 10,000,000 mou. Assume one third of the land was irrigated by water of the Grand Canal; then its average supply including all losses was about 14 inches (35.5 cm). The total consumption of water in that year was therefore, from 8 to 22 inches (20 to 56 cm). The yield of rice per mou was from 1.5 to 3.5 piculs. Based on this investigation, if some one foot (30.4 cm) of water be supplied by irrigation system, it would be sufficient to prevent famine even in case of extraordinary drought. Its production will naturally increase during the wet year. Hence a quantity of 18 inches (45.6 cm) of water may be considered necessary for rice production and half the value or 9 inches (22.8 cm) will be quite sufficient for cotton and other miscellaneous crops. During the irrigation season even in the dry year there is at least 4 inches (10 cm) of precipitation. Therefore the amount needed to be supplied by irrigation system is about 14 inches (35.5 cm) for rice field and 5 inches (12.7 cm) for cotton and others. The total amount of irrigation water can then be estimated on this basis.

CONVEYANCE The water carried in irrigation canals will be partly lost due to seepage and evaporation. The losses vary widely with local climatic conditions and the character of the bed of the canal. The quantity lost by evaporation is much less than that lost by seepage, while the loss in old canals is always smaller in comparison with the case of new canals. Now in the present irrigation districts, the amount of losses is assumed to be 15% for old canals and 30% for new ones.

IRRIGATED AREA In the region at the south of the Old Yellow River, the land to be irrigated may be divided into four districts, namely:

1.) the Eastern District of the Grand Canal
2.) the District of the Kao Pao Lakes
3) the District of the Tungyang Canal, and
4.) the Coastal District

The Eastern District includes all the land belong to the Hsiens of Kiangtu, Kaoyu, Paoying, Shinhwa, Tungtai, Taihsien and Yenchen. According to the estimation made by the Kiangsu Grand Canal Board, the area of this district, not including the land east of Fankung Dike, is about 11,740,000 mou, 86% of which is used for rice production and the remaining 14% is for other miscellaneous crops. The District of Kao Pao Lakes includes all the low land on the southeastern side of the Hungtze Lake and the west of the Grand Canal, that is, the land surrounding the Peima, Paoying, Kaoyu, Fankwan and Chiehshou Lakes, together with the reclaimed land. According to the estimation by the Kiangsu Grand Canal Board, there is approximately 1,840,000 mou of land between the highest stage and the ordinary water level of the lakes, and in addition another 1,000,000 mou of lake area can be reclaimed. After regulation of the Huai River, assume 20% of the total area to be occupied by villages and towns, highways and canals, and then the land available for cultivation will be 2,250,000 mou (see chapter on flood control). But for cultivation of the land in this district, not only irrigation canals are indispensable, but drainage systems must also be taken into consideration. Since the land is very low, the accumulation of rain water will cause much trouble. For this reason drainage canals and pumping stations must be provided (See Fig. 29). Judging by its local conditions, there will be probably 80% of the land to be used for rice planting and 20% for other crops. The District of Tungyang Canal partly overlaps with the Eastern District and the Coastal District, and partly depends its supply from the Yangtze. The additional land to be irrigated by the Grand Canal is about 2,500,000 mou, 30% of the land is of rice field, and 70% of it is for cotton and other crops. The Coastal District has an area of 5,000,000 mou approximately. During its progressive development in recent years cotton is almost the only kind of plants raised in this district. It demands less quantity of water for its production. But irrigation will be still necessary in case of drought during the months of April and May.

TOTAL AMOUNT OF WATER REQUIRED Based upon the foregoing discussions, the total amount of irrigation water needed for different districts may be roughly estimated. The Eastern District will demand a quantity of 2,670,000,000 cubic meters of water for irrigation in one year; the District of Kao Pao Lakes will demand 561,000,000 cubic meters; the District of Tungyang Canal, 351,000,000 cubic meters; and the Coastal District 512,000,000 cubic meters. The total annual demand for the land at the south of the Old Yellow River will then be 4,094,000,000 cubic meters.

Article 2. The Capacity and Elevation of the Hungtze Lake.

For the irrigation of the land south of the Old Yellow River, the flow of the Huai River will be the only source of supply. The natural flow of the Huai is very small in case of dry year. For instance in 1917, it almost entirely ceased to flow during the months of May and June. For meeting the demand of irrigation, the Hungtze Lake must be converted into a storage reservoir.

According to the record of the Huai, the year 1917 was the driest (see Fig. 27). The total amount of discharge during that year was still much greater than the demand of irrigation. Therefore if a portion of the flow during the flood season is stored up in the Hungtze Lake, it will be sufficient to meet the need in the dry season. In solving the problem of storage, two points must be taken into consideration. Firstly since the natural flow during the irrigation season can be directly utilized for partly supplying the need, the amount of water necessary to be stored in the lake will be somewhat less than that of the total demand. And secondly, because the lake has a large surface area, the quantity lost by evaporation will be considerable. Now for our case the total demand for irrigation is 4,094,000,000 cubic meters. Deducting the quantity of 1,370,000,000 cubic meters which can be supplied by the natural flow during the irrigation season, it amounts to 2,724,000,000 cubic meters. Assuming another 1,000,000,000 cubic meters lost through evaporation the total amount of storage will be 3,724,000,000 cubic meters. If the allowed lowest lake surface elevation be 11 meters, then from the capacity curve (Fig. 1) it is found that the lake surface must be maintained at 13.2 meters after the flood season in order to meet the demand. For additional safety, let it be maintained at 13.6 meters after every flood season is over.

The Hungtze Lake is used as storage reservoir for irrigation, as well as a detention basin for flood control. In order to utilize its full capacity for detention so as to reduce the cost of the improvement work for its flood channel, the lower the surface elevation of the lake kept before the flood season, the better would be the case. But as for irrigation, the elevation of the lake surface must have a certain lowest limit so that the storage can be surely accumulated to the required quantity before the irrigation season. Considering the worst case of 1917, the amount of storage, which could be supplied by the flow of the Huai during the period after the flood and before the next irrigation season, was found to be 2,500,000,000 cubic meters. As the capacity of the Hungtze Lake between the elevations 13.6 and 12.5 meters is 2,200,000,000 cubic meters, it is concluded that the lowest allowable limit of the surface elevation of the lake during the flood season may be as low as 12.5 meters. This will render great efficiency in flood control and at the same time no obstruction for irrigation.

In conclusion, for purpose of both irrigation and flood control, the W. L. of the Hungtze Lake during the flood season must at least be higher than 12.5 meters, and it must reach the elevation 13.6 meters before the next irrigation season.

Article 3. Distribution of Water for Irrigation

The topographical features of the land within the irrigation districts have a general tendency to slope down from north to south. The Inner Grand Canal and the Chuangchang Ho are also flowing in this direction, and their water surface is generally higher than the surrounding countries. Hence for the convenience and distribution of water during the irrigation season, they can be utilized as the main irrigation canals, but the way of supplying water to them from the Hungtze Lake is a problem worthy to be considered.

The Changfu Ho, an outlet of the Hungtze Lake, is used to supply water to the Grand Canal from the lake. At its north extremity where it joins with the Inner Grand Canal, its water surface is higher than the surrounding countries, so it may be utilized as a main irrigation canal. But its channel is very narrow and the land along the two banks is very high. After the installation of a lock at Huaiyin for the navigation of the Huai River and the Grand Canal, the discharge of the Changfu Ho, during the time when the water level of the Hungtze Lake is 12 meters, will be about 50 cubic meters per second, and when it is raised to 13.6 meters, will be about 140 cu. m. per second. But in average the total volume of water needed for all the irrigation districts is 475 cu. m. per second. In order to supply the necessary volume of water, the Changfu Ho should be deepened and widened, but the narrowness of the channel and the elevation of the two banks will render the excavation works too expensive to be executed as the main irrigation canal. According to the opinion of Prof. Otto Franzius, a great portion of water needed for irrigation should be conducted to flow from Kaoliangchien passing through the old channel of Hsun Ho to Chinghochai on the Grand Canal. Though the old channel of Hsun Ho is also quite narrow, yet the land along its two banks is very low, so excavation and dike construction with excavated earth can be done at the same time and the expense will be much cheaper. As to the Changfu Ho, its existing capacity can still be utilized for irrigation.

The volume of water necessary for the cultivation of crops at each of the irrigation districts during the hundred days of irrigation season is as follows:—

For the Eastern District	310 cu. m. per sec.
For the Kao Pao Lake District	65 cu. m. per sec.
For the Tungyang Canal District	40 cu. m. per sec.
For the Coastal District	60 cu. m. per sec.

The total volume of water consumed by the cultivated farms of the above districts amounts to 475 cu. m. per sec. But during the month when water is most needed for the fully cultivated districts, the volume of water actually consumed may be greater than this value. This condition will, however, not be occurred until after 10 or 20 years, and during that time further improvements will be made. At present the estimate for the discharge of the main irrigation canal can base on the average rate.

Now the discharge of the main irrigation canal which flows from the Hungtze Lake to the Grand Canal through the Chinghochai is assumed to be 425 cu. m. per second, and a small volume of water equal to 50 cu. m. per second is conducted to flow from the Changfu Ho to the Chuangchang Ho passing through the Yen Ho to Tsaikungtu and crossing the Old Yellow River to its south. As to the portion of water flowing to the Grand Canal at Chinghochai, a volume equal to 25 cu. m. per second is conducted to flow northward to irrigate the cultivated farms situated along the northern bank of the Grand Canal and another volume equal to 100 cu. m. per second is conducted to flow eastward to Chuangchang Ho passing through Ching Ho and crossing Sheyang Lake to irrigate the cultivated farms along the two banks of the river and to supply the Chuangchang Ho with remaining water, while a great portion of water equal to 300 cu. m. per second is conducted to flow southward to irrigate the cultivated farms of the Kao Pao Lake District and the Eastern District at the south of Sheyang Lake with the remaining water equal to 40 cu. m. per second flowing to Tungyang Canal through Shaopai to irrigate the cultivated farms of the Tungyang Canal District. The volume of water which flows from the Changfu Ho to Chuangchang Ho through the Yen Ho is used to irrigate the cultivated farms situated between the south of the Old Yellow River and the north of Funinghsien with remaining water flowing to Chuangchang Ho to join with the canal coming from Ching Ho and to irrigate the Coastal District. This is the method of distributing water to the irrigation districts in our irrigation project.

Article 4. Irrigation Canals

During the irrigation season, the water surface of the Hungtze Lake will be drawn down from the normal elevation of 13.6 meters to the lowest level of 11 meters. This lowest water level will be reached only during the most arid season and in a very short duration of time, and moreover the time of its occurrence will be mostly at the closing period of the irrigation season. During that time the flow of the irrigation canal will be left to itself, that is, drawing down to its limit, for otherwise, it requires expensive construction work in the sluices and canals. It is also very expensive to make all the irrigation canals used at the same time as navigation canals as in the case of the Inner Grand Canal. Moreover during the dry season, the water surface will be lowered, so even there may be plenty of water in the channel, yet it is very difficult to distribute it to the irrigation districts.

The irrigation canals are to be so designed that during the time when the water surface of the Hungtze Lake is at an elevation of 12 meters, they should give the maximum discharge for irrigation, and when the water level is lowered, the discharge is allowed to be less in quantity. At normal times the water level of the Grand Canal at Chinghochai is 6.8 meters, and during the irrigation season, it will be raised to 10 meters. The length of the channel from the Hungtze Lake to Chinghochai is 40 kilometers, and the slope of the water surface is 1:20,000. Now a channel to discharge a volume of water equal to 425 cu. m. per second can be designed by the Forchheimer's Formula with a coefficient of roughness of 0.0225. The resulted cross section is as follows:—

Width of water surface	=	75 meters
Width of canal bottom	=	45 ,,
Depth of water	=	8 ,,
Side slopes	=	1:2

The best cross-sectional design of the channel is to make the cut and fill in balance, that is, the quantity of excavated earth is just enough for dike construction. The quantity of excavated earth used for dike construction is 7,500,000 cu. m. and the expense for both excavation and dike construction is about $1,200,000.

As the quantity of water in the Grand Canal which flows northward from Chinghochai is only 25 cu. m. per second, the existing width of the channel is quite enough for its discharge and another volume of water equal to 300 cu. m. per second flows southward in the Grand Canal from Chinghochai with a remaining quantity of water equal to 40 cu. m. per second flowing to Shaopai. The water level of the canal at Shaopai Lock can be reduced to 6 meters, so there will be no obstruction for navigation. As the length of the channel from Chinghochai to Shaopai is about 100 km. and the difference of water level is 4.0 meters, the average slope of the water surface will be 1:25,000. Now with the diversity of discharge and different size of channel at each section of the irrigation channels, it will be economical to make the slope of the water surface steeper at those places where the cross-section of the channel is small, and to make the slope of the water surface flatter at those places where the cross-section of the channel is large so as to save the labor of excavation to its utmost limit. According to the cross-sections of the Inner Grand Canal surveyed by the Kiang Huai Conservancy Board, the channel from Fanshui to Kaoyu is both narrow and shallow and needs to be excavated, and for the rest of the canal the channel is wide enough to carry the allotted quantity of discharge. With the rise of water surface due to the construction of locks at each section of the canal, the top of the dikes from Huai-an to Fanshui should be raised about one meter higher. Now the quantity of earth for dike reparation is 472,500 cu. m., and if the labor of ramming for one cu. m. of earth is $0.16, the total expense for dike reparation will be $75,600. The quantity of excavated earth is 2,527,600 cu. m. and if the labor of excavation for one cu. m. of earth is $0.27, the total expense for excavation will be $682,000. The summation of these two items will be $757,600.

Water in the Grand Canal flows eastward from Chinghochai to Chuangchang Ho and the height of water surface at the eastern extremity of the irrigation channel which joins the Grand Canal with Chuangchang Ho depends upon the volume of water flowing southward from Yen Ho to Chuangchang Ho and the height of water surface at Chuangchang Ho necessary for irrigation. Now if the height of water surface at the eastern extremity of the irrigation channel is assumed to be 5 meters, and that at the down-stream side of the Chinghochai, 7 meters, that is, the difference of water level between the upper and lower pools of the Chinghochai is 3 meters, the difference of water level in the irrigation channel will be 7.0—5.0 = 2.0 meters. The length of the channel is about 84 kilometers, so the slope of water surface will be 1:42,000. The most economical cross-section is as follows:—

Width of water surface	= 40 meters
Width of channel bottom	= 12 ,,
Depth of water	= 7 ,,
Side slopes	= 1:2

The quantity of excavated earth is 14,000,000 cu. m. and the cost, $2,240,000.

The Changfu Ho and Yen Ho are not to be excavated and with their existing discharge capacity, the discharge of Yen Ho above the proposed Tsaikung Lock will be about 50 cu. m. per second during the time when the height of water surface at Hungtze Lake is 12 meters. When the water level at Huaiyin Lock is maintained at 11 meters, it will be reduced to 9.93 meters at Tsaikung Lock, and such height of water surface gives no obstruction to navigation. The length of the irrigation channel starting from the Yen Ho at Tsaikung Lock and crossing the Old Yellow River to Funing to join the Chuangchang Ho is about 48 kilometers. If the water level of Chuangchang Ho at Funing is 6.0 meters, the slope of the water surface will be 1:12,200. The cross section best adopted for the irrigation channel is as follows:—

Width of water surface	= 25 meters
Width of channel bottom	= 5 ,,
Depth of water	= 5 ,,
Side slopes	= 1:2

The total amount of excavated earth and earth used for dike construction is 6,720,000 cu. m. and the cost will be $1,110,000.

At Shaopai the volume of water in the Grand Canal is only 40 cu. m. per second, which flows from Shaopai to Liuchai to join the Tungyang Canal. At Liuchai the old structure should be reconstructed and the cost is estimated to be $50,000.

The dimension of each irrigation channel is based on the plans prepared by the Kiang Huai Conservancy Board, so after an accurate survey is completed, the design is likely subject to change.

The diversion and distribution of irrigation water are effected by regulators and sluices, their locations can only be ascertained by the local conditions and requirement. This is left for further investigation. In the sea outlets of the Chuangchang Ho and the bypasses to the Yangtzekiang on the Tungyang Canal should also be controlled by movable dams or gates. They will be dealt with after careful survey is completed. Besides these, there will be five head-gates to be constructed for the irrigation channels and the costs are estimated to be $600,000.

Article 5. Irrigation in the Middle Grand Canal District.

At the north of the Old Yellow River and both sides of the Middle Grand Canal, most of the crops such as wheats, beans, holcus, potatoes and other grains do not require much water. At these places, irrigation is unknown to the farmers. It is mostly caused by natural lack of water supply.

When the Huai River, Yi Ho, Sze Ho and Shu Ho have been controlled and improved, the Wishan Lake will be converted into a natural reservoir. Its storage of water amounting to some 2,400 million cubic meters will be used to irrigate the arid regions covering an area of 20,000,000 mou in the districts of Hsuchow and Haichow. Now the Middle Grand Canal and Pelao Ho can be utilized as the irrigation channels. The discharge of the Pelau Ho with a high water level at the Wishan Lake is about 100 cu. m. per second, and the remaining quantity of water necessary for irrigation is to be conveyed by the Middle Grand Canal. As the canal is also used for flood discharge, so its capacity is ample enough for conveying irrigation water. At Teshenchai and Hotingchai, there are movable dams for the regulation of flood discharge, and at Liulauchien a movable dam should be constructed to discharge the necessary quantity of water for the cultivated farms situated at the lower course of the canal. The cost is estimated to be $25,000.

Article 6. Works for the First Stage of Development.

Due to the vastness of irrigation districts, all irrigation works cannot be done at the same time, and as the engineering works for flood discharge, navigation and irrigation bear intimate relations with each other, so any work for the benefit of one thing should keep pace with that of the other. When the engineering works for controlling the Huai River to flow to the Yangtze River are in progress, some improvements should be made for the irrigation districts at the south of the Old Yellow River as the foundation of development. The most important region under consideration is the Eastern District of the Inner Grand Canal, where there are numerous lateral head works built in the eastern dikes, but due to improper management, much water is wasted. Hence at each of the lateral head works, a proper sluice-gate should be fitted. The method of its operation and the allotted amount of water should be carefully determined according to the commanding area, kinds of crops, and the nature of soil. There should also be patrol men to take charge of these duties, and give assistance to the farmers in using irrigation water. With the assistance of the general public, the distribution system is expected to be finished in a few years. But in the Inner Grand Canal at the time of preliminary development, no harm is done if the discharge of the canal is smaller than the total volume of water needed for irrigation, so the dredging of the channel between Fanshui and Kaoyu can be temporarily postponed, and improvement is done simply by the installation of 50 sluice-gates, the cost being estimated to be $100,000. This is the preliminary project for the irrigation of the Inner Grand Canal district.

At the Kao Pao Lake district, if irrigation and drainage works are built after the improvement of the Huai River, about 1,000,000 mou of marshy land can be reclaimed. If the cost of one mou is $40, $40,000,000 will be obtained from reclamation, which will nearly pay for the expense for the preliminary engineering works of that Huai River system. If the irrigation and drainage channels of the district are constructed at the same time, the excavated earth from the drainage channels can be used for dike construction along the irrigation channels. The arrangement of the irrigation and drainage channels are shown in Fig. 29. Their discharge capacities, cross-sectional areas, and excavation have been carefully investigated, and the expense of the engineering works is given in the following:—

Dike construction with excavated and borrowed earth, ramming included	3,341,000 cu. m.	@ $0.16/cu. m.	$ 535,000
Excavation of channel	17,863,000 cu. m.	@ $0.135/cu. m.	2,412,000
Land occupied by channels to be purchased	9,500 mou	@ $20/mou	190,000
Lock and sluice construction			460,000
Installation of five pumping plants			1,000,000
		Total	$4,597,000

The irrigation channel which is used to convey water from the Hungtze Lake to the Inner Grand Canal is one of the most important canals and its excavation will attract our first attention. For the sake of everlasting safety, the channel should have a discharge capacity of 425 cu. m. per sec. The new outlet of the Tungyang Canal should also be excavated so as to give no obstruction to the water source. Their designs and costs of excavation have been already discussed.

The following table is a summary of costs and works for the first stage of irrigation development.

Table 7. Estimates of Costs for Irrigation Projects.

Items	Estimates of Costs.				
	Excavation of channel	Structure	Purchasing of land	Installation of pumping plants	Grand Total
Irrigation channel (from Hungtze Lake to Chingho-chai)	$1,200,000	$300,000			$1,500,000
Installation of sluice-gates on the Inner Grand Canal		100,000			100,000
Irrigation and drainage works in Kao Pao Lake District	2,947,000	460,000	$190,000	$1,000,000	4,597,000
Outlet for the Tungyang Canal		50,000			50,000
					$6,247,000

The benefits of irrigation towards agriculture is so great that besides the $40,000,000 obtained from the reclamation of the Kao Pao Lake District, the value of the yearly crops at that district will be worth about $10,000,000. At the Eastern District, the area of the land to be irrigated is approximately 10,000,000 mou. If 5,000,000 mou are under irrigation at the beginning and the minimum return of one mou is $2.0, then $10,000,000 will be gained yearly from that district. Hence the benefit of the preliminary engineering project towards the wealth of the people is so great that its accomplishment should not be delayed.

Chapter V.

Works to be Performed

Construction works of flood control, navigation and irrigation for the whole system of the Huai basin are numerous. For those which is of primary importance, general schemes have been already laid down; and for the others, it remains to be investigated. The Engineering Bureau is preparing on one hand to carry out the construction works of the primary importance, and on the other to work out the definite projects, at the same time, for the construction works to be performed in the following years. Further investigations on economical selection and detail design are also necessary for the works to be carried out in the first few years. According to the general schemes laid down in the foregoing chapters, a list of works to be performed for surveying, designing and experimenting is scheduled as follows:—

(A) WORKS FOR SURVEYING:

1. The upper valleys of the Yi and the Shu Rivers;
2. The Wishan Lake and the Grand Canal in the Province of Shantung;
3. Lakes in the upper valley of the Huai River;
4. Precise levelling along the Grand Canal and the Huai River;
5. Topographical survey of the different sites of the proposed straight cuts on the upper Huai and its tributaries;
6. The proposed navigation channel to connect the Inner Grand Canal to Hungtze Lake from Kaoliangchien to Chinghochai;
7. The proposed navigation channel between the Yen Ho and Chuangchang Ho;
8. The proposed navigation channel from Chinghochai on the

Inner Grand Canal east to the Chuangchang Ho;

9. The sites for locks and sluices on the outlets of the Chuangchang Ho to the sea and on that of Tungyang Canal to the Yangtze;
10. The sites for locks on the Middle and Southern Grand Canal in Shantung;
11. Topographical survey of the Lihowa and the proposed cutoff of the Huai at Shuangkou;
12. The sites for lock and dam on the Huai River at Fushan;
13. To establish more hydrological stations on different rivers in the Huai basin; and
14. To connect the levelling lines on both banks of the Yangtze River.

(B) WORKS FOR EXPERIMENTING:

1. Soil exploration on the proposed sites of structures;
2. Test of bearing capacity of soil at the different sites for structures;
3. To establish the hydraulic laboratory for the experiment, by models, to predict the conditions of structures after construction;
4. Experiment by models the stability of the proposed river course and channel sections;
5. Experiment by models the percolation in earthern dikes;
6. Inspection and test on building materials; and
7. Actual measurement for determining Kutter's coefficient of roughness of river bed.

(C) WORKS FOR DESIGNING:

1. Selection and design of construction plants and equipment;
2. The field layout of construction;

3. Regulation for field offices and specifications for structures;
4. Provision of means of communications for different construction camps, and care for the living of laborers;
5. Detail designing for locks and movable dams;
6. Project on the systems of detention basins on Yi and the Shu rivers;
7. To design the navigation canal from the Wishan Lake to connect with the Yellow River;
8. Project for the improvement of navigation system in the Tungyang Canal;
9. Projects for regulation of the sources of the Huai River in the mountainous valleys;
10. Projects of local systems in drainage, irrigation and reclamation of lands for different districts;
11. Designing highways and bridges;
12. Different city-plans and harbor-plans such as Huaiyin, Shiang-shuikow, Kwanhokow and Sankiangying;
13. Planning of machine shops for repairing instruments and equipments used for construction;
14. Further investigation on the operation of the Hungtze Lake so as to reduce its maximum surface elevation; and
15. Rules and regulations for administration and maintenanae of the completed structures.

Geographical Names in English and Chinese

A

Ancient Canal, the	古運河
Anhowa	安河窪
Anhuaichih	安淮集

C

Chaimee Ho	柴米河
Changchuang	張莊
Changfu Ho	張福河
Changkushan	張谷山
Changpakaitze	張八坎子
Chaochiachih	趙家集
Chentzewa	成子窪
Chenyangkwan	正陽關
Chiangchiakou	姜家溝
Chiang Ho	港河
Chiangpa	蔣壩
Chichih	溪集
Chichshou	界首
Chienchiachih	錢家集
Chien Ho	芡河
Chienshu Ho or Front Shu Ho	前沭河
Ching Ho	涇河
Chitsung	齊村
Chiulungmiao	九龍廟
Chowchiakow	周家口
Chowhsien	鄒縣
Chuangchang Ho	串場河
Chu Ho	洙河
Chulopa	竹絡壩
Chunchiakow	叢家口
Chungshin	衆興
Chungyichih	忠義集

E

Ertaokow	二道口

F

Fankung Dike	范公堤
Fankwan Hu	汜光湖
Fanshui	汜水
Fei Ho	淝河
Fenghwang Ho	鳳凰河
Fengtai	鳳台
Fengtaitze	馮台子
Fengyang	鳳陽
Front Shu Ho	前沭河
Funing	阜寧
Fushanhsia	浮山峽
Fushingchai	福興閘

G

Grand Canal, the	運河

H

Haichow	海州
Hanchuang	韓莊
Hei Ho	黑河

Hotingchai 河定閘
Houchiu 霍邱
Hsiangchiaochih 項橋集
Hsiangchien Hu 香澗河
Hsifei Ho 西淝河
Hsin Ho 新河(金溝南)
Hsinhochen 新河鎮
Hsinpu 新浦
Hsintukow 新渡口
Hsinyangchiang 新洋港
Hsipa 西壩
Hsuchow 徐州
Hsuhsien 宿縣
Hsung Ho (Shun Ho) 潯河
Huai-an 淮安
Huai River, the 淮河
Huaiyin 淮陰
Huaiyuan 懷遠
Huchuangwei 胡莊圩
Huiliuchih 迴溜集
Hung Ho 洪河
Hunghokow 洪河口
Hunghwapu 紅花埠
Hungtze Lake, the 洪澤湖

I

Inner Grand Canal 裏運河
I-tsenchih 移村集

J

Ju Ho 汝河

K

Kaishan 開山
Kaokou 高溝
Kaoliangchien 高良澗
Kao Pao Lakes, the 高寶湖
Kaotzutze 高嘴子
Kaoyu 高郵
Kaoyu Lake, the 高郵湖
Koushangchih 溝上集
Kingkouchen 金溝鎮
Kingwan Ho 金灣河
Kotaitze 郭台子
Kuachow 瓜州
Kuan Ho 灌河(淮源之一)
Kwan Ho 灌河(龍溝下游)
Kwantien Ho 官田河
Kwei Ho 澮河
Kweishan 龜山
Kwo Ho 渦河

L

Lichuang 李莊
Lienshui 漣水
Lihowa 溧河窪
Lingchiapa 藺家壩
Linhungkow 臨洪口
Lingpi 靈璧
Liochiakou 廖家溝
Liuchai 六閘
Liulauchien 劉老澗

Liushupang 柳樹棚
Liutzekow 溜子口
Lochiaochih 羅橋集
Loma Hu 駱馬湖
Lukow 魯口
Lukowpa 盧口壩
Lunghochih 龍河集
Lungkou 龍溝

M

Main Liutang Ho 總六塘河
Malangkang 馬狼崗
Maotsechuang 茅茨莊
Matou 碼頭
Meihokow 沫河口
Mengchen 蒙城
Mengyi mountains 蒙沂山派
Middle Grand Canal, the 中運河
Ming Dike 洪湖大堤
Montao Ho 芒稻河

N

Nan Hu 南湖
Nanliutang Ho or
Southern Liutang Ho 南六塘河
Northern Liutang Ho 北六塘河

O

Old Yellow River, the 廢黃河

P

Paichiachien 柏家澗
Paichiawan 柏家灣
Paifangtaitze 牌坊台子
Pakiangkow 八江口
Peifei Ho 北淝河
Pei Ho 淠河
Peiliutang Ho or
Northern Lintang Ho 北六塘河
Peima Hu 白馬湖
Peito Ho 北沱河
Pelao Ho (Pelau Ho) 不牢河
Pengpu 蚌埠
Pien Ho 汴河
Pihu Ho 壁虎河
Pochiatu 卜家渡
Pochow 亳州

R

Rear Shu Ho 後沭河
Rose River, the 薔薇河

S

Salt Canal, or
the Yen Ho 鹽河
Sanchakow 三岔口
Sanchatu 三岔渡
Sangchu Lake 桑墟湖
San Ho 三河
Sanhochien 三河尖
Sanhokow 三河口
Sanhopa 三河壩
Sanhotou 三河頭
Sanhowei 三河衛

Sankangchih	三岡集
Sankiangying	三江營
Sanyang	山陽
Shachiafong	卸甲坊
Shachiakow	沙家口
Shakiang Ho	砂礓河
Shakouchih	沙溝集
Shaopai	邵伯
Shatou Ho	沙頭河
Sheyang Hu	射陽湖
Shiangshuikow	响水口
Shih Ho	史河
Shinanchen	興安鎮
Shinhwa	興化
Shiukangchih	垂崗集
Shouhsien	壽縣
Shuangkou	雙溝
Shu Ho	沭河
Shuhsiang Hu	碩項湖
Shui Ho	睢河
Shungti Ho	順堤河
Shunhochih	順河集
Shutangchih	瞿塘集
Shuyang	沭陽
Shuyi	盱眙
Siaoleechih	小李集
Sihsien	息縣
Sin Ho	新河(六閘下游)
SouthernGrandCanal	山東南運河

Southern Liutang Ho	南六塘河
Sze Ho	泗河
Szehsien	泗縣

T

Taichuang	台莊
Tai Ho	太河
Taihsien	泰縣
Tanchen	郯城
Tanchiachien	談家尖
Tangchia Lake	唐家湖
Tasha Ho	大沙河
Tashitu	大石渡
Tenghsien	滕縣
Teshenchai	德勝閘
To Ho	沱河
To Hu	沱湖
Tongchiakou	董家溝
Tsaikungtu	蔡工渡
Tsaochow	曹州
Tsaolingchih	棗林集
Tse Ho	池河
Tsematou	時碼頭
Tsingchungchih	清忠集
Tsingtao	青島
Tsingyi Lake	青伊湖
Tungchichai	通濟閘
Tungpai	桐柏
Tungping	東平
Tungtai	東台

Tungwan Ho	東灣河	Yangtzekiang	揚子江
Tungwashian	銅瓦廂	Yaowan	窰灣
Tungyang Canal	通揚運河	Yellow River	黃河
W		Yenchen	鹽城
Wanfuchih	萬福集	Yenchiachih	顏家集
Wanfu Ho	萬福河	Yenweichiang	燕尾港
Weichichai	惠濟閘	Yenwotze	鹽窩子
Wen Ho	汶河	Yi Ho	沂河
Wishan Lake	微山湖	Yin Ho	潁河
Wuchang Ho	武障河	Yinshang	潁上
Wuhohsien	五河縣	Yinsiaochih	殷小集
Wuhwachiao	五花橋	Yuantu	阮渡
Y		Yungchen	永城
Yangchow	揚州	Yunliuchai	濼流閘
Yangchuang	楊莊	**Z**	
Yangtu	楊渡	Ze Ka Wei	徐家匯

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