69TH CONGRESS } HOUSE OF REPRESENTATIVES { DOCUMENT
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SUSQUEHANNA RIVER, PA. AND MD.

LETTER

FROM

THE SECRETARY OF WAR,

TRANSMITTING

WITH A LETTER FROM THE CHIEF OF ENGINEERS, REPORTS ON PRELIMINARY EXAMINATION AND SURVEY OF SUSQUEHANNA RIVER, PA. AND MD., FROM HARRISBURG TO THE MOUTH.

JANUARY 6, 1926.—Referred to the Committee on Rivers and Harbors and ordered to be printed, with illustration

WAR DEPARTMENT,
Washington, January 5, 1926.

The SPEAKER OF THE HOUSE OF REPRESENTATIVES.

MY DEAR MR. SPEAKER: I am transmitting herewith a letter from the Chief of Engineers, United States Army, dated December 30, 1925, together with reports dated September 20, 1920, and November 1, 1923, with map, by Col. J. P. Jervey, Corps of Engineers, and Maj. F. C. Harrington, Corps of Engineers, on preliminary examination and survey, respectively, of Susquehanna River, Pa. and Md., from Harrisburg to the mouth, authorized by the river and harbor act approved March 2, 1919.

Sincerely yours,

DWIGHT F. DAVIS,
Secretary of War.

WAR DEPARTMENT,
OFFICE OF THE CHIEF OF ENGINEERS,
Washington, December 30, 1925.

Subject: Preliminary examination and survey of Susquehanna River, Pa. and Md., from Harrisburg to the mouth.

To: The Secretary of War.

1. There are submitted herewith, for transmission to Congress, reports dated September 20, 1920, and November 1, 1923, by Col.

J. P. Jervey, Corps of Engineers, and Maj. F. C. Harrington, Corps of Engineers, on preliminary examination and survey, respectively, of Susquehanna River, Pa. and Md., from Harrisburg to the mouth, authorized by the river and harbor act approved March 2, 1919.

2. The Susquehanna River rises in south central New York and flows generally south through Pennsylvania and Maryland into Chesapeake Bay. The United States has provided an improved channel 15 feet deep at low water from deep water in the bay to Havre de Grace, near the mouth of the river, and has removed a shoal above that point. Beginning at a point 5 miles above Havre de Grace the river is broken by a series of rapids and shoals so that navigation is possible only in isolated reaches. Request is now made for a navigable channel suitable for a large scale river commerce up to Harrisburg, a distance by river of 70 miles.

3. The State of Pennsylvania, through its department of internal affairs, has made a commercial survey with a view to estimating possible traffic on such a channel pertaining to territory in Pennsylvania, which includes practically the entire area that would be tributary to an improved channel in this section of the river. Based on this study, an estimate was made by local interests of the diversion from rail to water of existing freight to the amount of about 580,000 tons, which they believe might increase within 5 or 10 years to 1,500,000 tons under satisfactory conditions.

4. The district engineer reports that the steep slope and rocky bed of the river render impracticable an adequate improvement by open channel means, and that the provision of a lateral canal would be difficult and expensive and would involve so great a number of locks as materially to interfere with navigation. It would therefore be necessary to canalize the river. This could be done either from the point of view of navigation alone or in combination with a hydroelectric development. The latter is evidently the more desirable plan, since it would permit the full utilization of the resources of the river, and since the charge against navigation would be correspondingly less. The district engineer's report is therefore directed primarily to the development of a combined navigation and power project. The plan which he presents involves the construction of a movable dam at Steelton and fixed dams at Roberts Island, Conowingo, Holtwood, Safe Harbor, and Shocks Mills. The five fixed dams would have a total average head of 284 feet; under existing conditions of low water flow they would represent a potential primary horsepower of 150,000, and 500,000 or more secondary horsepower, dependent upon the utilization factor. Two power developments now exist on this stretch, at Holtwood and at York Haven. The former would become an integral part of the proposed project; its present primary and secondary horsepower production are included in the above figures. The existing York Haven development would be scrapped, the plant being purchased and submerged by the pool formed by the Shocks Mills dam. The estimated cost of the combined project is $114,400,000. Of this, $14,400,000 represents the cost of locks, of channel work, and of the movable dam at Steelton. In order to give the navigation interest the greatest possible credit in his computations, the district engineer assumes that only this sum is chargeable against navigation, though it is readily arguable that there should be added some portion of the cost of the dams.

5. Assuming the charge against navigation as 4½ per cent of the first cost of $14,400,000, plus annual operation and maintenance of locks and channels, there results an annual charge of about $1,070,000. Assuming that the entire commerce of 580,000 tons claimed by local interests would be diverted to the river, the cost of its movement to the Government would be $1.84 per ton. Of this traffic, 360,000 tons is understood to be northbound iron ore, which at present is received in ocean vessels at Baltimore and shipped by rail to Steelton at a rate of $1.21 per ton. The distance by water from Baltimore to Steelton over an assumed navigable channel in the Susquehanna is 100 miles. If the cost of water movement be taken at 5 mills per ton-mile, the total cost of shipping this ore by river, including the $1.84 per ton which represents the annual charge against the improvement, would be $2.34 per ton, nearly twice the present rail rate. If the annual cost to the United States could be spread over a traffic of 1,500,000 tons, the cost of moving the ore item, computed in the above manner, would be practically the same by water as by rail. Thus, taking the local estimate of present available commerce, and based on a study of an item comprising 62 per cent of it, there would be no economy, but a net loss, to the Nation in spending even $14,000,000 to divert this traffic from rail to river, and there would have to be a great increase in this liberally estimated commerce to produce even small savings. Should the navigation feature be charged, as in equity as it probably should be, with some portion of the cost of the dams, it would have an even less favorable aspect.

6. The district engineer presents a careful and valuable general study of the technical and financial aspects of power production under the scheme outlined by him. His conclusion is that, based on a charge of $100,000,000 against the power feature, it would be practicable to undertake the development and market the power on a financially successful basis. With the navigation feature eliminated, he is of the opinion that the cost of the power development would be less than the $100,000,000 estimated.

7. As a result of these studies, the district engineer recommends that no navigation improvement be undertaken. He considers that the development of the river for power purposes should be left to private interests, with suitable safeguards looking to the possibility of future navigation developments. The division engineer concurs in general in these views and recommendations.

8. These reports have been referred, as required by law, to the Board of Engineers for Rivers and Harbors, and attention is invited to its report herewith, agreeing with the district and division engineers.

9. After due consideration of the above-mentioned reports, I concur in the views of the district and division engineers and the Board of Engineers for Rivers and Harbors. The district engineer's study gives ground for believing that it would be feasible and commercially profitable to undertake a water power development utilizing practically the entire fall and flow of the river from Harrisburg to the mouth. Such a development could be adapted to navigation purposes by the installation of locks and dams and by supplementary channel work, together with a movable dam with low head at Steelton. Making the most liberal allowance, however, in the matter of division of costs and of prospective tonnage, it appears that under existing or reasonably prospective conditions the benefits to be derived from

the navigation part of the project would not be at all commensurate with its cost. Any alternative scheme, of providing a navigable channel without the power feature, would be even less justified. I therefore report that the improvement of the Susquehanna River, Pa. and Md., from Harrisburg to the mouth, in the interest of navigation, other than as authorized by the existing project up to Havre de Grace, is not deemed advisable at the present time.

10. It is advisable that the Federal Government, in granting authority for any future hydroelectric development on this stretch of the river, introduce such provisions as will permit and facilitate the provision of navigation installations at a later date, should a change in the economic and commercial situation render this desirable.

H. TAYLOR,
Major General, Chief of Engineers.

REPORT OF THE BOARD OF ENGINEERS FOR RIVERS AND HARBORS

SYLLABUS

The Board of Engineers for Rivers and Harbors concurs with the district and division engineers in the opinion that the prospective commerce on the Susquehanna River from Harrisburg to the mouth is not of sufficient magnitude to justify improvement for navigation even in conjunction with power development.

[Third indorsement]

BOARD OF ENGINEERS FOR RIVERS AND HARBORS,
Washington, D. C., November 17, 1925.

To the CHIEF OF ENGINEERS, UNITED STATES ARMY.

1. The following is in review of the reports on preliminary examination and survey of the Susquehanna River, Pa. and Md., from Harrisburg to the mouth, authorized by the river and harbor act approved March 2, 1919.

2. The Susquehanna River rises in the State of New York and flows generally south through Pennsylvania and Maryland, entering Chesapeake Bay at Havre de Grace. The drainage area above the mouth is 27,400 square miles, and above Harrisburg 24,030 square miles. The minimum, maximum, and average flows at Harrisburg, based on observations covering a period of 32 years, are 2,000 second-feet, 543,500 second-feet, and 39,272 second-feet, respectively. Similar figures for the flow at Roberts Island, 6 miles above the mouth, are 2,265 second-feet, 615,800 second-feet, and 44,476 second-feet. The river is under improvement by the United States under a project which provides for a channel 200 feet wide and 15 feet deep at mean low water from Chesapeake Bay to Havre de Grace, and for the removal of a shoal above that point. The improved channel extends about five miles into Chesapeake Bay. Above Havre de Grace the river is navigable for about 5 miles for vessels drawing 15 feet. Between that point and Harrisburg there is no through channel, navigation being limited to isolated reaches. Local interests desire a navigable channel of suitable dimensions for moving a large commerce between Harrisburg and Chesapeake Bay.

3. The existing commerce pertaining to the improvement at the mouth, which in 1923 amounted to 71,500 tons, would not be benefitted by the proposed improvement, as ample channel depth is

already available there. The department of internal affairs of Pennsylvania has made an investigation of the waterborne traffic which might result from a through channel between the present head of navigation and Harrisburg. This canvass was limited to tributary territory in Pennsylvania. It represents, however, practically the entire area which must be depended upon for water shipments, as the 10-mile stretch between the present head of navigation and the Pennsylvania-Maryland State line is a narrow, rocky valley with no areas suitable for extensive industrial development. Based upon this study, the State department of internal affairs estimates that 581,720 tons of freight now moving by rail would move by water if a suitable channel were provided. It thinks that, with proper organization and favorable contributing conditions, a total water movement of 1,500,000 tons might be developed in from 5 to 10 years after the improvement is completed.

4. The district engineer states that open channel improvement is not feasible on the Susquehanna on account of its steep slope and rocky bed. Reconstruction of an abandoned canal on the north side of the river, which at one time provided for navigation between Havre de Grace and the New York State line, would be difficult and expensive, and the number of locks required would prevent successful competition with the parallel railroad lines. He concludes that the only practicable method of improvement is canalization of the river. He discusses in detail the suitable dimensions of channel and locks, and concludes that the most practicable channel would be one 200 feet wide and 9 feet deep at normal pool heights, with locks 315 feet long and 60 feet wide having a depth of 12 feet over the mitre sills. A 12-foot project would thus be possible without involving their reconstruction should the traffic ever become sufficient to justify that depth. Analysis of the possible commerce, compared with the large cost of providing the necessary channels for navigation, leads the district engineer to conclude that improvement is not justified in the interests of navigation alone.

5. Consideration is therefore given to a possible coordinated development of hydroelectric power and navigation. In the 69 miles of river between Harrisburg and the mouth there is a drop of 287 feet. Development of the potential water power represented by this head would provide about 150,000 primary horsepower and some 500,000 secondary horsepower. The district engineer presents a plan of development involving the construction of one movable and five fixed dams, which he believes would utilize practically the full power of the stream in an economical manner and also provide adequate pools for navigation. The proposed location, available head and ultimate installed capacity of the power plants are as follows:

Location	Miles from mouth	Average head-feet	Ultimate installed capacity, horsepower
Roberts Island	6	42.3	154,000
Conowingo	12.2	75	273,000
Holtwood	24.5	55	140,000
Safe Harbor	33.2	65	236,000
Shocks Mills	49.5	47	171,000
Steelton	66	9	(1)

[1] Movable dam.

Two power developments already exist on this section of the river, one at Holtwood and one at York Haven. The former, with some alterations to the dam, would become an integral part of the project. The latter is less modern, and neither its location nor height coordinate well with the proposed project. The entire plant would have to be purchased, as it would be submerged by the pool formed by the Shocks Mills Dam. The Susquehanna Power Co. has plans for the development of the Conowingo site, which is considered the best on the river.

6. The total estimated cost of the combined power development and navigation project is $114,400,000. Of this, $14,400,000 represents the cost of locks and channels and of the proposed movable dam at Steelton, which is required for navigation of the stretch at and immediately below Harrisburg. This figure is used as a basis for determining the worthiness of the project. It may well be argued that navigation should properly be charged also with a share of the cost of dams, etc., and it is certain that the assumption adopted is the most favorable one to a navigation project. The district engineer analyzes his cost figures and shows that hydroelectric power can be generated and distributed at a profit in competition with other plants serving the same territory.

7. The annual cost of operation and maintenance of locks and channels would be $1,069,368, including interest at 4½ per cent on the estimated first cost. Assuming that the estimated commerce of 581,720 tons moved over the entire length of the improvement, the cost of the improvement per ton-mile would be 2.87 cents and the cost per ton $1.84. For a traffic of 1,500,000 tons the corresponding figures would be 1.11 cents per ton-mile and $0.71 per ton. The largest single item of prospective commerce shown in the State's study is 360,000 tons northbound, which the district engineer understands to be imported iron ore now shipped by rail from Baltimore to Steelton at $1.21 per ton. The distance between these points by water is 100 miles. If water movement be assumed to cost 5 mills per ton-mile, or 50 cents per ton, the total cost of shipping the ore by river, including the $1.84 per ton which represents the fixed charge to the United States, would be $2.34 per ton. If the annual cost of the improvement could be spread over a traffic of 1,500,000 tons, the total cost of moving the ore by water from Baltimore to Steelton would be practically the same as the existing rail rate. With the prospective commerce limited to the figures given, the district engineer feels that improvement for navigation, even in conjunction with power development, is not justifiable. He recommends that the development of the river for power purposes be left to private interests under such permits and licenses as would insure the possibility of providing for navigation in the future should improvement then appear justifiable.

8. The division engineer concurs in general with the district engineer.

9. Interested parties were advised of the tenor of the district engineer's report and given an opportunity of presenting their views. The report was held for a number of months at the request of local interests. They have submitted no additional information, and have recently indicated their willingness to have the board proceed with its consideration of the case.

10. The nature of the Susquehanna River below Harrisburg is such that a navigable channel could be provided only at great ex-

pense. The most feasible plan appears to be by the construction of a series of locks and dams. A large amount of power could be developed at these dams, and a ready market exists for the entire output. Assuming that the full potential power is developed, and that only that part of the cost pertaining to the construction of locks, channels, and the movable dam is charged to navigation, that part of the project would cost more than $14,000,000, and the annual charges would amount to over $1,000,000. The cost per mile of improved channel would be so high as to be justified only by a very large commerce. An adequate tonnage is apparently not available at present, nor is its development in the near future probable. The section of the river under consideration does not directly tap sources of raw materials, such as coal or ore, nor are any deposits within such distance that a joint rail and water haul might be profitable. The region bordering the river is not now intensively developed industrially except in the vicinity of Harrisburg, though such a development might result in the future if abundant cheap power is made available. Based upon existing and immediately prospective conditions the board concurs with the district and division engineers in recommending that no improvement of Susquehanna River, Pa. and Md., from Harrisburg to the mouth, other than as authorized by the existing project, be undertaken by the United States at the present time.

11. From the data submitted by the district engineer there is reason to believe that a hydroelectric development on the Susquehanna below Harrisburg at a cost of approximately $100,000,000 may prove, on further investigation, a paying investment. The board does not, however, believe that improvement for navigation can be economically combined with it under present conditions.

12. In compliance with law, the board reports that there are no questions of terminal facilities, water power, or other subjects which could be coordinated with the project proposed in such manner as to render the improvement advisable in the interests of commerce and navigation.

For the board:

HERBERT DEAKYNE,
Colonel, Corps of Engineers, Senior Member Present.

PRELIMINARY EXAMINATION OF SUSQUEHANNA RIVER, PA. AND MD.

WAR DEPARTMENT
UNITED STATES ENGINEER OFFICE,
Baltimore, Md., September 20, 1920.

From: The District Engineer.
To: The Chief of Engineers, United States Army.
Subject: Preliminary examination of Susquehanna River, Pa., and Md., from Harrisburg to the mouth.

1. In accordance with directions contained in letter[1] of April 16, 1919 this report on the preliminary examination of the Susquehanna River, Pa. and Md., from Harrisburg to the mouth, called for by the river and harbor act of March 2, 1919, is submitted.

[1] Not printed.

2. The Susquehanna River drains one of the largest and commercially most important drainage areas in the North Atlantic States. Above the junction at Sunbury, Pa., it consists of two branches, the North and the West.

3. The former rises in Otsego Lake, N. Y., at an elevation of 1,193 feet above sea level and flows in a southeasterly direction through three counties of the State of New York into Susquehanna County, Pa., thence in a westerly-northwesterly direction through this county and again enters New York taking a westerly course to near the western boundary of Tioga County, where it turns south and reenters Pennsylvania. Before leaving New York its volume is rapidly swelled by many large tributaries. After reentering Pennsylvania it flows through mountain regions, its course being tortuous in many places, in a generally southeast direction to the confluence of the Lackawanna River at Pittston, Pa., whence it takes a generally southwesterly course to the junction of the two branches near Sunbury.

4. This branch of the river and its tributaries drains an area of 6,080 square miles of New York and 5,060 square miles of Pennsylvania. It has a very uniform declivity and offers comparatively little water power. In New York the bed is of gravel and sand with an occasional rocky ledge; in Pennsylvania the bed is mostly of gravel, sand, and boulders. In New York the banks are generally high and seldom overflowed, although the river has a rise of as much as 30 feet. In Pennsylvania the banks are generally high and excepting in the Wyoming Valley the section from the Lackawanna River to the gorge at Nanticoke, about 18 miles, are seldom overflowed.

5. The West Branch rises in Cambria County, Pa., at an elevation of not less than 2,000 feet above sea level. It flows first in a northward direction into Clearfield County, then bending to the right northeast between Center and Clinton Counties, east through Clinton and Lycoming and south between Union and Northumberland Counties, to the junction with the North Branch, to form the main stream above Sunbury.

6. As far up as Queens Run, a distance of about 41 miles, the fall of this branch is comparatively small, while above that point, in the mountain region, it is much greater. Furthermore, the banks of both the stream and its tributaries above Queens Run are generally high, and there are few low grounds subject to overflow. Below Queens Run the river traverses a wide, fertile valley, without, however overflowing its banks to any considerable extent. The bed of the river is generally gravel and sand, with a rocky ledge at places. In former years this portion of the drainage was largely used by lumbermen for floating logs. On most of the streams splash dams were built, sometimes flooding considerable areas, and serving to hold the logs which were sent down until a sufficient number were collected. The gates in the dam were then raised, letting the water out suddenly, so that the logs were carried down on the swell or wave to the next dam or to the main river, where the natural current would be sufficient to carry them along. As the forest areas are now largely cut off but very little logging is done either on this or other portions of the river.

7. Below the junction of the North and West Branches the river flows nearly south, between Northumberland, Dauphin, and Lancaster Counties on the east, and Snyder, Juniata, Perry, Cumberland, and York Counties on the west, passing then into Maryland, where

it flows between Cecil County on the east and Harford County on the west, and empties into Chesapeake Bay at its northern extremity.

8. Below the mouth of the West Branch the fall becomes more irregular than above, and there are rapids where the stream flows over a rocky bottom. In the lower part of its course from Marietta to Havre de Grace the river occupies a deep valley, varying in width from a few hundred yards to more than 2 miles, and on either shore it is for the most part bounded by rocky bluffs surmounted by a tableland 100 to 500 feet above the stream. The channel is in many places filled with small rocky islands, some of which are cultivated. The fall of the main river is rapid. Its elevation at the mouth of the West Branch is about 400 feet above mean sea level at Havre de Grace. The distance between this point and Havre de Grace is about 125 miles, hence the mean slope of the main river is nearly 3½ feet per mile. The slope is, however, extremely variable, being over 5 feet per mile in the lower 40 miles and about 2½ feet per mile in the upper 40 miles. The change in slope takes place as the river passes from the Allegheny Mountain and the Allegheny Valley regions to the Piedmont Plateau region.

9. Harrisburg, the upper limit of the part of the river subject of this report, the capital of Pennsylvania, is between 65 and 70 miles by river from its mouth. The elevation of the low-water level at this point is about 292 feet above sea level.

10. The drainage area of the river above the mouth is 27,400 square miles, comprising 13 per cent of the area of the State of New York, 47 per cent of the area of Pennsylvania, and 2 per cent of that of Maryland. Above the gauging station, located at Walnut Street bridge, Harrisburg, it is 24,100 square miles, leaving 3,300 square miles as the area below Harrisburg.

11. The river is navigable for vessels of 15 feet draft and under from the mouth as far as Port Deposit, Md., about 5 miles; above this point it is so, in disconnected reaches, only for small flat-bottom boats adapted to local trade, ferry transportation, pleasure, recovering of coal and sand excavation, and this only during certain seasons of the year.

12. There is an existing project for a channel 200 feet wide and 15 feet deep at mean low water from Chesapeake Bay to Havre de Grace and for the removal of a shoal opposite Watson Island, just above Havre de Grace, to a depth of 8 feet at mean low water. The length of this channel which extends into the bay is about 5½ miles, the lower end being about 5 miles below the mouth of the river.

13. In addition a small channel was dredged some years ago in the vicinity of Wilkes-Barre, Pa., and some dikes were constructed but were soon abandoned.

14. The only terminal facilities along the river are the open-pile and bulkhead wharves at Havre de Grace and the bulkhead wharves at Port Deposit, which are amply sufficient for all commerce on this part of the river.

15. The river is subject to floods and ice gorges which occur with varying degrees of severity almost annually. Prior to the construction of the dam at Holtwood, which is believed to have exerted considerable influence in ameliorating these conditions, ice gorges with severe flood damage were of frequent occurrence in the vicinity of Port Deposit.

16. Between the mouth and Harrisburg the river is crossed by 4 highway, 5 railroad, and 1 combination highway and railroad bridges. Eight of these are trussed bridges, the other two consist of masonry arches.

17. Between the mouth and Harrisburg the river is crossed by three dams, one of 50 feet height, one of 22 feet, and one of 4 feet.

18. Until its abandonment about 1889 there was a canal extending along this river from tidewater to the coal regions above Harrisburg. It is now practically obliterated along the lower part of the river.

19. Though they do not seem to know just what improvement they desire, interested parties express the opinion that an improvement of the Susquehanna River for navigation would draw commerce in great volume from Adams, Cumberland, Dauphin, Franklin, Lancaster, Lebanon, Perry, and York Counties in Pennsylvania, Franklin and Lebanon being the only ones of these that do not border on the river. They present statistics for this locality as follows:

Area of the counties named, square miles	5,096
Population	737,644
Cities and towns of over 2,000 population within this area	30
Towns along the Susquehanna River	60
Number of schools	3,694
Total number of industrial plants	2,222
Total number of employees in these plants	83,730
Total market value of products	$323,997,844

Total production by units

Chemicals and allied products:	
Tons	37,983
Gallons	19,275,707
Barrels	1,213
Bushels	70,776
Dozen	36,998
Clay, glass, and stone products:	
Tons	768,874
Gallons	1,221,888
Barrels	5,292
Units	30,350,556
Square feet	118,513
Cubic feet	950
Thousands	1,068,728
Clothing manufacture:	
Dozen	6,274,430
Food and kindred products:	
Tons	85,893
Gallons	293,839
Barrels	1,455,943
Dozen	43,468
Cans	7,571,311
Leather and rubber goods:	
Tons	2,128
Barrels	3,000
Dozen	82,615
Pieces	127,269
Pairs	9,690,806
Sides	115,208
Cases	32,774
Boxes	4,210,477
Lumber and its remanufacture:	
Tons	1,537
Pieces	23,903,947
Cars	336
Liquors and beverages:	
Gallons	141,275
Barrels	202,958
Dozen	788
Bottles	360,000
Cases	166,639
Paper and printing industry:	
Tons	166,890
Pieces	5,029,000
Boxes	12,212,280
Gross	1,260,177
Rolls	40,751,473
Cases	12,399
Textiles:	
Tons	3,953
Dozen	4,775,000
Pieces	4,175
Pairs	85,724
Yards	21,639,834
Metals and metal products:	
Tons	1,703,167
Dozen	1,201,395
Pieces	32,623,841
Sets	16,000
Square feet	185,379,566
Mines and quarries:	
Tons	1,038,170
Perches	7,450
Tobacco and its products:	
Thousands	511,434,150
Tons	500,283

Total agricultural production

	Bushels	Value
Wheat	10,276,847	$22,330,226
Corn	20,609,618	31,333,456
Rye	743,913	1,133,711
Oats	5,733,223	4,362,710
Potatoes	3,257,416	5,118,673
Total	40,621,017	64,278,776
	Tons	
Hay	782,805	20,200,369
Total		84,479,145

Fruit:

Bearing trees—	
Apple	307,230
Peach	474,105
Nonbearing trees—	
Apple	272,745
Peach	87,550

20. Those presenting the above statistics state that it is impossible to reduce them to tons as desired—owing to the fact that they have been received from various sources in the different units given.

21. The evidence at hand, after repeated and exhaustive efforts to obtain the views and arguments of interested parties, does not warrant the conclusion that the river is worthy, at this time, of improvement for navigational purposes, and therefore this matter has not been gone into in greater detail.

22. A previous unfavorable report was made on the Susquehanna River below Northumberland, Pa., in 1903, and is published as House Document No. 219, Fifty-eighth Congress, second session.

23. There are no questions of flood control or land reclamation or other related subjects, excepting water-power development and possibly an increase in the water supply for Baltimore City in the distant future, that could be considered in connecton with the proposed improvement to lessen the cost for navigation.

24. There are two feasible ways of making the Susquehanna River navigable; first, by a lateral canal along its banks; second, by the construction of locks and dams in the stream itself. The first method has been tried and abandoned; it is therefore useless to consider trying this same method again, which would involve the acquisition of a costly right of way, the destroying of much valuable private property, much rock excavation, and the construction of numerous locks at unit costs greatly in excess of those which prevailed at the time of the construction of the original canal. Considering the canalization of the river itself, there are at present already constructed dams at York Haven and Holtwood, with heights of approximately 25 feet and 50 feet, respectively, at which the Government would have to secure the rights to build locks or preferably purchase the plants in their entirety. From an examination of available profiles of the river, its canalization involves a lock and dam of 17-foot lift at the head of Conewago Falls; a lock at York Haven with 25-foot lift; two locks and dams between York Haven and Columbia, each with 14-foot lift; two locks and dams between Columbia and Turkey Hill, each with 13-foot lift; two locks and dams between Turkey Hill and Safe Harbor, each with 16-foot lift; two locks in flight at Holtwood, each with

25-foot lift; two locks in flight and dam at Conowingo, each about 32-foot lift; two locks and dams between Conowingo and Port Deposit, each with about 20-foot lift, making a total of 14 locks and 10 dams. Ten of the locks would be single and the remaining four in two flights of two each. The location indicated, lifts, etc., are merely approximate. This scheme would involve the expenditure of many millions of dollars, and it is evident on the face of it that neither the present nor reasonable prospective commerce alone would justify the project.

25. The total fall in the Susquehanna River from Harrisburg to the sea is 290 feet; of this head, probably 17 feet above York Haven and 15 feet in the vicinity of Port Deposit could not be economically developed for water power, considering it as a hydroelectric proposition alone, but as dams would be needed for navigation, the entire head of 290 feet will be considered as available for development. The minimum discharge of the river as already indicated is 2,300 feet per second; this small discharge, however, occurs very rarely, and the average discharge is 40,000 cubic feet. The following table shows approximately the total electric energy which could be delivered annually to the great tributary industrial centers assuming the whole river is fully developed and an efficiency at high tension terminals in distribution stations of 66⅔ per cent.

	Kilowatt-hour
Minimum year	2, 230, 000, 000
Average year	2, 913, 000, 000
Maximum year	3, 396, 000, 000

This includes existing and possible plants and assumes that existing plants will be acquired by the Federal Government. There seems a probability that a ready market would be found for this energy, both primary and secondary, in the cities of the Susquehanna Valley, at Philadelphia, Wilmington, Del., Baltimore, and Washington, where large steam reserves could be easily made available. Even at a very reasonable figure of 1 cent per kilowatt-hour the minimum annual return would be $22,300,000. With the existing high prices and scarcity of coal, a greater possible sale price does not seem unreasonable. The existing plant at Holtwood is constructed looking to the ultimate utilization of 32,000 cubic feet per second. The ponding of the entire river bed would justify probably the construction of plants capable of utilizing approximately 40,000 cubic feet per second. This would make the total horsepower of the turbines for the entire project approximately 1,000,000, allowing a small amount for loss of head due to slope.

CONCLUSION

In view of the foregoing, it is my opinion that the survey of this stream considering the interests of water-borne commerce alone is not justified. In view, however, of the probability of securing a reasonable return from the hydroelectric plants, which could be purchased or constructed in connection with the dams needed for canalization, I am of the opinion that this survey should be made under the direction of the Chief of Engineers.

J. P. JERVEY,
Colonel, Corps of Engineers,
District and Division Engineer.

[Second indorsement]

BOARD OF ENGINEERS FOR RIVERS AND HARBORS,
November 16, 1920.

To the CHIEF OF ENGINEERS, UNITED STATES ARMY.

1. It seems clear that the improvement of the Susquehanna River from Harrisburg to the mouth is not justified in the interests of navigation alone.

2. Whether or not the development of water power in connection with navigation would add sufficiently to the value of the improvement to warrant the undoubted large cost of the work can be determined only after survey and estimates of cost have been made.

3. In view of the increasing public interest in questions of practical water-power development, it is the opinion of the board that the problem here should be fully investigated, and it therefore concurs in the recommendation of the district engineer, who is also the division engineer, that a survey be made in order to determine the extent and advisability of the improvement. As the value of the power will depend on its marketability, this phase of the problem should be carefully developed by investigation in the tributary power-using centers of population. It is already known that the amount of primary power possible of development from the natural flow of the river is relatively small, and that the commercial value of any power development will depend on putting to use the large amount of secondary power which, in turn, will depend upon the availability of an adequate amount of auxiliary steam-generated power.

4. It is probable that any use by navigation of the portion of the Susquehanna River here under consideration will arise only as a consequence of an intensive industrial development of the territory close to its banks, so planned as to permit the use of the waterway under conditions of maximum advantage. This means that industries must be built up as near the river as possible so as to minimize the cost of transfer to and from vessels. Under such circumstances, considerable business to coastwise and foreign ports may become possible.

5. The survey report should cover the above points and include an expression of opinion as to the likelihood of the kind of industrial development above outlined. It should be made in such detail as may be necessary to afford general information as to the best type of improvement for the joint benefit of power and of navigation. While foundation conditions should be verified, it is unnecessary to make many borings or very elaborate researches, not is it desirable that any attempt be made to prepare definite plans for the structures involved.

6. The power possibilities of the Susquehanna River are of interest to the Federal Power Commission and the above views are based upon a conference with the engineer officer attached to that commission.

For the board.

H. TAYLOR,
Brigadier General, Corps of Engineers,
Senior Member of the Board.

SURVEY OF SUSQUEHANNA RIVER, PA. AND MD.

SYLLABUS

The prospective commerce on the Susquehanna River from Harrisburg to the mouth does not justify improvement for navigation even in conjunction with power development. A considerable portion of the hydroelectric power available in the river below Harrisburg can be profitably developed and marketed, but the projects that would be justified as commercial investments would not necessarily provide continuous slack-water navigation, even if locks were built at the dams. The development of the river for power purposes should be left to private enterprise under suitable safeguards to prevent such installations as will impair or destroy the possibility of providing navigation in the future.

WAR DEPARTMENT,
UNITED STATES ENGINEER OFFICE,
Baltimore, Md., November 1, 1923

To: The Chief of Engineers, United States Army
(Through the Division Engineer).

Subject: Survey of Susquehanna River, Pa. and Md., from Harrisburg to the mouth

1. The following report of survey of the Susquehanna River, Pa and Md., from Harrisburg to the mouth is submitted in accordance with instructions contained in letter,[1] from the Chief of Engineers, dated December 9, 1920.

SCOPE OF SURVEY

2. The scope of the survey was as recommended by the Board of Engineers for Rivers and Harbors in second indorsement dated November 16, 1920, on the report of preliminary examination. Not only has no attempt been made to prepare definite plans for the structures involved, but the character, location, and general layout of these structures have been determined only so far as was necessary to select what is believed to be the best type of improvement for the joint benefit of power and navigation, to ascertain that the plan proposed is feasible from an engineering standpoint, and to obtain a reasonable approximation of the cost. The magnitude of the project is such that more detailed studies and plans would involve very large expenditures.

3. The geography of the Susquehanna River valley is quite completely covered in the report of preliminary examination and no further description is considered necessary. The drainage area is shown on sheet No. 1[2] and the general plan and profile of the river from Harrisburg to the mouth on sheet No. 2.[2]

EXISTING DATA

4. Before field work was begun a canvass was made to secure all available data from previous investigations. Unusually complete information covering drainage areas, floods, and discharges of the Susquehanna River is contained in Water Supply and Irrigation Paper No. 109, United States Geological Survey, and subsequent papers of the same series; in the Water Resources Inventory Report of the Water Supply Commission of Pennsylvania; and in the records of the Pennsylvania Water & Power Co. No independent discharge measurements were made during this survey. In 1920 the work

[1] Not printed.

[2] Only sheet 5 printed in this connection.

known as the "Superpower survey" was begun under the direction of the Secretary of the Interior and with the collaboration of a notable array of engineering talent. The report of this survey was most opportunely published in 1921 as Professional Paper 123, United States Geological Survey, Department of the Interior, under the title, "A superpower system for the region between Boston and Washington," and contained information of the greatest value which has been freely used in connection with the preparation of the portions of this report dealing with the development, transmission, and utilization of the power available in the portion of the river under consideration. In the work of making the superpower survey the area between Boston and Washington, designated as the superpower zone, was separated into several divisions, one of which, the southern division, practically coincides with the area in which power generated on the Susquehanna River below Harrisburg can be economically marketed.

5. The data which had been gathered in making hydrographic surveys of the tidal portion of the river up to Port Deposit were on file in this office. The Susquehanna Power Co. had surveyed the section from Port Deposit to Holtwood with a view to hydroelectric development. The Pennsylvania Water & Power Co., owner of the hydroelectric plant at Holtwood, was in possession of quite complete information on the portion of the river extending upstream from their plant as far as Columbia. On the section from Columbia to Harrisburg only meager information could be obtained although some data were furnished by the York Haven Power Co. covering the vicinity of their plant at York Haven. The rail lines of the Pennsylvania system lie on the east bank of the river from Perryville to Shocks Mills and on both east and west banks from that point to Harrisburg. The vertical control of the survey was based on the Pennsylvania system's bench marks, which were everywhere available. The datum for these bench marks is mean tide at Sandy Hook and all elevations shown on survey drawings are referred to that datum. The elevations of bench marks are taken from the Pennsylvania Railroad Bench Mark Book, corrected to May, 1912. All of the corporations named above cooperated to the fullest extent in supplying information in their possession.

FIELD WORK

6. The field work of the survey was begun on April 18, 1921, and carried on until October 15, 1921, when it was suspended for lack of funds, to be resumed June 26, 1922, and completed August 17, 1922. Sixty-two cross sections of the river bed and banks were taken in the locations shown on Sheet No. 2. Topographical surveys of dam sites were made and the following areas subject to overflow for which no accurate maps could be obtained were also surveyed: East shore from Swatara Creek (mile 60) at Middletown to above Highspire (mile 64); east shore from Chickies Creek (mile 44) to above the Shocks Mills railway bridge (mile 50); and both shores in the vicinity of York Haven (mile 55). These cross sections and detailed surveys are not submitted with this report, but as they will be of value in all future investigations of the hydroelectric possibilities of the Susquehanna River, whether by the United States or private interests, they have all been plotted and traced and are

filed in this office. Airplane photographs [1] of the river valley from Harrisburg to the mouth were made by the Air Service, United States Army. These were assembled into mosaics in this office. The mosaics were rephotographed and prints are submitted herewith, the dam sites recommended being indicated thereon. The negatives of the original photographs are on file with the Air Service at Langley Field, Va., and the negatives of the photographs of the mosaics are filed at the Engineer reproduction plant, Washington Barracks, D. C. In addition to the survey operations described, data were collected relative to the character of material in the river bed and banks, the value of the land subject to overflow, flood heights, and existing bridges.

DRAINAGE AREA

7. The drainage area of the river at its mouth is 27,400 square miles and at Harrisburg 24,030 square miles. The drainage areas at intermediate points are shown in Table 1. This table is compiled from information obtained from Water Supply and Irrigation Paper No. 109 and other sources. For the locations marked with an asterisk actual figures were available, and at the other locations the values were obtained by interpolation, on the assumption that the drainage area decreases in proportion to the distance upstream. The table also shows the percentage of the drainage area at each place in terms of that at Holtwood, which is the point selected for the tabulation of discharges.

TABLE 1

Location	Miles from mouth	Drainage area, square miles	Per cent of drainage area at Holtwood
Harrisburg	69	24,030	89.8
Steelton (dam site)	66	24,130	90.1
York Haven	55	24,500	91.5
Shocks Mills (dam site)	49.5	24,910	93.05
Chickies	44	25,320	94.58
Turkey Hill	36	25,920	96.8
Safe Harbor (dam site)	33.2	26,120	97.5
Holtwood (dam site)	24.5	26,770	100
Conowingo (dam site)	12.2	27,040	101
Roberts Island (dam site)	6	27,220	101.7
Mouth	0	27,400	102.35

PRECIPITATION AND RUN-OFF

8. The following data covering precipitation and run-off in the Susquehanna Basin above Harrisburg for the 14 years, 1891–1904, are taken from Water Supply and Irrigation Paper No. 109.

TABLE 2

	Maximum	Minimum	Average
Mean annual rainfall, inches	44.3	31.4	39.4
Annual run-off, inches	29.1	16.6	21.6
Proportion of run-off (per cent)	71	49	54

[1] Not printed.

The run-off is a minimum in August, September, and October, during which months it ranges from 5 per cent to 30 per cent of the rainfall and averages about 15 per cent. Precipitation records for the years from 1905 to date are obtainable but have not been tabulated in convenient form and in view of the unusually complete discharge data discussed in the succeeding paragraph it has not been considered necessary to collect and compile them.

DISCHARGE

9. Complete and reliable records of the discharge of the river from 1891 to date are available. For the years 1891–1913 these are contained in Water Supply and Irrigation Papers Nos. 109, 167, 203, 241, 261, 281, 301, 321, and 351, and are given for a gaging station at Harrisburg for the entire period. During some of these years there were also gaging stations at McCalls Ferry (Holtwood) or at Cullys Falls (about 4,000 feet below Holtwood). As Holtwood is situated about midway of the stretch of river under consideration in this report, the flow data used as a basis for the report have been tabulated for that point. For those years when no discharges were measured at Holtwood, they have been obtained by multiplying the flows past Harrisburg by the coefficient 1.114. From 1914 to date the records of the Pennsylvania Water & Power Co. give the daily flows at Holtwood and these have been used. The maximum discharge for the 32-year period, 1891–1922, occurred May 22, 1894 and the minimum, December 11, 1909. These maximum and minimum flows are tabulated below, as are also the average for the 32-year period and the median flow, i. e., the minimum which occurred 50 per cent of the time.

TABLE 3

	Minimum, cubic feet per second (Dec. 11, 1909)	Maximum, cubic feet per second (May 22, 1894)	Average, cubic feet per second (1891–1922)	Median, cubic feet per second (1891–1922)
Harrisburg	2,000	543,500	39,272	21,364
Steelton	2,006	545,500	39,403	21,435
Shocks Mills	2,072	563,400	40,694	22,138
Safe Harbor	2,171	590,300	42,640	23,196
Holtwood	2,227	605,500	43,733	23,791
Conowingo	2,249	611,500	44,170	24,029
Roberts Island	2,265	615,800	44,476	24,195

10. Sheet No. 3 [1] contains a table analyzing the daily flows at Holtwood from 1891 to 1922, inclusive. The table shows the number of days in each year, the total number of days in the period, and the percentage of the total time that the discharge has been between the values shown in the first column, and also contains a summation of the number of days and the percentage of the total time that the discharge has been equal to or less than these values. On this same sheet are plotted curves showing the duration of various discharges for the maximum and minimum years and for the entire period.

11. Sheet No. 4 [1] contains the discharge rating curve for the Harrisburg gage of the Water Supply Commission of Pennsylvania as well

[1] Not printed.

as the daily discharge hydrograph for the period from April 10 to October 31, 1921, during which field work on the survey was in progress. Time and crest-relation curves for the river are also plotted on this sheet.

FLOODS

12. The most notable floods of the Susquehanna River during the past century are those of March 18, 1865; June 2, 1889 (the Johnstown flood); May 22, 1894; and March 8, 1904. The flood of 1865 was caused by the rapid melting of the large quantity of snow and ice which had accumulated during an unusually cold winter and was accompanied by ice gorges. The height on the Harrisburg gage is reported to have been 24.6 feet and the discharge at that point, 602,000 second-feet, which is probably an overestimate. The flood of 1889 was probably the greatest that has occurred on the Susquehanna since the settlement of the country. It was caused by severe rainfall over practically the entire drainage basin from May 30 to June 1. On the west branch of the river the average duration of the rainfall was 34 hours, during which 6.6 inches fell. It is estimated that the runoff reached the high figure of 75 per cent. As the flood occurred in the late spring, it was not accompanied by ice gorges, and thus may be taken as a typical clear-water flood. Various methods of estimating the maximum discharge have been used. It is stated in Water Supply and Irrigation Paper No. 109 that the most reliable estimate shows a discharge of 593,000 cubic feet per second at Harrisburg and 671,000 cubic feet per second at Holtwood. The flood of 1894 is estimated to have caused a discharge of 543,500 second-feet at Harrisburg and 605,000 second-feet at Holtwood. It is reported that its crest was from 2 to 3 feet below that of the 1889 flood at the latter point. The flood of 1904 was remarkable for the amount of damage caused by ice. The ice broke up in January of that year when there was not enough water behind it to force it downstream. Gorges formed at various points and solidified during the extremely cold weather of February. There were heavy rains on March 6 and 7 and on the morning of March 8 the flood began to force the ice barriers. The gorge at Highspire broke, then formed again successively at Bainbridge, Turkey Hill, and Shanks Ferry. After the flood subsided blocks of ice from 3 to 10 feet in thickness were found on the shores. The maximum height of the water at York Furnace was about 3 feet higher than during the flood of 1889, a mile above McCalls Ferry it was about the same, at McCalls Ferry it was 3 feet lower, and at Cullys Falls it was again the same. The estimated discharge at Holtwood momentarily reached 631,000 second-feet although this was in the nature of a wave. Within half an hour the water had fallen 2 to 3 feet. The ice conditions accompanying this flood were probably as severe as any that will ever affect hydroelectric plants.

13. Part VIII of the Water Resources Inventory Report of the Water Supply Commission of Pennsylvania contains records of flood discharges at Harrisburg for the period 1874 to 1890. By multiplying these discharges by 1.114 and combining them with the discharges tabulated on Sheet No. 3 a record covering floods at Holtwood during

the 49 years from 1874 to 1922 is obtained which is summarized below:

TABLE 4

Discharge second-feet	Number	Equivalent
300,000 to 400,000	33	Once in 1.5 years.
400,000 to 500,000	10	Once in 4.9 years.
500,000 to 600,000	2	Once in 24.5 years.
600,000 to 700,000	2	Do.

A total of 47 floods occurred during the period, indicating that on the average a discharge in excess of 300,000 second-feet may be expected once a year.

FOUNDATION CONDITIONS

14. While no borings have been made as part of the survey, it is not believed that any difficulty will be encountered in securing suitable foundations for locks and dams. From Columbia to the mouth the river flows in a deep valley over a rocky bed which is largely exposed at low water and appearances indicate that satisfactory foundations can be obtained at practically any site by stripping off the overlying earth and loose rock. There has been no evidence of leakage at the Holtwood Dam, which is built largely on a gneiss which was considered too soft for use in concrete. Foundations at the Conowingo dam site have been investigated by core drilling by the Susquehanna Power Co. Five holes were drilled, some being as deep as 40 feet. The rock encountered throughout was granite without serious cracks or seams. Additional investigations are now being carried on at this site by the Susquehanna Power Co. under a preliminary permit from the Federal Power Commission.

BRIDGES

15. Nine bridges cross the river between Harrisburg and the mouth. Of these only two, the Pennsylvania Railroad bridge and the highway bridge at the mouth, are drawbridges. They have swinging draws affording clear horizontal openings of 100 feet. The principal information relative to the nine bridges mentioned is tabulated on the following page.

TABLE 5

Miles above mouth	Owner	Type	Span (c. to c. of piers)	Total length of bridge	Elevation above mean sea level [1]		Clear height above pool at channel [1]	Clear horizontal opening at channel	Use	Remarks
					Maximum	Minimum				
			Feet	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*		
1	State (Maryland)	Swing [2]	1—310 1—204 1—261 1—167 1—259 2—136 7—258	3,282	26.5	26.5	[3] 26.5	100	Highway	Steel truss, built 1862–1866.
1	Pennsylvania R. R	do	8—260 1—196 7—200 2—140 1—197	4,153	52.9	19.5	52.9	100	Double track railroad	Steel truss, built 1906.
2	Baltimore and Ohio R. R	Fixed	2—520 21— 90 1—300 1— 80 9—240 1— 77 1—119 1— 72 1—114 1— 70 1—103	6,106	88.5	25.0	88.5	500	do	Steel truss, built 1884–1886. Rebuilt 1906–1910.
11.8	State (Maryland)	do	2—206 1—162 3—200 2—137 1—164 2—107	1,826	63	63	18	190½	Highway	Steel and wood trusses.
42.4	Pennsylvania R. R	do	25—198 1—191 1—148	5,289	254.7	246.6	6.6	178	Highway and single track railroad.	Steel truss, rebuilt 1917.
49.9	do	do	6— 83 20— 78 2— 74	2,209	290	290	3	70	Double track railroad	Stone arch, built 1903–4.
69	Philadelphia & Reading R. R	do	44— 76 2— 70	3,496	363.8	341.4	45.4	66	do	Concrete arch, now being rebuilt.
69.2	Pennsylvania R. R	do	23— 88 22— 85 1— 83	3,995	344	326.8	30.8	74½	do	Concrete arch, built 1915–16.
69.4	Harrisburg Bridge Co., Harrisburg, Pa.	do	32— 89	2,859	324.4	317.8	28.4	80	Highway	Half through girder, built in 1813, rebuilt 1917.
69.5	Peoples Bridge Co., Harrisburg, Pa.	do	3—240 12—175	2,820	319.7	319.7	23.7	232	do	Steel truss, built in 1889.

[1] For bottom chord of trusses and top of arch for stone or concrete bridges.

[2] Clear opening through draw, 100 feet.

[3] With draw closed.

EXISTING DEVELOPMENTS

16. Two hydroelectric developments are in existence on the main river below Harrisburg. These are the plants of the Pennsylvania Water & Power Co. at Holtwood and the York Haven Water & Power Co. at York Haven. The following descriptions of these developments are taken from Part VII, Water Resources Inventory Report of the Water Supply Commission of Pennsylvania (1917). Views of the plants from the air are shown on sheets 5 and 11 [1] of the aerial photographs submitted herewith.

PENNSYLVANIA WATER & POWER CO.

This development is at Holtwood, about one-half mile below McCall Ferry and 26 miles above the mouth of the river. It is the largest hydroelectric plant in the State, and supplies power to Baltimore, 40 miles south, and Lancaster, 15 miles north. It is reached by the Columbia & Port Deposit Branch of the Pennsylvania Railroad, which follows the east bank of the Susquehanna from Columbia to the mouth.

The importance of power possibilities in this vicinity have long been known, and numerous charters have been obtained by corporations aiming to develop the power. All of these active at the time were taken over by the McCall Ferry Power Co., incorporated in 1905, which also bought the real estate and rights of the Columbia & Tidewater Canal (an abandoned waterway), so far as these affected the project, and began construction in October, 1905. In the financial panic of 1907 this company went into the hands of receivers and construction ceased, but in the fall of 1908 was resumed by the receivers. The company was subsequently reorganized as the Pennsylvania Water & Power Co. and now operates the plant which is not yet completed, although power delivery began from one unit in October, 1910. Eight of the projected ten units are now in operation, the last having been installed late in 1914, and the others will be installed as the power demand increases.

The Susquehanna at the point of development flows through a narrow valley bordered by steep hills. It has a rate of fall of 5.4 feet per mile, much greater than the average of the river. Another feature of the site is the presence of islands in the river which lowered the cost of dam and tailrace construction.

The maximum discharge used up to the present by seven units has been 18,000 second feet. At present the average consumption is about 10,000 second feet, but with all the units installed it is expected that an average peak consumption of 24,000 second feet will be reached when this quantity is available.

The dam is a monolithic spillway structure, of ogee section, built of 1:3:5 concrete with a small proportion of "plum" stones, and placed on solid rock, the foundation being gneiss with streaks of quartz and schist. The width at base is 65 feet and the maximum height is 65 feet although the average height in the channel is 55 feet and is materially diminished over Fry Island. The crest elevation is 165 feet and the length of the crest 2,368 feet.

The dam floods 3.95 square miles, with the pool at elevation 165 feet while at elevation 169.5 feet, to top of flash boards, the area submerged is 4.77 square miles. Elevation 160 feet is taken as the lower limit of pondage, and the storage between that elevation and 165 feet is computed to be 614,000,000 cubic feet; while between 165 and 169.5 feet it is 1,047,000,000 cubic feet, which would supply 12,100 second-feet for 24 hours. The storage possibilities are practically limited to the daily regulation of flow in dry season. The backwater extends to the valleys of the Conestoga and Pequea Creeks, and the power plants on these streams are said to have felt its influence at times of heavy flood.

The plant has no headrace, but has a large forebay, which is chiefly of value as a feature of the protection against ice troubles.

The power house is a massive concrete structure, placed at an angle of 42° with the axis of the dam, its dimensions being about 500 by 200 feet. The principal parts are the gate house, the generator room and the transformer house, the last being largely occupied by switches and offices.

In the generator room are eight units, operating under 54-foot head, with the pool elevation at 165 feet. All are double runner, vertical shaft turbines except

[1] Not printed.

the eighth unit. Five have runners 105.5 inches diameter and operate at 94 revolutions per minute, each wheel being rated at 13,500 horsepower under 53-foot head. The sixth and seventh have runners of 97.5 inches diameter and are rated at 17,000 horsepower under 62-foot head. The eighth unit has a single runner and is rated at 16,500 horsepower under 63-foot head.

Nos. 1, 2, and 3 generators are of 7,500 kilowatt capacity; Nos. 4 and 5 of 10,000 kilowatts, while Nos. 6, 7, and 8 are rated at 12,000 kilowatts, all generating 3-phase current at 11,000 volts and 25 cycles. Two exciter sets, each of 750 kilowatts are driven by water turbines of 1,000 horsepower, and there is also one motor-driven exciter of 500-kilowatt capacity, all operating at 240 revolutions per minute and 250 volts. Thorough provision for excitation has been made, largely in anticipation of ice troubles.

The plant has unusually good ice protection. The upstream end of the fore bay is formed by a rock fill extending out from the shore 500 feet, downstream from the end of which is a floating timber boom with a vertical face 5 feet deep; this is 240 feet long and is supported at the ends by two massive concrete piers. Between the boom and the junction of the dam and power house are three submerged masonry arches through which water enters the fore bay, these being so proportioned as to limit the velocity through them to 4 feet per second. No floating ice has ever passed into the fore bay from the river, but should this occur, provision is made for its disposal by three ice chutes at the shore end of the power house. To prevent ice from entering the screen room, submerged masonry arches are provided along the entire length of the building; such ice and débris as passes this skimmer can be discharged through two ice chutes within the limits of the structure. The latter has never been used for the passage of ice and the former only to dispose of ice formed in the fore bay.

The tailrace, 150 feet to 250 feet wide, and about three-quarters of a mile long, was formed by deepening the natural channel east of Piney Island and necessitated the removal of about 150,000 cubic yards of material. A wall from the junction of the dam and power house downstream to Piney Island closes the upper end of this channel.

Three-phase current is transmitted at 70,000 volts to Baltimore and Lancaster. An additional tower line to Baltimore, parallel with the original line, is under construction. Elaborate protection against lightning has been made.

The present customers are the Baltimore Consolidated Gas, Electric Light & Power Co., the United Railways & Traction Electric Co., of Baltimore, and the Edison Electric Co., of Lancaster. All these have steam power available for use when low stream flow seriously curtails the output of the plant.

The annual report of the Pennsylvania Water & Power Co. for 1922 states:

So great has the demand for energy become that your company, which has made no major additions to its generating capacity since 1914, now feels it expedient to consider the advisability of installing two additional generating units at Holtwood * * *.

The present plans of the company are for two new turbines rated at 20,000 horsepower each at 62-foot head. The discharge from these turbines will increase the height of tail-water, thus cutting down the output of the existing units so that the net estimated increase in output after the new installation is complete is 30,000 horsepower, making the total station capacity about 140,000 horsepower. The new units are to generate current at 60 cycles. Transmission lines are to be built to York and Coatesville, Pa., to permit the sale of energy to the Edison Light & Power Co. and the Chester Valley Electric Co., respectively. These lines will be designed and insulated for 110,000 volts but will be operated at the start at 70,000 volts.

YORK HAVEN WATER & POWER CO.

This plant at the borough of York Haven, on the west bank of the Susquehanna River, is the second largest hydraulic station in the State. It is about 13 miles from York and 15 miles below Harrisburg and supplies power to both cities.

The company was incorporated January 16, 1895, for the supply of water and power to the public in the borough of York Haven, and construction was begun about 1901. It was nearly completed in March, 1904, when a heavy ice flood wrecked the power house and necessitated reconstruction. The plant was placed in operation September, 1904, with 10 units, which number has since been doubled.

The power site is at Conewago Falls, where the river has a descent of about 23 feet over a series of rapids within a distance of three-quarters of a mile. This rate of fall exceeds the general slope of the river, which is about 5 feet per mile, both above and below the falls. The site was previously used by the York Haven Paper Co., which still holds a preferential right to a portion of the water. Its mills adjoin the power station and draw water from the race.

Just above Conewago Falls is a large island known as Three-Mile Island, and the principal channel of the river is on the west side of this. A long diversion dam extends from the island diagonally across and down the stream to the headrace; the channel east of the island is closed by a dam. The power house lies parallel with the shore, and water passes through it from the headrace directly into the river below the rapids.

The diversion dam is about 3,300 feet long. A length of 1,400 feet was built prior to 1904, extending part of the distance from the headrace to the island. This was a timber-crib structure resting upon bed rock, and has since been reinforced on the lower side with a heavy concrete wall. After the plant was in operation, the dam was extended to the island, and this portion of the structure, built of stones and bowlders, was covered both upstream and down stream with concrete. This arrangement completed the diversion of the water in the west channel during low stages. Most of the dam is quite low, especially the newer construction, and the older portion probably does not exceed 16 feet in maximum height. The headrace, about 3,000 feet long, is formed by a heavy masonry wall parallel with and about 500 feet from the west shore. The wall varies in height from 18 feet to 39 feet, and is of substantial masonry, chiefly large blocks of trap rock laid in Portland cement mortar. It has received severe treatment from ice and other floods without material damage.

The power house is a brick structure upon concrete and masonry foundations, 450 feet by 50 feet, and contains 20 generator and 2 exciter units. Each main unit consists of two vertical shaft turbines, geared to a horizontal shaft, which is coupled direct to an alternating-current generator of the induction type. The turbines, built after designs of the Escher-Wyss Co. of Switzerland, are 78.5 inches in diameter, rated at 613 horsepower under 22 feet head and 80 per cent gate, and at the same power under 19 feet head and full gate. The generators are of 750 kilowatts each, and produce current at 60 cycles and 2,300 volts. The wheels are mounted in a concrete flume, with a rectangular, hand-operated steel gate at the entrance, and vertical steel draft tubes lead to tail-water. Each exciter is driven by a single 62.5-inch turbine rated at 415 horsepower under 22 feet head and 80 per cent gate.

This plant has suffered great damage from ice. Anchor ice has occasionally choked the turbines and more frequently floating ice has clogged the headrace so as to diminish the available water. A continuous set of racks, formed of heavy steel bars, keeps floating ice out of the wheel chambers and also catches drift and trash. The heavy masonry wall terminating the headrace and connecting the power house with the shore, has no effective spillway and floating ice is pocketed between the power house and the shore. This condition resulted in the practical demolition of the power house in 1904, and a spillway for the passage of ice is under consideration.

Operation is controlled from switchboards above the generating floor and supported by the roof trusses. From the switchboard the current passes through cables in a gallery over the boundary wall to the transformer house on the shore. Here the voltage is stepped up to about 22,000 for transmission to Harrisburg, Middletown, Steelton, and York. Some current is supplied locally direct from the switchboard and a small line supplies the village of Mount Wolf, about 4 miles distant. Control is secured by compensating governors applied to 9 of the 20 units, the others are hand-regulated according to directions of the operator.

The principal market is in and around the city of York, where are supplied the Edison Light & Power Co., the Merchants Electric Co., and the York Railways Co. In addition, there is a large commercial load, mainly in York. Under agreement, the Edison Light & Power Co. maintains a steam plant of sufficient capacity to supply auxiliary power during low water.

Subsequent to the date of this description, the crest of the dam across the east channel of the river between Three Mile Island and the mainland has been raised to elevation 278.2 and openings for the passage of ice have been made in the headrace wall.

17. The city of Harrisburg has constructed a sanitary dam with the crest at elevation 292 at mile 68.8 to form a pool opposite Harrisburg. If the river were improved for navigation it would be necessary to remove a portion of this dam.

METHOD OF IMPROVEMENT

18. There is little choice in the method of improvement to be adopted. The rocky river valley and bed, the steep slope, and the small low water discharge render open channel regulation out of the question. The lateral canal which once provided navigation from Havre de Grace to the New York State line has been abandoned for many years. Its restoration would be an expensive and difficult proceeding and even if restored the number of locks necessary would be an effective obstacle to its use in competition with the railway lines which parallel the stream. Furthermore, neither open channel improvement nor a lateral canal will enable full use to be made of the available water power and any improvement for navigation which is not coordinated with water power development to the fullest possible degree will involve expenditures out of all proportion to the resulting benefits. The only method of improvement worthy of consideration is by locks and dams.

DIMENSIONS OF LOCKS AND CHANNELS

19. In determining the dimensions of channels and locks to be used as a basis for estimates the two governing factors are the dimensions of interconnecting waterways and the most economical size for vessels which would use the improvement. The Susquehanna River is a tributary of Chesapeake Bay and natural depths of 15 feet can be carried to the mouth of the river. It is not considered probable that traffic navigating the stretch of river under consideration would proceed by coastwise routes to or from Atlantic ports when it can use the protected chain of inland waterways stretching from Delaware Bay to the sounds of the Carolinas, of which Chesapeake Bay is one of the most important links. The northern outlet from Chesapeake Bay is by the Chesapeake & Delaware Canal, which has recently been purchased by the United States and is to be converted, under the project adopted by Congress, into a sea-level canal 12 feet deep and 90 feet wide at the bottom. The present controlling dimensions are those of the locks which are 220 feet long, 24 feet wide, and 9 feet deep over the sills. The principal protected outlet from Chesapeake Bay to the south is the Albermarle & Chesapeake Canal for which a depth of 12 feet and a width of 90 feet has been adopted. This is a sea-level canal and is the property of the United States. The privately owned Dismal Swamp Canal affords an additional connection from the southern end of Chesapeake Bay, its navigable capacity being determined by the locks which are 250 feet long, 39 feet wide, and 9 feet deep.

20. There is a considerable diversity of opinion as to the proper size and type of vessel to provide economical transportation in inland waterways and a strong tendency to cling to local variations in type. The canalized portions of the upper Ohio River resemble the Susquehanna below Harrisburg. The governing consideration in determining the dimensions of the locks on that stream has been the easy passage of tows of coal barges and neither the towboats nor the tows in use on the Ohio could navigate Chesapeake Bay with safety. The sizes of the locks now being built on the Ohio and its tributaries and on certain other canalized streams are shown below:

TABLE 6

	Length (feet)	Width (feet)	Normal depth over sills (feet)	
			Upper	Lower
Ohio River	600	110	15.4	11.0
Allegheny River	360	56	8.0	8.0
Monongahela River	360	56	10.0	10.0
Tennessee River	265	60	6.5	6.5
Black Warrior River	285.5	52	8.5	8.5

The locks of the New York State Barge Canal are 328 feet long, 45 feet wide, and 12 feet deep over miter sills. The special board of engineer officers which reported on the intracoastal waterway stated on page 80 of the report published in House Document No. 391, Sixty-second Congress, second session, that it was the general opinion of commercial bodies that channels should be of sufficient size to be navigated by vessels of from 2,000 to 3,000 tons capacity.

21. After consideration of all available information it has been decided to adopt as a basis for estimates a project for the Susquehanna River calling for channels 200 feet wide and 9 feet deep at normal pool heights with locks 315 feet long, 60 feet wide, and 12 feet deep over miter sills. Such a project would provide 9 foot navigation at the outset and the locks are of sufficient size to pass on 8-foot draft with suitable clearances a barge having a net capacity of 3,000 tons as well as steamboats of the general type now being used on Chesapeake Bay. Should the growth of traffic later justify it, a navigable depth of 12 feet can be provided by deepening by 3 feet the relatively short lengths of excavated channel at the upper ends of the pools. The 200-foot channel width adopted is considered necessary because the channels will have rock sides which would prove disastrous to any vessel which came into contact with them.

LOCATION AND HEIGHT OF DAMS

22. As is stated in the report of preliminary examination, it is apparent that neither present nor prospective commerce alone will justify the improvement of the stream and that the development of navigation, if feasible at all, must be closely coordinated with the utilization of the available hydroelectric power. It is also obvious that the most economical hydroelectric development will result from the construction of a small number of plants of the largest capacities and highest heads that can be secured without prohibitive costs in

the way of flowage damages and railroad relocations. Once the number and location of the dams have been determined, the crest heights and pool heights can be varied within reasonable limits so as to reduce channel excavation for navigation to a minimum, without injurious effect upon power development. This is because the section of river under consideration is to be pooled throughout its length and the head lost at any dam, under ordinary conditions of flow, due to raising the pool below, will be approximately compensated for by the gain in head at the next plant downstream. The only portion of the total head between tidewater and elevation 287 which is not used for power development is that lost due to the slope in the pools

23. In determining dam locations and pool heights, the river is divided into two sections by the existing dam and pool at Holtwood (see sheet No. 5). In the section below Holtwood there must necessarily be a dam at or near the head of tidewater and another at Conowingo, which is conceded by all who have investigated the subject to be the most favorable remaining site on the river for hydroelectric development. To take advantage of the possibilities of the Conowingo location the dam there must have a crest elevation of at least 100. By the use of gates the pool elevation can be raised to a height sufficient to provide navigable depths to Holtwood. This increase in pool height will require little additional railroad relocation above Conowingo beyond what is necessary for a dam without gates and with crest at elevation 100, for the reason that the flood flow over such a dam would rise to approximately elevation 116. The advantages resulting from the added head of 20 feet due to gates will overcome the additional cost of the gates and of relocation. There will be a loss of head due to increased height of tailwater at Holtwood which, however, will be compensated for by the increase in the elevation of the Holtwood pool that is necessary to extend navigation to the next dam site upstream. Having decided upon a single dam at Conowingo the only remaining question to settle in the section of the river below Holtwood is whether there shall be one or two dams between tidewater and that point. From the viewpoint of ecomonical power development, the advantage of a single plant with an available head of about 42 feet over two plants with heads aggregating that amount is obvious. The principal drawback to a single dam is the difficulty of relocating the Columbia and Port Deposit branch of the Pennsylvania Railroad in and near the town of Port Deposit. The Susquehanna Power Co., which has had the development at Conowingo under consideration for several years, had an agreement with the Pennsylvania Railroad covering necessary relocations in which a maximum grade of 0.3 per cent was specified. The agreement expired by limitation in 1913 but probably indicates the maximum grade to which the consent of the railroad company could now be secured. With a dam at head of tidewater with crest at elevation 36 and gates providing a pool at elevation 45, the railway at this point would have to be raised to elevation 52. To attain this elevation with a grade of 0.3 per cent requires 2½ miles of relocation below the dam and the raising of grade through the town of Port Deposit by about 25 feet. The railway and a portion of the town lie in a contracted area between the river and steep rocky cliffs and the right of way needed for embankments of the size necessary to secure the desired elevation would require the acquisition of much of the low-

lying land. There are buildings on the top of the hills and side-hill cutting would be extremely expensive. A viaduct involves the necessity for maintenance and is undesirable for that reason. Both the railway and the town are now subject to overflow under flood conditions and the raising of the railway line would be a positive benefit. If the necessary real estate could be secured at a reasonable figure the relocation on a fill would not be unduly expensive. A possible alternative would be to carry the railway across to the west shore of the river on the top of the dam and to connect with the main line at Havre de Grace instead of at Perryville as at present. In any event the advantages accruing from the construction of a single dam at tidewater far outweigh the disadvantages.

24. For providing navigation from the pool at Holtwood to Harrisburg several plans have been considered and studied. It was first decided to raise the Holtwood pool to elevation 175 by gates installed on the top of the present dam. This gives navigable depths to the vicinity of mile 33 where a suitable dam site is situated. Comparative estimates were then made of the cost of reaching Harrisburg by five different projects as follows:

TABLE 7

Project	Number of dams	Location	Type	Pool elevation	Comparative cost
No. 1	2	Mile 33.3	Fixed	234	$27,500,000
		Mile 48.7	do	295	
No. 2	3	Mile 33.3	do	234	28,300,000
		Mile 48.7	do	287	
		Mile 66.0	Movable	296	
No. 3	3	Mile 33.3	Fixed	229	31,200,000
		Mile 43.7	do	255	
		Mile 55.9	do	296	
No. 4	4	Mile 33.3	do	232	31,500,000
		Mile 48.7	do	260	
		Mile 55.9	do	290	
		Mile 66.0	Movable	296	
No. 5	5	Mile 33.3	Fixed	224	36,600,000
		Mile 41.0	Movable	232	
		Mile 48.7	Fixed	255	
		Mile 55.9	do	290	
		Mile 66.0	Movable	296	

The amounts shown in the last column above are comparative and not total costs, as the items common to all projects have been omitted from the estimates. Project No. 1 shows the cheapest first cost but investigation disclosed that to secure a pool height of 295 by a dam at mile 48 7 with the highest practicable gates on the crest would, under extreme flood conditions, cause backwater which would do extensive damage at Middletown and vicinity. Project No. 2 was therefore adopted as the basis for this report. After further study it was found desirable to modify this project by raising the pool above the dam at mile 33.3 to elevation 240 and by moving the next dam upstream from mile 48.7 to mile 49.5. The reasons for these changes are discussed in detail hereafter. The advantage of projects 1 and 2 over projects 3, 4, and 5 is even greater than shown by the comparative costs, due to the fact that large items to cover flowage damages and railroad relocations in 1 and 2 will enter into first cost only and will not involve annual charges against navigation and power production for operation, maintenance, and depreciation.

REGULATING GATES

25. The use of gates on the crest of the fixed dams is considered essential and is provided for in the plan of improvement submitted. The purpose of these gates will be to pass floods and to regulate pool heights at flows in excess of the capacity of the turbines. Their adoption is disadvantageous in introducing an initial outlay for installation and annual charges for operation, maintenance, and depreciation. However, these charges are more than overbalanced by the saving resulting from the decreased number of dams required when gates are used and the shorter length of spillway which is requisite on those which are constructed. To improve the river for navigation by means of fixed dams without regulating devices it would be necessary that the dams be located at the widest sections of the river in order to secure sufficient length of spillway to pass floods without excessive backwater. The maximum discharge to be expected has been taken as equal to that accompanying the flood of June 2, 1889, and the resulting flows at each of the five fixed dams together with the heights of water above the dams with all gates fully open are shown below:

TABLE 8

Location	Maximum flood discharge, second-feet	Elevation of crest of dam	Elevation of water at dam
Shocks Mills	626,000	267	283.0
Safe Harbor	654,000	215	232.3
Holtwood	671,000	165	183.7
Conowingo	678,000	100	118.0
Roberts Island	683,000	36	50.2

The gates vary in height from 25 feet at Safe Harbor to 9 feet at Roberts Island. No effort has been made to design machinery or structures in detail but the estimates are based on the use of Stoney gates affording a clear opening of 65 feet supported by concrete piers 10 feet thick spaced 75 feet, center to center. Gates of this type 46 feet 3½ inches long from center to center of bearings and 19 feet high were successfully used on the Gatun spillway of the Panama Canal and Stoney gates 25 feet high affording a 65-foot clear opening were proposed for use on the crest of a dam at Great Falls, Potomac River, by Mr. Clemens Herschel in a report contained in House Document No. 1400, Sixty-second Congress, third session. There is no ice to cope with in Panama, but ice conditions in the Susquehanna and the Potomac will probably be about equally severe. In making final designs very careful consideration would have to be given to the protection of the Stoney gates against damage by ice. Tunnels for operating machinery similar to the one used in the Gatun spillway dam are proposed for all fixed dams in this project except the one already constructed at Holtwood where the operating machinery would be placed on a bridge above the dam.

26. Neglecting the movable dam at Steelton the minimum lift is 42.33 feet (at mean tide) at Roberts Island, and the maximum, 75 feet at Conowingo. Two locks are used at each fixed dam except at

Conowingo where three are included in the project. The normal lift per lock varies from a minimum of 21.2 feet (at mean tide) to a maximum of 32.5 feet.

27. The principal characteristics of the plan of improvement proposed exclusive of the electrical installations are shown below:

TABLE 9

Location of dams	Roberts Island	Conowingo	Holtwood	Safe Harbor	Shocks Mills	Steelton
Distance from mouth, miles	6.0	12.2	24.5	33.2	49.5	66.0
Length of cross section at pool elevation, feet	4,960	3,230	3,280	3,360	4,040	2,020
Length of spillway less gate piers, feet	3,250	2,210	2,080	2,275	2,470	1,902
Elevation of crest of dam, feet	36	100	165	215	267	[1] 278
Height of gates, feet	9	20	10	25	20	18
Number of gates	50	34	32	35	38	0
Elevation of upper pool, feet	45	120	175	240	287	296
Total lift at normal pool heights, feet	[2] 42.33	75	55	65	47	9
Number of locks	2	3	2	2	2	1
Lift per lock, feet	21.16	25.0	27.5	32.5	23.5	9.0

[1] Sill of navigable pass. [2] Above mean tide.

ELECTRICAL DEVELOPMENTS

28. Estimates for the electrical developments are based on an ultimate installation at each power dam except Holtwood capable of utilizing, with full gate openings, a maximum of 40,000 second-feet. At Holtwood, where space for two additional 20,000 horse-power units is provided in the exisiting power house foundations the maximum capacity of the turbines will be about 29,000 second feet. Six units are to be installed at each of the other four power developments, a unit consisting of a vertical shaft, single runner, spiral case turbine with direct connected alternating current generator. One unit is considered as a spare. Three motor-driven exciters are included for each plant. The estimates provide for all apparatus up to and including the main switchboard but do not include transformers and high tension busses and switches which are considered as transmission equipment and would be placed in a separate building or out of doors. The proposed power houses are each 500 feet long by 160 feet wide and have inclosed gate houses to facilitate winter operation. On account of the success of the features embodied in the Holtwood plant of the Pennsylvania Water & Power Co. for protection against ice, all of the tentative layouts submitted herewith include a rock fill on the upstream side of the forebay and a concrete wall with submerged arches extending downstream from the outer end of the rock fill. Floating ice from the main river will be kept out of the forebay and any ice which forms therein will be disposed of through ice chutes. To reduce the amount of rock excavation in the lower approach channels and tail races to a minimum the locks at each power development excepting at Shocks Mills have been located on the land side of the power house and the outer guidewalls extend beyond the forebay without opening into it. The effect of suction in the upper pool approaches is thus avoided. At Shocks Mills the location to accomplish the same result is found near the middle of the spillway. On the downstream side of the dams at Conowingo, Holtwood, and Safe Harbor it is necessary in order to avoid

excessive excavation to use the same channel as an approach to the locks and a tailrace. The turbines at each plant discharge into slack water and it is not believed that excessive currents will be caused in the lower approaches to the locks but to minimize this objectionable feature the locks and lower river walls have been extended downstream as far as practicable. The following table shows the generating capacity which it is proposed to install ultimately at each power plant.

TABLE 10

Location	Average head available, feet	Ultimate installed capacity, horsepower
Roberts Island	[1] 42.3	154,000
Conowingo	75	273,000
Holtwood	55	[2] 140,000
Safe Harbor	65	236,000
Shocks Mills	47	171,000

[1] At mean tide. [2] Present installation to be increased by two 20,000-horsepower units.

ROBERTS ISLAND

29. The location of the dam at Roberts Island was determined after consideration of the various features affecting its cost. Due to the width of the river in this locality a long dam can not be avoided. Moving downstream decreases the length of lower approach channel to be excavated but increases the cost of railroad relocation through the town of Port Deposit. The location selected is on the most economical section that could be used while maintaining a reasonable balance between these items. The dam crosses Roberts and Wood Islands and the presence of these islands reduces the amount of concrete therein. Steels Island near the eastern shore forms a natural barrier between the tail race and the approach to the lower lock and will prevent disadvantageous currents in the latter. The dam crest is placed at elevation 36, and gates 9 feet high are used to maintain the pool at elevation 45. With the crest at elevation 36 a flood discharge of 682,407 second-feet will raise the upper pool at the dam to 50.2. Such a flood will occur only at very long intervals and, due to the character of the river valley from Roberts Island to Conowingo, the resulting high water will not cause excessive damage. The general features of the dam, power plant, and locks are shown on sheet No. 6. The necessary relocation of the Columbia & Port Deposit branch of the Pennsylvania Railroad through Port Deposit and above the dam to Conowingo has been discussed in paragraph 23. The Octararo branch of the Pennsylvania Railroad will also have to be relocated for a distance of about three-fourths of a mile from its junction with the Columbia and Port Deposit branch at Octararo. The dam will form a pool about 6 miles long which is crossed near its upper end by the existing highway bridge at Conowingo. With the pool at elevation 45 the clearance under this bridge is 18 feet and a draw would be necessary.

CONOWINGO

30. The Conowingo dam is located at the head of a deep gorge in the river known as Jobs Hole, which forms a natural tailrace and approach channel. This site has been under investigation with a view to power development since 1907. The bulk of the work of preliminary investigation has been carried on by the Susquehanna Power Co., which has obtained a preliminary permit from the Federal Power Commission dated August 3, 1923, covering the construction of a dam and power plant at Conowingo. The crest of the dam which the company proposes to build is to be at about elevation 103 without regulating gates, and the application for the preliminary permit states that it is intended to install ultimately turbines capable of using flows up to 50,000 second-feet and generating 360,000 horsepower.

31. The Conowingo site is considered the best on the river from the standpoint of power development. The general layout proposed for dam, power plant, and locks is shown on sheet No. 7, and is quite similar to that proposed by Messrs. Sanderson & Porter, consulting engineers, in a report to the Susquehanna Power Co., dated January 11, 1919, except that that report made no provision for locks or for regulating gates. The fixed crest of the dam is at elevation 100, and 34 gates 20 feet high are provided which, when fully opened, will pass the maximum flood of 678,000 second-feet with the water surface at elevation 118 above the dam. Extensive railroad relocation is involved which, however, can not be avoided if the advantages of the site are to be utilized. The highway bridge belonging to the Maryland State Roads Commission, which was mentioned in paragraph 29, crosses the river some 2,000 feet below the dam and it is reported that consideration is being given to its reconstruction. If the dam were built the highway could readily be carried across on top of the gate piers, but the plans and cost estimates in this report do not provide for doing so. The dam will form a pool approximately 12 miles long with an area of about 11 square miles and will provide slack water navigation to Holtwood. There are no bridges on this section.

HOLTWOOD

32. The existing power plant at Holtwood has already been described in paragraph 16. The clear length of spillway on the dam is now 2,368 feet. By making a slight extension on the western end 32 gates can be installed, taking up a total length of 2,400 feet and providing clear openings less piers totaling 2,080 feet. The flood discharge of June 2, 1889, amounting to 671,000 second-feet, could then be passed with the water surface above the dam at elevation 183.7. By allowing 30,000 second-feet to pass through the penstocks this elevation would be reduced to 183. The present elevation of the Columbia & Port Deposit branch, Pennsylvania Railroad, at Holtwood station is 183. As the discharge of 671,000 second-feet has occurred but once in the last 60 years it is not considered necessary to raise the grade of the railroad at and above the dam. The locks are located on the eastern shore, with the lower approach in the present tailrace. The wing wall which now extends from the eastern end of the spillway to Piney Island ceases to serve any useful purpose when the water level below the dam is raised by the dam at Conowingo and it is proposed to remove the wall in order to permit free discharge from the turbines

into the lower pool and to avoid excessive currents in the lower approach. The location selected for the locks requires the relocation of about 1,800 feet of railway. Operating machinery for the regulating gates will be installed on a bridge above the dam, due to the impracticability of constructing an operating tunnel. The general features of the modified layout are shown on sheet No. 8. Aerial photograph No. 5 contains an excellent view of the present plant.

33. Gates 10 feet high are to be installed on the dam and the elevation of the upper pool raised to 175. The increased head thus secured will about compensate for the loss of head due to raising the elevation of tail-water to secure a navigable pool from Conowingo to Holtwood. The existing dam is sufficiently strong to stand the increased head and the gate piers can be designed to be self-supporting. A pool at elevation 175 will provide navigation about 9 miles upstream. There are no bridges on this section.

SAFE HARBOR

34. The dam designated in this report as Safe Harbor is located about 2 miles above the railway station of that name at the upper end of the Holtwood pool, where the river valley is quite narrow. The general layout is shown on sheet No. 9. The location is one which is favorably considered in the superpower survey as a site for power development. Some of the advantage due to the short length of the dam is offset by the presence of a deep narrow gut on the eastern side of the river and the difficulty of controlling the flow of water during construction. It is possible that a more detailed investigation of the site will show the economy of moving the dam upstream or down. Moving upstream is disadvantageous in that the discharge from the turbines would be confined to the narrow channel, which would also serve as the lower approach to the locks, while any location farther downstream will require a much longer dam. The elevation of the crest of the dam is 215 and regulating gates 25 feet high are installed to maintain the upper pool at elevation 240. With all gates fully open the maximum flood of 654,000 second-feet will raise the water to elevation 232.3 at the dam. The power house and locks are placed on the east bank of the river. The grade of the single track Columbia & Port Deposit branch of the Pennsylvania Railroad must be raised for about 1.5 miles below the dam in order to obtain an elevation of 246 at the site, with a gradient of 0.3 per cent. Above the dam 10.7 miles of this branch and 6 miles of the double-tracked Atglen & Susquehanna branch must be raised. The construction of the locks will require both branches to be moved back from the river, which involves heavy rock excavation. It is believed that the rock excavated in this operation can be used for concrete or for making the fill at the head of the forebay. The dam will back water up to Shocks Mills and create a pool about 16.3 miles long. With the water surface at 240 the vertical clearance at the deepest water under the Columbia-Wrightsville bridge will be 6.6 feet and a draw will be necessary. The construction of the draw can be required under the authority of section 9 of the river and harbor act of March 3, 1899, and the cost will have to be borne by the owners, as no item to cover it has been included in the estimates.

SHOCKS MILLS

35. The natural slope of the river for some distance above mile 37 is very flat and the next dam above Safe Harbor is located at the head of this section. The site selected for the dam is about one mile above the village of Shocks Mills. The elevation of the crest of the dam is 267 and regulating gates 20 feet high maintain the upper pool at elevation 287. With all of these gates open the maximum discharge of 626,000 second feet can be passed while the water level above the dam is held at elevation 283. Somewhat less than half a mile above the site of the dam the two freight tracks of the Pennsylvania Railroad cross the river on a masonry arch bridge. The presence of this bridge introduces several complications. Due to its arched construction it will be difficult to alter it so as to build a draw. If the dam is placed above the bridge it will be excessively long and a large amount of rock excavation in the approach channel to the lower lock will be necessary. Furthermore, with the dam above the bridge, the width of the clear channel would be limited by the arches to 70 feet unless the bridge were modified. With the dam below the bridge and the upper pool at 287 the water will be within 3 feet of the tops of the arches. Rather than reconstruct the bridge it may be cheaper to carry the two freight tracks down the west bank of the river, over the forebay on a curve, and across the river on the piers for the regulating gates, with a draw at the locks. The eastern extremity of the dam could then be curved downstream to provide a landing at that end. As the expense of modifying the existing bridge to provide for navigation would have to be borne by the owners, the added expense of the plan just mentioned, if it were adopted, should be contributed by the railroad company. The general layout of the Shocks Mills dam, power plant, and locks is shown on sheet No. 10. The Shocks Mills pool is 16½ miles long and is not crossed by any bridges except the one just mentioned. To raise the two railroad lines on the east shore to 293 at Shocks Mills will require the relocation of the equivalent of 7.2 miles of single track below the dam. With the pool height adopted the grades on both the east and west banks above the dam must be raised. The increased elevation required on the west bank is comparatively small, but the railway on the east bank must be raised as much as 32 feet in one place. The total length of line to be relocated both above and below the dam is equivalent to 43 miles of single track. The plant of the York Haven Water & Power Co. at York Haven, described in paragraph 16, will be completely drowned out. It appears advisable to acquire the plant outright by purchase if a reasonable price were placed upon it. The present customers of the company would be supplied from the new plant at Shocks Mills. No attempt has been made to appraise the property of the York Haven Water & Power Co., but an item of $4,000,000 to cover damages or the cost of acquisition of the plant is included in the estimates. As the machinery has been in operation since 1904 without substantial changes or replacements it is believed to be nearing the end of its efficient life and the above figure is considered a liberal estimate.

STEELTON

36. The movable dam at Steelton was located with a view to securing the most economical section possible. The type of dam in general use on the Ohio River has been adopted and no attempt at detailed design has been made. The two bear traps and the wier section will pass flows of approximately 110,000 second feet. During the past 30 years this flow has been exceeded at Harrisburg about 6.5 per cent of the time. At discharges exceeding this amount, a depth of 9 feet can be carried over the sill of the navigation pass and into Harrisburg with the dam lowered. The lock is located on the east bank of the river. The general layout is shown on sheet No. 11. This dam will provide depths of 9 feet to the vicinity of mile 70, but the three lower bridges at Harrisburg (see table in paragraph 15) will require modification to provide sufficient clearances.

USE OF WATER FOR LOCKAGES

37. The proportion of water used for lockages will be small even when compared with the extreme low water flow of the river. The maximum consumption for this purpose will occur at the Safe Harbor Dam where the lift per lock is a maximum. Fifty lockages per day at this dam, which is believed to be much in excess of anything that need ever be anticipated, would consume the equivalent of a flow of approximately 355 second feet. This is about 16 per cent of the minimum flow, 1.5 per cent of the median flow, and 0.8 per cent of the average flow for the 32-year period, 1891–1922, at Safe Harbor.

STORAGE

38. The limited scope of this survey has precluded the investigation of possible sites for storage reservoirs. It is the general opinion of persons familiar with the subject that no reservoirs of sufficient magnitude to effect a material increase in the low water flow can be economically developed. The subject has received some study from the standpoint of flood prevention, both in New York and Pennsylvania, but no system of flood control involving the use of storage reservoirs has been adopted. In a report published in House Document No. 320, Sixty-fifth Congress, first session, the New York State Conservation Commission is quoted as follows:

> This commission and its predecessors, the New York State Water Supply Commission and the River Improvement Commission, have made detailed studies of flood prevention on rivers in New York State by storage reservoirs. * * * Owing to the lack of feasible storage reservoir sites on the Susquehanna River and its tributaries, no plans have been made for the control of this stream.

39. The river valley from Harrisburg to the mouth is so narrow that the capacity of the pools for storing water to be used during periods of small flow is extremely limited. The maximum storage available for any one of the power plants under most favorable operating conditions is the aggregate available storage in all the pools above that plant. The following table shows the approximate superficial areas of the pools at normal levels and the aggregate areas above each dam:

TABLE 11

Location	Area of pool (acres)	Aggregate storage area (acres)
Steelton	1,417	1,417
Shocks Mills	10,131	11,548
Safe Harbor	9,429	20,977
Holtwood	3,552	24,529
Conowingo	7,734	32,263
Roberts Island	3,187	35,450

The volume of water required to operate one of the units (turbine and generator) to its full capacity at any of the plants except Holtwood is about 6,667 second-feet. For every foot that the pools are lowered a flow of 6,667 second-feet is made available at each of the plants for the following periods: Shocks Mills, 21 hours; Safe Harbor, 39 hours; Holtwood, 45 hours; Conowingo, 59 hours; Roberts Island, 65 hours. Considering the needs of navigation the maximum permissible lowering of the pools is about 3 feet. Practical conditions governing operation would probably never permit the utilization of the maximum storage available.

ORDER OF CONSTRUCTION

40. Many questions must be decided before the most advantageous construction program can be determined. From the viewpoint of navigation alone, the works should be constructed in order upstream from the mouth of the river. This method is also desirable in that it provides water transportation for materials needed in construction, but the saving thus effected is less than appears at first glance due to the presence of suitable rock for concrete at or near the dam sites and the location of numerous cement mills in northeastern Pennsylvania, whence shipments could be economically made by rail. The principal use of the water route would be for sand from Chesapeake Bay and machinery and equipment from manufacturing plants located on tidewater. Considering power development alone the first plant built should be that which shows the smallest cost per horsepower installed and the lowest cost for transmission to the load centers. This is undoubtedly the Conowingo plant and the others should be added as the power demand increases. So far as can be determined, at the present time it appears that construction for the joint development of navigation and power should be divided into two phases, the first including the building of the Roberts Island and Conowingo plants and the installation of gates at Holtwood, and the second the developments at Safe Harbor and Shocks Mills and the movable dam at Steelton.

41. All dams except at Safe Harbor should be built simultaneously from both banks of the river. There is a continuous line of railway on the east bank from Harrisburg to the mouth. The western end of the Roberts Island dam can easily be reached by a construction railway along the river bank which can be extended 6 miles farther to reach the Conowingo site. The highway bridge at Conowingo also gives access to the west bank just below the dam site. The most difficult construction conditions are encountered at Safe Harbor

where the hills rise steeply from the water and there is a deep gut in the river. The power-house foundations and the portion of the dam crossing the gut should be built to above the normal water level in one low water season under the protection of cofferdams, and the railroad relocation should be made at the same time. Average discharges and less can then be passed through the penstocks while the remainder of the dam is being built. At Shocks Mills a construction railway can be built from the existing Pennsylvania Railroad tracks to the western end of the dam. No unusual conditions are encountered at Steelton, and there are railways on both banks at this point.

COST ESTIMATES

42. The detailed estimates of first cost and annual cost for the project, up to and including power-plant switchboards, are contained in Appendix A. A special discussion of the estimates relating to the Holtwood plant will be found in paragraphs 44 and 45. The estimates are itemized sufficiently to permit the separation of the amounts chargeable, respectively, to navigation and to power production. Twenty-two and one-half per cent is added to all estimated costs, with the exception of certain items relating to the Holtwood plant, to cover the following overhead expenses: Engineering, 5 per cent; interest during the construction period, 7½ per cent of the cost; contingencies, 10 per cent. In estimating annual costs, depreciation on masonry structures is charged at 2 per cent per year, depreciation on steel work and machinery at 4 per cent per year, and interest on the capital invested at 4½ per cent per year. An annual sinking fund charge of 0.55 per cent of the first cost of all portions of the project except locks and channels is also added. This sinking fund, if compounded semiannually at 4½ per cent, will be sufficient to retire the original investment at the end of 50 years.

DIVISION OF COST

43. It is necessary to select some basis for dividing the total cost of the project between navigation and power development. This is a subject upon which in the discussion of other projects many conflicting opinions have been expressed and no general agreement or policy has been established. It is not believed to be essential in this report to restate the various arguments which have been advanced on the question. The purpose of the survey is to investigate the feasibility of improving the river for navigation and it is apparent at the outset that it is doubtful whether the volume of traffic to be expected will be sufficient to justify the construction of those portions of the project which are essential to navigation and nonessential to power production, i. e., locks and channels. The total costs have therefore been divided by charging only the locks with their appurtenances and the approach channels thereto against navigation, and by placing all other charges against power production. The division on this basis is shown in the following table:

TABLE 12.—*First cost and annual cost of power development and navigation (all first costs except locks and channels charged against power development)*

Item	Roberts Island	Conowingo	Holtwood	Safe Harbor	Shocks Mills	Steelton	Total
POWER DEVELOPMENT							
First cost:							
Dam	$2,540,000	$3,946,520	[1] $21,377,100	$3,427,300	$2,834,640		
Power house foundations and forebay	2,483,500	2,448,000		2,694,000	2,540,500		
Power house and machinery	6,331,000	6,555,000		6,759,000	5,883,000		
Flowage damages and relocations	1,908,750	1,373,850		1,773,675	9,469,300		
General construction costs	300,000	375,000		400,000	150,000		
Total first cost	13,563,250	14,698,370		15,053,975	20,877,440		
Overhead 22½ per cent	3,051,732	3,307,133		3,387,145	4,697,424		
Total first cost	16,614,982	18,005,503	21,377,100	18,441,120	25,574,864		$100,013,569
Annual cost:							
Operation and maintenance	350,000	400,000	350,000	375,000	400,000		
Depreciation	420,677	478,326	378,469	487,900	417,512		
Interest, at 4½ per cent on first cost	747,674	810,248	961,969	829,850	1,150,869		
Sinking fund $\frac{5}{6}$ per cent on first cost	91,382	99,030	117,574	101,426	140,662		
Total annual cost	1,609,733	1,787,604	1,808,012	1,794,176	2,109,043		9,108,568
NAVIGATION							
First cost:							
Locks and channels	2,210,780	2,005,576	1,714,350	2,352,600	1,400,090	$2,069,000	
Overhead 22½ per cent	497,426	451,255	385,729	529,335	315,020	465,525	
Total first cost	2,708,206	2,456,831	2,100,079	2,881,935	1,715,110	2,534,525	14,396,686
Annual cost:							
Operation and maintenance	30,000	45,000	35,000	30,000	35,000	20,000	
Depreciation	31,398	38,248	32,553	36,657	36,750	50,911	
Interest, at 4½ per cent on first cost	121,869	110,557	94,504	129,687	77,180	114,054	
Total annual cost	183,267	193,805	162,057	196,344	148,930	184,965	1,069,368
Total first cost	19,323,188	20,462,334	23,477,179	21,323,055	27,289,974	2,534,525	114,410,255
Total annual cost	1,793,000	1,981,409	1,970,069	1,990,520	2,257,973	184,965	10,177,936

[1] Includes $18,000,000 for acquiring existing plant; $2,500,000 for installing two additional units; and $877,100 for modification of dam and site.

It is fully realized that the division of costs in the above table is open to reasonable criticism on the ground that navigation should properly bear a share of first and annual costs due to expenditures on dams, real estate, relocations, and general construction which are for the joint benefit of both navigation and power development. Furthermore, the relatively large cost of the development planned for Shocks Mills is largely accounted for by the necessity of creating a navigable pool extending to the vicinity of Harrisburg, and a plant designed for power development alone would be cheaper. Many other logical arguments can be advanced for increasing the amounts charged to navigation. However, if navigation is charged only with the cost of locks and channels; and if, on this most favorable basis, the conclusion as to the desirability of improvement for navigation is adverse, then the navigational features should be eliminated and the river should be developed for power production alone, under

suitable safeguards to prevent such installations as would make it impracticable to provide navigation in the future should it ever become advisable to do so.

ACQUISITION OF HOLTWOOD PLANT

44. If the project described in this report were adopted and the plant of the Pennsylvania Water & Power Co. could be acquired at a reasonable figure, it would appear advisable to do so. The distribution and sale of the power developed at Holtwood and that generated at the other power plants could then be coordinated to the best advantage and complications arising from increasing the elevation of tail-water and installing gates on the crest of the dam would be avoided. The cost estimates include an item of $18,000,000 for the acquisition of the plant. It is desired to emphasize the fact that this figure is not based on an appraisal of the property and that nothing is known as to the attitude of the company toward such a transaction. The statement of the condition of the company as of December 31, 1922, and the profit and loss account for 1922 as published in the annual report for that year are given below:

ASSETS

Plant, property, and power development			$17, 916, 192. 05
Securities in other companies			3, 388, 033. 55
Loose plant and stores			87, 050. 78
Prepaid charges			5, 378. 30
Accounts receivable			282, 119. 05
Bills receivable			25, 000. 00
Cash in hands of trustees for bond redemption			75, 096. 57
Cash in banks and with agents			265, 194. 86
			22, 044, 065. 16

LIABILITIES

Capital stock			8, 495, 000. 00
First mortgage 5 per cent bonds		$12, 035, 000. 00	
Less held in Treasury	$450, 000. 00		
Less bonds redeemed by trustees or canceled for sinking-fund investment	546, 000. 00		
		996, 000. 00	
			11, 039, 000. 00
Accounts payable			63, 464. 18
Sinking fund			550, 000. 00
Reserve for sinking fund			25, 000. 00
Reserve for taxes			163, 307. 37
Depreciation reserve			985, 104. 20
Contingent fund			721, 539. 55
Profit and loss account			1, 649. 86
			22, 044, 065. 16

PROFIT AND LOSS ACCOUNT

By income from all sources		$2, 003, 478. 33
To operating expenses	$136, 980. 71	
To general expenses	138, 094. 84	
To taxes	125, 000. 00	
To maintenance	147, 002. 30	
		547, 077. 85
By balance brought down		1, 456, 400. 48
To interest on first-mortgage bonds		535, 144. 46
Net revenue		921, 256. 02
Balance from 1921		3, 253. 94
Total		924, 509. 96
Distributed as follows:		
Dividend 1¾ per cent for quarter ending Mar. 31		148, 662. 50
Dividend 1¾ per cent for quarter ending June 30		148, 662. 50
Dividend 1¾ per cent for quarter ending Sept. 30		148, 662. 50
Dividend 1¾ per cent for quarter ending Dec. 31		148, 662. 50
To depreciation reserve		173, 210. 10
To reserve for sinking fund		75, 000. 00
To contingent fund		80, 000. 00
Profit and loss account		1, 649. 86
Total		924, 509. 96

These figures, which are for a year of small flow, indicate that the company is in a sound condition. Its stock and bonds are both selling near par in the present market. If the plant were actually to be acquired, the first step would be a complete appraisal of the items listed as assets in the statement quoted above. "Plant, property, and power development" probably includes those portions of the property devoted to power development. The "Securities in other companies" are understood to consist largely of stock in the independent subsidiary companies which own the transmission lines which connect Holtwood with Lancaster and Baltimore. The earnings of these transmission lines are presumably included in the "Income from all sources" shown in the profit and loss account. It is not possible to determine the earnings from power production alone from the statement but, for the purpose of the estimates in this report, it is believed to be sufficiently accurate to use $18,000,000 as the present value of the property (see also par. 46).

45. The Pennsylvania Water & Power Co. proposes to install at Holtwood two additional units each having a rated capacity of 20,000 horsepower at 62 feet head. The actual net increase in capacity will be about 30,000 horsepower. The new units will generate 60-cycle current and will be tied in with the eight existing 25-cycle units by two 5,000-kilowatt frequency changers. The company estimates the total cost of installing this increased capacity at $2,500,000, which figure is used in this report.

46. The acquisition of the property of the Pennsylvania Water & Power Co. is not essential to carrying out the scheme of development described herein and if it could not be purchased on reasonable terms the development would still be feasible but it would be necessary to negotiate a special agreement covering the installation of regulating gates on the dam and the raising of the water levels above and below the dam. The dam at Holtwood was not built under an act of

Congress and a Federal permit, presumably because it was constructed at a time when the Susquehanna River, under a decision of the Secretary of War of March 8, 1904, was considered to be a stream whose navigable portion lay entirely within the State of Maryland. This decision was reversed in 1914 by a succeeding Secretary of War, but by that time the dam had been completed. It therefore appears to be a matter requiring determination in the courts whether the Federal laws for the protection and preservation of navigation could be invoked to require the company to build the locks necessary to pass the dam. The company has not applied for a license under section 23 of the Federal water power act. Definite legal power to enforce the construction of locks is, however, conferred by the following decree of the court of common pleas of Dauphin County, Pa.:

> And now this 14th day of January, 1907, the above cause having come on to be heard upon bill and answer having been argued by counsel, it is ordered and decreed that the right of the defendant, the McCall Ferry Power Co., to continue the construction of a dam now in course of erection on the Susquehanna River and to maintain said dam after the same shall have been constructed, shall be subject to its making and maintaining adequate provision for the passage of fish, and further shall be subject to the condition that said defendant corporation, its successors and assigns, whenever the navigation of said Susquehanna River shall hereafter be improved either under State or Federal requirement in such way and manner as will secure by the additional construction of a proper lock, or locks, a continuous navigation of said river between Columbia and Havre de Grace, such lock or locks necessary to make said navigation continuous shall be erected without delay by the defendant corporation and its assigns, at its and their own expense, and the physical condition of said lock shall be maintained in good order thereafter.
>
> It is further ordered and decreed that the McCall Ferry Power Co. be, and is hereby, enjoined from the further maintenance of said dam after such time as, said navigation of said river having been made otherwise continuous, said company shall fail within a reasonable time to erect and construct, at its expense, said lock.

The Pennsylvania Water & Power Co. took over the McCall Ferry Power Co. mentioned in this decree when the latter went into the hands of a receiver in 1909. The existence of this obligation to construct locks and maintain them might reasonably be considered as a liability of the company which should be deducted from the physical value of the property if it were purchased by the United States. An exhaustive discussion of the various phases of this question is beyond the scope of this report.

EXTENT OF GOVERNMENTAL PARTICIPATION

47. There are no precedents for the participation of the Federal Government in a power project of this character and magnitude. The policy to be adopted in making use of the power which will be available upon the completion of the Wilson Dam in the Tennessee River has not been decided upon by Congress. The report on the superpower survey outlines a plan for the coordinated development and distribution of power in the area designated as the Superpower Zone but contains no recommendation as to financial cooperation by the United States. The most definite expression of the policy of Congress in such matters is contained in the Federal water power act, the pertinent sections of which will be quoted later.

48. If it were decided to undertake to provide navigation to Harrisburg, it is believed that the United States should assume the

responsibility of constructing the dams. While there is every indication that additional power development will be carried on by private capital on the Susquehanna below Harrisburg, progress will be slow and it is doubtful whether 50 years of such development will result in a series of slack water reaches above power dams sufficiently continuous to make it feasible to provide the connecting links necessary for navigation. Furthermore, even though continuous navigation were ultimately secured by connecting these slack-water reaches, the resulting water route would be less adapted to serve commerce than one constructed under a comprehensive plan in which the needs of navigation have received due consideration at the outset.

49. The construction of dams by the United States would necessarily involve the expenditures on real estate and railroad relocation, which are given in the cost estimates. Power-house foundations and fore-bay structures could be built much more economically during dam construction than afterwards and the work should be done at the same time. The extent of Federal participation up to this point is determined by fairly definite engineering factors. Aside from the question of providing navigation, however, there are certain advantages, from the standpoint of power development, in having the dams built by the United States. Private capital is somewhat loath to face the financial engineering and legal hazards inherent to water-power projects, especially in view of the widespread feeling that when the obstacles have been surmounted and the project is in operation regulatory bodies may fix such low rates for the sale of power that the return on the invested capital will be no greater than can be secured in much less risky business enterprises. The history of the financing of water-power projects contains many instances of disaster which tend to discourage the investor; even so successful a development as that of the Pennsylvania Water & Power Co., which is now earning profitable returns, was completed only after a receivership and a financial reorganization. In certain respects it is less risky for the United States to undertake the work of dam construction than it is for a corporation or individual to do so. The Federal Government is less likely to be held up by ruinously expensive legal delays, would stand a better chance of securing helpful State or municipal cooperation, and the very magnitude of the project if carried through as a whole would lessen the relative importance of such flood losses as might occur during construction.

50. Under the assumption that the United States would build the dams, power-house foundations, and fore-bay structures, it is necessary to consider the further extent of its participation in the power development. That Congress considers that in certain cases it may be advisable for the United States to undertake the actual operation of power projects is indicated by the following extract from section 7 of the Federal water power act:

> That whenever, in the judgment of the commission, the development of any project should be undertaken by the United States itself, the commission shall not approve any application for such project by any citizen, association, corporation, State, or municipality, but shall cause to be made such examinations, surveys, reports, plans, and estimates of the cost of the project as it may deem necessary, and shall submit its findngs to Congress with such recommendations as it may deem appropriate concerning the construction of such project or completion of any project upon any Government dam by the United States.

51. In carrying out the development of the Susquehanna the Federal Government might adopt any of the following courses:

(*a*) Selling power to ultimate consumers. This course would not only involve the acquisition or duplication of existing distributing systems and the steam-power plants necessary to provide reserves; but would also bring about governmental intrusion into the realm of private business to an extent not countenanced by present public policy.

(*b*) Wholesaling power to distributing companies at load centers. This would require the construction of transmission lines and the negotiation of contracts for sale and distribution in each load center.

(*c*) Selling power at plant switchboards. This would require the construction and operation of the power plants by the United States.

(*d*) Leasing the power-development privileges to corporations and individuals.

The last course, which involves the smallest degree of Federal participation beyond that considered absolutely essential, is believed to be the most advantageous. Assuming that it would be adopted, certain pertinent sections of the Federal water power act and the regulations of the Federal Power Commission issued thereunder will be quoted.

52. A "Government dam" is defined in section 3 of the act as "a dam or other work, constructed or owned by the United States for Government purposes, with or without contribution from others."

By section 4 (d) the Federal Power Commission is authorized and empowered—

> To issue licenses * * * for the purpose of utilizing the surplus water or water power from any Government dam except as herein provided.

The same section contains a restriction to the effect—

> That in case the commission shall find that any Government dam may be advantageously used by the United States for public purposes in addition to navigation, no license therefor shall be issued until two years after it shall have reported to Congress the facts and conditions relating thereto, except that this provision shall not apply to any Government dam constructed prior to the passage of this act.

It is not believed that power from the Susquehanna could be advantageously used for "public purposes" within the meaning of the clause just quoted.

Section 6 of the act provides:

> That licenses under this act shall be issued for a period not exceeding 50 years. Each such license shall be conditioned upon acceptance by the licensee of all the terms and conditions of this act and such further conditions, if any, as the commission shall prescribe in conformity with this act, which said terms and conditions and the acceptance thereof shall be expressed in said license. Licenses may be revoked only for the reasons and in the manner prescribed under the provisions of this act, and may be altered or surrendered only upon mutual agreement between the licensee and the commission after 90 days' public notice.

Section 10 (e) of the act contains a provision to the effect—

> That when licenses are issued involving the use of Government dams or other structures owned by the United States * * * the commission shall fix a reasonable annual charge for the use thereof, and such charges may be readjusted at the end of 20 years after the beginning of operations and at periods of not less than 10 years thereafter in a manner to be described in each license; * * * but in no case shall a license be issued free of charge for the development and utilization of power created by any Government dam and * * * the amount charged therefor in any license shall be such as determined by the commission.

Section 4 of regulation 14 of the Federal Power Commission, which also bears on this matter, reads as follows:

For recompensing the United States for the use of Government dams or other structures and the lands adjoining and pertaining thereto owned by the United States, the commission will fix a reasonable annual charge for the use thereof; and in no case will licenses be issued free of charge for development and utilization of power created by Government dams. The amount charged shall be the fair annual value of the power so created as determined by the commission, and shall not be less than the interest at current rates plus maintenance and depreciation upon so much of the cost of such dams, structures, or land as would be justified if built or purchased solely for purposes of power development, together with any expenses incurred by the United States in operating such dams or structures primarily for the benefit of power development. Depreciation charges shall be based upon the rates of depreciation fixed by the commission for similar structures built by licensee or, in the absence of such rates, upon rates fixed by the commission for the case under consideration. The charge shall begin on the 1st of January immediately succeeding commencement of operation.

The rate of construction of projects under licenses is governed by section 13 of the act, which reads in part as follows:

That the licensee shall commence the construction of the project works within the time fixed in the license, which shall not be more than two years from the date thereof, shall thereafter in good faith and with due diligence prosecute such construction, and shall within the time fixed in the license complete and put into operation such part of the ultimate development as the commission shall deem necessary to supply the reasonable needs of the then available market, and shall from time to time thereafter construct such portion of the balance of such development as the commission may direct, so as to supply adequately the reasonable market demands until such development shall have been completed.

The disposition of funds derived under licenses for the development of power from Government dams is provided for in section 17 of the act, the pertinent portions of which are quoted below:

* * * All other charges (except those from Indian reservations) arising rom licenses hereunder shall be paid into the Treasury of the United States, ubject to the following distribution: Twelve and one-half per cent thereof is hereby appropriated to be paid into the Treasury of the United States and credited to "Miscellaneous receipts"; * * * and 50 per cent * * * is hereby reserved and appropriated as a special fund in the Treasury to be expended under the direction of the Secretary of War in the maintenance and operation of dams and other navigation structures owned by the United States or in the construction, maintenance, or operation of headwater or other improvements of navigable waters of the United States.

53. It is believed that if Congress adopted a project of the magnitude of that outlined in this report, special legislation should be passed to express definitely the policy of Congress on the points which are covered in a general way by the sections of the Federal water power act quoted in the preceding paragraph. The possibility of leasing the power development privileges to responsible private interests should be fully investigated and, if possible, a contract or license should be negotiated before construction is begun. It is beyond the scope of this report to discuss the details of such a contract. However, for the purpose of estimating the cost of power to the licensee at the plant switch boards under the leasing plan discussed, an analysis of the division of capital investment and annual cost for power production alone between the licensee and the United States is shown in Table 13:

TABLE 13.—*Division of cost of power development between United States and lessee*

Item	Roberts Island	Conowingo	Holtwood	Safe Harbor	Shocks Mills	Total
UNITED STATES						
First cost:						
Dam	$2,540,000	$3,946,520	[1] $18,877,100	$3,427,300	$2,834,640	
Power house foundations and forebay	2,483,500	2,448,000		2,694,000	2,540,500	
Flowage damages and relocations	1,908,750	1,373,850		1,773,675	9,469,300	
General construction costs	300,000	375,000		400,000	150,000	
Total	7,232,250	8,143,370		8,294,975	14,994,440	
Overhead, 22½ per cent	1,627,256	1,832,258		1,866,369	3,373,749	
Total first cost	8,859,506	9,975,628	18,877,100	10,161,344	18,368,189	$66,241,767
First cost:						
Power house and machinery	6,331,000	6,555,000	[2] 2,500,000	6,759,000	5,883,000	
Overhead, 25 per cent	1,582,750	1,638,750		1,689,750	1,470,750	
Total first cost	7,913,750	8,193,750	2,500,000	8,448,750	7,353,750	34,410,000
LESSEE						
Annual cost:						
Operation and maintenance	350,000	400,000	350,000	375,000	400,000	
Depreciation	420,677	478,326	378,469	487,900	417,512	
Interest at 6 per cent on amount invested by lessee	474,825	491,625	150,000	506,925	441,225	
Interest at 4½ per cent on amount invested by United States	398,678	448,903	849,470	457,260	826,568	
Sinking fund $\frac{5}{6}$% per cent on amount invested by lessee	43,526	45,065	13,750	46,468	40,445	
Sinking fund $\frac{5}{6}$ per cent on amount invested by United States	48,727	54,866	103,824	55,887	101,025	
Total annual cost	1,736,433	1,918,785	1,845,513	1,929,440	2,226,775	9,656,946

[1] Includes $18,000,000 for acquiring present plant and $877,100 for modification of dam and site.
[2] Estimated total cost of installing 40,000 horsepower in addition to present capacity.

54. It should be noted that Table 13 takes no account of the expenditures on locks and channels. The first costs and annual costs of power houses and machinery are greater than those given in Table 12 and in Appendix A for two reasons. Interest on invested capital is increased to 6 per cent, as it is not believed that private interests could secure a lower rate, and overhead is increased to 25 per cent to include an item of 2½ per cent for organization expenses. Due to the fact that the construction of power houses and the installation of the machinery therein could proceed more rapidly and on a more definite schedule than the construction of the dams, the item of 7½ per cent for interest during construction has not been changed. Under section 4 of regulation 14 of the Federal Power Commission, issued pursuant to section 10 (e) of the Federal water power act (see par. 52), the amount to be charged under licenses for developing power from Government dams is fixed as "the fair annual value of the power so created as determined by the commission, and shall not be less than the interest at current rates on so much of the cost of such dams, structures, or land as would be justified if built or purchased solely for purposes of power development, together with any expenses incurred by the United States in operating such dams or structures primarily for the benefit of power development." In specifying this minimum no provision for amortization is included. However, section 10 of the act contains a provision for setting up amortization reserves under all licenses out of surplus

earned above a reasonable rate of return after the first 20 years of operation and for expropriating excessive profits prior to that time. The matter of amortization reserves is treated in more detail in regulation 17 of the Federal Power Commission. It is not believed that the Susquehanna project should be undertaken unless the power can be marketed at reasonable rates which will still provide a sufficient surplus to retire the capital investment in power production of both the United States and the licensee in a term of 50 years. A sinking fund charge sufficient to accomplish this is therefore added to the annual costs in Table 13. The total annual costs in Table 13 are used as the basis for all further estimates of the cost of power in the remainder of this report. It should be noted that the figures are for cost alone, and that no allowance has been made for profit above interest requirements.

55. The estimates in Table 13 are based upon the total ultimate installation and represent costs for the power finally developed. Obviously any lessee would expect to install capacity only as the power market was built up and it would probably be impossible to negotiate a contract providing from the outset for payments equal to the annual costs as estimated in Table 13. The use of a clause embodying a sliding scale of payments, increasing as the power demand increased, would undoubtedly be necessary.

OUTPUT AND COST OF POWER

56. The following table shows the annual output in millions of kilowatt-hours at the switchboard with 100 per cent and 60 per cent utilization factors for the maximum, minimum, and average years of the 32-year period 1891–1922. The efficiency of conversion of theoretical power to actual power at the switchboard is taken as 80 per cent.

TABLE 14.—*Output in millions of kilowatt-hours*

Plant	100 per cent utilization factor			60 per cent utilization factor		
	Maximum year, 1891	Minimum year, 1910	Average year	Maximum year, 1891	Minimum year, 1910	Average year
Roberts Island	777	455	631	466	273	379
Conowingo	1,374	803	1,115	824	482	669
Holtwood	814	497	679	488	298	407
Safe Harbor	1,175	684	950	705	410	570
Shocks Mills	836	483	672	502	290	403
Total	4,976	2,922	4,047	2,985	1,753	2,428

The following table shows the cost in mills per kilowatt-hour at the switchboard for these same years and for the same utilization factors. In determining these unit costs the annual costs which appear in Table 13 are used:

TABLE 15.—*Cost in mills per kilowatt-hour (at switchboards)*

Plant	100 per cent utilization factor			60 per cent utilization factor		
	Maximum year, 1891	Minimum year, 1910	Average year	Maximum year, 1891	Minimum year, 1910	Average year
Roberts Island	2.235	3.816	2.752	3.726	6.360	4.586
Conowingo	1.396	2.390	1.721	2.326	3.983	2.868
Holtwood	2.267	3.713	2.718	3.780	6.190	4.530
Safe Harbor	1.642	2.821	2.031	2.736	4.701	3.385
Shocks Mills	2.664	4.610	3.313	4.440	7.683	5.521
Average	1.941	3.305	2.386	3.235	5.508	3.977

The output and cost per kilowatt-hour for any other utilization factor can be readily computed as the output varies directly and the cost inversely with the utilization factor. If one unit is considered strictly as a spare and 72 per cent of the flow within the capacity of the remaining five units is used, the utilization factor will be 60 per cent. It is believed that this figure can be reached or exceeded as soon as the power market is fully developed. At the Holtwood plant in 1917 and 1918, 90 per cent of the flow within the wheel capacity was converted into power. In 1919, according to the report of the superpower survey, the annual effective capacity factor for hydroelectric plants in the southern division of the superpower zone was 66.2 per cent, this factor being defined as "the average load on a plant expressed as a percentage of the effective capacity of the plant." The term "utilization factor" as used in this report has the same meaning as "capacity factor" in the superpower survey. The estimated cost of production for the new hydroelectric plants proposed for the southern division of the superpower system is 3.3 mills per kilowatt-hour. The actual production cost for the hydroelectric plants in the southern division in 1919 was 6.6 mills per kilowatt-hour.

COST OF POWER DELIVERED

57. Sheet No. 1 shows the territory lying within 50, 100, and 150 miles of Holtwood and brings out the exceptionally favorable location of the Susquehanna River with reference to load centers. It is entirely feasible to transmit Susquehanna power to New York City on the east and to Washington on the south but it would be more economical to develop the available power of the Delaware and Potomac Rivers for New York and Washington and to supply the power from the Susquehanna to the cities of Philadelphia, Wilmington, Baltimore, Harrisburg, Lancaster, and York, which lie in or near the 50 mile zone. This distribution can be accomplished by constructing a transmission line paralleling the river from Harrisburg to Havre de Grace (70 miles) and another from Baltimore, through Havre de Grace and Wilmington, to Philadelphia (95 miles). The existing Holtwood-Baltimore, Holtwood-Lancaster, and York Haven-York transmission lines can also be used for distribution. If a profitable load is available in Reading the Holtwood-Lancaster line can be extended to that point. No estimate of the cost of transmission lines and substation equipment is included in this report. The report of the superpower survey

contains estimates of transmission and conversion costs for that system for the years 1919, 1925, and 1930. The southern division of the superpower zone corresponds very closely to the area in which Susquehanna power would be marketed and the estimated cost of transmission and conversion between plants and load centers in that division per kilowatt-hour of power delivered is as shown below:

	1919	1925	1930
Power delivered, millions of kilowatt-hours	3,548	5,112	7,446
Transmission cost, thousands of dollars	3,489	3,752	4,160
Transmission cost per kilowatt-hour, mills	.98	.81	.56

In the light of these costs it appears safe to estimate that the cost of transmission and conversion for the Susquehanna development will not exceed 1.25 mills per kilowatt-hour delivered in the average year. Considering the short distances to load centers an efficiency of 90 per cent in transmission should be attained. On this basis and with power costing 3.977 mills at the plant switchboards for a 60 per cent utilization factor (see par. 45) it should be possible in an average year to deliver 2,185,200,000 kilowatt-hours to load centers at a cost of 5.67 mills per kilowatt-hour. This is, of course, actual cost with no allowance for profit. In this connection it is of interest to note that according to the records of the Public Service Commission of Maryland, the Consolidated Gas, Electric Light & Power Co. of Baltimore in the calendar year 1921 bought at wholesale from the Pennsylvania Water & Power Co. 242,964,500 kilowatt-hours of electrical energy for which it paid $1,314,704. This makes the average price paid 5.4 mills per kilowatt-hour. For the calendar year 1922 the corresponding figures are 248,342,300 kilowatt-hours, bought for $1,243,634.74, making the average price about 5 mills per kilowatt-hour.

GROWTH OF POWER DEMAND

58. No independent canvass has been made to determine present power demands and predict future growth as the information gathered in the course of the superpower survey and tabulated in the report of the survey cover the area in which Susquehanna power would be distributed and is unusually complete. The electrical energy actually produced by public utilities in Philadelphia, Baltimore, and Harrisburg in 1910, 1915, and 1919 and the predicted requirements in 1925 and 1930 are given in the superpower survey as shown below:

TABLE 16.—*Output of electrical energy (millions of kilowatt-hours)*

Load center	Actual			Predicted	
	1910	1915	1919	1925	1930
Philadelphia	455.2	738.0	1,279.7	2,891.0	4,397.0
Baltimore	161.6	357.3	680.4	1,080.0	1,269.0
Harrisburg	109.6	161.4	259.5	635.0	970.0
Total	726.4	1,256.7	2,219.6	4,606.0	6,636.0

The output for 1910, 1915, and 1919 includes the energy used for lighting, industrial power, electric street railways, and electrified sections of railroads. The estimates of future growth do not include increases due to possible additional railroad electrification or to the substitution of purchased energy for that now produced in isolated manufacturing plants which are now operating their own prime movers. The four new plants of the Susquehanna project and the additional generator capacity to be installed in the Holtwood plant will make possible in the year of average flow the delivery of 1,869,300,000 additional kilowatt-hours of energy to load centers on the basis of 60 per cent utilization factor, 80 per cent generating efficiency and 90 per cent transmission efficiency. The above table shows that the estimated increase in the requirements for Philadelphia, Baltimore, and Harrisburg alone from 1919 to 1930 is 4,416,400,000 kilowatt-hours or more than two and three-tenths times the amount of additional energy provided. In other words, there is little doubt that all the power produced by the Susquehanna can be marketed within the area to which it can be economically transmitted.

PRIMARY POWER AND STEAM RESERVE

59. The minimum amount of power from the Susquehanna below Harrisburg that can be delivered at load centers on the minimum flow for the period 1891–1922 is 38,200 kilowatts, based on 80 per cent generating efficiency and 90 per cent transmission efficiency. This absolute minimum discharge has occurred only once in 32 years and during that period a flow of more than 6,000 second-feet was available for 92.55 per cent of the time. It therefore seems reasonable to use 6,000 second-feet at Holtwood as the basis for computing primary power and steam-electric reserves. This discharge will operate one unit in each of the four new plants at 90 per cent of its full load capacity and will make possible the delivery from these four plants of 83,025 kilowatts at load centers under the same assumptions as to efficiency as given above. The four new plants with five of their six units operating at full capacity can deliver 373,300 kilowatts. The difference or 290,275 kilowatts represents the steam-electric reserve necessary to carry these four plants over periods of low-water flow. As the utilization factor for the hydroelectric plants approaches 100 per cent additional steam-electric reserve will be required to carry peak loads. In the above discussion no provision is made for steam-electric reserve for the present installation or the proposed increase in capacity at Holtwood. This is because there is sufficient reserve now installed in the load centers where this power is used to provide for periods of deficient flow and to meet peak demands.

60. It is obvious that economical development and marketing of the power to be obtained from the Susquehanna will require that the operating agency either purchase or acquire operating control of the more efficient steam-electric plants now installed in the important load centers. This is also necessary in order to avoid the duplication of the distribution systems which are owned by the electric utilities. The most favorable situation for marketing Susquehanna power would be secured if a combination of the electric utilities companies in Philadelphia, Wilmington, Baltimore, Harrisburg, and other load centers could be formed for the purpose of

leasing the power development privileges. The advantages of interconnection and unified operation aimed at by the superpower survey would then be secured in a large area. The efficient steam-electric plants could be retained as reserves and the inefficient ones scrapped. The following table shows the character and performance of the steam-electric plants of the electric utilities in Philadelphia, Baltimore, and Harrisburg in 1919. The information is from the report of the superpower survey.

TABLE 17

	Philadelphia	Baltimore	Harrisburg
Number of plants	51	14	17
Generator capacity, thousands of kilowatts	481.5	202.5	75.7
Effective capacity, thousands of kilowatts	422.9	185.3	65.2
Generated output, millions of kilowatt-hours	1,259.1	175.4	175.6
Annual effective capacity factor, per cent	34	10.8	30.7
Coal per kilowatt-hour, pounds	2.62	2.74	3.78
Cost of coal, per short ton	$4.77	$5.10	$3.28

The effective capacity, being generally limited by boiler capacity, is less than the generator capacity. The effect of the hydroelectric power transmitted from Holtwood to Baltimore is strikingly apparent in the output and capacity factor of the Baltimore steam-electric plants.

RIVER COAL

61. When additional steam-electric plants must be built, as will ultimately be necessary, interesting possibilities for economical power production with cheap fuel are offered at locations along the stretch of the Susquehanna which is under consideration. The river in periods of large flow carries down large quantities of finely divided coal which is deposited in the slack water reaches. The dredging of this coal in the pool opposite Harrisburg has been carried on for years. More recently, since the creation of the pool above the Holtwood dam, large deposits have formed therein. The following are excerpts from the 1920 and 1922 reports of the board of directors of the Pennsylvania Water & Power Co.:

REPORT FOR 1920

The Susquehanna River, flowing as it does through the anthracite coal regions of Pennsylvania, carries down stream quantities of more or less finely divided coal, which in the past it has been the custom to dredge with small equipments at various points along the river below the coal fields. The shortages in the supply of bituminous coal during recent years have promoted the development of methods of using this anthracite river coal under boilers for steam generation, and this new demand, coupled with an increased demand for anthracite coal for domestic purposes, has led to a greater activity in the recovery of such coal from the river bed. The great reservoir formed by your company's dam is apparently acting as an efficient settling basin for the depositing of this water-borne coal and its separation from the lighter silt which is carried off further down the stream. Though no accurate survey is as yet possible, it would appear that there are, perhaps, millions of tons of such coal deposited in this reservoir, and your company has made arrangements with a dredging concern looking toward the commercial recovery of river coal. Your company feels it desirable to conduct such operations slowly and in a conservative fashion until such time as the recovery

has been demonstrated to be commercially important, so that it may at that time arrange for the recovery upon a scale commensurate with the amounts of river coal brought down and deposited. It is expected that, perhaps, for a few years this recovery will be rather in the experimental stage.

REPORT FOR 1922

So great has the demand for energy become that your company * * * is looking into the question of building a steam plant at Holtwood for use during the periods of low river flow, availing itself of the exceptional opportunity of utilizing the great amounts of river coal which have accumulated in the basin formed by the dam.

This river coal is at present being hauled to near-by cities to be burned under boilers for power generating purposes. However, at Holtwood it would seem posssible to accumulate and store on the property of the company, a stock of such coal that might, by being burned under boilers at Holtwood, prove of benefit in the event of coal strikes or railroad transportation difficulties, in which case, energy generated from this coal might be transmitted to the cities near by over the transmission lines of your company. It would seem such stock of reserve coal might easily be accumulated during normal times by a short rail haul of only five miles along the lake created by the dam, provision being made for barging the coal down the lake, if, and when railroad transportation proved insufficient.

During the past year the dredging concern with which your company made arrangements for the delivery of river coal, has made available over 50,000 tons of anthracite coal, which, after removal from the river bed was cleaned, prepared, and shipped to a number of cities.

If the development of the river were carried out, the construction of steam-electric plants along its shores would secure the advantage of a cheap fuel supply transported by the river itself, ample condensing water, and proximity to the transmission lines of the hydroelectric plants.

EXISTING POWER RATES

62. It is not possible within the limits of this report to undertake a detailed discussion of the prevailing rates charged for industrial power within the area in which hydroelectric power from the Susquehanna River would be marketed or to predict the extent to which these rates would be affected by the development of the river. The charges of the electric utilities companies are regulated by separate public service commissions or equivalent bodies in each State, but there is a lack of uniformity in the approved tariffs in different cities in the same State or even for different companies in the same city. The value of the plant of the utilities company is ordinarily taken as the basis for determining the fair return to be allowed, but this value is in controversy in many cases. In a rate hearing recently concluded in Baltimore the utilities company and the Public Service Commission differed by $40,000,000 as to the fair value of the plant. The most important single factor in determining the cost of producing power in steam-electric plants is the price of coal and this item fluctuated over an abnormal range in 1922 as a consequence of the miners' strikes. The average cost of coal used by electric utilities in the southern division of the superpower zone in 1919 was $5.23 per long ton, while in October, 1922, coal cost $9.27 per long ton delivered in the bunkers of the principal producer of electric energy in Baltimore. The future trend of coal prices is uncertain. Recent investigations of the coal industry indicate the possibility of considerable reductions in prices if various measures looking to greater efficiency and economy in the production and distribution of coal can be put into effect, but it is too early to predict such reductions.

The great bulk of the electric energy generated from steam is now sold under tariffs containing some form of coal rate adjustment clause under which the price of power varies with the price of coal. There is no uniformity in the coal rate adjustment clauses, as is apparent from the examples cited below for the principal producing companies in Philadelphia, Wilmington, and Baltimore.

Philadelphia: Base rate, $4 per long ton. Price of power increases one-twentieth of a mill per kilowatt hour for every increase of 5 cents per ton of coal delivered.

Wilmington: Base rate, $3.05 per long ton. Price of power increases one-tenth of a mill per kilowatt hour for every increase of 10 cents per ton of coal delivered.

Baltimore: Base rate, $5.60 per long ton. Price of power increases one-tenth of a mill per kilowatt hour for every increase of 10 cents per ton of coal delivered.

It is worthy of note that the rate of increase is the same in these three cities but that that basic cost of coal on which the adjustment is made is different in each case.

63. Appendix B [1] contains the terms and conditions of service and the schedule of charges under which industrial power is sold in Philadelphia by one of the large producers there. Appendix C [1] contains similar information for Baltimore. These rates are applicable only to loads of 200 kilowatts and above and are for untransformed high-tension alternating current. For purposes of comparison the cost of power under these schedules for a load having a maximum of 1,000 kilowatts and an average of 500 kilowatts for 8 hours per day for 300 days per year has been worked out. Fuel adjustment was based on a cost of $7 per ton of coal. The cost per kilowatt hour for such a load is 2.77 cents in Philadelphia and 2.535 cents in Baltimore.

64. In 1919 in the southern division on the superpower zone the average amount of coal burned to produce one kilowatt-hour of energy was 2.74 pounds and the average cost of coal was $4.67 per short ton. The average cost of fuel per kilowatt-hour was therefore 6.4 mills. The cost of coal in the fall of 1922 in Baltimore was approximately 80 per cent above the average cost in Baltimore for 1919. It seems reasonable to assume that some reduction in this high price will be secured, although it is doubtful whether the cost will be reduced to the 1919 figures in the near future. However, even on the basis of 1919 fuel prices, the delivery of 2,185,200,000 kilowatt-hours to load centers from the Susquehanna in an average year (see par. 45) will result in the saving of 2,993,724 short tons of coal costing $13,980,691.08. This is the saving on fuel alone. For any assumed price of coal above the 1919 average the saving is proportionally increased. The total average production cost of steam-electric power in the southern division of the superpower zone in 1919 was 2.02 cents per kilowatt-hour. The delivery of 2,185,200,000 kilowatt-hours from the Susquehanna to load centers at 5.67 mills per kilowatt-hour should therefore effect an annual saving of $31,750,956. The total annual cost of the hydroelectric plants and transmission equipment having already been charged against the unit cost of 5.67 mills per kilowatt-hour for hydroelectric power, the apparent saving shown above is

[1] Not printed.

chargeable only with the profit to be allowed the operating corporation the annual cost of maintaining the necessary steam-electric reserves (which is the total annual cost of such plants less the return they will make during the period when they are actually generating power), and general overhead administrative expenses. It is therefore concluded that practically all of the hydroelectric power available in the Susquehanna River between Harrisburg and the mouth can be profitably developed. If no attempt is made to provide navigation, the cost of this development can be reduced below the estimates given in this report. Especially profitable opportunities for development are offered at Conowingo and Safe Harbor.

TRAFFIC POSSIBILITIES

65. Returning now to consideration of the possibilities of the river from the viewpoint of navigation, it is at once apparent that if any considerable volume of traffic is to be secured it must be drawn from the territory adjacent to the stream between Harrisburg and Columbia. From the latter point to the mouth the river flows through a narrow rocky valley with steep sides where there are no areas suitable for extensive industrial development. The distance from Harrisburg to Port Deposit near the mouth of the river where a navigable depth of 15 feet is now provided is 68 miles by rail and 64 miles by water. The comparative distances to various traffic centers on tidewater by rail and water are as follows:

TABLE 18—*Distances from Harrisburg*

To—	Rail	Water	To—	Rail	Water
Trenton	125	165	Washington	124	260
Philadelphia	104	137	Norfolk	345	245
Wilmington	105	113	Richmond	240	324
Baltimore	84	112			

A canvass of traffic possibilities in case of improvement was undertaken by the department of internal affairs of Pennsylvania. A report embodying the results of this investigation is transmitted herewith as Appendix D.[1] The report is deleted in accordance with the statement in the third paragraph of the letter of inquiry sent to industrial plants to wit: "It is the purpose to only publish the aggregate amount of the estimated river traffic and not in any case individual reports." The canvass covered the territory tributary to the river in Pennsylvania which includes practically the entire area from which new traffic would come as navigation now extends to Port Deposit about 10 miles below the Maryland-Pennsylvania boundary. The different industries which answered the questionnaire estimated that if the river were improved they would ship or receive by water annually 456,900 tons of freight northbound, 110,570 tons southbound, and 14,250 tons which was not classified as to direction of movement, making a total of 581,720 tons. The percentages are as follows: Northbound, 79 per cent; southbound, 19 per cent; unclassified, 2 per cent. The detailed figures showed that one

[1] Not printed.

corporation had submitted an estimate of 360,000 tons of freight northbound. This is 79 per cent of the entire northbound movement and 62 per cent of the total estimated traffic. Mr. George M. Lehman, who conducted the investigation, states in his report that "it is estimated that grand total of 1,500,000 tons might be developed if under proper organization and favorable contributing conditions. It might take from 5 to 10 years after completion of the improvement for that volume to be reached." Placing the annual cost of providing navigation at $1,069,368 and under the assumption that the tonnage moves over the entire length of the improvement, 64 miles, the cost per ton of freight moved would be $1.8383 per ton, or 2.87 cents per ton-mile on a basis of 581,720 tons per year, and $0.7129 per ton, or 1.11 cents per ton-mile on a basis of 1,500,000 tons per year.

66. The 360,000 tons of northbound traffic for one corporation which was mentioned in the preceding paragraph presumably consists of imported iron ore which is unloaded at Baltimore. The present rail rate on this ore from Baltimore to Steelton in carloads is $1.21 per ton. The distance by water is about 100 miles and the ore might be transported at 5 mills per ton mile or $0.50 per ton, but when $1.8383 per ton is added as the cost of the improvement the total cost of transportation by water becomes $2.3383 per ton. On the basis of 1,500,000 tons per year the cost of the improvement is reduced to $0.7129 per ton moved and the total cost of transporting ore by water from Baltimore to Steelton is $1.2129 as compared with $1.21 by rail.

67. Aside from the movement of ore just discussed, the principal traffic on the river would be raw materials moving to Harrisburg and finished articles, mostly steel products, shipped out. On both inbound and outbound traffic transshipment would be necessary for coastwise or foreign commerce. It is doubtful whether the Susquehanna would get any considerable proportion of this traffic which now moves by rail to or from shipside at Baltimore (84 miles) or Philadelphia (104 miles). The present rates on steel in carloads from Harrisburg to Philadelphia, Wilmington, or Baltimore is 14½ cents per hundred pounds. This rate in the case of Baltimore includes handling on board steamers. Efficient terminals and a highly developed water transportation service would be necessary in order to divert any of this freight from its present route.

68. Direct shipments from Harrisburg without transfer to larger vessels would, under present conditions, be limited to Trenton, Philadelphia, Wilmington, Baltimore, Washington, Norfolk, Richmond, and less important intermediate points, with possibly a small movement farther south via the Chesapeake and Albemarle Canal. It is on this traffic that savings in freight rates sufficient to justify the expenditure must be made. With tidewater (at Port Deposit) now 68 miles away by a direct rail line paralleling the river, practically not a ton of freight moves by rail and water between Harrisburg and the eastern tidewater cities. To justify the expenditure of $9,656,946 and an annual cost of $1,069,368 to extend navigation from Port Deposit to Harrisburg would require an intensive industrial development in the vicinity of Harrisburg far beyond what now exists or may be expected for many years to come.

69. The possible traffic reported includes no movement of coal, probably for the reason that the coal supply of the industries in and near Harrisburg comes principally by rail from the West. Consideration should, however, be given to the possibility of using the river to reduce the cost of transporting coal to eastern industrial centers. The project under consideration would not extend navigation to any of the mining districts. The bituminous fields nearest Harrisburg lie in the Clearfield region, which is about 125 miles distant by rail. The present rate per ton in carloads on Clearfield coal delivered in Harrisburg is $2.33. In the following table is shown the comparative cost, with the present rail rates on Clearfield coal, of shipping coal from the Clearfield region to various points by rail and by rail and water. The water rate is made up of the freight rate from Clearfield to Harrisburg, a transshipment charge of 50 cents per ton at Harrisburg, and a charge of 5 mills per ton-mile for transportation by water.

TABLE 19.—*Comparative cost per ton of shipment of Clearfield coal by rail and water*

To—	Rail rate	Rail and water rate
Philadelphia	$2.84	$3.515
Wilmington	2.84	3.395
Baltimore	2.84	3.390
Norfolk	4.85	4.055

Except in the case of Norfolk there is no saving and the bulk of coal now moving to Norfolk is for shipment to New England or export, for which purposes coal of higher calorific value from the Pocahontas, Kanawha, and New River regions is preferred. It is not believed that the Susquehanna, if improved, would be used to any considerable extent for the transportation of bituminous coal. The possibilities of moving anthracite down the Susquehanna are even less as the anthracite fields lie east of Harrisburg and the bulk of the shipments from there go east by short-rail routes to Philadelphia and New York, or by rail or rail and water to New England.

70. A river improvement involving a high cost per mile may be successful under various conditions such as the following:

(*a*) It may tap directly sources of raw materials such as coal or ore which can be cheaply transported by water without transshipment to the industrial centers where they are used.

(*b*) It may extend navigation into proximity to either the sources of raw materials or the points where these materials are used so that they may be moved by a short rail haul and a water haul long enough to absorb the cost of transshipment.

(*c*) It may extend into an intensively developed industrial region and connect this region by an all water route with the points at which its manufactured products are marketed.

The project for improving the Susquehanna up to Harrisburg does not fulfill any of these conditions. The industrial development at Harrisburg is not sufficient to insure the volume of traffic necessary to justify the expenditure required. Such additional development as might follow the provision of abundant cheap power could just as well occur on tidewater as in the region around Harrisburg.

71. It should be remembered in considering the cost of moving traffic on the Susquehanna that the estimates have been made in such a way as to present the cost of improvement for navigation in the most favorable light possible by charging every item used jointly for navigation and power production to power production alone. Even on this basis it is not possible to show that the benefits to be expected will justify the expenditure involved.

LOCAL COOPERATION

72. If the project described in this report were carried out it would stimulate industry throughout the area in which the power was marketed and cause material increases in property values both along the river and at more distant points. Some degree of local cooperation should certainly be demanded. This might well take the form of requiring the States of Maryland and Pennsylvania to convey to the United States free of cost all lands and riparian rights necessary to the completion of the project, including the sites for locks, dams, and power houses; the rights of way necessary for railroad relocations; and the areas to be flooded by the pools. This would reduce the first cost of the project by a considerable amount which would fall approximately 90 per cent on Pennsylvania and 10 per cent on Maryland. It is believed that these two States would be benefited by the improvement in about that proportion.

RATE OF APPROPRIATIONS

73. If this project is adopted the sum of $500,000 should be appropriated to be used for detailed topographic and hydrographic surveys, for foundation investigations, and for the preparation of plans. This will require a minimum of two years following which proposals for leasing the power-development privileges should be invited. No definite statement as to the rate at which actual construction should be carried on is possible at this time.

CONCLUSIONS

74. The following conclusions have been reached as a result of this survey:

(*a*) The prospective commerce on the Susquehanna River from Harrisburg to the mouth does not justify its improvement for navigation even in conjunction with power development.

(*b*) A considerable proportion of the hydroelectric power available in the river below Harrisburg can be profitably developed. The most favorable sites for present development are at Conowingo and Safe Harbor.

(*c*) The total power available in the river can be marketed at industrial centers within economical transmission distance.

(*d*) Economical power development will not necessarily provide continuous slack-water navigation even if locks are built at the dams.

RECOMMENDATIONS

75. It is recommended that no project for improving the Susquehanna River for navigation from Harrisburg to the mouth be undertaken by the United States. It is further recommended that

the development of the river for power purposes be left to private enterprise under suitable safeguarding clauses in permits and licenses designed to prevent such installations as would impair or destroy the possibility of providing navigation in the future.

F. C. HARRINGTON,
Major, Corps of Engineers,
District Engineer.

[First indorsement]

OFFICE DIVISION ENGINEER, NORTHEAST DIVISION,
New York City, December 28, 1923.

To the CHIEF OF ENGINEERS, UNITED STATES ARMY:

I concur generally in the views of the district engineer.

H. C. NEWCOMER,
Colonel, Corps of Engineers,
Division Engineer.

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