

HISTORY OF THE WASHINGTON AQUEDUCT WASHINGTON DISTRICT CORPS OF ENGINEERS 1953

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#### INTRODUCTION

Water systems develop with the growth of a city. Looking back over the 160 years since Washington was founded, it is apparent that the history of its water system can be divided into three periods corresponding with the advance of population.

During the first period, from 1790 to 1863, the population was small for a long time and houses were far apart so springs and wells satisfied practically all water supply needs of the citizens. With the more rapid increase in population, beginning about 1850, Congress realized that a municipal water system was essential and appropriated federal funds to construct the original works of the Washington Aqueduct which were placed in service in 1863.

The second period in the history of the water system, from 1863 to 1905, was a time which might be described as one in which there was a supply of very muddy water which was far from being safe, satisfactory, or ample. Extensive sedimentation schemes to remove the mud were tried without any appreciable success and the public resentment was continuous. Springs and wells provided the only clear water for drinking and, therefore, were kept in service. Filtration was discussed many times but was considered too expensive. Original works were large enough to bring an ample supply as far as the edge of the city but the distribution mains were not large enough to provide the required quantity or pressure, especially on Capitol Hill. The city water tunnel, started in 1883, was a bold attempt to obtain better distribution and an improvement in quality by increased storage and sedimentation. Complete filtration, however, was the only possible solution for the muddy Potomac River water and the 75 million gallons per day McMillan filtration plant was constructed and placed in service in 1905 thus introducing clear water into the city mains for the first time.

The period from 1905 to the present date was marked with the construction of another filter plant at Dalecarlia, several large pumping stations, and many other improvements which have made the Washington water system a model for the nation.

Grateful acknowledgement is made to Mr. Philip O. Macqueen of the Washington District Office, now retired, whose efforts in research and preparation have made this book possible.

# SPRINGS AND WELLS

When Washington was founded in 1790, the site was already occupied by the two other smaller and much older cities of Alexandria and Georgetown which were obtaining water from numerous springs and wells. It was natural, therefore, to assume that the new national capital could obtain its water from the same source. The center of the new city was in a comparatively low and wide valley and a generous supply of ground water of good quality was readily available for the limited domestic use then prevalent. The only reference made to a water supply at the time of the founding of the city appears in a note on the original plan of Washington as presented by L'Enfant as follows:

"Piney Creek (now Rock Creek) whose water, if necessary, may supply the city".

L'Enfant also considered the possible use of a small stream known as Tiber Creek to create a cascade in front of the Capitol. This latter suggestion was never adopted by Congress but serious study was given in later years to a water supply from Rock Creek.

For the first twenty years after the city was founded, the growth in population of Washington was extremely slow. Pennsylvania Avenue was the principal street. F Street was known as Ridge Street and was considered the edge of the town. A water supply from a good spring or well was a decided financial asset to any property. The four largest and best known springs were the old City Spring on the north side of C Street between 4-1/2 Street and 6th Street, Caffrey's Spring on the north side of F Street between 9th Street and 10th Street, Franklin Square Spring which supplied the White House, and Smith Spring which supplied the Capitol and Pennsylvania Avenue.

The old City Spring, also known as City Hall Spring, was the first water supply to be piped to houses in Washington. In 1802, wooden pipes made of bored logs joined together with short wrought-iron pipe connections were used to convey the water from the spring to a few houses on Pennsylvania Avenue and to Woodward's Tavern. These pipes were paid for entirely by the citizens who used the water. The overflow from this spring emptied into Tiber Creek near Pennsylvania Avenue and 2nd Street. It is recorded that between 1790 and 1810 City Spring was a favorite spot for picnics and town meetings.

Caffrey's Spring was named for the first pastor of St. Patrick's Church. About the year 1890, the water from this spring was collected in a small sandstone reservoir and conveyed through bored logs to the corner of Pennsylvania Avenue and 12th Street. One-third of the cost of this work was paid by the city government and the balance by the residents on Pennsylvania Avenue. This was the first instance of the city undertaking to pay any part of the cost of pipes for water within the city of Washington, Caffrey's Spring is said to have afforded a flow of two barrels of water a minute and the quality was considered very good. It was known also as Burn's Spring and, at different periods, as Federal, St. Patrick's, and Hotel Spring. The leases of the property owners who used this water supply had special clauses concerning water rights.

Franklin Square Spring was the best known and largest spring in the downtown section of the city. It was really a series of springs and the supply was considered inexhaustible. Log pipes were used in 1816 to convey the water to various houses down 13th Street and along F Street to 15th Street. In 1819, the United States government bought the springs and the surrounding land, now Franklin Park, and installed a pipe system to the President's house and to the adjacent executive buildings. Congress appropriated \$9,000 for this work and, ten years later, gave \$12,000 more to complete it and to improve the grounds around the springs. Several small brick vaults were used to collect the water and it was piped down 13th Street to New York Avenue and along New York Avenue to the White House, a distance of about 3,000 feet. These springs supplied the White House, the Treasury, and the War and Navy Buildings with water for over eighty years.

However, the largest spring-water pipe system in the city was the Capitol supply which was installed in 1832 following an appropriation of \$40,000 by Congress. The spring was located on the farm of John A. Smith just south of Soldiers' Home grounds. From this spring, the water was conducted for a distance of about 2-1/2 miles through a 6-inch pipe to two brick reservoirs, one on each side of the Capitol building. In 1837, the Capitol supply was extended along Pennsylvania Avenue to the Treasury and twelve fire plugs were installed.



Many of the house owners in the vicinity of Pennsylvania Avenue drew their supply of water by small pipe connections from this 6-inch main.

While the spring-water supply was of great importance to the city, it undoubtedly is true that most of the water used came from the wells and rainwater cisterns scattered over the city. The cost of the wells and pumps was paid partly by the nearest house owners and partly by the city. In 1865, it is recorded that 1,382 wells were in service and that the position of municipal pump repairman was one of the busiest jobs in the city. Nearly all of these pumps gave a generous supply and certain wells were highly prized for the medicinal quality of the water. The Spa Pump, near Center Market, was one of the most popular wells, although this honor was not conceded in the case of other wells by any means. In all probability, real estate ventures and advertising had a lot to do with the reputed quality of the water. The two pumps which partly supplied the Capitol were not considered very good and a spring near 4th and C Streets, S. E., was used extensively by members of Congress. When the Potomac water was introduced into the city, these wells were gradually eliminated so that, in 1898, only 194 wells were in service within the District of Columbia. In 1907, sixty-two of the wells were closed and, at the present time, there are only a few wells remaining in the city.

The first house in Washington to have running water in the building is said to have been the old Van Ness mansion located on the site of the present Pan American building. These pipes were installed in 1820 from the wells on the grounds. No fixed bath tubs were used in the White House until after 1850. After they came into general use in the city, between 1865 and 1870, they had a marked effect in increasing the per capita consumption of water not only in Washington but in other large cities. It is recorded that, in 1845, Boston became alarmed over the extravagant waste of water through the use of bath tubs and passed laws against their use. However, it soon was found that the laws were rather difficult to enforce.

The old springs and wells of Washington are remembered by thousands of the older generation of the city, perhaps with considerable regret because of the pleasant and familiar taste of the freshly-drawn water. Very few, however, would care to go back to the long line, waiting in turn to fill their buckets or pitchers and to carry them the distance of one or two blocks to their homes.

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Original Map of the Washington Aqueduct Signed by President Franklin Pierce.

# STUDIES FOR MUNICIPAL WATER SUPPLY

The use of springs and wells for supplying small amounts of water to federal and private buildings in Washington was satisfactory for many years but conditions were quite different as far as fire protection was concerned. Valuable state papers were stored in the United States Capitol and other large buildings, and there was considerable fear of fire. Partial protection for the Capitol building was obtained by the construction of two large, brick cisterns which were kept full of water at all times from Smith Spring but this was insufficient for the purpose. Between 1832 and 1850, it became increasingly evident to Congress that the springs and wells could be of local use only and that, eventually, the city would have to get its water from a much larger source.

The first report on a complete water supply for the city was made by Colonel George W. Hughes of the Corps of Engineers, following an appropriation of \$500 from Congress in 1850 for this purpose. Colonel Hughes gave consideration to both Great Falls and Rock Creek as sources of supply but mostly to the latter. In his report\*, the recommendation was made that a dam be put across Rock Creek Valley just inside the present District of Columbia line and that a conduit four feet in diameter be used to convey the supply to a distributing reservoir with a capacity of 10 million gallons, on a hill just north of Franklin Park. The total supply possible from this source was only 12 to 22 million gallons daily. This was not considered satisfactory by Congress which, accordingly, appropriated \$5,000 in 1852 for a second survey and report which would provide a plan for an unfailing and abundant supply of water.

The second report to Congress on water supply was made by Lieutenant Montgomery C. Meigs of the Corps of Engineers who, afterwards, was appointed the first engineer of the Washington Aqueduct. This report is an extremely interesting and remarkable study of the water supply situation and it shows a vision of the city's needs far beyond the average conception of those times. The report covers 55 pages and discusses, among many other subjects, the present and future population of Washington, water requirements, water supplies of other cities in both the United States and in Europe, storage,

\*House Document No. 33, March 3, 1851

fire service, pumps, filtering, sedimentation, sewerage, fountains, sanitation, water power, and estimated costs.

Even Lieutenant Meigs, however, was not able to foresee the actual growth of the city's water requirements. In his report, he discussed the existing daily water consumption in other cities of from 30 to 60 gallons per capita and decided to use 90 gallons per capita for his estimates which then was considered an unusually safe figure. Upon this basis, he estimated that the city would require 22,500,000 gallons of water per day in the year 1900, and that the capacity of his 9-foot conduit from Great Falls would not be reached for almost 200 years. The people of Washington and other cities did not realize, however, how much water they would require and the actual capacity of the conduit was reached within less than onethird of this period.

The story of the construction of the various parts of this great project which covered a period of ten years, from 1853 to 1863, is given in detail in the succeeding pages. Serious difficulties were encountered at the very beginning and lack of adequate funds from Congress completely stopped the work on many occasions. In addition to these troubles, the Civil War of 1861-1865 was in the minds and hearts of every citizen of the United States, and all public work was postponed wherever possible. Construction of the project proceeded slowly, however, and it eventually was completed practically in accordance with the original plans of Lieutenant Meigs. Two quotations from Lieutenant Meigs' report to Congress are inserted here to indicate his interesting literary style:

## Great Falls Site, Page 24:

"The traveller ascending the bank of the Potomac from Georgetown to Great Falls would conclude that a more unpromising region for construction of an aqueduct could not be found. Protected by high walls against the face of jagged and vertical precipices, in continual danger of being undermined by the foaming torrent which boils below, the present canal is a monument of the energy and daring of our engineers. The route seems occupied, and no mode of bringing in the water except by iron pipes șe, ;s.

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Montgomery C. Meigs

secured to the rocks or laid in the bed of the canal seems practicable. Such were my impressions, and though I knew that, in this age, with money, any achievement of engineering was possible, I thought the survey would be needed only to demonstrate by figures and measures the extravagance of such a work. But when the levels were applied to the ground, I found, to my surprise and gratification, that the rocky precipices and difficult passages were nearly all below the line which, allowing a uniform grade, would naturally be selected for our conduit; and that, instead of demonstrating the extravagance of the proposal, it became my duty to devise a work presenting no considerable difficulties, and affording no opportunities for the exhibition of any triumphs of science or skill."

#### Fountains, Page 9:

"Fountains, judiciously placed and kept constantly flowing, induce, by the currents they cause in the sewers, as much to the health of a city as by the coolness they diffuse, they add to its comfort, while, by the grace of their sparkling jets, they please the eye, and add beauty to comfort and health. The pleasure derived from a fountain seems instinctive; it is associated with our earliest reading, The cool fountain in the desert by which the patriarch of old watered his flocks, and the noble fountains of ancient and modern Rome have been objects of admiration and sources of pleasure from the earliest times; and the same feeling that makes the rude but devout Arab invoke the blessings of Allah upon the builder of the murmuring fountain or desert tank is shown in our modern cities where crowds gather in the heat of summer and enjoy the grateful coolness of the Roman fountains--legacies from the ancient

people--or the splendid jet of Boston Common, the profuse display of the New York Park or the Philadelphia Fairmont."

Aside from the "flowery" style used in various places in the report,\* it is also notable that facts and figures were presented in an extremely effective manner. The Congress must have had the same impression, as funds for initiating the work were appropriated almost immediately.

The final plan prepared by Lieutenant Meigs for the Washington Aqueduct called for a dam at Great Falls; intake works on the Maryland shore; a brick or stone conduit 9 feet in diameter between Great Falls and Georgetown, a distance of approximately 12 miles; a receiving reservoir at Dalecarlia to settle out the mud; a distributing reservoir at Georgetown for further sedimentation; and cast-iron pipe lines leading from the Georgetown reservoir to various sections of the city of Washington together with various bridges and water tunnels.

\*Senate Document No. 48, 32nd Congress, 2nd Session

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#### THE OLD CONDUIT

The conduit from Great Falls to Georgetown reservoir was the largest single structure involved in the construction of the Washington Aqueduct and Captain Meigs, promoted shortly after his designation as Chief Engineer, decided to concentrate his first efforts upon this part of the project. As a matter of fact, the name "Washington Aqueduct" is merely another name for the Washington conduit. Congress appropriated \$100,000 in 1853 for commencing the work and surveys were begun at once to secure the necessary right of way. Design of the old conduit was based, to a large extent, upon the early New York and Boston aqueducts which were completed in 1842 and 1848, respectively. In his report for 1856, Captain Meigs states that the conduit for Washington more nearly follows the design of the Cochituate Aqueduct for Boston than the Crotan Aqueduct for New York.

Work of obtaining the right of way for the conduit was a difficult procedure and much more expensive than Captain Meigs had anticipated. Most of the property had to be condemned and appraised by a special jury. In a few cases, the owners would not sell under any condition. This was true especially in the vicinity of Great Falls where the question of available water power was raised immediately. The Great Falls Manufacturing Company, from a charter dated 1839, claimed that it was the "owners of the Great Falls of the Potomac with the tract of land thereunto belonging" and prevented the government from getting access to the land in every possible way. Captain Meigs found that he could not start the conduit at the head of Conn's Island, as he planned originally, so it was shortened about 3,000 feet but the cost of the dam was increased greatly. Ownership to a small parcel of land adjacent to the river just above Lock No. 20 on the canal finally was obtained and this location, therefore, was selected as the head of the conduit.

In November 1853, about 8 months after Congress had given its approval to the work, a force of laborers and mechanics was collected at Great Falls and ground was broken for the conduit. Operations were directed particularly to the crossing under the Chesapeake and Ohio Canal at the head of the conduit and to the opening of the line along the first mile of the work. Tunnel nos. 1, 2, and 3 were started in the latter part of November with day

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labor. Those operations were continued through the winter and the following spring with a force of from 300 to 400 men.

Seven months later, in June 1854, practically all of the first appropriation by Congress had been used up and construction work was suspended. Congress had adjourned without making any appropriation for continuing the work and construction was delayed for an entire vear. In that first year of the work three tunnels had been started, a small section of the brick conduit had been built, and all land in Maryland needed for the conduit had been condemned. A first-class sandstone quarry at Seneca, seven miles above Great Falls, also had been purchased and opened up to supply the cut stone needed for the culverts, gate house and bridges. Preliminary plans and estimates for the entire aqueduct had been made in a very hasty manner and Captain Meigs made good use of the year's delay to get his plans in better shape.

The next two appropriations by Congress were relatively small and the entire work was delayed for almost three years until the first large appropriation of \$1,000,000 was finally made in 1857 and followed by \$800,000 more in 1858. With these relatively large sums, active work on all parts of the aqueduct was begun and continued for a period of over two years. This period of activity continued until June 1859 when all work was again suspended due to lack of funds. Good progress had been made on the conduit, however, and when the third suspension of the work occurred it was approximately 98 percent completed. Cabin John Bridge was the only large item of work remaining unfinished.

Brick, natural cement, and stone obtained from the excavation were the principal materials used in building the old conduit. These materials were selected with unusual care and were placed in the work under rigid inspection. A few of the specifications, prepared by Captain Meigs and used in this work, are quoted in the following paragraphs in order to show the manner and care with which construction was carried on:

"SPECIFICATIONS FOR CONDUIT - The conduit will be circular and generally of nine feet interior diameter; it will when of brick, generally be built of three separate four and a half-inch rings of hard brick. Where it passes through the ground rising as high as the intrados of the arch, the inner ring will sometimes be omitted, and the brick work reduced to nine inches.

"In rock cuts and other deep cuts where suitable stone is on hand, concrete or rubble stone masonry will be substituted for brick, in whole or in part, particularly in the lower or reversed arch.

"The center of the conduit at any point is the grade of the aqueduct at that place. The excavations and embankments will be made to the level of the grade at each place of operations before the contractor for the conduit will be allowed to commence his work The excavation for the lower semithere. circle or reversed arch, however, will generally be made by the contractor for the conduit and it will be trimmed out but little in advance of the laying of the masonry." (Note - The earth fills over the smaller valleys were made almost a year ahead of the actual conduit construction to allow for all settlement possible which was certainly a wise precaution.)

"BRICK MASONRY IN CONDUIT - The bricks, at the time of laying, will be thoroughly wet; every brick must be laid and pressed down into a full bed of mortar, which shall cover its bed and joint; and this bedding shall be done at one operation for each brick, so that no mortar need be worked in after the brick is placed. The inner edge of the joint of each course will be the least possible to admit of mortar between the bricks. The joint of mortar between each two rings will not be less than threeeights of an inch in thickness.

"CONCRETE - One barrel of cement (300 lbs. net) with two and a half barrels of sand and thirty cubic feet of stone will make a batch of concrete. The mortar having been spread on a bed of plank, the broken stone will be spread evenly over it

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and the whole mass turned over twice and thoroughly mixed with a hoe or shovel. When mixed and laid it shall be rammed into a compact and water tight mass." (Note - These proportions are, roughly, 1 :2 :10 and it is astonishing to observe how strong this old concrete is after almost 100 years.)

"MORTAR - The mortar for masonry will be made of two and a half parts of sand to one part of cement. The sand and cement after being measured, will be mixed dry and small quantities only taken from the heap, will be mixed with water as required." (Note - The mortar for concrete was made first and amount of water was kept extremely low.)

"CEMENT - All cement must pass the test of setting hard under water and not breaking up into lumps. Three hundred pounds net of cement will be estimated as one cask or barrel." (Note - This was of course natural cement, as Portland cement was not made at that time. It came from Maryland, New Jersey, and Pennsylvania and was delivered on the dock in Georgetown. The inspectors tested small specimans which were considered good if the set occurred in thirty minutes or less.)

"SAND - None but good, clean, sharp, flint sand will be received. Proposals will state the number of bushels and bidder will undertake to deliver." (Note - The contract price was six cents per bushel delivered on the bank of the canal in bins prepared for its reception. Competition was brisk and lower prices were obtained later.)

These paragraphs taken from Captain Meigs' specifications form only a small part of the entire set but give some idea of the care with which the work was done. All materials, such as cement, sand, brick and even forms and centers, were furnished by the United States for reasons of economy and the various contractors were quickly penalized for any waste. The amount of cement and other materials needed for each unit of the work was carefully computed, and if a contractor exceeded this amount the value of the excess material was deducted from his monthly statement. Construction under contract was done on the unit cost basis throughout, and it is interesting to compare the costs at that time with present-day prices. Average unit costs are shown in the following table:

Earth excavation\$ 0.15 per cr	u. yd.
Hard rock excavation 1.25 " "	ÎŤ
Soft rock	18
Laying brick 2,25 " "	12
Laying stone masonry 3.00 " "	**
Furnishing Seneca sandstone 0.26 per cu	u。ft。
Concrete in place 3.25 per cu	u.yd.
Furnishing brick 8.25 per th	housand

Present-day unit costs are approximately ten times those noted above which agree, roughly, with the comparative increase in labor costs. Concrete, at \$3.25 per cubic yard, is the labor cost only of transporting, mixing, and placing the materials. The only machine available for construction purposes in those days was the steam-driven hoist or derrick. Tunnels often were found to be cheaper than deep open-rock cuts, and the old conduit contains a total of eleven tunnels with an aggregate length of 5,392 feet. It is recorded in one of the early reports that a steam-operated rock drill was considered as not worth a trial, as drilling by hand was so far superior and faster.

During most of the period of construction of the conduit, from 1853 to 1863, labor was plentiful and wages were comparatively low. Masons, stone cutters, plasterers, carpenters, and painters all earned from \$2.00 to \$3.00 per day and average unskilled labor was paid from \$1,00 to \$1,25 per day. An unusually large payroll for the entire Aqueduct for May 1858 contains the names of 5 assistant engineers, 50 surveymen and inspectors, 700 unskilled mechanics, 1,100 laborers, 40 teams, 60 cooks and waiters, 30 overseers, 20 clerks, and 12 slaves. This monthly payroll was \$36,600 and the total force was about 2,000 men. In addition to this force, the various contractors hired about 1,000 men so the entire force was from 3,000 to 4,000 men. This was for a period of great activity. When funds were low, all work was practically suspended and the payrolls contained only about 50 names. Out on the various parts of the work, the men lived in boarding houses furnished by the Government and were charged from \$10 to \$13 per month for bed and meals. Conditions must have been rather rough, as saloons and gambling places thrived

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on private property just a few paces distant from Government boarding houses, in spite of efforts to have them closed.

A few slaves were employed on the construction, between 1857 and 1860. They were paid \$1.20 per day and the money was turned over to the various owners who signed the payrolls. The maximum number of slaves used was approximately fifteen.

Sickness among the men was high, and several times the work was entirely closed down due to outbreaks of malarial fever. The "sickly season" is often mentioned in the early reports and for this reason the months of August, September, and October frequently show a large drop in the labor force. The cold weather, beginning in November, eliminated malarial conditions each season and winter and spring were busy periods. Other factors which held back the work were the scarcity of labor during the Civil War period, from 1860 to 1865, and the fear at certain times of Confederate raids.

When the work closed down for the third time, in June 1859, due to the lack of funds, it remained this way another year until Congress appropriated \$500,000 to complete the project. Captain Meigs was transferred from the work by the Secretary of War from September 1, 1860, to February 22, 1861, and his place was taken by Captain Benham. Many interruptions occurred in 1861, the first year of the Civil War, and work on the Aqueduct was suspended for the fourth time. Most of the laborers connected with the Aqueduct at this time were transferred to the Engineer branch of the Army and used to erect military earthworks in nearby Virginia and Maryland.

Water from the Potomac River was first introduced into the conduit in December 1863 and, two days later, it was allowed to flow into the receiving reservoir. Two weeks later, it was shut off to point up the conduit. After these repairs were made, the water again was turned on, in July 1864, and the conduit was placed in regular service from that date. The care and skill which Captain Meigs had used in constructing the old conduit were amply proved by the remarkable watertightness of the structure. After it was placed in full service, it was not drained again, completely, until September 1891 or for a period of over 27 years. The annual report for 1866 states that "all parts of the conduit appear to have been built in a most substantial manner and not a dollar has been expended on any portion of it for repairs."



## CABIN JOHN BRIDGE

Considering each of the various structures of the Washington Aqueduct from historical and engineering viewpoints, Cabin John Bridge easily occupies the most important place although its total cost was less than that of many of the other features of the work. Built by Captain Meigs during the period from 1857 to 1863 for the purpose of conveying the conduit over Cabin John Valley, this imposing granite arch immediately won its reputation as the longest masonry arch in the world and held this record for about 40 years. It is a familiar landmark to practically all of the citizens of Washington and, in the early days, it was visited by thousands of persons including many engineers from foreign countries.

Work on the conduit was begun in 1853 but no work was started on Cabin John Bridge, or Bridge No. 4 as it was called at first, until 1857. In this interval, from 1853 to 1857, Captain Meigs changed his mind regarding the design and decided to construct a long, single arch in place of the series of small arches as originally proposed. Early records do not show any specific estimate for the change in design. The appropriations by Congress for the first four years of the work were small and Captain Meigs probably did not make up his mind to substitute the single arch for the series of arches until 1857 when Congress made its first large appropriation of \$1,000,000 for continuing all of the work on the Aqueduct.

The reason for this change of design is easy to analyze. Captain Meigs wanted to build a novel and monumental structure and he knew that the single arch would be the longest in the world. He probably also knew that the cost of the single arch would be much greater than the cost of a series of small arches but considered that certain money saved by the revised conditions at Great Falls and other places could be used for this purpose. The appropriations were made for the entire Aqueduct and not individual structures and special permission of Congress was not required for the change.

Actual work on the bridge was begun in the Spring of 1857, as soon as the first large appropriation by Congress became available. Plans for the bridge were prepared by Mr. Alfred L. Rives and approved by Captain Meigs. Mr. Rives was a graduate of the University of

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Paris and a very capable designer. Soon after work on the bridge started, Mr. Rives was placed in charge of the construction by Captain Meigs as Resident Engineer and remained on the work until 1861 when he resigned to join the Southern Forces. Mr. Rives' principal assistant was Mr. C. T. Curtis who acted as foreman of masons and inspector.

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Economical transportation of the heavy timbers and the stone for the bridge was an important question requiring an early solution. All of the granite and sandstone was brough to the site on the Chesapeake and Ohio Canal which was only about 1,000 feet away from the bridge. Transportation from the canal to the bridge was obtained by constructing a dam across Cabin John Creek near the canal together with a lock to permit boats to pass from the canal up to the pool under the bridge. At the direct site of the bridge, timbers and stone were hoisted into place by derricks and a travelling crane working along the bridge center line. A quarry for all of the abutment stone was opened a few hundred feet up the valley. At the present time the valley is overgrown with trees but indications of the old canal lock, piers, and quarry can be readily found.

The main arch of the bridge has a span of 220 feet and a rise of 57-1/4 feet. The arch ring is constructed of dressed granite from Quincy, Massachusetts, 4 feet 3 inches thick at the crown and 6 feet 2 inches thick at the spring line. The arch rests on abutments of dressed Fort Deposit granite. The granite arch is backed with a secondary arch composed of Seneca sandstone in slabs 10 inches thick, place in radial position. The brick conduit 9 feet in diameter an enclosed in cut stone rests over the top of the arch. Railings were not placed on the structure when it was first put into service, as Captain Meigs did not plan to use the bridg for highway traffic.

Preliminary work on the bridge progressed rapidly at first and, in May 1858, a contract was signed for the settin of all of the masonry. At this point the work was slowed up for many months, due to failure of the other contractors to deliver the granite for the arch. By the end of September 1859, the arch and part of the spandrels were finished but the work was stopped entirely owing to lack of funds. In Ma 1861, the work was again started by the contractor. In Capt Meigs' report at the end of the fiscal year 1861 he makes th following statement:

"The centering of the bridge has been removed and the weight of the arch rests on its own bearings. During the striking of the centers of the and reoin the s Mr. pector.

and the iring an as brough was only ion from g a dam h a lock ol under ers and velling ry for feet up grown lers, and

Peet and of spring peposit y arch k, place meter an Railrst put he bridg

ly at e settin lowed up tors to tember ed but . In Ma In Capt makes th the closest instrumental observations failed to discover the slightest settlement in this largest stone arch in the world, 220 feet in span."

In this report Captain Meigs also gives the name of "Union Arch" to Cabin John Bridge but this name was never adopted for general use. The total time that the bridge was under construction was about six and one-half years but work was delayed at least 50 percent of this time due to lack of money and other causes.

Soon after the bridge was placed in service, it was realized that it was almost essential to use the structure for highway traffic as well as for conveying water as it was needed to give access to the top of the conduit between Cabin John and Great Falls for repairs and maintenance of the conduit. Congress was asked for funds for this purpose but the country was engaged in the Civil War and the work was not considered essential. Copings or parapets were not built on the bridge until 1873.

Several inscriptions were cut in the stone on the bridge by order of Captain Meigs, while it was being built and shortly after its completion. On the west abutment is the following:

> WASHINGTON AQUEDUCT Begun A.D. 1853. President of the U.S. Franklin Pierce Secretary of War Jefferson Davis. Building A.D. 1861 President of the U.S. Abraham Lincoln Secretary of War, Simon Cameron

During the Civil War, the feeling against Jefferson Davis was so intense that the Secretary of the Interior, Caleb B. Smith, ordered the erasure of Mr. Davis' name. This was done in 1862 and the space was left blank. Forty-six years later, in 1908, the incident was brought to the attention of President Theodore Roosevelt and he ordered Jefferson Davis' name to be cut again on the tablet in its original position. In order to comply, it was necessary to cut all of the letters off the stone and to carve the entire inscription again with new letters. The present inscription is an exact copy of the original. On the east abutment of the bridge appears the following inscription:

UNION ARCH Chief Engineer, Capt. Montgomery C. Meigs, U.S. Corps of Engineers Esto Perpetua wi th Ca

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This tablet was cut in 1861 by order of Captain Meigs, in order to fix the proposed new name for the arch. It is believed that Captain Meigs also intended to place the name of Alfred L. Rives on this tablet as Assistant Engineer but this was changed when Mr. Rives resigned to join the Southern Forces.

During the short absence of Captain Meigs from the Washington Aqueduct in 1860, when he was temporarily assigned to other work, Captain Benham and Lieutenant Morton caused their names to be inscribed on the arch stones near the east abutment. When Captain Meigs returned in 1861 he immediately had these names cut out and his own name inscribed as follows:

• • • • • • • • • • • • • • • • • • • •	•
M. C. MEIGS	:
Chief Engineer	:
· Washington Aqueduct	:
· A.D. 1858	:
Fecit	:
	:

From an historical standpoint, Cabin John held the record as the longest stone ashlar masonry arch in the world from the time of its completion in 1863 to 1903 when the Luxemburg Bridge in Europe was opened. The span of this bridge was 277.7 feet or 57.7 feet longer than the Cabin John arch. One year later, in 1904, the masonry arch at Ploven, Saxony, was completed. This arch has a span of 295.3 feet and it is at present the longest stone arch in the world. The locations of a few other long span masonry arches are Trieste, Austria (span 278.9 feet), Mantanzas, France (span 262.8 feet), and Algiers (span 227.0 feet). History records, also, a long arch with a span of 251 feet at Trezzo, Italy, constructed in 1380 and destroyed in 1427, over 400 years before Cabin John arch was built.

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All long-span masonry arch bridges are designed with hollow spandrel arches, above or at the ends of the main arch, to relieve the load as much as possible. Cabin John Bridge has five spandrel arches at the west end and four spandrel arches at the east end. These spandrel arches are hidden by the vertical side walls for the sake of appearances as they were constructed of less expensive materials. Many people, no doubt, believe that Cabin John Bridge is solid masonry but this, of course, is not correct. Two steel doors in the abutments, one at each end, have been provided to give access to the interior of the bridge so that it may be inspected at any time.

The origin of the title "Cabin John" as applied to the bridge and the stream is somewhat traditional. There is a story that a character by the name of "Captain John" or "John of the Cabin" had a small log house in the valley just above the site of the bridge in the early days but that he left or disappeared many years before the bridge was built. The old deeds of Montgomery County, Maryland, record the name of the creek clearly as "Captain John" and this is undoubtedly the correct original name, although the source of the name is unknown. However, The name "Cabin John" is the one that is now used both officially and by the general public. The name "Union Arch" was discontinued ten years after the bridge was completed.

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# ROCK CREEK BRIDGE

Judging from Captain Meigs' reports and notes, it is readily observed that his special pride in the construction of the Washington Aqueduct was reserved for the Cabin John Bridge and for the Rock Creek Bridge which conveyed the flow of the aqueduct over Rock Creek in the District of Columbia. In one of his reports, he states:

"Both bridges are unique among engineering structures; the Cabin John Bridge being the (longest) stone arch in existence and the Rock Creek Bridge being the only one in which (cast iron pipe) arch ribs are utilized to convey the water supply of the city and at the same time to support the roadway. The Centennial Commissioners voted to me their diploma and medal for the plans of these bridges and they have been much admired. Their elevations and plans have been published in the engineering journals of England, France and Germany."

Cabin John Bridge is higher and more imposing than Rock Creek Bridge and it has naturally received most of the praise. Rock Creek Bridge was an entirely different structure. Its essential features were two 48-inch cast iron pipes built in arch form with a 200-foot span and resting on masonry abutments. These pipe arches were used to convey the entire city water supply, and also to support the street for many years. At the present time, these two massive cast iron arches are entirely hidden by the new and much wider reinforced concrete arch bridge built over the original structure at the same site. The pipes themselves are visible, however, in recesses on the under side of the new bridge and they still are used to convey a portion of the water supply to the city.

In his original estimate in 1853, Captain Meigs proposed to convey the water supply under Rock Creek by means of cast iron pipes and not to use any bridge at this site. The plans were changed, however, in 1857 and it was decided to use the pipes themselves as arches for a bridge over the creek. This was an engineering feat of major importance at that time and would be even at this date, and Captain Meigs gave particular attention to this part of the work. Construction of the bridge was begun in the Spring of 1858 under two contracts, one for the masonry work and one for the cast iron pipes and superstructures. Progress was comparatively rapid and two years later the structure was practically completed. An interesting description of the bridge is given in a news clipping dated 1860 from Captain Meigs' scrap book and is quoted, in part, as follows:

"Among the public works now in course of completion at Washington, one of the most remarkable, though least known, is the Washington Aqueduct Bridge over Rock Creek, at the western end of Pennsylvania Avenue, now nearly completed from the designs and under the direction of Captain Meigs. This bridge is a cast iron arch of twenty feet rise and two hundred feet clear span between the abutments. The arch consists of two ribs, each of which is composed of seventeen cast iron pipes of forty-eight inches internal diameter, one and a half inches thick, and twelve feet three inches in length. They have flanged ends pierced with holes for screw bolts by which the pipes are firmly connected together. After being cast, they were placed in a lathe, and the ends and flanges were accurately turned or faced off. They are put together in the form of a circular arc, the faced ends abutting against each other, and forty screw bolts firmly secure each joint. Such is the accuracy obtained by the present use of machinery in engineering, that these joints are watertight, under the aqueduct pressure of 120 feet head, by mere application of the dressed surfaces of cast iron, no packing or cement being used in the joints.

"This bridge is particularly remarkable for the double duty which the arch performs. While it supports a roadway, forming a beautiful and much needed communication, by which the traffic between the cities of Washington and Georgetown is carried over, the water of the Washington Aqueduct is conveyed into the city of Washingtom through the pipes of which the arch is composed. To guard against all danger of freezing, the pipes are lined with staves and resinous pine timber, three inches in thickness, leaving a clear water-way in each rib of three and a half feet in diameter. ring rk r the g de-

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"Had either of these bridges been constructed in Great Britain, the public press would have teemed with illustrations and descriptions of them, and every reading man, woman and child in Europe and America would have been as familiar with their history as with that of the Menai Bridge or the "Great Eastern", while in Washington they are executed and few but those who have bestowed upon them the thought and toil necessary to their design and construction, seem to know of the existence of such national achievements of science and skill."

The "Menai" bridge referred to in the above paragraph was built for a railroad by Robert Stevenson in 1849 in England. It was one of the earliest wrought-iron structures in the world and was composed of plates so that it had the appearance of a large rectangular tube. It is said that, when it was first placed in service, it was considered such a daring structure that the passengers would hold their breath until the train had crossed safely. The "Great Eastern" referred to was the largest steamship at that time and the forerunner of the many large ships now in ocean service.

After the Rock Creek Bridge was opened for traffic in 1862, it immediately became more popular than the old wooden bridge across M Street which was just a few hundred feet away, as it offered a more direct highway between Washington and Georgetown. The bridge, however, was only 17 feet wide and the street was about 50 feet wide so that a traffic congestion was almost immediately encountered. Adding to the difficulty, one of the railroads obtained authority of Congress to lay their tracks across the bridge and this was done as soon as it was opened. Travel over the bridge was so heavy that another act of Congress was obtained about ten years later which forced the railroad company to remove its tracks.

In spite of the traffic congestion which became much more complicated in later years, Rock Creek Bridge continued in service for slightly over half a century which is a fairly good record for a metal bridge. The principal repairs consisted of an entire new wooden floor about every three years, painting the pipe arches, and tightening the bolts. In 1913, Congress appropriated funds for building a new bridge on the same site and the structure was turned over to the District of Columbia. When the present concrete arch bridge over Rock Creek at Pennsylvania Avenue was built, the superstructure of the old Washington Aqueduct bridge was entirely removed and the 48-inch pipes were left in special recesses between the new concrete arch ribs so that no part of the weight of the new structure is carried on the original arches. The new bridge was finished in 1916.

Considering the size and unusual features involved in the construction of Rock Creek Bridge, it is rather a surprise to find that it gained so little attention and praise from either the public or the technical press. Captain Meigs has stated that its plans were copied in many foreign engineering magazines. This was undoubtedly true but, here in the United States, it is not mentioned in any encyclopedia or civil engineering books that can be found whereas Cabin John Arch is mentioned in practically all of them. The exact reason for this is unknown as it is believed to be still the longest unsupported metal pipe arch in the world.

There are, however, two reasons which can be given which had some effect in keeping the bridge out of public attention. In the first place, the history of bridge engineering shows that cast iron as a bridge material came into prominence in Europe about 1840 and continued in use for about 20 years. In the meantime, the Pratt and Howe trusses, made of wrought iron, had been invented and these two types rapidly replaced all other metal bridges. Cast iron was discontinued as a bridge material about 1860 as it was found to be not suited to withstand shocks and vibration, If the Rock Creek cast iron pipe arch had been built twenty years earlier it probably would have been received as one of the wonders of the world, but it just happened that, when it was built, cast iron as a bridge material already was being superseded by better materials. In fact, its safety was questioned by the District Engineer in 1877, only a short time after it was completed, but a special board, appointed by the Chief of Engineers, found it to have "a superabundance of strength under any statical or moving loads likely to be placed upon it." \*

Another reason which may be given for the little attention paid to the original bridge was due to the surroundings. The bridge was located in an unsightly section of the city near many industrial shops and yards which detracted greatly from the appearance of

\* Annual Report, Washington Aqueduct 1877

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the arches. Rock Creek, itself, at this point was not much more than a stagnant, muddy pool and, under these conditions, few could find anything to admire in the structure. Cabin John arch, with its deep wooded ravine and naturally beautiful setting, had an entirely different appeal. Bridges are, perhaps, more dependent upon artistic surroundings for appreciation of their appearance than any other type of architecture and, if additional funds had been provided for parking a small section of Rock Creek in the vicinity of the bridge when it was first built, it undoubtedly would have added greatly to its general appreciation in both public and engineering opinion.

#### OTHER WORKS

It will be interesting to present a brief summary of the principal remaining items starting at the Potomac River inlet at Great Falls.

# Great Falls Inlet

These works were built by Captain Meigs as part of the old conduit and consisted of a stone masonry intake and blowoff, a cut and cover header under the Chesapeake and Ohio Canal and a control gate house, all substantially built and in good condition now after almost 100 years of service. In the gate house is an elaborate stone tablet with the following inscription:

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	n 9
WASHINGTON AQUEDUCT	0 4
Projected by Captain Montgomery C. Meigs	•
U. S. Corps of Engineers, Chief Engineer	•
Begun November 8, 1853 by Franklin Pierce	•
President of the United States	0
This stone is erected in the unfinished gate-house	9 9
at the Great Falls of the Potomac	e O
June 10, A.D. 1858 James Buchanan	•
being President of the United States	•
Captain M. C. Meigs, Chief Engineer of the Washington Aqueduct	÷
The assistant engineers have been	e D
W.H. Bryan, C. Crozel, C.G. Talcott, A.L. Rives	•
W.R. Hutton, E.T.D. Myers	0
Cost of work as estimated 1853, \$2,300,000	0 9
Actual cost when finished $\$$	0
Dei Gratia	0
Esto Perpetua	ů
	•

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One of the interesting features in the gate house is the old control equipment for shutting off the flow of water to the conduit, consisting of 20 small cast iron slide gates two feet wide and four feet high in two sets of 10 each, operated by iron stems 30 feet long with threaded hand wrenches. At the present time two large motor operated sluice gates or, perhaps, one 8 x 8-foot gate would do the same work. However, the 20 small gates still are in service and may remain in service for another 100 years.

#### Tunnels

Detail specifications for tunnel excavation for the Washington Aqueduct as written by Captain Meigs consisted of only two short paragraphs and are quoted in full as a matter of considerable interest and comparison with present-day language:

"The tunnels shall be circular, and of eleven feet in diameter. They shall have the same grade as the adjacent parts of the aqueduct, and they shall be cut as smoothly and evenly as the nature of the ground through which they pass will admit of; and, in the measurement, the net section of the circle of eleven feet diameter only shall be considered.

"The materials removed from the tunnels shall be disposed of as the engineer shall direct, and shall be transported two hundred feet from the entrance without any additional charge; but any haul over this two hundred feet, or any expense incurred by the contractors in disposing of this material by the direction of the engineer, other than in the usual dump, shall be paid for at the estimate to be made by the engineer." (Note - These specifications deserve a prize for brevity and for the last sentence that the engineer is allowed to set the price for over-haul.)

Low prices for tunnel excavation of about \$5.00 per cubic yard probably explain why Captain Meigs decided to use eleven tunnels, ranging in length from 86 feet to 1,437 feet, in the nine miles of conduit between Great Falls and Dalecarlia reservoir. It was his intention to line all of the tunnels with brick but the rock was firm and most of them remained unlined for over 50 years.

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#### Reservoirs

One of the most important features of Captain Meigs' plans, one which he hoped would provide ample sedimentation to clarify the muddy Potomac River water, was the construction of a large receiving reservoir, followed by a distributing reservoir, in the line of the conduit between Great Falls and the city. The receiving reservoir or, as it is known at the present time, the Dalecarlia reservoir consisted simply of an earth dike across the valley of Little Falls brook at the District boundary line. This reservoir had a total capacity of about 150,000,000 The distributing or Georgetown reservoir, 10gallons. cated two miles closer to the city, was a much more difficult engineering problem. No valley was available at this location and it was necessary to excavate the site and to construct a long rectangular earth dike to provide storage space. Money available for this item was scarce and work was deferred so often that, eventually, Captain Meigs came to the end of his tour of duty before the reservoir was started. He did, however, build a bypass conduit at the site which served to convey the flow of the aqueduct until the reservoir was completed about ten vears later. The water remained in these reservoirs several days before it was sent to the city but they did not eliminate the fine, unsettled material carried in suspension which was destined to give the city water supply a muddy, yellowish color for over forty years until filtration finally was adopted.

#### Bridges

Altogether, the Washington Aqueduct has six bridges, two of which, at Cabin John and at Rock Creek, have been described in previous sections. Bridge nos. 1 and 2 were only 16 feet long and were little more than special culverts. Bridge No. 3, about a mile above Cabin John, was a very attractive stone arch with a clear span of 75 feet. The inscription on this bridge contains the names of Captain Meigs and the Division Engineer, Charles G. Talcott, C. E. Bridge No. 5, over College Pond, was similar to Rock Creek bridge in that two cast-iron pipes were used for arches but the span was only 120 feet. In retrospect, it is hard to see why Captain Meigs used bridges at all for either the Rock Creek or the College Pond crossings as the cast iron water mains could have been laid under both of these small streams for much less than the cost of making them

into bridges. The bridges, of course, were picturesque and imposing and Captain Meigs was human enough to enjoy publicity. The College Pond bridge, in fact, has been buried under an earth fill so that it has disappeared entirely. Cabin John Bridge, however, still is considered one of the most graceful and impressive stone arches in existence.

#### <u>High Service Reservoir and Pump Station</u>

One of the principal reasons for adoption of the scheme of obtaining water from Great Falls was that the elevation would be sufficient to provide pressure by gravity over almost the entire city as built up at that time including Capitol Hill. However, one small section, located in Georgetown near 31st and R Streets, was above the hydraulic gradient and a small pump station and reservoir had to be included to supply this area. Ninetynine engineers out of one hundred would have used a small steam pump and a standard masonry reservoir for this purpose, but not Captain Meigs. There was an opportunity here for some original engineering which he used to the The reservoir, probably the first and last of its limit. kind in the world, located on top of a high hill, was a circular-domed brick structure, 120 feet in diameter and 50 feet high, reinforced with flat bands of wrought iron embedded in the masonry to take care of the tensile stresses. Not much attention was paid to this structure when it was built but when it was torn down about 15 years ago the National Association of Brick Manufacturers was astonished to find a method of construction which preceded reinforced concrete by several decades.

In addition to the reservoir, Captain Meigs adopted an original idea in pump stations by use of a massive duplex water ram or "water pressure engine" as it was first called. The entire specifications for this machine were as follows:

"The engine will be duplex; one portion moving the valves of the other; double-acting upon the principle of Henry R. Worthington patent of 1855. The motive pistons will be 10 inches in diameter and the pumping plungers of such size that the machine shall work at the velocity of eighty feet per minute." Installed in a vault in the west abutment of Rock Creek Bridge, this water-pressure engine lifted about 200,000 gallons per day to the high-service reservoir for about fifteen years when it was replaced by a steam pump. The mechanical construction of this water-pressure engine is so interesting that it has been preserved as a permanent exhibit in the Smithsonian Museum of Washington.

# Pipe Lines

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The stub ends of four 48-inch cast iron pipes in the old pipe vault at Georgetown reservoir bear mute testimony to the ambitious arrangements made by Captain Meigs for distributing the Potomac River water to the In his original estimate, he asked for and obcity. tained funds for a 12-inch and a 30-inch pipe with the idea, as he states, of replacing the 12-inch main with a larger one at a later date. This was obviously poor judgment since a water shortage developed almost the first day the 12-inch pipe was placed in service, due to the insufficient capacity of the main. Even the 30-inch pipe failed to satisfy the needs of the city at that time as the population was about 60,000 and was growing rapidly. Both pipes extended from Georgetown reservoir to the United States Capitol and the 12-inch main was continued on to the Navy Yard. The four 48inch pipe stubs were destined never to be used in their full capacity as the City Water Tunnel, completed forty years later, served to carry the major portion of the flow of the conduit. The old pipe vault in Georgetown reservoir, a vaulted brick structure 40 feet long and 25 feet underground, is still the largest pipe vault in the city and a very interesting example of early water works installation.

Under the terms of the Act of Congress appropriating money for the Washington Aqueduct, the District of Columbia Water Division began immediate construction of the many miles of smaller branch water mains throughout the city and thus provided the essential means for distribution of the new supply from the Potomac River.

# Conclusion of Captain Meigs' Work

The tour of duty of Captain Meigs with the Washington Aqueduct lasted for about ten years, from November 1852 to June 1862, with the exception of eight months in 1860-61 when he was transferred temporarily to Dry Tortugas Island off the coast of Florida near Key West to take charge of the construction of Fort Jefferson. Neither correspondence nor his annual reports give a fair insight into his character and we have to gain a picture of his personality from his plans and works and an interesting scrap book, a volume about the size of Webster's unabridged dictionary in which he enclosed photographs, plans, sketches, clippings, estimates, and a few personal notes. He was a tall, strong, and very good-looking man with rather a flair for high hats and dress coats even when out on construction work. He was an extremely strict disciplinarian and held the respect and perhaps a little fear of all of his immediate employees.

He was intensely proud of his engineering work and had his name carved in the granite arch stones in many places as "Chief Engineer of the Washington Aqueduct". He even had his name cast in the metal risers of thirty nine cast-iron steps leading down into one of the valve vaults and also on hundreds of valves, fire hydrants, and pieces of water pipe under the city streets. To his credit, however, it should be noted that he also included the names of his principal assistants in many cases.

The temporary transfer of Captain Meigs to Dry Tortugas Island was probably the result of his very strict sense of For some reason, the appropriation by Congress of duty. \$500,000 for Washington Aqueduct in 1860 contained the wording that "the money is to be expended under the supervision of Captain Meigs". President Buchanan was particularly incensed with this statement and sent a strong letter to Congress stating that "he would order Captain Meigs to any other duty he might deem expedient". Almost immediately thereafter, the Secretary of War issued an order appointing Captain Benham as Chief Engineer of the Washington Aqueduct and directed Captain Meigs to furnish him with plans and arrange for Captain Benham to pay for all work performed. Captain Meigs refused and returned all of Washington Aqueduct money back into the Treasury. At this point, he was ordered to take up the work on Dry Tortugas Island which amounted, in effect, to banishment.

When he was ordered back eight months later to take charge of the Washington Aqueduct, he had a complete audit made and found that about \$150,000 had been spent in his absence which he considered illegal. He could not get this money returned but he promptly refused to pay all claims for work performed in his absence, probably with considerable satisfaction, as stated in detail in his last annual report.

When Captain Meigs left the Washington Aqueduct in June 1862 for military duty, he was promoted to the rank of Brigadier General and Quartermaster General of the United States Army, a commission which he held for the rest of his life. He always retained an interest in Washington Aqueduct affairs and frequently expressed an opinion on various features of the work, in letters to members of Congress, especially when his plans were changed. He died at his home in Washington in 1892 and was buried in Arlington.

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# PERIOD OF UNFILTERED WATER 1863 - 1905

It has been noted in the introduction that, during the 40-year period from the time the aqueduct was placed in service in 1863 to the end of the century, the water supply in the city mains of Washington was not safe, satisfactory or ample. This would sound as though Captain Meigs had made a great mistake in planning the structures, but the source of the trouble was almost entirely due to other reasons. In fact, at this time, all of the large cities such as Philadelphia, Cincinnati, Pittsburgh, St. Louis, and Kansas City, where the public water supply was obtained from rivers, were having the same difficulty with muddy water in the city mains and, in most cases, even greater trouble than in Washington. Plain sedimentation was considered as the most suitable method of purifying water. Although filtration was used in France and England at a much earlier date, it did not come into practice in the United States until after 1880 and then only on a relatively small scale. Captain Meigs followed the plans of Boston and New York in designing the Washington Aqueduct, and he no doubt anticipated that the two large storage and sedimentation reservoirs in his plans would result in a water fully as clear as that obtained in New York.

It is not intended to imply that the water supplied to Washington was as bad as that described by Mark Twain in his life on the Mississippi where:

"If you let your glass stand for half an hour, you can separate the land from the water as easy as Genesis; and then you will find them both good; the one good to eat, and the other good to drink. The land is very nourishing, the water is thoroughly The one appeases hunger; the wholesome. other thirst. But the natives do not take them separately, but together, as nature mixed them. When they find an inch of mud in the bottom of a glass, they stir it up, and then take the draft as they would gruel. It is difficult for a stranger to get used to this batter, but once used to it he will prefer it to water."

In their annual reports on the Washington Aqueduct, the district engineers described the water in the city mains as clear on 200 to 300 days of the year and slightly to very turbid for the balance of the time. The local newspapers described the water as "murky", "brownish", "dirty and impure six months of the year", and "not a drop fit to drink". In any event, the water was not safe or satisfactory. As far as volume was concerned, the supply in the city mains was never ample as the rapid growth in population created demands for additional new water mains and other facilities as fast as they were completed, a condition which has existed even up to the present day.

By special Act of Congress in June 1862, the Washington Aqueduct was transferred, temporarily, to the Interior Department where it remained during the period of the Civil War. Due to scarcity of labor and materials and to lack of appropriations, this was a time of limited construction activity. The balance of funds available at the date of transfer was only \$224,000, and the next appropriation by Congress of \$150,000 was not made until 1864. Silas Seymour, one of the leading engineers of the Interior Department, was appointed by the Secretary of Interior to be Chief Engineer and General Superintendent of the Washington Aqueduct.

The first effort of Mr. Seymour was directed toward getting the Washington Aqueduct into service from Great Falls on a limited basis. All of the structures were complete except the dam at Great Falls, and the distributing reservoir at Georgetown which was provided with a by-pass conduit thus making its immediate construction unnecessary. Captain Meigs' plans for the dam at Great Falls called for a simple rock-fill structure consisting of an embankment of heavy rubble stone with a top width of twenty feet and slopes of one to one on the upper side and one to five on the lower side. The Interior Department requested funds for a cut-stone dam solidly anchored to the bed-rock of the river. Mr. Seymour, in the meantime, planned to obtain a limited flow of about 25 million gallons per day through the conduit to the city and he found that this could be accomplished by means of a temporary rock-fill deflecting dam in the Maryland channel of the river. Water from the Potomac River was introduced into the conduit in this way, in December 1863.

The Interior Department also changed the plans of Captain Meigs on the design of Georgetown reservoir and called in various consultants on the questions involved which were presented in a special report\* to Congress. Captain Meigs had planned to line the slopes of the reservoir with broken stone from three inches to one and a half inches in size and 18 inches thick; whereas, the Interior Department recommended the use of heavy riprap stone resting on a 12-inch bed of broken stone.

Congress appropriated \$150,000 in 1864 for beginning construction of a dam of solid masonry across the Maryland channel at Great Falls and a connecting byconduit around Dalecarlia reservoir. Contracts for these structures were let but the work was suspended in the latter part of the fiscal year due to lack of funds. A second appropriation by Congress was made in 1866 to complete the structures and the work was finished in 1867. In March 1867, Congress transferred all work on the Washington Aqueduct back to the Chief of Engineers.

During the five years that the Washington Aqueduct was in the charge of the Interior Department, the work was under the supervision of Mr. Silas Seymour for the first three years and Mr. Theodore B. Samo for the remainder of the period.

Major N. Michler, Corps of Engineers, was placed in charge when the work was transferred back to the War Department and Mr. Samo was kept as assistant engineer in direct charge of the work. In his report for fiscal year 1867, Major Michler states:

"It is very gratifying to have it in my power to report the very able and conscientious manner in which Mr. Samo has discharged his duties, and, after very careful inspections of the entire work, to coincide with him in the views entertained in relation to its progress, and to approve of the estimates submitted for the completion of many important parts upon which labor has been suspended for want of necessary appropriations."

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\* Senate Document No. 83, 38th Congress, 1st Session.

During the 15-year period from 1867 to 1882, appropriations were small and work was confined mostly to completion of existing structures and general maintenance and repairs. Major N. Michler was in charge from March 1867 to October 1870; Major George H. Elliot to October 1871; Colonel O. E. Babcock to March 1877; and Colonel Thomas Lincoln Casey to August 1882. Colonel Casey later served as Chief of Engineers from 1888 to 1895.

The first half of the solid masonry dam across the Potomac River at Great Falls was begun in 1864 and completed in 1867. This structure, with a length of 995 feet and a crest elevation of 147.0, served as a deflecting dam which was expected to provide a head of six feet in the conduit. However, when the dam was completed, it was found that most of the flow of the river was through the Virginia channel at this site and, as a result, the head of water in the conduit inlet dropped at times to less than three feet during dry weather. Temporary measures to obtain extra flow were provided by constructing low, rock dikes in the bed of the river at the head of Conn Island and removing rocks and brush in order to deflect a small additional amount of water to the Maryland side of the Fortunately, the city was using only about 20 river. million gallons of water a day at this time but, even with this low demand, the flow barely was sufficient to supply the needs of the city. Congress was requested to provide funds to extend the dam all the way across the river to the Virginia shore but this recommendation of the District Engineer was not approved for many years.

The other unfinished Washington Aqueduct structure was the Georgetown reservoir. Due to the lack of funds, this reservoir had remained in an unfinished state for six years and the plain earth dams were so badly eroded by wave action that they were in danger of being washed away. Each year that the Interior Department was in charge, Congress had been asked for approximately \$300,000 to complete the work. When Major Michler took charge he increased the estimate to \$411,000. He proposed to deepen the entire reservoir to 20 feet; to provide more sedimentation; pave all of the inside slopes with heavy riprap; and to construct the gate houses and screen chamber. Congress, however, took a different view of the need for the improvements and, although Major Michler renewed his request for the work each year, funds were not appropriated until the close of his term of office in 1870. When funds were appropriated, in the amount of \$126,000, the deepening of the reservoir from 12 feet to 20 feet was omitted on account of the relatively high cost and the reservoir has remained shallow to this date. The other improvements, however, were completed in 1872 during Colonel Babcock's term of office. During Colonel Casey's term of office from 1877 to 1882, work was confined to maintenance and repairs only.

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City Water Tunnel During Construction

# CITY WATER TUNNEL

In order to describe the city water tunnel which was begun in 1883, and which was one of the largest improvements to the Washington Aqueduct, it is necessary to go back, briefly, seven years and bring Montgomery C. Meigs (now General Meigs\*) again into the picture, since one of the disturbing factors in connection with the work at this time was the way in which he crossed swords with each of the district engineers who followed him in charge of the Aqueduct. Iſ he read or heard about some improvement being made for the Washington water system, he wrote a strong letter to the newspapers condemning the method and explaining what he would do. As a followup, he would send a copy of the letter to the Chairman of the Senate Committee on District of Columbia affairs. This procedure, needless to say, did not endear him to his successors. Colonel Babcock was so disturbed about these incidents that he wrote a letter to the Chief of Engineers about this "interference"。(Annual Report 1877).

In 1876, a new 36-inch water main from Georgetown reservoir to Capitol Hill was recommended by the District Engineer and General Meigs immediately published a letter condemning the idea as a waste of money and suggesting, in its place, a "grade" tunnel four miles long extending the old conduit in an easterly direction from Georgetown reservoir to the vicinity of Howard University. Nothing happened to these proposals but they must have "planted some seeds" as three years later the Senate set up a special committee to "investigate the best means of securing to the cities of Washington and Georgetown an ample supply of pure water." The District Engineer, Colonel Casey, recommended construction of a 48-inch main but General Meigs again wrote a letter condemning the idea and again suggesting a "grade" tunnel. The Engineer Commissioner of the District of Columbia agreed with General Meigs and the Senate approved this scheme. Shortly after this, Colonel Casey was relieved from supervision of the Washington Aqueduct at his own request for reasons which we can readily understand, and Major G. J. Lydecker, then Engineer Commissioner for the District of Columbia, was appointed to take his place. Ten years later, Colonel Casey was to have the satisfaction of seeing his 48-inch water main approved and the work on the City Water Tunnel

\*Promoted to Brigadier General May 15, 1861

# temporarily discredited.

Construction of the City Water Tunnel is described in the Annual Reports of 1882 and 1887 and the special report by the Senate\* covering about 1,000 pages. A few highlights of the work will be of interest. The records show that the tunnel was planned in 1882, partially constructed between 1883 and 1887, investigated by a board of engineers appointed by the Senate in 1888, abandoned for a period of approximately ten years, reinvestigated by a board of engineers appointed by the Chief of Engineers in 1896, reactivated as a project in 1898, and completed in 1902. In its present capacity, it is considered not only a vital link in the water supply system, but also as a very substantial and safe structure.

The original plans and estimates for the project, made by the Engineer Commissioner, were based on a series of short-grade tunnels with a few cut and cover sections and a pipe siphon under Rock Creek Valley, as suggested by General Meigs. In order to get into harder rock, Major Lydecker changed this scheme to a single deeppressure tunnel which he anticipated would be unlined for its full length. When lining was later found to be essential, the appropriation proved inadequate.

Five working shafts were established, one each at three low points in the tunnel and at the western and eastern ends. The Rock Creek shaft was sunk to a depth of 58 feet below the bed of the stream and this formed the lowest portion of the tunnel, 30 feet below sea level and 175 feet below the hydraulic gradient. Working conditions must have been extremely difficult as forced ventilation was unknown at that time. Lighting was done with kerosene lanterns and gas jets which the men called "Christmas trees". Rock drilling was done partly by hand but mostly by compressed air obtained from a central compressor plant located in Georgetown at the mouth of Rock Creek. Compressed air pipes were laid up the valley of Rock Creek and east and west along the line of the tunnel, a total distance of almost ten miles, forming what was said to be the most extensive compressed air plant in the world to that date.

\*Senate Report No. 2696, 50th Congress, 2nd Session, 1888-1889 After four years of work, the tunnel was "holed thru" in July 1887. Work on the lining was continued a year longer during which time 14,617 feet of tunnel were lined and 6,079 feet unlined, making a total length of 20,696 feet. At this time, the Senate ordered an investigation and, upon the advice of a board of experts, the tunnel was abandoned. The original estimated cost of the tunnel was \$600,000 and the amount spent on the work up to the time it was stopped was about \$1,200,000.

The board of experts appointed by the Chief of Engineers\*, in 1895, found that the tunnel could be placed in first class condition for about \$900,000. With the approval of Congress, the project was reopened by Captain Gaillard in 1898. Repairs consisted of lining the unlined portions, cleaning and grouting the dry rubble backing, installing pump stations, and building a 9-foot diameter cast-iron pipe siphon in the Rock Creek Valley section. In one of the many old cavities or "crows nests" as they were called, above the tunnel, it was necessary to remove 65 cords of wood and 241 cubic yards of rotten stone and mud. It was a tedious process and almost five years were required to finish the work. Completion of the water tunnel set the stage for the McMillan filter plant, the next major improvement of the Washington Aqueduct.

\*Annual Report 1896. Appendix BBB

#### MCMILLAN RESERVOIR

The Senate Act of 1882 appropriating money for the tunnel also authorized construction of a reservoir near Howard University with a capacity of not less than 300,000,000 gallons. General Meigs called it a "useless waste of money" and Colonel Casey was all for enlarging Georgetown reservoir. Major Twinning, the Engineer Commissioner of the District of Columbia, who preceded Major Lydecker, made the original estimates and appears to have recommended the work. In any event, the Senate wanted "pure" water and hoped that the extra sedimentation provided by a reservoir with twice the total capacity of Dalecarlia reservoir would solve the problem.

This structure is now called the McMillan reservoir and is formed by an earth dam across a rather wide valley. The cost of the 66 acres of land required was \$209,000 and the structure itself cost \$505,000, making a total of \$714,000 which was about twice as much as the cost of the other two reservoirs combined. It happened that Smith Spring was located exactly in the center of the reservoir and a brick tower with an ornamental top was built over the spring as a marker which is still visible. Work on the reservoir was performed mostly with horses and scrapers over a five-year period from 1883 to 1888, under Major Lydecker. After work on the tunnel was stopped, there was no way in which it would be filled with water so it was left empty and full of weeds and bushes for over 15 years. It was placed in full service in 1903 and forms a valuable feature of the present water system, although its usuable capacity is only 100,000,000 gallons instead of the 300,000,000 gallons anticipated.

#### AUXILIARY IMPROVEMENTS

When work on the water tunnel was stopped by the Senate in 1889, the city was faced with a serious water shortage, since the 30- and 36-inch transmission mains from Georgetown reservoir were not able to deliver much more than half of the water required. Congress ordered the "immediate" construction of a new 48-inch transmission main five miles long. This main was completed by Colonel Elliot in the record time of 12 months, thus doubling the water supply.

The city was now facing another water shortage, this time traceable to the Great Falls dam. This dam, when built, extended only one-third of the distance across the river and it did not provide sufficient head to fill more than one-half of the conduit. Twenty years later, during Major Lydecker's term of office, the dam was extended to the Virginia shore but the crest was stopped at elevation 148.0 which still did not fill the conduit. In order to obtain the full capacity, it was necessary to raise the crest to elevation 150.5, the work finally being completed by Captain Gaillard in 1898. It was an extremely difficult job as each of the heavy coping stones had to be held down with iron pins two inches thick and seven feet long drilled into the solid masonry.

One other improvement made by Colonel Elliot in this period was the diversion of Little Falls branch around Dalecarlia reservoir which served to keep considerable mud out of the reservoir during heavy rainfall in this area. Colonel Elliot thought that this would prove to be a help in clarifying the water in the city mains but the result was disappointing. Filtration had been postponed as long as possible.



In 1901, Congress approved the construction of McMillan filter plant. At that time, filtration was a large and ever-present problem, disturbing not only Washington but many other cities in the United States. Controversy on the relative merits of the English or slow-sand filters and the five or six American or rapidsand filters was so intense that city officials were greatly in doubt as to which to recommend. Construction, in some cases, was delayed for many years while issues were being settled.

Prior to 1900, nearly all of the filtration studies for Washington by the District Engineer were made in response to inquiries by the Senate on measures necessary to obtain pure water. The first of these by Colonel Casey in 1880 described a 26 mgd\* slow-sand filter plant but recommended more sedimentation in its place. The next report in 1886, by Captain Symons, engineer assistant to Major Lydecker, was on a much more comprehensive scale. He described both types of filtration and recommended rapid-sand filters with a capacity of 40 mgd, located on the area southeast of Georgetown reservoir. Between 1890 and 1894, Colonel Elliot discussed filtration in each one of his annual reports but strongly endorsed more sedimentation in its place, especially for the Dalecarlia reservoir. As an indication of some of the primitive opinions of the day, it is amusing to note that, in one of Colonel Elliot's reports, one sanitary writer stated "sewage-polluted water should be drunk as soon as possible after its pollution in order to avoid the disagreeable putrefactive phenomena which might ensue." One other preliminary report on filtration, in response to a Senate inquiry, was made by Captain Gaillard in 1898 recommending steps to reduce water wastage, and also the appointment of a commission of experts to determine the most suitable method of purifying the water for Washington.

The first city in the United States to filter its water was Poughkeepsie, New York, which in 1872 installed a small slow-sand plant with a capacity of about 2 mgd. This was followed by Hudson, New York, in 1874 with a slow-sand plant of 1 mgd. No more slow-sand plants of any appreciable size were built until 1899 when Albany, New York, placed in service a 15 mgd plant designed by

\* million gallons per day

Allen Hazen who later became consulting engineer for the McMillan filter plant in Washington. Each of these three plants obtained their raw-water supply from the Hudson River which was not as muddy as the Potomac.

Beginning about 1885, rapid-sand filtration came into limited use in the United States. Cost of installation was much less than slow-sand filters. Treatment with alum was essential for this type and, with proper sedimentation, water with higher turbidities would be handled better than with slow-sand filters. Many patents were issued for these filters which around 1890 were held by six different filter companies, all claiming theirs as the best. A few of the cities that installed rapid-sand filters prior to 1900 included Chattanooga, Tennessee, 1887; Davenport, Iowa, 1889; Little Rock, Arkansas, 1891; and These plants were mostly Wilkes-Barre, Pennsylvania, 1895. 2 mgd and 3 mgd, except Wilkes-Barre which had a capacity of 10 mgd, the largest rapid-sand filter plant in the United States prior to 1900. With this picture in mind. of the diverse views on filtration by other cities in the United States and the relatively small size of plants, it is easy to understand the wording of the Senate Act of 1898 requesting the District Engineer to report on the "feasibility and propriety" of filtering the water supply of Washington. A filter plant for Washington, D. C., would be five or six times the size of the 15 mgd plant at Albany which then was the largest in the United States so the decision was difficult.

Colonel Miller's report on filtration was over a year and a half in preparation as he wanted ample time to study the situation. Philadelphia and Pittsburgh at the time were planning slow-sand filters, and Cincinnati and Louisville had decided to use rapid-sand filters. Louisville, in particular, was engaged in a large-scale experiment on Ohio river water with three full-sized rapid-sand filters Colonel Miller felt the need of exof different types. perimental work and set up two small filters near his office, one slow-sand and one rapid-sand. Mr. E. D. Hardy, a young civil engineer from Dartmouth, who was later to become superintendent of the Washington Aqueduct for over 30 years, was placed in charge of the experimental filters. Two chemical and two bacteriological experts were employed to make tests on water quality. Colonel Miller submitted his report in March 1900 recommending construction of a 60 mgd rapid-sand filter plant, thereby starting one of the

hottest controversies in the Senate on filtration that had ever taken place.

It was a "battle royal" of rapid-sand vs slow-sand filters and alum treatment vs natural sedimentation. The medical profession and the Public Health Service were opposed to the use of alum and rapid-sand filters. The majority of engineers was in favor of rapid-sand filters and the use of alum. A few engineers, including Allen Hazen, were in favor of slow-sand filters and the intermittent use of them. The Senate Committee listened to all sides and finally decided in favor of a slow-sand filter plant located at the McMillan site, leaving the question of alum treatment for future study.

Fortunately, McMillan filter plant was designed on the old conservative basis of 3 mgd per acre instead of the presently nominal rating of 4 mgd per acre. The plans called for 29 slow-sand filters of one-acre each which, with an allowance of four being cleaned, made 25 filters at 3 mgd or a total of 75 mgd which was the capacity of the conduit at that time. Pipes and other facilities were designed for 25 percent overload so that the actual nominal size of the plant as constructed was 100 million gallons per day. Many changes of ideas occurred during the design. Plans and specifications were in preparation for over two years; construction was begun in May 1903; and the plant was placed in full service in October 1905 at a total cost of about \$3,400,000. The cost, at the present time, would be at least \$12,000,000. A full description of the plant itself with all events leading up to its construction is given in a special report by the Senate in 1909 entitled "Purification of the Washington Water Supply".

# WATER WASTAGE

The McMillan plant, carefully planned and built, was an immediate success and Washington scored the honor of having one of the first large filter plants in the country. Mr. E. D. Hardy, principal assistant engineer on its design and construction under Colonel Miller, was its first superintendent, a position he was to hold for many years. Operating records of the new filter plant, even in the beginning, showed reductions in bacteria and turbidity approaching 100 percent so that at last the phrase "crystal clear", which had been used with anticipation so many times in the past, could be applied to the water sent to the city. The struggle for improvement in quality was won but the question of how to obtain sufficient quantity still was unsolved, a problem which was not new by any means.

Each of the district engineers, prior to this time, had called attention to the alarming increase in water consumption and had recommended metering of the entire city as the most economical solution but Congress hesitated to act, probably, on account of the cost and the Perhaps, also, Congress may have felt that difficulty. it was improper to place any restriction on the use of Oddly enough, the maximum daily consumption ocwater. curred on the coldest days of winter when a great number of the citizens at that time opened the water spigots in their homes to keep the water pipes from freezing, In any event, the average consumption had risen steadily from 26 mgd\* in 1880 to 71 mgd in 1905, and the maximum had touched a peak of 90 mgd for 13 consecutive days in February of 1905. This represented a per capita consumption of 218 gallons per day per person, about the highest that had ever occurred in the city of Washington. The safe year-around capacity of the gravity system, from Great Falls to McMillan reservoir, was considered as 75 mgd with a possible short period peak capacity of 90 mgd by maximum lowering of water levels in all of the reservoirs which, obviously, was not safe. Successful operation of the McMillan filter plant had solved the longstanding problem of purification of the water supply but it had not added to the quantity available by a single Clearly, it was a case of metering the entire gallon. city promptly or building a new conduit. Congress accepted the former remedy and in 1906 appropriated \$100,000 to begin the long process of installing meters.

\*million gallons per day

The results of metering and the very important work of the District of Columbia Water Division, on leak detection and water waste survey, were effective almost immediately in preventing further increase in water consumption. In a few years, a noticeable decrease began to occur. It was anticipated that the city could be metered in from three to four years but the best progress that could be made was less than 10 percent a year. In 1915, the District Engineer, Colonel Newcomer, noted in his annual report that the city at that time was 70 percent metered and that the average daily consumption had decreased from 67 mgd in 1907 to 55 mgd in 1915. The maximum daily consumption in the latter part of this period was less than 80 mgd, an amount which could readily be handled by the water supply facilities at that time.

Although the reduction in water consumption due to metering was encouraging, the demand still was too close for safe operation and four special reports by the district engineers on various methods of increasing the water supply were sent to Congress--one by Colonel Morrow in 1909(1) and three by Colonel Langfit, one in 1911(2) and two in 1913(3)(4). Colonel Morrow recommended a speedup in the metering program and a parallel conduit when needed. One of the 1913 reports was an investigation of the Patuxent River as a new source of supply and the other 1913 report was a study of the dam on the Potomac above Little Falls which would furnish hydroelectric power for the city and, also, additional water for the Washington Aqueduct. Due to the effects of metering, the water situation then was quite easy and no action was taken by Congress on these reports. Appropriations were made, however, for various useful improvements including macadamizing Conduit Road, dredging Dalecarlia reservoir, lining some of the tunnels near Great Falls, a cast-iron pipe lining for the brick conduit under the structure of Cabin John Bridge, meters for Federal buildings, and studies for the Dalecarlia coagulation plant and remodeling of Georgetown reservoir. In general, the period from 1905 to the entrance of the United States in World War I was one of studies and minor improvements which served as a valuable preparation period for future water supply expansion.

(1)	House	Document	347.	61st	Cong.,	2nd	Sess.,	Dec.	1909
(2)	House	Document	1329	61st	Cong.,	3rd	Sess.,	Jan.	1911
(3)	House	Document	1266	62nd	Cong.,	3rd	Sess.,	Jan.	1913
$(\underline{\lambda})$	House	Document	1400	62nd	Cong.,	3rd	Sess.,	Feb.	1913



Dalecarlia Filter Plant

# INCREASE OF WATER SUPPLY 1921 - 1928

Population estimates for Washington are extremely precarious. In the past 40 years, the total number of Federal and District employees has risen from 30,000 to about 300,000. This, in turn, makes predictions of water consumption quite difficult.

Fortunately the water meter program, started in Washington in 1906, was well on its way to completion by 1917 and the existing water supply facilities were able to handle the demand when the city became crowded due to World War I. In 1919, however, it was evident that the population jump was causing an alarming increase in water consumption and a major increase in water supply facilities was necessary as soon as possible. Major M. C. Tyler, the District Engineer in charge of the Washington Aqueduct, was authorized by Congress to make the necessary studies for this work. This report\*, submitted in 1921, recommended construction of a new conduit from Great Falls to Dalecarlia, an 80 mgd filter plant at Dalecarlia, and various transmission mains and storage reservoirs at a total estimated cost of \$8,738,000. This report was approved by Congress almost immediately. Construction on this project was begun in 1922 and completed in 1928. Major Tyler was District Engineer until July 1923, Major J. A. O'Connor to August 1926, and Major Brehon Somervell to September 1930. Mr. E. D. Hardy was in direct charge of design and construction during the entire period. A full description of the work is given in the annual reports of the Washington Aqueduct.

The general purpose of the "Increase of Water Supply" project was to double the supply of raw- and filtered-water for the city in such a way as to provide safety and security for the entire water system. The new conduit was built parallel to the old conduit and provided with interconnections at three different points so that individual sections of either conduit could be drained for repairs at any time and still supply the city on an emergency basis. Dalecarlia filter plant, the pumping station, and the new transmission mains were connected independently to the high-service areas of the system so that either filter plant could function without curtailing the output of the other plant. When the new Dalecarlia pumping station went into service, the District of Columbia Water Division pumping station at Bryant Street temporarily became a

\* Senate Document 403, 66th Cong., 2nd Sess., Feb. 1921

standby plant but this was only for a period of about ten years.

The new structures were very successful. with the exception of their limited capacities which began to be apparent almost as soon as they went into service. But who could have guessed, in 1920, that the city would be crowded by the vast changes in Government functions following 1932 and another and larger World War ten years later which would combine to extend both filter plants to their upmost capacity? Steps were necessary to obtain the maximum water output possible from the existing plants. This could be accomplished partly with a booster pumping station at the upper end of Dalecarlia reservoir which would materially increase the flow in the conduits and at the same time raise the water level on Dalecarlia filters, thus providing a larger output of filtered water. The additional flow through the conduits, when not required by the city, could be converted into electrical power at the hydro plant. This plant could also be used for pumping water from the Chesapeake and Ohio Canal to supplement the raw water from the conduits in periods of high demand. Completion of the booster pumping station in 1935, together with the installation of some larger units in Dalecarlia pumping station, provided an additional volume of water sufficient to meet, temporarily, the increasing demands.



#### PROGRAM FOR FUTURE IMPROVEMENTS

It seems odd, in retrospect, to think that hardly a decade has passed in the history of the Washington Aqueduct without an actual or potential water shortage. The increase of water supply facilities, completed in 1928, was carefully planned to supply all of the water demands of the city up to the year 1980 and yet, by 1945, due entirely to unexpected contingencies such as World War II, water consumption had risen to the maximum daily demand of over 200 mgd as compared with a safe filtered water capacity of 185 mgd. Plans for another increase again were in order and this time it was decided to plan for the next fifty years or up to the year 2000 and, also, to allow for reasonable contingencies.

Experience has shown that a water supply capacity or the ability to furnish a certain quantity of pure water should be not less than forty years ahead of water demands. As a rule, at least ten years are required to complete even a moderate program of new facilities and the extra time is simply a protection for unusual conditions which might occur. Shortage of water in a large city creates health and fire hazards which can be very serious, and a complete failure of a water works could close sewer systems, heating plants, cold storage plants, transporta-Α tion, and practically all the activities of a city. few years ago, Cincinnati was faced with a water famine, due to the temporary failure of a major pumping station, and the residents were forced back to water carts and to sanitary arrangements in back yards and parks which, fortunately, did not cause an epidemic.

Studies "for the development of a plan to insure an adequate future water supply for the District of Columbia" were initiated in 1942 and completed and published in a special report in 1946\*. This plan was a joint study by the Water Division of the District of Columbia and the Washington Aqueduct, and it attempted to cover every conceivable contingency. The program includes major improvements to the collection, purification, pumping, transmission, storage and distribution facilities at an estimated cost of \$70,000,000. Work on the initial features of this program is now in progress.

\*House Document 480, 79th Cong., 2nd Sess., Feb. 1946

The entire program has been arranged to follow the need for new facilities as determined by the increasing demand for water. Improvements to the Washington Aqueduct already completed at the Dalecarlia and McMillan filter plants have added a total of about 50 mgd filtered water capacity to the system, and a new pumping station and clear-water basin at Dalecarlia are now under way. In the District of Columbia Water Division, the electrification of Bryant Street pumping station is almost finished and many new pipe lines have been added. Joint plans are being made by the Washington Aqueduct and the Water Division to complete the major items of the program within the next ten to fifteen years so that the capacity of the water system will be practically doubled.

# ENGINEERS IN CHARGE

The story of the Washington Aqueduct would not be complete without mention of its civilian engineers in charge. The office of the District Engineer has been rotated frequently, under Army control. In the past eighty years, there have been about sixty district engineers or acting district engineers. However, during this same period, there have been only four civilian engineers in direct charge of the Washington Aqueduct.

Theodore B. Samo, the first assistant engineer of the Washington Aqueduct, held the position from about 1867 to 1880 under four district engineers. His special reports frequently appear in the annual reports of the Chief of Engineers. Prior to 1867, Mr. Samo was Chief Engineer of the Washington Aqueduct while it was under the Interior Department.

Mr. R. C. Smead, who followed Mr. Samo, served from about 1880 to 1900 under eight district engineers and was in direct charge of important construction work. During this period, the allotment by Congress for Operation and Maintenance of the Washington Aqueduct was only \$20,000 a year, a sum which would not last the present organization one week. In 1893, Colonel Elliot became "desperate" and asked Congress for an increase to \$21,000 a year but nothing happened. Money, however, went a long way in those days, as a dollar was all that was expected for ten hours' work and upkeep was relatively simple. Special repairs or maintenance costing over \$2,000 required an act of Congress with corresponding delay of several years. Three of the overseers at this time, Thomas Sullivan, Thomas Ferguson, and Daniel Harrington, who held their positions for thirty years or more, are especially well remembered as some of their children and grandchildren are still with the office.

Mr. E. D. Hardy, the next civilian engineer in direct charge of the Washington Aqueduct, held the office for thirty five years, from 1900 to 1935, under about twenty-five district engineers, during the design and construction of both Dalecarlia and McMillan filter plants. His devoted interest in his work was of great value to the office, so much so that he is remembered as the "father of Washington water filtration." Many of the employees now with the Washington Aqueduct, professional and otherwise, have had the benefit of being trained under his careful guidance.

The fourth civilian engineer to have direct charge of the Washington Aqueduct is Mr. Edwin A. Schmitt, the present Head Engineer who has held the office since 1935 under thirteen district engineers. Prior to his present duties, he was head of the River and Harbor Division of the office. Under Mr. Schmitt, the Washington Aqueduct has initiated, planned, and partially executed an extensive new water works construction program designed to double the water supply of the Nation's Capital.

# WATER DIVISION OF THE DISTRICT OF COLUMBIA

It is regretted that space is not available in this history to describe the work of the Water Division of the District of Columbia which has separate responsibilities from the Washington Aqueduct. The water supply system, as a whole, is under the joint control of the Department of the Army and the District The Department of the Army, through the of Columbia. Chief of Engineers, has jurisdiction over the collection and purification divisions and part of the pumping and storage facilities, known, collectively, as the Washington Aqueduct. The distribution division of the system, consisting of about 1,100 miles of water mains and various pumping stations and reservoirs, is under the jurisdiction of the Water Division of the District of Columbia. Zones of authority are established at precise boundaries so there is no question of responsibilities and the two offices maintain contact on all essential matters.

#### FUNDING

The original works of the Washington Aqueduct, completed in 1863, were paid for entirely by the Federal Government. After this time and up to 1928, the Federal Government paid for approximately half of the cost of improvements. At the present time, the entire cost of all water supply activities is paid for out of water revenues. No water bonds have ever been sold for improvements. At this date, Washington is entirely free of any water works indebtedness which is believed to be a record for any city of its size in the world.

# A D D E N D A



Tablet on West Abutment of Cabin John Bridge Showing Jefferson Davis' Name Erased

# HOW JEFFERSON DAVIS' NAME WAS ERASED

The true story of the erasure of Jefferson Davis' name from Cabin John Bridge as told by Mr. William R. Hutton, one of Captain Meigs' assistants and later Chief Engineer of the Washington Aqueduct under the Department of the Interior, in his own words, was as follows:

"Removal of Jefferson Davis' name from Cabin John Bridge which has been attributed to General Meigs is wholly without reason, he being at that time Quartermaster General. In June 1862, at the request of the Secretary of the Interior, Hon, Caleb B. Smith, to whose department the aqueduct had just been transferred, I accompanied the Secretary and a number of members of Congress on a tour of inspection of the aqueduct by way of the canal. Opposite Cabin John several of the party disembarked and walked to the bridge for a nearer view. Returning in hot haste, "Do you know" said Hon. Galusha Graw to the Secretary, "that d----d rebel Meigs has put Jeff Davis' name on the bridge." Turning to me the Secretary said: "The first order I give you is to cut Jeff Davis' name off the bridge." A few days later I was appointed Chief Engineer of the Aqueduct. Not taking seriously the Secretary's remark, I did nothing in the matter. A week later Mr. Robert McIntyre, contractor, arrived to resume his work on the bridge and called to pay his respects to the Secretary. The Secretary said to him that they had put Jeff Davis' name on the bridge; he wished he would cut it off. "With the greatest pleasure Mr. Secretary" was the reply. And the contractor's first work was to remove Mr. Davis' name."

As related in the section on Cabin John Bridge, Mr. Davis' name was restored on the inscription forty-six years later, by orders from President Theodore Roosevelt.

#### GOLD MINES

If gold mines and water tunnels could be combined in some way, it would be much easier on the financial programs for water works but probably this is too much to expect. In any event, some vague hopes for such a condition actually did occur during construction of one of the new water tunnels for the Washington Aqueduct about twenty-five years ago and it came about in this wav: Shortly after the close of the Civil War in 1865, gold-bearing rock was found on a hill just below Great Falls and a shaft was sunk which proved quite success-This led to other shafts and gallaries and very ful soon the mine was on a paying basis at a rate of from \$20 to \$40 a ton of rock. The gold often was found in leaf form which could be scraped out of the seams with a knife. This gold mine, said to be the largest in the State of Maryland, was operated, intermittently, from 1866 to 1920, although in its last period it was not very profitable. The buildings and machinery are still there and may be seen on the left side of the road about half a mile below Great Falls.

The new water tunnel mentioned above passed through the same hill in which the gold mine was located, just about a third of a mile away, so it was natural to hope that some of the excavation for the tunnel would bring up a few nuggets, but they were mighty scarce. Headlines appeared in some of the local newspapers during the construction of this tunnel to the effect that the men should "ignore the gold and go ahead on the watersupply work." There was, literally, gold in the hills but unfortunately not at the site of the tunnel. The only benefit, perhaps, was that it added to the interest in the work.