# MESSAGE

FROM

# THE PRESIDENT OF THE UNITED STATES,

COMMUNICATING,

*In compliance with a resolution of the Senate, a report of Lieutenant Meigs, with surveys, plans, and estimates for supplying the cities of Washington and Georgetown with water.*

February 22, 1853.—Ordered to be printed.

February 24, 1853.—*Ordered*, That 2,000 extra copies be printed—500 copies thereof for Lieut. Meigs, 1,000 for the city of Washington, and 500 for the city of Georgetown.

*To the Senate of the United States:*

In compliance with your resolution of the 19th of February instant, I herewith communicate a report from the Secretary of War, containing the report of Lieutenant Meigs, of the engineer corps, on the surveys, projects, and estimates for supplying the cities of Washington and Georgetown with an unfailing and abundant supply of water.

MILLARD FILLMORE.

Washington, *February* 21, 1853.

War Department,
*Washington, February* 19, 1853.

Sir: I have the honor to submit herewith a communication from the Chief Engineer, with the report of the surveys recently made for the purpose of determining the best manner of affording to the cities of Washington and Georgetown an unfailing and abundant supply of good and wholesome water.

Very respectfully, your obedient servant,

C. M. CONRAD,
*Secretary of War.*

To the President of the United States.

Engineer Department,
*Washington City, February* 14, 1853.

Sir: The President of the United States, in his letter of September 13, 1852, committed to this department the duty of making the necessary surveys, projects, and estimates for determining the best manner

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of affording to the cities of Washington and Georgetown an unfailing and abundant supply of good and wholesome water.

The late Captain Frederick A. Smith, of the corps of engineers, was ordered upon this duty, upon which he had just entered, when he was suddenly removed by death.

Lieut. Montgomery C. Meigs, of the corps of engineers, was then, on the 3d of November, assigned to this service. He has been assiduously engaged therein ever since, and I have now the honor to fulfil the wishes and commands of the President, by transmitting, for his information, the accompanying report and documents.

In the opinions of Lieut. Meigs, set forth in this report, I entirely concur, and I have no hesitation in recommending the construction of the aqueduct from the Great Falls.

The construction upon the enlarged scale suggested by Lieut. Meigs is much to be preferred. It will nearly double the delivery of water, and, while it would remove all danger of an insufficient supply of water hereafter, it would introduce into the city, available for manufacturing purposes, and at a small increase of cost, a water-power of near seventeen hundred horses.

Lieut. Meigs has not perhaps dwelt so much as he might have done upon the advantages to the city of dispensing, in a great measure, with the labor of working fire-engines; the head being sufficient, in every part of the city, for extinguishing fires by the use of hose alone, especially if the velocity of the water in the mains be kept up, as he suggests, by the use of fountains.

At my request, thinking that the President might not have time to have read to him the whole of the report, Lieut. Meigs has prepared a recapitulation, giving a general comparison between the different projects, and exhibiting, at a glance, their advantages and disadvantages. This recapitulation is appended hereto.

Accompanying the report are two maps and a sheet of sectional drawings.

Should yourself or the President desire it, Lieut. Meigs will be ready to exhibit his detailed studies of the different constructions, or to explain any part of the work not clearly set forth in the report.

I am, very respectfully, your most obedient servant,

JOSEPH G. TOTTEN,
*Bvt. Brig. Gen., and Col. Engineers.*

Hon. C. M. Conrad,
*Secretary of War.*

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*Recapitulation.*

The aqueduct from Rock creek, complete, to the Capitol, navy yard, and public buildings, including the high service in Georgetown, will cost $1,258,863. Advantages over the others, *cheapness;* supply in winter and spring, 26,732,300 gallons, but liable, in the heats of summer, to be diminished to 9,860,000 gallons.

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The Little Falls work, complete, will cost $1,597,415. Advantages—over the Great Falls project, cheapness; over Rock creek, steadiness of supply; which, at the above cost, will be 12,000,000 of gallons, to be increased in time, by another pump and wheel, to 18,000,000. Disadvantages—a doubt as to the sufficiency of the water-power for a greater supply than 12,000,000 of gallons, and, by some engineers whom I have consulted, even for this amount in very dry seasons; want of simplicity; use of machinery always, however well constructed, liable to injury and interruption; want of reservoir space for settling the water; liability to interruption, for a time, during floods.

The Great Falls project will cost, complete, $1,921,244. Constant and everlasting daily supply, 36,015,400 gallons. Advantages—simplicity and durability; perfect security and inexhaustible and unfailing source; lavish use, which can be indulged in in consequence of abundant supply; power of street-washing, cooling the air, and embellishing the city by great fountains; use for driving small machines, lathes, printing presses, and the like; great space for settling and purifying in reservoirs, and great quantity in store for emergencies; small expense of keeping up the works when once established, and consequent low price of water delivered in houses or factories.

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## SUMMARY.

Objects of survey.
Time of commencement—Hurry thence resulting.
Estimates—How made.
Drawings of details—Studied.
Contingencies—Sum allowed for.
Supply needed.
Water-works—Generally fail from being on an inadequate scale.
Supply, not allowing a free use, complaints made of waste.
Supply of Croton aqueduct—Exhausted.
Uses in washing streets and flooding gutters—Removing offal, &c.—Fountains.
Daily average and maximum supply in Philadelphia—Gradual increase of use—In New York—Boston.
Philadelphia water-works judiciously planned.
Supply in various cities—Hoboken and Jersey city, Boston, New York, Philadelphia, London, Paris—Enormous cost of service by water-carriers.
Ancient Rome—Aqueducts.
Modern Rome—Supplied by the remains of ancient aqueducts—Their durability.
Population of Washington and Georgetown in 1850—Increase in two years—Probable increase in ten—in forty.
Supply needed in 1863—In 1893, for domestic use—Quantity to be used in fountains—Great need for them in Washington—Views of the founders of the city—Magnificence of plan.
Boston common—Fountain—quantity of water used—can be supplied only for a few hours—Advantage of fountains in their effect upon the water in the mains.
Height of fountains—Supply for free use obtainable only from Great Falls.
Increased growth of a city from construction of aqueducts.
Monopolies—Example in London.
Reservoirs—Quantity that should be held in store varies with the nature of the source as to quantity and purity of supply.
Difficulties when the supply is raised by machinery.
Steam pumping from the Potomac, at Georgetown, not advisable.
Cost of pumping by steam and water-power, at Philadelphia.
Advantages of natural flow.
Storage in other cities—Philadelphia, Spring Garden, Boston, Cincinnati, Detroit, Buffalo, Chicago, Greenock, Manchester, Ashton, Oldham, Preston, London, New York—additional reservoirs there proposed.
Storage proposed for Washington and Georgetown.
*Filtering*, common methods, principle—all fail on a great scale—Difficulties—Small proportion of whole supply which needs filtering—Best domestic filter.
New mode of purifying water, suggested by Mr. Wetherill—the best—Quantity of soluble matter in Potomac and Rock creek waters—Analysis of Professor Torrey.

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Sources of supply for Washington—Rock creek and Potomac, Great Falls—Advantages and disadvantages of each—Remarks upon Valley of Rock creek, of Croton—Great storage in the latter, not to be had in the former.
Colonel Hughes's survey and project for aqueduct from Rock creek.
Gauging—Remarks—Wet season—Minimum.
Flow—Evidence of millers—Table of rain fall—Mean annual fall—Result—Minimum supply from Rock creek.
Rock creek aqueduct—Description—Dam and reservoir—Contents—Objection to reservoirs higher up the stream—Conveyance from reservoir—Size and construction of conduit—Reasons for adopting circular form—Delivery in wet seasons—in hot and dry seasons.
Wasteweirs.
Nature of the country.
Bridge over Piney Branch Valley—Might be replaced by pipes—Objections—Experience on the Croton, at Harlem bridge.
Route of the aqueduct—Tunnel—Distributing reservoir—Construction—Paving of bottom dispensed with—Drainage of surface water—Wasteweir—Supply to be drawn from either conduit or reservoir.
Effluent mains.
Height of water surface—Mains—Size and remarks upon double—Lead to public establishments.
High service in Georgetown—Provided for by a turbine, and pump, and small reservoir.
Length of this aqueduct.
Potomac aqueduct from Great Falls.
Nature of country—Apparent difficulties—Disappear upon survey—Favorable ground—Tunnels few and short—Line direct—Light cutting—Filling—Few and inexpensive bridges—Length—Culverts.
Elevation of the Potomac above Great Falls—Dam—Conduit near the dam—Pipe chamber—Precautions against floods—Remarks upon possible change of construction—Crossing of canal by pipes—Precautions against floods—Valves and gates—Gate-house—Construction of conduit—Size—Slope—Depth—Delivery—Increased delivery consequent upon increased diameter, with comparatively slight increase of cost.
Description of line—Two tunnels.
First Bridge—Second, over Mountain Spring Brook—Third, over Cabin John Valley—Construction and cost—Reasons for preferring it to pipes.
Tunnel at receiving reservoir.
Comparison of tunnels with the Croton receiving reservoirs—Dam, &c.—Area—Capacity—Advantages—Addition given by the Little Falls branch.
Advantages in early introduction of water to the city—as early as next winter—Distance to distributing reservoirs—Nature of ground between.

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WASHINGTON CITY, *February* 12, 1853.

SIR: I have the honor to report the result of the examinations undertaken in obedience to your orders of 3d November, 1852, by which I was directed to make "the necessary surveys, projects, and estimates for determining the best means of affording the cities of Washington and Georgetown an unfailing and abundant supply of good and wholesome water."

The late period of the season at which I received these orders, with the necessity of making, as required by the act of Congress, report during the present session, has hurried our surveys, and caused them to be more costly than if time had been available for a better organization of the necessary field parties, and the more deliberate prosecution of the field work.

Nevertheless, it is believed that all the probable sources from which a supply of water could be advantageously drawn, have been sufficiently examined; and though we had short time for considering the projects and preparing the estimates—thanks to the energy and zeal of my assistants—estimates have been prepared with great care; in which nothing that could be measured or calculated has been arbitrarily assumed, and which I hope and believe will be found fully sufficient for the perfect execution of the work, upon the plans, and in the style, proposed.

Drawings have been made by myself, of all the important structures—not, for want of time, elaborate or finished, but still sufficient to show the mode of construction, and to enable us to calculate accurately the quantity of material, and the labor necessary for their execution.

As in projecting any new work, many things must necessarily be forgotten, and many difficulties, not to be foreseen, will arise during its execution, I have added to the estimates a liberal amount for these contingencies, as well as to cover the expenses of engineer services, purchase of land, &c.

The first question which arises in the preparation of these projects, relates to the quantity of water which should be furnished. Upon this subject I submit a few remarks—the result of my inquiries into the history of such undertakings in other cities.

The water-works in this country seem generally to have been designed on an inadequate scale. The growth of our cities has been so much more rapid than anticipated, and the quantity of water required for domestic use by each family has gone so far beyond all calculations, that the works designed by engineers, and opposed in their inception as extravagant, have almost invariably failed, within a few years after their completion, to supply the wants of the builders. Hence, complaints on the part of managers, boards, and civic authorities of wastefulness and extravagance.

No man complains of the extravagant use of water while the supply exceeds the demand, but each finds this extravagance a luxury and a comfort, conducive to his own health and that of his neighbors.

In New York, whose great aqueduct, commenced in 1837, was finished only in 1842, eleven years ago, we find the commissioners, in their late annual reports, warning the people that "the last drop of

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water which the works, in their present state, can supply, is now daily delivered in the city." They denounce its waste in various ways: some of them certainly inexcusable—such as leaving open the hose which supply the shipping, and allowing the water uselessly to run into the harbor. But others, I am persuaded, would, by the commissioners, as by the perpetrators, be considered just and proper uses if the supply was greater. Such are—the opening of the fire-hydrants, and the street-washers, which cleanse the streets and gutters, and, washing into the sewers the offal of the city, remove at once from sight and smell these offensive and fruitful sources of disease and death.

I think it may well be considered that these latter uses in flooding gutters and sewers are among the most appropriate to which the water can be applied.

Fountains judiciously placed, and kept constantly flowing, conduce, 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, 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 heats of summer to enjoy the grateful coolness of the Roman fountains—legacies from that ancient people—or the splendid jet of Boston common; the profuse display of the New York Park, or the Philadelphia Fairmount.

For many years, the experience of Philadelphia was taken as a guide in determining the quantity of water to be supplied to a city. This city was one of the first, if not the first, in this country to provide properly for the supply of her inhabitants. When first introduced, the habits of economy of water, necessarily acquired while all the water for a family was brought by the servant-maids from the street-pump, as is generally done now in Washington, influenced the people in its use. Baths were few, and were looked upon as luxuries; and it was many years before the average daily use exceeded twenty-eight gallons for each inhabitant. In 1851 the average had increased in Philadelphia to thirty-three gallons, and the demand in midsummer was over three times as great as in winter—the delivery on the 12th of September being at the rate of fifty-three gallons for each person.

In New York, the Croton board complain that the use on Saturdays, during the hot weather, has been at the rate for each person of ninety gallons per day, and that, while they consider this to be a wasteful use, the prevention of such waste is entirely beyond their power.

As I before remarked, had the supply been ample, I do not think the board would have complained of this as a waste; and doubtless it added to the happiness, the comfort, and the health of the citizens who thus used it.

But the full supply of the aqueduct was exhausted, and the reservoir was drawn down to half its capacity; hence complaints of "the zealous

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housewifery, which puts every street-washer into requisition," on Saturday.

In Boston, the same complaints of waste are made, and for the same reason.

Relying upon the old experience of Philadelphia, Boston, in 1848, completed her aqueduct for introducing from Cochituate lake a supply of seven and a half millions of gallons daily. Fortunately for the city, the works provided for seven and a half millions of gallons have proved capable, by being run at a greater depth than originally intended, of delivering over ten millions.

The calculated provision of 28½ gallons to each individual—allowing a large margin for the future growth of the city—already proves insufficient for the wants of the population, who used, in 1849, 61 gallons each; in 1850, 63½ gallons; and in 1851, 66½. Since then I have no report, but the total consumption in one day of 1852 was 12,044,062 gallons by a population of 170,000. Thus in four years the works have proved insufficient.

When Mr. Frederick Graff planned and commenced the erection of the water-power works at Fairmount, Philadelphia, in 1819, the demand for the city was such that one wheel and pump supplied it; yet, with more foresight than other cities have shown, Philadelphia allowed him to construct the engine-house with room for eight wheels and pumps, doubtless supposing they had provided for centuries. Mr. Graff lived to put the eighth wheel and pump into operation, and his plans proved sufficient from 1819 to 1844—35 years, when new works were erected by some districts of the city; and Philadelphia is now supplied by the water-power works, to which a ninth wheel has been added by the son of Mr. Graff, and by two separate steam-pumping establishments, which supply the northern districts.

In investigating the history of the different water-works I have been particularly struck with the foresight displayed by Mr. Graff at that early day. The earliest works erected proved adequate for a longer time than any of those built within a few years past.

Hoboken and Jersey city, with a population of 17,000 persons, are about providing themselves with a daily supply of six millions of gallons.

Boston has now a supply of ten millions.

New York of thirty millions.

Philadelphia, with the Northern Liberties and Spring Garden, of fifteen millions.

London is supplied with forty-five millions of gallons, according to the latest dates I can find.

Paris, by the Canal de l'Ourcq, is supplied with about twenty millions of gallons daily, all of which is devoted to public fountains and cleaning the streets; whilst the supply of pure water for domestic use is raised from the Seine by pumps, and distributed by water-carriers. The quantity thus supplied is about one million of gallons daily, for which the inhabitants pay the enormous annual sum of $767,836. To replace the Seine water, on account of its cost, pumps and wells are used, from which an inferior and less wholesome supply is drawn.

Turning from these modern cities, let us look at ancient Rome. Fron-

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tinus, superintendent of the aqueducts of Rome, in the year A. D. 101, has left an account of their condition in his time. There were then nine aqueducts constructed from B. C. 312 to A. D. 90, whose aggregate length, including auxiliary feeders and branches, was 255 miles, the longest being 57 and the shortest 10½ miles in length, and which, together, daily poured through fountains and baths, into the Cloaca of Rome, the ample supply of three hundred and seventy-seven millions of gallons of water. Of these three have survived the wreck of barbarian invasion; and modern Rome thanks the Pagan emperors for a supply of water amounting to fifty millions of gallons a day. These are the Aqua Virgini, first built 22 years before Christ, and which continues to perform its functions after the lapse of eighteen and three quarters centuries. The Aqua Felici, part of which was built 146 years before the Christian era, and the Aqua Paola, the ancient Alsietina, built in A. D. 14.

Ancient Rome was probably better supplied with fountains and baths than any modern city; and the great works of her emperors are conferring benefits upon their descendants after the lapse of nearly two thousand years.

The present population of Washington is about fifty thousand souls, having increased ten thousand in the two years which have elapsed since the last census. Georgetown contained, in 1850, eight thousand. I have not, in her case, the means of determining her increase, afforded me for Washington by the valuable and accurate tables prepared by Mr. Sessford, and appended to this report. The present population to be provided for, then, is 58,000, who, at the rate derived from the experience of New York in the past summer, would require for washing the streets, and for domestic uses, 5,220,000—five and a quarter millions of gallons.

If Washington increases, not at the same per-centage, but adds to its population only the same number of persons every two years for ten years, as she has done in the last two years, she will contain, in 1863, 100,000 souls, and require for her own use 9,000,000 of gallons, independent of the quantity which may be wanted for fountains, and the greater quantity needed for watering the dust and washing the offal from her wide streets and squares. At this rate, in forty years from this date, her population would be 250,000, requiring for the hotter "Saturdays" than those which exhaust the Croton, but at the same rate of use, (90 gallons a head,) 22,500,000 gallons a day, without fountains. The real increase in Washington, if the present prosperity of our country continues, must be much more rapid—cities of 100,000 inhabitants add much more than 5,000 annually to their population.

The quantity of water to be advantageously used in fountains can be limited only by the supply. In a city of such long continued summer heats—the metropolis of a great country, where assemble and suffer together, from dust and heat, the leading and most honored citizens, from the confines of Canada with those from the borders of the tropics—the supply of water used to cool the air, and to protect and preserve the health of its inhabitants, should be lavish. The founders of the city foresaw this necessity when they planned its broad and spacious avenues and its extensive public squares; not on the crowded model of a business city, but with reference to the future wants of a

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great metropolis—leaving place for fountains and trees at every intersection of its main avenues, and preparing streets, not for the passage of the busy throng of merchants, but for the pomps and processions of a great capital.

The greatest fountain in our country is on Boston common, where a six-inch jet rises to the height of ninety-eight feet, and expends per hour 392,280 gallons. This is at the rate of nearly four millions of gallons in ten hours, and if run a whole day, the quantity drawn from the reservoirs would be 9,414,720—nine and a half millions of gallons.

As the daily supply of Cochituate aqueduct is only ten millions, it is needless to say that the luxury and the spectacle of this fountain can be enjoyed by Boston only for a few hours at a time, on great occasions.

One advantage from fountains which I have not seen adverted to, is their keeping up the velocity of water in the mains.

In case of a sudden demand for extinguishing a fire, upon opening the fire-hydrants and closing the fountains, the current is at once turned into the hose.

Mr. Graff has remarked, that in Philadelphia, upon first attaching hose to the hydrants, the flow of water is slow, requiring several hose to supply one engine. After the velocity of water in the pipes is once established, however, a reduced number of hose will keep the engine overflowing.

The head of water obtained by either of the plans which I shall propose for supplying the cities, is sufficient to give a jet in the Capitol grounds of one hundred and twenty feet in height; but the supply of water necessary for a free use of such jets can be obtained only from the Great Falls of the Potomac.

The impetus to the growth of a city given by the construction of an aqueduct on a liberal scale, cannot be estimated. New York feels its advantages, and, heavy as is the burden of taxation there, and great the debt—over $12,000,000—incurred in constructing her Croton aqueduct—probably no citizen could be found willing to forego its advantages for the relief it might afford from taxation.

The diminished rates of insurance, the increased comfort of living, cause a rise in the value of property, and a demand for houses and lots, which more than compensate the inhabitants for any increased taxation.

Thus it would be in Washington.

Some cities are supplied by joint stock companies. London groans under the infliction of half a dozen monopolies, which dole out water by the hour, and by the cistern full, thick with the sewage from the gutters of 2,300,000 inhabitants, instead of supplying a constant source, to be obtained at any time and in any quantity needed for luxury or use, by simply turning a handle.

Philadelphia, New York, and Boston have wisely taken upon themselves the supply of their citizens with water, and no bloated monopoly should be allowed to pamper itself by the sale of the first necessary of life and health to the inhabitants of our metropolis and the representatives of our States. Water should be free as air, and should always be supplied by the government—if for a city solely, then by the city government; if for the metropolis of a nation, then by the nation.

The quantity of water for daily use being determined, the next ques-

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tion is what quantity should be stored in reservoirs. This question admits of no accurate solution; the quantity will vary with the nature of the source, and with the demand. If the source is small, affording little over the average daily supply, the reservoirs should be larger, than when, from an ample stream, an increased quantity can be poured into them at any moment, to meet such contingencies as great conflagrations, or great summer heats. If the source is liable to fail entirely, or in part, the reservoirs must contain enough not only for the minimum daily use, but for these same contingencies, which are most likely to occur during long continued droughts, which dry up the streams.

If the source be like the Potomac—an unfailing river, always giving an ample supply—still it is liable to great floods, during which the turbid and discolored waters should, if possible, be excluded from the reservoirs, which, in this case, should contain enough for several days' supply, until the swollen waters have subsided within their ordinary limits, and returned to their ordinary state of purity.

When a river is the source, the reservoirs should be large enough to allow the water to remain some time in them, to deposite the earthy and other insoluble matters mechanically mixed with it; which injure its appearance far more than the more deleterious ingredients which, being dissolved, do not diminish its clearness.

When the supply is obtained by machinery, it is commonly difficult to provide a sufficient storage to meet these various requirements.

In the case of steam, especially, where every gallon of water represents so much coal, paid for and burned, there is a natural dislike to keep filled large reservoirs, which, by the waste caused by the evaporation from their surface, increase the daily expense for fuel.

Pumping by steam from the Potomac at Georgetown, though requiring less expenditure of capital than the erection of long lines of conduit, and large reservoirs, can be considered, at best, but as a temporary resort. When the quantity of water wanted is great, the expense for fuel becomes very great also, and what is dearly paid for will be sold to consumers at a high rate.

The water here flows back and forth, with the tide, over the extensive flats between Georgetown and the Long Bridge, collecting and retaining the sewage water of the cities; and, as these cities increase in size, the water will become less and less fit for domestic use.

The steam engine—an invaluable assistant where better means are wanting—is, at best, an eating sore, which consumes the fuel paid for by taxation; and not to-day only, nor to-morrow, but forever.

This led, in Philadelphia, after many years' trial, to the erection of the costly and beautiful water-works there; and, though the conflicting interests of rival corporations have lately caused the construction of steam works, a comparison of the cost of raising water by the two modes is strongly in favor of the water-power. In 1850, the cost at Spring Garden steam-works, for coal, wages, repairs of engine, &c., during the year, was $60 66 per day; pumping a daily average of 3,231,254 gallons, which is about $18 77 per million of gallons.

The expense at the Fairmount water-power works, for wages, repairs, &c., was $7 70 per day, for pumping an average of 4,785,338 gallons, which is about $1 61 per million of gallons.

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Great, however, as are the advantages of pumping by water-power, undoubtedly the best mode, when practicable without too great expense, is to lead the water in a suitable channel, propelled by its own gravity, to reservoirs, whence it can be drawn by pipes and distributed wherever wanted. There is then no need (provided proper and ample provision is made in the first place) for restricting its use, and denouncing as waste the many practices which, when it is abundant, become habits and necessities. During the night the stream flows on, replenishing the reservoirs, and providing, untended, for the wants of the day.

There is then no reason to diminish the reservoirs, but ample space for purification can be safely given; the loss by evaporation being replaced by the constant flow.

### STORAGE IN OTHER CITIES.

The quantity of water held in store in different cities varies not so much according to the wants as to the means of their inhabitants. Changes are constantly being made tending to increase the reservoirs, and the notes I have, though doubtless correct, when published, may not truly represent their present condition.

Philadelphia and Spring Garden, which have, within a few weeks, completed a new reservoir, can now store 48½ millions of gallons—about five and a third days' supply—at a height varying from 96 to 115 feet in the different reservoirs.

Boston, 135,362,983—equal to about twelve days' supply—at a height of 128 feet.

Cincinnati, 1,700,000, at a height of 177 feet above low water in the Ohio.

Detroit, 353,430, at a height of 70 feet—only one-third of a day's supply; but they are about enlarging their works, and providing for the storage of 10,000,000 more.

Buffalo, ———, at 96 feet height.

Chicago is providing a reservoir to contain 1,235,000 gallons, at a height of 80 feet.

The reservoirs at Greenock, in Scotland, contain 5,236 millions of gallons, at an elevation of 513 feet; but this is devoted chiefly to manufactories.

The reservoirs at Manchester contain 300 millions.

At Ashton, 100 millions.

At Oldham, 85 millions.

At Preston, England, a city of 80,000 inhabitants, the reservoirs, at various heights, contain 167 millions of gallons.

London is supplied by pumping. She has no great reservoirs, I believe, but depends, in case of conflagration, upon the numerous steam-engines, which furnish her daily supply at a height of from 120 to 152 feet. Her supply is about 44½ millions a day, and for the fountain in Trafalgar Square a special engine is provided, which forces the water through the jet over and over again.

New York has, in the two reservoirs on the island, containing a surface of about 35 acres, storage for 170 millions of gallons, at a height of 115 feet—about four and a quarter days' supply in hot weather.

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The Croton board, in their report for 1850, say that their reservoirs are "barely equal to furnish the wants of the city for the few days that the aqueduct is drawn off to permit examinations and repairs in its interior; nor can it now be drawn off without a sensation of fear and anxiety which is every year renewed and increased; and if the means of storing a more copious supply be not provided within the next five years these examinations must be abandoned, or the city be without water during a portion of the time when they are in progress."

Suppose a great flood to make a breach in the Croton dam, or a water-spout among the hills to wash away one of the bridges or culverts on the line of the aqueduct, in what condition would New York find herself?

Influenced by these considerations, she has bought, at enormous expense, the ground adjoining her receiving reservoir, and is preparing to erect a reservoir covering 96 acres.

The reservoirs proposed for the Great Falls line will not, in view of the above facts and the growth to be anticipated for the cities of the District, be thought extravagant. They will contain about 250 millions of gallons, available in an emergency; a quantity which, forty years from this date, will be, I am persuaded, less than a supply for ten days for domestic uses, supposing the fountains to be closed.

## FILTERING.

I have given some study to the subject of filtering, not so much as its importance and difficulty demand, for my time has been too short, and I have had many others of more immediate and pressing claims to attention. Little reliable or valuable information upon this subject has been within my reach.

The ordinary modes of filtration on a great scale are founded upon the same principles as the smallest domestic filters, in which sand, by straining the water through its inter-spaces, removes the ingredients mechanically suspended, and charcoal, by its chemical affinity, takes up the organic matter dissolved.

But the difficulties are very much increased when, instead of pints the quantity to be filtered becomes millions of gallons. The filters, large and expensive in construction and maintenance, are soon choked with deposite. They require to be duplicated to allow for the frequent cleansing, which can only be effected by the removal and renewal of the filtering material. Attempts have been made to cleanse them by reversing the direction of the current, but up to this time, upon a great scale, unsuccessfully; and, after all, how small a proportion of the water delivered to a city needs filtering, even for the most fastidious. When the allowance to each person is ninety gallons daily, less than one-ninetieth can be used for cooking and drinking; and if we provide filters, the eighty-nine gallons which might just as well be poured unfiltered through the fountains and baths, clog up the filters and defeat their object.

For drinking and cooking, the best filter I have seen is a small one to be attached to the nose of the hydrant; it contains a layer of finely pulverized quartz-sand, kept in place by wire gauze, and when choked

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by deposite on one side is readily reversed, and the action of the stream cleanses it at once. This can be used when needed; and the far greater quantity of water, which is of sufficient purity, unfiltered, for its purposes, can be allowed to flow without the expense of filtering.

A beautiful application of a mechanical principle, used in laboratories for the sorting of chemical precipitates into different degrees of fineness, has been suggested by Mr. J. Price Wetherill, for many years chairman of the Watering Committee of Philadelphia.

In his whitelead works, as in establishments for the pulverization and sorting of emery, a stream of water, thickened with whitelead, mixed with it by brisk agitation, is allowed to flow through a trough divided by cross partitions. The stream is slow, the heavy material tends to sink to the bottom, and in passing across the first division the coarser particles descend below the level of the partition and are retained; the next arrests those which are finer, and thus, by multiplying the partitions, the water, which entered thick and turbid, can be made to leave the trough clear and bright, retaining only those impurities which, being dissolved, no mechanical means will separate.

He proposed, I have been told, to build walls across the reservoirs of Fairmount, rising to near the water-surface, and thus apply, on the great scale, what has so well fulfilled the same purpose on the small one. I see no difficulty in this application, and I believe that here is the best mode of purifying the water of rivers when used for cities.

The substances which discolor water are mechanically diffused. No city will supply itself from a source much contaminated by chemically dissolved impurities.

The waters of the Potomac and Rock creek, according to Professor Torrey's analysis, contain of salts, soluble in pure water, not more than one grain, and of carbonates of lime and magnesia, insoluble in water alone, but held in solution by excess of carbonic acid, from three to four grains to the gallon.

The mud and sediment suspended during floods is all heavier than water, and tends to sink as this becomes tranquil. The large receiving and settling reservoir will allow the greater part to be deposited. The quantity there in store will enable us, if the Potomac line be adopted, to shut out the river when turbid from floods; and if we find that when delivered in the houses, it is still, sometimes, too much discolored for domestic use, the erection of walls across the distributing reservoir will, as in the whitelead works, effectually remove all that can be disagreeable to the eye.

I have provided for one division in the distributing reservoir, believing that upon the scale adopted this will be sufficient.

In regard to the purity of the water available for these cities, I add to this report extracts from a letter of Professor Torrey, of New York, to whom specimens of water taken from Rock creek, from the Potomac at the Great Falls, at the Little Falls, and at high and low tide near Georgetown, were submitted for analysis. Unfortunately the detailed notes of his analysis were lost before his report was written out, and he was able to furnish only the general results contained in the extracts herewith; but these are highly satisfactory.

They show that the water from either source is of uncommon purity

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and softness, well adapted to drinking, washing, and manufacturing, and, indeed, superior to the far-famed Croton. His chief difficulty in the analysis was caused by the extreme purity of the water—such that the specimens, two gallons each, did not afford him enough of the impurities to determine accurately their quantities. That is, the quantity of most of the dissolved ingredients was so small as to be inappreciable.

These specimens were taken in November, when both streams were sensibly turbid or discolored, being swollen by autumnal rains, and may, therefore, be considered as at least fair average specimens. When the water from the aqueduct shall have been further purified by settling in extensive and capacious reservoirs, as provided in the plan proposed, Washington will be supplied with water unrivalled for purity and salubrity, and which will need, I think, no complicated and expensive filtering arrangements.

The sources of supply available for Washington seem to be limited to Rock creek and the Potomac river.

Rock creek is so near to Washington, its waters are so clear and pure, its valley near the city so rocky and apparently so well calculated for storing and preserving uncontaminated an abundant supply, that it has naturally attracted attention; while the great volume of water in the Potomac, and the height at which it reaches the brink of the Great Falls, with its well-known reputation among shipmasters for purity and excellence, have equally given it claims to notice.

I am informed that, during the administration of Mr. Jefferson, a survey was made, by his direction, with a view to bringing in the water from the Great Falls to supply the city, and to fill a dry-dock at the Navy-yard.

The advantages of Rock creek are its purity and wholesomeness, the shortness of the works necessary for the introduction of its waters, and their consequent less expense.

In purity, the waters of the Potomac are at least equal to those of Rock creek now, while they have the advantage of being certain to retain this purity for ages. Their volume is so great, that no establishment of manufactories on its banks is likely to pour into it enough of impurity sensibly to deteriorate it.

Rock creek does not possess this advantage. Its valley for about eight miles is narrow and deep, its sides uncultivable, and it is unexceptionable. But above the point to which the head of the reservoir to be made for the aqueduct will extend, the stream becomes sluggish, the valley widens, and its sides are pastured by herds, or cultivated in grain, annually receiving a coat of manure, the lighter particles of which, in severe rains, must find their way to the stream, whose volume is not sufficient to give assurance that their effect will be insensible. Dye-works and bleacheries may, in time, be established without the limits of the District. This is a source of contamination which caused Charles river, a much larger stream, to be rejected, when projects were discussed for supplying Boston.

The valley of the Croton possesses uncommon advantages for the supply of a great city. Its shores are unfit for cultivation, and its sources are in numerous mountain lakes, covering a surface of about



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three thousand five hundred and sixty acres—one of them, Mohapack, containing a thousand in one body. Dams at the small outlets of these lakes would, by raising their surface and retaining the water of the autumnal rains, store up almost unlimited quantities. A dam raising Mohapack lake only ten feet would give a supply available in the dry season of more than three thousand millions of gallons.

The upper part of Rock creek valley does not afford these advantages: reservoirs there of large capacity would be comparatively expensive, and would make the supply from this source more costly than from the Potomac.

In our examination of Rock creek we were much assisted by the very complete map prepared by Colonel Hughes, of the topographical engineers, who surveyed it in 1850, and made a project and estimate for supplying the city from that source. Indeed, the line I propose is almost identical with his—the principal changes being the selection of a site for the dam some distance below his, and an increased size of conduit.

These changes involve increased expense—the dam being nearly twice as high, and the conduit much larger. But they have the advantage of doubling the quantity of water in store, and much more than doubling the quantity which can be delivered.

The growth of Washington at the time his survey was made, had, for years, been slow. At that time it received an impetus, and has already added twenty-five per cent. to its population. Calculations based upon its former growth fail to apply to its present prospects; and the consumption then commonly assumed of thirty gallons has since, in Boston, reached seventy, and in New York ninety gallons per day.

Our gauge of Rock creek agrees with that made by Colonel Hughes. He found, as the daily flow at Hoyle's farm, 22,021,080 gallons. We found, in the same place, by a very careful gauge, 19,036,000 gallons—the difference, about one-seventh, such as would be made by a little difference of season. This gauge was made on the 29th of October. There had been litle rain for some time before, and probably the above is near the minimum flow of 1852. The early part of the season had been very wet. The springs still felt the influence of this season; and the creek, by the testimony we were able to collect along its shores, had not, during that summer, been below an average low water.

The minimum flow must determine the quantity of water available for a city. It is precisely in seasons of long-continued heats and droughts that there is greatest need of an abundant supply.

Mr. Lyons, who has been a miller on the creek for thirty-nine years, thought that he was using about half the flow on the 28th of October, and that he had seen three or four seasons when he had not half as much as he needed for his mill. This would give for the minimum flow about one-fourth of that we gauged.

Mr. White, at Adams's mill, thinks he has had water generally during summer for three pairs of burr-stones. Has been there since 1844. About six years since, during a long dry season, he could only run one pair of stones. In 1852, run the whole three, and had some water to waste all the time.

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These facts or opinions would show that the minimum flow, in his experience, was less than one-third of the minimum flow of 1852.

Mr. Hoyle, senior, who managed a mill for many years, and, though he has given up the mill, still lives on the stream, thought that it was seldom lower than in 1852; but he remembered one season when, from the middle of August to the end of September, the flow was probably less than one-half, but greater than one-fourth, of that in October, 1852. Mr. Hoyle's statement would give as the minimum, perhaps, one-third. These observations are necessarily loose, but, coming from millers, who observe more carefully than others the state of the stream upon which their business depends, are the best approximations to be obtained without gauging carried on through a long series of years.

The table below, prepared from the meteorological reports of the army, shows the quantity of rain, for several years, which fell at Fort McHenry, near Baltimore, during the seven, six, and four months preceding the 30th of October, and also the quantity falling during the three hot months of July, August, and September:

*Rain-fall at Fort McHenry, in inches.*

| Years. | April 1 to October 30 | May 1 to October 30. | July 1 to October 30. | July, August, & September. |
|---|---|---|---|---|
| 1837 | 27.50 | 25.40 | 16.30 | 13.20 |
| 1838 | 30.40 | 27.60 | 18.60 | 15.50 |
| 1839 | 33.00 | 23.90 | 11.30 | 9.70 |
| 1840 | 24.80 | 20.50 | 11.50 | 7.00 |
| 1841 | 22.05 | 17.55 | 10.45 | 7.65 |
| 1842 | 21.45 | 17.15 | 10.50 | 9.10 |
| 1843 | 24.60 | 21.705 | 17.30 | 14.25 |
| 1844 | 22.80 | 21.20 | 14.60 | 10.20 |
| 1845 | 15.85 | 14.36 | 9.27 | 5.54 |
| 1846 | 25.49 | 23.11 | 15.56 | 14.26 |
| 1847 | 19.37 | 18.96 | 14.41 | 11.03 |
| 1848 | 19.41 | 18.60 | 11.10 | 9.30 |
| 1849 | 19.33 | 18.46 | 12.78 | 6.51 |
| 1850* | ........ | ........ | ........ | ........ |
| 1851* | ........ | ........ | ........ | ........ |
| 1852 | 27.30 | 19.50 | 15.10 | 12.50 |

* These two years not accessible when I sent to consult the reports.

From this it will be seen that in 1852 there was more than the average quantity of rain—the quantity falling in July, August, and September being, in 1852, twelve and a half inches, while in 1840 it was seven inches, and in 1845 only $5\frac{54}{100}$ inches.

At the end of this report will be found a letter from Mr. Blodget, of the Smithsonian Institution.

He gives the mean annual rain-fall for a long series of years as from

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forty to forty-one inches, while it varies from year to year between the extremes of twenty-five and fifty-four inches.

The total fall at Fort McHenry in 1852 was 51½ inches—ten inches more than the average, and more than double the minimum.

These data go to confirm the general statements of the millers; and I therefore conclude that the average flow of Rock creek during the hot season may be taken at not much less than 19,000,000 gallons, while it occasionally is diminished to one-fourth of that quantity, or 4,750,000 gallons.

There are three or four small streams which enter the creek below the point at which the gauge was taken. They add something to the supply; but, having no gauge of them—for they were swollen by autumnal rains when I took charge of the survey, and it was useless to measure their flow in that condition—I do not consider them in the above rough calculation of quantities.

It will be obvious, therefore, that, in obtaining a supply from Rock creek, the right to use all the water will be wanted, and all the mill-seats now occupied, or capable of being occupied, must be purchased.

Large reservoirs will be necessary for storing up supplies for use during periods of drought.

The reservoir made by the dam proposed will contain, above the level of the bottom of the conduit, two hundred and thirty millions of gallons.

The dry season extends from the middle of August to the end of September—say forty-five days.

This would afford a supply from this reservoir of 5,110,000 gallons a day, which, added to 4,750,000 gallons, the minimum daily flow, would give a supply of 9,860,000 gallons a day. This, I think, is as much as it would be safe to assume for the minimum supply from Rock creek.

In view of the growth of Washington to be expected within the next twenty or thirty years, and the expenditure of water in such great fountains as public taste will demand, and in the many small ones which public health and comfort will require, I cannot think this a sufficient supply. In ten years from this time, ten millions of gallons a day, I am confident, will be found too little for the domestic use alone of its inhabitants; and in undertaking a great work, such as the supply of a city with water, I cannot think that a project which provides only for ten years is wise or judicious. Still, leaving the decision of this question to the wisdom of Congress, I present a project and estimate for making the best use of this source.

### DESCRIPTION OF THE ROCK-CREEK AQUEDUCT.

I propose to erect, at a point shown upon the accompanying map of Rock creek, a dam of masonry. Its height will be, in the middle of the valley, 41 feet above its foundations. It will be built of rubble masonry, faced with large stones, roughly dressed, and laid in hydraulic mortar. The foundation and abutments are of sound gneiss rock, which is well calculated to resist the abrasion of water falling from such a height. The rock will be excavated under the site of the dam

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till all the loose and unsound stone is removed. The plan of the dam will be an arc of a circle of 282 feet chord, and 30 feet verse sine—adding to the inertia of the masonry the strength of the arch. The back of the dam will be embanked with earth, as usual.

To prevent the slow wear of the masonry and foundations caused by the constant flow of a thin sheet of water, 20 feet of the dam near the west end will be left as a waste-weir, two feet lower than the rest, and a channel will be excavated through the rock, which here rises within 10 feet of the lip of the dam, to carry off the ordinary flow of the stream. This weir will be regulated by stop-planks, in the usual way.

The water will flow in the channel prepared for it without injury to the dam, which will be exposed to wear for a short time only, during freshets.

Wings 10 feet above the crest of the dam extend into the hill on each side, protecting the abutments from wash during floods.

The water will be raised at the site of the dam 37 feet, and a pond of about two miles and three-eighths in length will be formed, whose surface, at a level of $166\frac{4}{10}$ feet above high tide in the Potomac, will contain $141\frac{1}{4}$ acres.

The upper part of this reservoir will be excavated to secure a depth of five feet near the shore, so as to prevent, as far as possible, the growth of aquatic plants.

The water contained in this pool, within five feet of the surface, will be about 231,000,000 gallons.

A greater reservoir, but at great cost, might be made above the termination of this one; but the character of the valley here changes, and, without much expense in excavating its head and borders, we should only obtain a wide shallow pool, which, by the heats of summer, would be rendered too warm for drinking, and which in time—filled with aquatic plants and the countless millions of infusoria—would become a stagnant lake, deleterious to the health of the neighborhood, and unfit for use in the city.

From this reservoir, I propose to convey the water by a conduit of brick six feet in diameter and nine inches thick, laid, wherever it is possible, entirely beneath the natural surface. Where raised upon embankments or masonry, it will be covered with a depth of at least two feet of earth, sufficient in this climate to protect it from any damage by frost.

I propose the circular form, because it gives greatest water-way, with least friction on the sides and least expenditure of material. The diameter is determined by the necessity of allowing free passage to workmen and officers engaged in the periodical inspection and repairs.

This conduit will be capable of delivering much more than the minimum supply of Rock creek; but there is no good reason why, because we can get only ten millions in dry seasons, we should not take twenty when they are to be had. The slope being one foot per mile, and the depth of water five feet, the discharge will be 26,732,300 gallons a day.

Waste-weirs will be erected in the proper places to relieve the conduit from the surplus caused by floods, and a gate-house near the dam will regulate the quantity admitted.

The route is very rough and rocky, requiring several deep cuts, four

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bridges, and one tunnel. Generally, however, the line has been so placed as to require but little excavation and embankment. To secure this result, and lighten the expense, we were obliged to make the line very crooked. It is traced in red upon the accompanying map.

The most considerable bridge is at Piney branch, where the valley is 537 feet wide and 73 feet below the water-line of the aqueduct. I propose to cross this by a bridge of eight arches of fifty feet span—the arches to be, except at the heads where exposed to the weather, of brick; the piers of good rubble masonry; and the style of the whole work substantial and plain. Its magnitude and simplicity will give it a good effect, which will be little inferior, I think, to that of a more ambitious and decorated structure. The cost of this bridge will be $68,123.

I do not particularly describe the other three. They are designed in much the same style, but, being smaller, are less costly. They might all be replaced, with some reduction of cost, by pipes; but I have in these projects avoided the use of pipes in crossing valleys. They always occasion a loss of head, or else exceed in cost the bridges they replace. New York now regrets the unwise economy which, to save $100,000 in a work costing $12,000,000, choked the aqueduct at the great Harlem bridge, sacrificed two feet of head, and reduced to one-half the capacity of a work everywhere else able to pass sixty millions of gallons a day. At a much greater expense it is now proposed to raise the Harlem bridge, as it should have been at first, to the general grade of the aqueduct.

The conduit crosses the high ground near the Russian minister's country-seat by a tunnel, about 1,500 feet in length, through hard gneiss rock; shortly afterwards it crosses Piney branch by the aqueduct bridge above described, and then, ascending the valley of a small brook, a tributary of Piney branch, turns, near the toll-gate on the 7th-street road, to the south, and, by a cut of thirty-one feet in depth, reaches a ravine between Mr. Stone's house and 7th-street road, where it is proposed to locate the receiving reservoir.

This reservoir will be formed by throwing a bank across the ravine. This bank will be fifteen feet wide on top—the interior sloping to the low-water level at an inclination of one and a half to one, and protected from wash by a paving of brick secured at the low-water line with broken stone. Thence to the bottom, the slope will be three to one. The exterior slope will be two to one, and will be sodded.

A bank, paved on the interior, will surround this reservoir.

It is usual, in other cities, to pave the bottoms of the distributing reservoirs, but for this I see no necessity; and indeed I do not know but it would be as well, in construction, if the soil proves to be a good compact gravel, to omit the paving on the borders, except on the exposed bank which forms the retaining dam. Nevertheless, I have estimated for the construction of the banks in the customary mode, leaving it to be determined, upon further consideration, whether the paving may be safely dispensed with.

The drainage of the surface water, which should not be allowed to flow from the fields into this reservoir, offered, owing to the form of the ground, a difficulty. It is provided for by a small sewer, three feet in

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diameter, outside the bank. Probably more careful study of the ground than I have had time to bestow may enable us to devise a less expensive arrangement. Certainly we are safe in estimating for this one.

The usual precautions of puddling, &c., have been provided for in estimating for this reservoir. A smaller one might be erected at much less expense; but the smaller the supply from the source the larger the reservoirs required for storage, and I have estimated for completing this work upon a liberal scale. The price of the embankment has been put at a high rate; but it must be made with extreme care, for the consequences to the city of a breach in these embankments, holding millions of cubic feet of water, at a height of 160 feet above it, would be disastrous. The water would probably seek a direct course to the Potomac, sweeping everything in its way.

A waste-weir gives escape to the surplus water, which is carried off by the drainage-sewer surrounding the reservoir.

The conduit is continued on the east side of the reservoir to its south-eastern corner, where a pipe-chamber and mains enable us to draw the supply directly from the conduit, in case of accident, foulness, or cleansing of the reservoir.

The effluent mains and drainage-pipes will be contained in a brick vault, under the centre of the dam; so that the whole water of this reservoir can be drawn off for use in a great conflagration or any other extreme case. Its ordinary level will be $162\frac{64}{100}$ feet above high tide, which is $6\frac{78}{100}$ feet above the roof of the wings of the Capitol, and $70\frac{22}{100}$ feet below the top of the balustrade on the dome.

The mains which lead the water into the cities I have estimated to be 30 and 12 inches in diameter. These are sufficient for the present, and, unlike the aqueduct, are easily replaced by larger; or new ones can be laid beside them, as the wants of the cities increase.

All leading and important mains should be double, to prevent the interruption of the supply by accidents; but it is not necessary that they should all be of the same size. The twelve-inch main will afford enough for an economical use during the short time needed for repairs of the larger one.

In the estimate I include the mains to where they enter the great main in Pennsylvania avenue. Thence the mains to Georgetown and the public buildings of Washington, to the Navy-yard and Greenleaf's Point, are common to all the plans proposed.

A portion of Georgetown is at too great a height to be supplied by the natural flow of water from any source within reach.

I propose for this high service—supplying perhaps a thousand persons—to pump the water into a reservoir upon the heights of Georgetown. This reservoir will be of earth, the materials of the bank being supplied by the excavation of the centre. It will be about three-fourths of an acre in extent, and contain, when filled to a depth of 10 feet, about 2,500,000 gallons. The pump will be worked by a small turbine placed near the river in Georgetown, and driven by a pipe from the main with a head of 162 feet. The difference of level to be overcome being only 48 feet, the expenditure of a small quantity from the main will suffice to keep this reservoir full. The wheel and pump

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will be of sufficient power to raise the quantity needed for the daily consumption in 10 hours; so that the water necessary may be drawn from the mains at those hours of the night or day when it can be best spared.

The length of this aqueduct will be as follows:

| | | |
|---|---|---|
| From the head of retaining reservoir to dam.... | 3.625 miles. | |
| Conduit.................................. | 3.8067 | |
| | | 7.4317 |
| Add length of mains to Pennsylvania avenue............... | | 1.818 |
| Total length to where pipes are common to all plans proposed, | | 9.2497 |

—nine and a quarter miles.

### DESCRIPTION OF THE POTOMAC AQUEDUCT.

The traveller ascending the bank of the Potomac from Georgetown to the Great Falls would conclude that a more unpromising region for the construction of an aqueduct could not be found. Supported 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 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 secured to the rocks or laid in the bed of the canal seems practicable. Such were my own 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.

Indeed, the nature of the country is such as to present less than the ordinary difficulties to be expected in such an undertaking. There are several tunnels of an average length of only 220 feet; but three bridges, and only one of these large enough to make its erection an object of ambition to an engineer. The line runs on the slope of the hills, which is generally moderate, and such as to afford choice of ground. It has been located so as to conform to the surface, and requires very light excavation and embankment. As will be evident from the accompanying map, it is a very direct line, of remarkably easy curves, much less crooked than the line we were compelled to adopt on Rock creek; though longer, with fewer bridges, and those, except in one instance, less costly. The distance in a right line from the beginning of the conduit to the north end of the Georgetown aqueduct is 11¾ miles; the length of the conduit is about 14 miles, including the reservoirs and the pipe, to this same point.

One great source of expense, however, is the number of small ravines which furrow the hill-sides, generally dry, sometimes containing

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small streams, but all liable, after heavy thunder-showers, to pour down torrents, requiring liberal culverts for their passage.

The elevation of the water in the Potomac opposite the fifteenth mile-stone on the canal, which is somewhat less than three-quarters of a mile above Collins's Great Falls House, is, at low-water, 147 feet above high tide at Washington. Our examination showed an average depth of less than five feet, a ledge of rock extending across the river and forming a natural dam.

In ordinary stages, the water is two or three feet higher. A dyke of rock thrown across the stream, 1,541 feet in length, and eight feet in height, will raise the water, at its lowest stage, to the level of (150.) A brick conduit laid in a trench, and covered up with rock and earth, will conduct the water to the tail of the 18th lock on the canal. Here a large pipe-chamber will be constructed, serving as a waste-weir to relieve the conduit from the superabundant waters of great floods. Wastes will be put in at several points between this chamber and the head of the conduit at the dam to establish an equilibrium between the pressure within and without in floods, which may rise to a height, in some places, of nearly twenty feet above this conduit.

It may prove, upon further examination, a better and cheaper arrangement to carry a wall or dyke from the end of the dam along some islands near the Maryland shore, so as to make this part of the aqueduct an open canal; but the determination of this question must be left to the surveys for a final and definite location.

The height is not sufficient to cross over the canal, and any location between the canal and river below this point will be insecure and very expensive.

The water will, therefore, be conveyed by large iron pipes, under the canal, to a gate-house on the opposite side, where regulating gates, worked by screws, will control the quantity to be admitted; while throttle-valves in the pipes, governed by a large float, will cut off the communication entirely when the river rises to a height likely to be injurious to the conduit.

After leaving the gate-house, the water will be conducted to the receiving reservoir through a brick circular conduit seven feet in diameter, nine inches thick, covered always with at least two feet of earth. With a slope of 0.792 foot (a little over nine inches) to the mile, the water running at six feet depth, this conduit will discharge 36,015,400 gallons in twenty-four hours. At a depth of three and a half feet, the discharge would be 17,734,300.

A small increase in the size of the conduit would very much increase the quantity of water. A conduit of nine feet interior diameter, water eight feet deep, would deliver 67,596,400 gallons a day. The quantity which can be supplied by the river being almost unlimited, it is difficult to decide upon the size of the conduit.

I have taken seven feet diameter, because I considered it safe to construct one of that size, with an arch of nine inches thickness; while a larger size would probably require a half brick to be added to the arch, and thus considerably increase the cost. The difference in the excavation and embankment, however, would not be very great, and

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the increased expense by no means proportioned to the increased delivery.

There are two short tunnels near the pipe-chamber—one 215, the other 272 feet in length. They must be driven through hard gneiss rock, but offer no particular difficulty.

After leaving these tunnels, the line for about a mile is principally in rock; but the excavation is light, as will be seen by the profile upon the map. It crosses a ravine and small brook by an arch of 24 feet span, and soon after passes through two tunnels—one 115, the other 61 feet in length. The character of the rock is the same as in the first tunnel. At five and three-quarters miles from the dam it crosses Mountain-spring brook by an arch of 50 feet span, and proceeds in easy cutting to the end of the seventh mile, where it meets the only serious obstacle on its whole course. This is the valley of the Cabin John branch. The bottom of the stream is 95 feet below the water in the aqueduct. This valley might be crossed by pipes; but the reasons given in describing the bridges on the Rock-creek line, and the experience of the Harlem bridge, on the Croton aqueduct, are sufficient, I think, to prove that a bridge, unless very costly, should be preferred.

The bridge proposed will be 482 feet in extreme length; its greatest height, 101 feet; width, 20 feet; and will consist of six semi-circular arches of 60 feet span, resting upon piers 7 feet thick by 20 feet long at the top, and of various heights, the highest being 52½ feet.

The piers will be of rubble masonry of large stones, which can be quarried within a quarter of a mile of the site; the ring-stones, at the ends of the arches, of well-cut stone; and the remaining part of the arches, of brick.

This bridge will cost $72,409, and is the only large one upon the route.

The line then passes through favorable ground, being generally two-thirds of its depth below the natural surface. There are some ravines requiring embankments near the Little Falls, and the hill-side there is steep and stony.

Near the end of the tenth mile the line turns to the northeast, and, by a tunnel of 440 feet, reaches the valley of Little Falls or Powder-mill branch. This is the last tunnel. The aggregate length of the whole five is 1,103 feet, or less than a quarter of a mile.

A comparison with the tunnelling of the Croton aqueduct will show how favorable is the ground.

There are on the Croton aqueduct sixteen tunnels; the shortest 116, the longest 1,215 feet in length—longer than the whole of those upon this line.

The aggregate length of the sixteen tunnels on the Croton is 6,953 feet.

A dam across the valley of the Little Falls branch, 41 feet in height above its foundation, and 200 feet in length, floods 50.65 acres, making a reservoir of irregular shape containing, above the level of 140 feet above high tide, 82,521,500 gallons. This is the receiving and settling reservoir. The water leaves it at a distance of 3,000 feet from the point where it enters; and, in slowly passing across the pool,

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which deepens to 30 or 40 feet near the exit, it will deposite most of its sediment.

Powder-mill or Little Falls branch is itself a valuable addition to the supply. The water is beautifully clear, and pleasant to the taste. During summer it never, I am informed, entirely fails; and at the time of our surveys I judge that it yielded as much as two or three millions of gallons a day.

An important advantage results from the formation of this reservoir, in hastening the time at which the water can be introduced into the cities. There are no tunnels or bridges on the line below this point; and the work, being light, except the construction of the distributing reservoir, the completion of which might be dispensed with for a short time, can be finished in a few months: so that, as soon as pipes are laid, and the dam on this stream completed, the two or three millions it affords in the autumn and winter can be introduced.

This could, without difficulty, be accomplished by the beginning of the next session of Congress.

The dam here is planned upon the model of the Croton dam, but with less cut stone, and in a less expensive but equally durable style.

The distance from the effluent gate-house of the receiving reservoir to the influent gate-house of the distributing reservoir is not quite two miles. The slope of the conduit, on leaving the receiving reservoir, is diminished to about three inches per mile. The two reservoirs are so near each other that their level is expected to remain nearly the same—145 feet above high tide.

The cutting on this portion of the line is almost entirely in clay, and the work is light, and offers no difficulties.

From the influent gate-house of the distributing reservoir the conduit is continued under the reservoir bank to an effluent gate-house and pipe-chamber at the end near Georgetown. An iron pipe communicating with the mains leading from the reservoir into the cities will afford the means of drawing a supply direct from the conduit when cleansing the distributing reservoir, or in case of interruption to its use during repairs.

The distributing reservoir is upon the 13th mile, making the whole distance from the dam to the end of the distributing reservoir, and including three-fifths of a mile in the receiving reservoir, less than 13 miles.

The distributing reservoir is near the Drover's Rest, above Georgtown. There is much land here suitable for the erection of a reservoir, and perhaps more exact surveys may induce a change in the location. The bank between the reservoir and the bluff will be constructed upon the same general plan as that proposed for the Rock-creek line. The soil being clay, however, this bank will not require the heavy puddle-ditch in its centre there provided for. Its average depth is about 14 feet, its water surface is 36¾ acres, and is 145 feet above tide. Contents at 14 feet depth, 167,530,000 gallons; within five feet of the surface it contains 59,783,000 gallons.

The two reservoirs will afford, supposing the conduit to be interrupted by floods or accident, or during the periodical examinations necessary for repairs, 142,304,500 gallons, without reducing the head

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below 140 feet; and in case of emergency, supposing the surface lowered to 131 feet above tide, they will yield two hundred and fifty millions of gallons, besides what will be supplied during this time by the flow of the Little Falls branch.

A pipe is inserted under the bank of this reservoir to drain it into the canal, for cleansing or necessary repairs. It is divided into two nearly equal parts by a bank rising nearly to the surface of the water, designed to assist, by allowing only the surface water to flow over it, in separating the turbid from the clear water, as explained in the remarks upon filtration submitted in the earlier part of this report. A communication-pipe and stop-cock are inserted in this division bank. The effluent pipe-vault is at the southeast end towards Georgetown. It contains two pipes of thirty-six inches diameter.

The mains proposed are double, to guard against accidents, and admit of repairs without cutting off the supply entirely. One will be of thirty inches, the other, laid beside it, of twelve inches diameter. They follow the most direct route into Georgetown, down Bridge street and Pennsylvania avenue to the Capitol.

In the estimate I have provided for a small reservoir for high service in Georgetown, as in the project for the Rock-creek aqueduct. It will be supplied in the same way, by a force-pump, worked by a turbine with water drawn from the mains.

The estimate for the Great Falls aqueduct includes the mains to the intersection of High and Bridge streets, in Georgetown, whence the pipes leading to the Capitol, Navy-yard, and principal public buildings are common to all the plans proposed.

A reduction might be made in these estimates by diminishing the size of the distributing reservoir; but this, I think, for reasons given above, would be an unwise economy.

I have estimated throughout to do the work in what appears to me the best manner. We have within our reach, at a moderate expense, the finest supply of water ever offered to a city; and to build an imperfect work now, would only entail the necessity of enlarging it, at great expense, hereafter.

The mains leading from the reservoirs are, I think, enough for the present. In a few years it will be necessary to enlarge them. Then the twelve-inch can be taken up and relaid in the distribution of the city, its place being supplied by one of thirty-six inches.

A separate estimate provides for the mains to the Capitol, the Navy-yard, the Arsenal, the Patent Office, the City Hall, the Mall, and the Observatory.

In comparing the estimates for the Rock-creek and Potomac aqueducts, it will be seen that the cost of reservoirs is nearly the same—

| | |
|---|---|
| Those for Rock-creek costing | $260,403 |
| Those for Potomac costing | 266,291 |
| The iron mains for Rock creek will cost | 451,063 |
| For Potomac | 398,726 |

The excess in cost of the Potomac line arises chiefly from the greater size and greater length of the conduit.

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The total cost of the Rock-creek aqueduct, including distribution to the public buildings, will be $1,255,863; of the Potomac, $1,921,244.

The former will deliver, when the creek can supply it, in the wet months of winter and spring, 26,732,300 gallons a day; but will sometimes, in hot weather and long-continued droughts, be reduced to 10,000,000.

The latter will always be capable of affording, in the hottest seasons, 36,015,400 gallons a day.

### CAPITOL.

The height at which the water of the Great Falls can be delivered in the Capitol, fourteen feet above the upper floor, is, I think, quite sufficient to secure the safety of the building, and of the invaluable collections therein contained; but should it be desired to have the power of pouring the water upon the roof itself, this can be done by a small turbine-wheel and force-pump, which, as for the high service of Georgetown, can be worked by water from the main.

Thus an iron tank on the roof might be kept constantly overflowing, and this store could be let loose at any moment, and its stream be directed upon any point required.

I say constantly overflowing. There would then be no danger of the tanks being frozen; and the surplus water, conveyed away by a pipe, might escape in a fountain in the grounds.

Were it not for the great importance of protection to this building, it would be better to reduce the height of the reservoirs, in order to diminish the pressure upon the mains and service-pipes, which require to be made of great strength to resist the strain caused by such a head. The full head, however, has an advantage in permitting the use of much smaller leaden service-pipes in houses.

### DESCRIPTION OF THE PROJECT FOR SUPPLYING WATER FROM THE LITTLE FALLS OF THE POTOMAC.

When I took charge of these surveys, I had formed an opinion that the nature of the ground between Georgetown and the Great Falls was such as would make any line of aqueduct thence enormously expensive.

I knew of the country only what can be seen in riding along the canal, whence it presents a series of ravines and precipices.

I knew also that Rock creek was not a very large stream; and I turned my attention to the Little Falls of the Potomac.

There is a dam, built by the Chesapeake and Ohio Canal Company, about four and a half miles above the Georgetown aqueduct. The fall of the river between this dam and Georgetown is thirty-six feet. The great size of the river, with the height of the fall, and the great water-power thus created, appeared to offer the means of raising, by machinery, the water necessary for a supply.

London, by steam-power, pumps up forty-five millions of gallons daily.

The Great Falls route proved, upon examination, much more favorable than I expected; and, fearing I would not be able to perfect all these projects during this session of Congress, I studied and completed

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first the design for the work from the Great Falls. That from Rock creek was next taken up; and, time pressing, I have been obliged to make the estimate for this from the Little Falls with less exactness than the others.

The difficulties to be overcome are great. The Potomac, one of the great rivers of the continent, rises in floods sometimes more than thirty feet above its ordinary level. The people of Georgetown and Washington have seen proofs of its power in the wreck of their bridges and canals. Unlike the Mississippi and Ohio, which, when at their highest, move calmly and majestically, the Potomac, shut in between steep hills, and chafed by its rocky bed, resembles, at these times, a mountain torrent. Every new construction in such a river tends, by diminishing the space for its waters, to cause the next great flood to rise still higher. The engineers of the Chesapeake and Ohio canal have long fought it, replacing their guard-banks, destroyed by the floods, too often only to find the next freshet going beyond their calculations, and sweeping away the barriers placed in its course.

These difficulties, however, I believe, can be overcome; but they entail the necessity of very expensive constructions.

I regret that I have not more time at my disposal for a careful study particularly of this project. Perhaps it might safely be reduced in expense. It cannot be perfectly and fairly presented without detailed drawings, which I have not time to prepare; and, doubtless, further and more deliberate study would enable us to improve it. For each difficulty I am obliged to seize the first and readiest solution. I have had but three months to survey, devise, project, and estimate three great works, either of which is well worthy the study of a year.

I propose, then, to bring the water of the Potomac, by a canal, about 100 feet wide and 6 feet deep, at the level at which the present Chesapeake and Ohio canal enters Georgetown, and located between this canal and the river, to a suitable place, about two miles above the Georgetown aqueduct, and there, by the proper machinery, to elevate it to such a height as will enable us, partly by a brick conduit, partly by iron pipes, to convey it to the cities.

For the construction from the end of the pumping-mains to the cities, I have adopted a part of the project for the Great Falls aqueduct. I believe it is well adapted to the object, and it will have the advantage of being capable of extension, at a future day, to the Great Falls, when the wants of the cities increase to such an extent that the use of pumping machinery becomes too expensive.

One advantage of this plan is the security it will give to the Chesapeake and Ohio canal. To render ourselves safe, we must necessarily secure them. But the works for security must be high, and strong, and costly.

Part of the dam at present existing would be repaired, and a new location adopted for the rest of it. It would extend from the island shown on the map, in the middle of the river, to the head of High island. Under protection of this rocky island, a guard-lock and sluice-ways will be placed. A guard-bank, revetted on the exterior with masonry, will extend from this lock to the Maryland shore; and, a stop-lock being placed upon the Chesapeake and Ohio canal, the bank and

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wall will be connected with the high and rocky shore on the northeast side of the canal.

If these structures are high enough to overtop the highest floods, and strong enough to resist their pressure, they will render this portion of the work secure.

The highest flood known is that of April, 1852. By marks then placed by Mr. Bryan, it reached, at the location of these works, a height of $17\frac{7}{10}$ feet above the top of the dam.

Our guard-bank, shutting out the river from the space between High island and the Maryland shore, will, by contracting its water-way, cause the next great flood to rise still higher—how much, it is impossible for me to predict with exactness; but I believe that works rising ten feet above the flood of 1852 will be safe from overflow. I have adopted this height in our project, keeping our banks and walls everywhere ten feet above the flood of 1852.

The construction of a lock will be necessary in order to permit the passage of boats which occasionally will need to navigate the river, and for our own use when engaged in repairs of the dam.

The water will be admitted to the canal through ten sluices, six feet by four feet, in each of which are sliding-gates worked by screws. The gates are double, to guard against accidents; and there are grooves for stop-planks, to permit the gates to be taken out for repairs.

The sluice-ways and facing of the lock-walls are of cut stone; the rest of the work of heavy gneiss rubble masonry, laid in hydraulic mortar—the walls of great strength and thickness.

They have been carefully calculated, and are believed to be sufficient to resist the floods and ice.

The location alone of these works could be represented on the map. Slight drawings of them I have made; and I have sufficiently studied their details for the estimate.

High island forms a portion of our guard-bank. Below its foot a high embankment, ten feet wide on top, with slopes of two to one, divides the canal from the river. It extends to within two miles of the Georgetown aqueduct. Its length is about two miles. Its top is kept ten feet above the level of the highest recorded flood. Its exterior slope is protected from wash during floods by a thick covering of loose stone. In ordinary stages of the river, it is not reached by the water.

The crossing of the stream known as the Little Falls branch presents a serious obstacle. To make our canal safe, it is necessary to shut out the floods, which here rise to a height of six feet above the surface of the water in the canal. Thence may result an upward pressure of a column of water six feet in height, tending to burst up the culvert. The flood, too, may come at a time when the Chesapeake and Ohio canal is empty: the upward pressure will then be that of a column of water twelve feet in height. The brook is too large to be passed in iron pipes, and a culvert of masonry will be needed. The river might be shut out of this culvert by sluice-gates; but if the brook should happen to be swollen at the same time as the river, it would then overflow into the canal, and might do serious damage. The sluice-valves, too, might be obstructed by the heavy stones brought down by this brook, which is sometimes a torrent. An open sluice, by admitting the river,

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would involve great danger to the works. The only complete solution seems to be, so to arrange the mansonry in masses, leaving proper passages for boats on the canal, but connected by counter arches, as to bring its whole weight to bear as one mass in resisting the upward pressure. This has been done.

The details of the pump-house I have not, for want of time, much studied, but its general arrangement and size I have determined. For the machinery, I propose to use pumps of similar design to those for so many years in use in Philadelphia, but of greater size. They would be driven by turbine-wheels, upon the same principle as that so successfully applied by Mr. Graff at the Fairmount water-works.

The quantity proposed to be raised by each pump would be 6,000,000 gallons, which would be raised to the height of 145 feet in twenty hours, allowing four hours a day for repairs, oiling, cleaning, &c.

I have procured an estimate from Mr. Geyelin, the designer and builder of the turbine and pump at Fairmount. It is appended to this report. In the development of our plans, the case has somewhat changed from that submitted to him, but it would not probably much alter the cost.

I propose to establish at once two sets of such machinery, each capable of raising 6,000,000 gallons a day.

The machinery must be in duplicate, to guard against accidents, and allow for repairs. Other wheels and pumps could be added as the wants of the cities increase. The water from the pumps will enter a stand-pipe—a vertical tube of wrought-iron boiler-plate, six feet in diameter, 160 feet high. It might be supported by stays of iron; but it will be better to surround it by a tower of masonry, with a spiral stair-case between it and the masonry, to admit of frequent examination and repairs of leaks. The tower I would make circular in plan, and of brick; the stairs of cast-iron.

The stand-pipe is necessary to avoid the strain upon the pumps caused by pumping directly into the long mains leading to the reservoir. Air-vessels will assist in relieving the pumps, but will not alone be sufficient where the quantity of water to be raised is so great.

Two 36-inch mains will lead the water under the canal and up a small ravine to a pipe-chamber on the hill. The aqueduct from the pipe-chamber shown on the general map is a part of that described in the Great Falls project, and needs no further remarks here.

Perhaps it would be better to shorten the canal, and locate the pumps higher up the river, so as to bring in, with considerable increase of cost, but with great advantages to the project, the settling reservoir at the Little Falls branch.

This project requires for its execution more skill and science than either of the others, and it bears a tempting aspect. The engineer who bridles and masters the Potomac will achieve fame.

The whole cost estimated, $1,597,415, would be not much less than that of the aqueduct from the Great Falls; and, that being far better, I should not have presented this to your notice, had not public attention been attracted to the Little Falls as a source of supply. My instructions were, to make surveys, projects, and estimates for determining the best means of affording to the cities of Washington and Georgetown an un-

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failing and abundant supply of good and wholesome water. I present all those which I have made—as well those which I think are shown by our investigations not to be the best, as that from the Great Falls, which I believe to be the only one which will continue for many years to supply the wants of the metropolis and Georgetown.

Should the route from the Great Falls be adopted, and money be appropriated so as to be available early this season, I would advise the immediate commencement of the dam at the Little Falls branch, and the conduits and mains thence to the Capitol.

The water from this stream could then be introduced next winter, and the remainder of the work could be pushed through within the next year or eighteen months.

If the work is delayed by meagre appropriations, its expense will be much increased; and I hope, in that case, not to be held responsible for its cost above my estimate, which is based upon a steady and vigorous prosecution of the work.

The sum necessary to complete the work between the city and the settling reservoir on the Little Falls branch, not including the construction of the distributing reservoir, is about $700,000; but this would not allow us to commence the dam and the tunnels on the line above, which should be among the first works undertaken.

In preparing these estimates, I have supposed the work to be substantially but plainly done. In the few bridges and buildings required, I have adopted a simple style, without much ornament, but suitable to the greatness and importance of their object. I have avoided all those expedients which, while they might somewhat reduce the cost, would impair the efficiency of the work.

There was time only to make a first location, and no doubt further surveys and more close examinations will show some changes to be proper. But the line we discovered from the Potomac is marked so plainly by the natural features of the ground, that I do not believe any great changes will be made.

The work, as located, can be built for the estimate, and will fulfil its purpose. Any changes will be made, not for greater security, but for economy, and will result, therefore, in diminishing, not increasing, the cost of the work.

I have been particularly cautious not to lead Congress into error as to the cost. The prices adopted are liberal—the quantities carefully calculated. Wherever we had a doubt, we took the higher price. And I feel assured that the estimate is a safe one. Its preparation has involved a great deal of labor; and if it fails, it will be from some unforeseen contingency, which no care or foresight on our part could provide against.

In conclusion, I have to recommend, as, in my opinion, the "best means of affording to the cities of Washington and Georgetown an *unfailing* and *abundant* supply of good and wholesome water," the construction of the aqueduct from the Great Falls of the Potomac.

The source is pure and unfailing; the quantity inexhaustible; the expense, when compared with its objects, moderate. Every dollar of capital expended will bring, for centuries, nineteen gallons a day of good and wholesome water into the cities.



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In New York, each dollar of capital expended in the construction of the Croton delivers two and a half gallons a day.

In Boston, each dollar delivers two gallons only.

The Croton aqueduct cost twelve millions of dollars; the Cochituate, five millions of dollars. Buffalo has spent four hundred thousand dollars. Jersey City is spending six hundred thousand dollars. One district of Philadelphia, Spring Garden, has expended three hundred thousand dollars.

I might multiply instances tending to show that the sum estimated above for the supply of the metropolis, on a scale commensurate with its prospects, is moderate. But I fear that, while those not accustomed to the great expenditures common for such purposes may think it large, I shall be censured by engineers for making the estimate too small. The supply of thirty-six millions of gallons by an aqueduct costing, exclusive of distributing-pipes, little over a million and a half, is so contrary to the experience of New York and Boston, that it may well excite surprise. The explanation is to be found in the shortness of the line—less than thirteen miles—and the favorable character of the ground on which it is located. A comparison of the tunnels with the Croton has been made above; and the same relation holds throughout. There are no deep cuts; no high walled embankments; no Harlem bridge, costing near a million itself. The most costly bridge on this line can be built for $72,500.

The length of the Croton, from the head of the retaining reservoir to its termination in the distributing reservoir, is forty-five miles.

The Cochituate, from the lake to the Beacon Hill distributing reservoir, is twenty miles in length. The Potomac aqueduct, to the end of the distributing reservoir, will be less than thirteen miles.

Were I to recommend any change in this project, it would be to increase the diameter of the conduit. An increase of two feet, making a nine-foot conduit, would nearly double the quantity of water—delivering 67,596,400, instead of a little over 36,000,000 gallons.

The reservoirs would not require to be enlarged, and the increase of expense would fall chiefly upon the grading and embankment—which cost for the seven-foot conduit only $352,543, and would not be increased more than $100,000—and upon the conduit-trunk itself, which would cost about $250,000 more than the present one. The increase of cost to bring in 30,000,000 gallons more of water would thus be about $350,000, which is at the rate of eighty-six gallons daily for each additional dollar of capital expended.

The great supply obtained by the aqueduct from the Great Falls has the advantage of making it available for the numerous manufacturing purposes where a small steam-engine is too expensive, and heavy labor falls upon the mechanic in consequence.

It can be applied cheaply to the driving of lathes in the smaller work-shops of a city. To the printing press, and to many other such uses, it is particularly adapted. I am informed that a newspaper of large circulation in Boston is printed upon a press driven by a small rotary pump, the power being supplied by a service-pipe from the street-main. The water is sold by the city at a fixed rate per gallon. The revolution of the pump measures the quantity, as in a gas-meter,

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and there is no waste. The cost is not greater than the wages of an engineer to attend a steam-engine—thus saving the expense of fuel and fireman, and the trouble and delay of getting up steam. The power is always at hand, and, on turning a cock, the machine is at once in action.

On the 28th page of this report, I made a comparison between the cost and advantages of the Rock-creek and Great Falls lines. Perhaps it will be well to give in this place a summary relating to each of the three projects submitted.

The Rock-creek project is less costly than either of the others. Its supply is large enough for the present in winter; but it is liable to be diminished, at the time when a full supply is most needed, to about 10,000,000 gallons a day. The cost, complete, will be $1,258,863.

The Little Falls project offers the advantage of securing the Chesapeake and Ohio canal from damage by floods. It is less costly than the line from the Great Falls.

Its disadvantages are, that it requires the use of pumps and machinery; and I think the reasons given on pages 13 and 14, in discussing the different modes of gaining proper height, are sufficient to justify my preference for a supply by the natural flow of the water.

The quantity to be thus raised is limited, also. The Potomac is a great river, but it diminishes in summer; and, though I have no doubt of its power at any season to supply the canal, and spare water enough to pump up twelve or fifteen millions of gallons, it may be doubted whether the power to raise thirty-six millions—the supply given by the Great Falls aqueduct—will be always available. And should this latter be constructed on the enlarged scale suggested of nine feet diameter, capable of delivering sixty-seven millions of gallons a day, it will be still more decidedly superior.

This project is also deficient in reservoir space; and though we could add to it the Little Falls branch settling reservoir, it would be at the sacrifice of some of its advantages. The cost of the Little Falls work, as designed and estimated, will be $1,597,415.

The aqueduct from the Great Falls offers, I think, uncommon advantages. They are set forth on pages 28 and 29 of this report, and I shall only slightly recapitulate them here. Among them are: the simplicity and durability of the work; the purity and abundance of the source; the extent and capacity of the reservoirs, by which ample supplies are gained to guard against accidents and great emergencies. and which, allowing space and time for settling, secure the delivery of a supply clear and free from mud; the height at which it is delivered—fourteen feet above the upper floor of the Capitol; its adaptability to manufacturing purposes; the great quantity it will supply, while it takes from the river only what it delivers in the cities, not drawing off, as when machinery is used, seven or eight times as much to drive the wheels as those wheels and pumps raise for use. This enables us to use the water more freely than from either of the others. The streets, in hot weather, may be flooded every morning by hose. Every particle of dust or of offal prejudicial to health or comfort would thus be washed into the sewers. The most magnificent fountains could be kept constantly flowing; and the city of Washington, unrivalled in

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grandeur and beauty of plan, would, in a few years, refreshed by living streams, and beautified by sparkling jets and towering columns of water, become a place of summer resort and the admiration of our whole people.

What American looks upon the great public buildings of our capital but with a feeling of pride and pleasure. Let our aqueduct be worthy of the nation; and, emulous as we are of the ancient Roman republic, let us show that the rulers chosen by the people are not less careful of the safety, health, and beauty of their capital than the emperors who, after enslaving their nation, by their great works conferred benefits upon their city which, their treason almost forgotten, cause their names to be remembered with respect and affection by those who still drink the water supplied by their magnificent aqueducts.

The cost of this work will be $1,921,244.

For the discharge of the conduit I have used with confidence the formulas of D'Aubuisson, as reduced to English units in his admirable work on hydraulics, so well translated by Mr. Joseph Bennett, civil engineer, of whose assistance I have had the advantage in conducting the Rock-creek survey.

The revetment and other walls submitted in these projects have been calculated by the formula of Poncelet; the thickness of the arches, by that of Peronnet; and, for their thrust and equilibrium, I have used the tables of Captain Petit, of the French corps of engineers, contained in the Memorial du Génie.

I ought perhaps to apologize for the length to which this report has extended. My studies, until this duty was assigned me, had been turned in a different direction. I could point to no great work whose construction by myself would give me the right to speak with authority on such a subject, and I have felt obliged to give in detail the facts and the reasons from which I have formed my opinions.

In conclusion, I have to acknowledge my obligations to the gentlemen from whose reports I have derived information. Schramke's description of the Croton aqueduct, the reports of Messrs. McAlpine, Baldwin, Eddy, Jervis, Johnson, Chesbrough, and Graff, and of the Croton Board, the Cochituate Water Board, and the Watering Committee of Philadelphia, contain a body of valuable information upon this subject, of which I have freely availed myself.

To the gentlemen who have assisted me in the surveys I am also under obligations. Mr. Joseph Bennett conducted the survey upon Rock creek. Mr. J. M. Wampler, of the Coast Survey, made the topographical map of the Potomac river.

To Mr. William H. Bryan, civil engineer, who conducted all the explorations for bringing the water from the Potomac, I am under particular obligations. His knowledge of the river, gained during a long experience upon the Chesapeake and Ohio canal, was invaluable. It enabled him to make valuable suggestions, many of which I have adopted; and, indeed, we have discussed together the various means of mastering the difficulties of the problem, till it would be difficult to determine with which of us many of its features originated: while his zeal and untiring industry in the office have alone enabled me so soon

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to present the estimates in the complete state in which they now appear.

I am sir, very respectfully, your most obedient servant,

M. C. MEIGS,
*Lieutenant of Engineers, in charge of surveys, &c.*

Gen. JOSEPH G. TOTTEN,
*Chief Engineer.*

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*Extracts from a letter from Prof. John Torrey, M. D., to Lieut. Meigs.*

"All the waters are soft and very good, both for washing and for drinking. There is no hurtful ingredient in any of them. The quantity of free carbonic acid which they contain is from two to three cubic inches to the gallon. Of solid matter left by evaporation, there was in no case more than a fraction over five grains to the gallon. Of this residual matter, the quantity of salts soluble in water did not exceed one grain, consisting chiefly of chlorides of calcium, sodium, and magnesium.

"The salts insoluble in pure water (and undoubtedly held in solution in the waters examined by an excess of carbonic acid) were the carbonates of lime and magnesia—the quantity varying in the different waters from three to four grains in the gallon.

"Of sulphates, we could only find a trace. Organic matter was present, but less than half a grain to the gallon.

"Our chief difficulty in analyzing these waters was *their purity*, and the small quantity submitted to us for examination. Several of the constituents were only to be estimated approximately, from the minute amount of them existing in the waters.

"Finally, I would say that the waters sent us exhibited a great uniformity of composition, and are all sufficiently pure for drinking or for manufacturing purposes; indeed, they are superior to the Croton water, according to the analysis of Professor Silliman.

"I would not be willing to undertake a new analysis, except on a larger quantity of water, or, what would amount to the same thing, on a quantity of solid matter obtained by boiling down at least twenty gallons of each variety of the water to be examined.

"We have now our processes so perfected that a re-analysis would take comparatively little time.

"I am, dear sir, yours, respectfully,

"JOHN TORREY."

NOTE.—The waters submitted to Prof. Torrey for examination were—

A. Two gallons taken from the Potomac at the Great Falls.
B. Two gallons taken from the Potomac at the Little Falls.
C. Two gallons taken from the Potomac 300 feet below Mason's foundry, above Georgetown, at high tide, 2 p. m., November 6, 1852.
D. Two gallons taken from the Potomac 400 feet below Mason's foundry—taken at low tide, 8½ a. m., November 6, 1852.
E. One and a half gallons taken from Rock creek, on Hoyle's farm, November 25, 1852.

M. C. MEIGS,
*Lieutenant of Engineers.*

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PHILADELPHIA, *December* 8, 1852.

DEAR SIR: Your favor of the 30th ultimo came to hand only a few days ago, having been absent from Philadelphia. Before leaving the city, I sent to your address two new estimates of cost: 1st. Of two Jonval turbines, on a horizontal shaft, capable of lifting, with one pump, 5,000,000 gallons in 24 hours; 2d. Of two sets of above-named turbines, capable of lifting, together with two pumps, 10,000,000 gallons in 24 hours.

Since the receipt of your favor, and my sending you the above, I had a conversation with Mr. Frederick Graff, and also reflected more fully on the project of the whole apparatus, and found it necessary to present you with a new estimate of cost, which, of course, would annul the one forwarded to you under date of December 1.

Following Mr. F. Graff's information, one-tenth of the amount of theoretic labor ought to be allowed as loss at the pump's feeding, under a head of 8 to 10 feet.

On account of the immense size of pump and the pressure thereon, I found that it would not be safe to make the thickness of metal, at all parts of the pump, less than 3 inches, and to have an air-vessel of at least three and a half times the volume of the one at Fairmount, which is 3 feet inside diameter, 10 feet high; that it would be prudent to calculate only on 20 hours' labor in a day on an average—thus leaving 4 hours for oiling, cleaning of machinery, chances of getting out of order, and packing of stuffing-boxes, &c., as the turbine-wheel at Fairmount could only have this average: the wooden wheels at Fairmount having only an average of $12\frac{1}{2}$ hours a day.

I found, also, that it would not be advisable to go above the speed of 146 feet per minute with the pump.

I read, also, in your favor of the 30th ultimo, "and the pump made of such size as, if working without loss, to discharge 6,000,000 gallons a day, and the wheel should have the necessary horse-power to raise this quantity." Then, taking the Fairmount pump as standard, it would require 285 horse-power to raise 6,000,000 gallons 200 feet high.

40 horse-power would lift 1,700,000 gallons 100 feet high in 20 hours.
141 horse-power would lift 6,000,000 gallons 100 feet high in 20 hours.
282 horse-power would lift 6,000,000 gallons 200 feet high in 20 hours.

The pump capable of lifting the above amount in 20 hours, at a speed of 146 feet per minute, and, say, 9 feet stroke and 7 strokes per minute, would require to be of a diameter of $30\frac{1}{4}$ inches.

Area × speed per minute × 60 × 20 hours = 880,000 cubic feet, or 6,600,000 gallons, theoretical.

5 square feet × 146 × 60 × 20 = 880,000.

5 square feet = 720 inches, or a circular area of $30\frac{1}{4}$ inches diameter.

In the hope that the above will be of interest to you, I remain yours, very respectfully,

EMILE GEYELIN.

P. S.—Shall I make you a plan of this project to lay before the committee?

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*Pumping apparatus for Washington and Georgetown water-works—estimate of cost.*

1st. Of two Jonval turbines together, of 285 horse-power, on a horizontal shaft, operating under 30 feet fall, all complete in themselves.

2d. The necessary gearing to transmit said power to a double-acting pump, at a speed of 7 revolutions per minute.

3d. A double-acting pump, 30¼ inches diameter, 9 feet stroke, and operating at a speed of seven strokes per minute, with the necessary air-vessel, all complete, to lift 6,000,000 gallons 200 feet high per day.

The whole delivered, put up, and put in successful operation for $27,500.

EMILE GEYELIN,
*Office Franklin Institute Hall, Philadelphia.*

Lieutenant M. C. Meigs,
*U. S. Engineers, Washington, D. C.*

---

Smithsonian Institution,
*February* 10, 1853.

Dear Sir: Your note of yesterday was referred by Prof. Henry to me for answer. The preparation of the matter required some time and care, and was accidentally interrupted to-day, so as to prevent sending it at 12 o'clock.

No reliable determination of the mean annual precipitation of the eastern slope of the Alleghanies, as a whole, has been made, nor has, as I am aware, been attempted. The materials are still very meagre, and perhaps inadequate for your purpose. But the same information has been sought from Baltimore and other places, and I have hastily grouped the records giving the means for the longest observed periods. The most important conclusion presented by the registers here is, that there is no local effect exhibited in any portion of the general plain east of the mountains from New York to South Carolina; nor is any decided change in the amount shown at stations on the mountains themselves. Philadelphia, Baltimore, Washington, and Richmond give very nearly the same amount for the year, and the same distribution among the months.

This being the case, any local observations are unnecessary to fix the amount for this locality, or for any portion of the Potomac district. Most of those made here are interrupted or unreliable in some one or more months of the year.

The amount of 40 or 41 inches will very nearly represent the mean annual fall, with extremes of 25 and 54 inches, and a very nearly *equal mean distribution among the months.*

A fuller preparation of all existing records is being made for the whole country, which will more definitely establish the needed determinations in this much-neglected matter.

Very respectfully, yours,

LORIN BLODGET,
*In charge of meteorological reductions and report.*

Lieut. M. C. Meigs.

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*Exhibit of the whole number of dwellings and shops on each square in the city of Washington to the present time.*

**FIRST WARD.**

| Squares. | Houses. | Shops. |
|---|---|---|
| 1 | 10 | 1 |
| 3 | 1 | ..... |
| W. 4 | 7 | 1 |
| 4 | 2 | 1 |
| 5 | 9 | ..... |
| 8 | 6 | 1 |
| 9 | 2 | 1 |
| 10 | 1 | ..... |
| 11 | 6 | ..... |
| 12 | 9 | ..... |
| 13 | 3 | ..... |
| 14 | 5 | ..... |
| 15 | 6 | 1 |
| 16 | 15 | 1 |
| 13 | 4 | ..... |
| 19 | 2 | ..... |
| 20 | 11 | ..... |
| 21 | 1 | ..... |
| 22 | 4 | ..... |
| W. 23 | 5 | ..... |
| 25 | 3 | ..... |
| 26 | 4 | ..... |
| 27 | 4 | ..... |
| 28 | 19 | ..... |
| 30 | 2 | ..... |
| 32 | 7 | ..... |
| 33 | 4 | ..... |
| R. 4 | 1 | 1 |
| 35 | 1 | ..... |
| 36 | 1 | ..... |
| 37 | 15 | 1 |
| 38 | 17 | ..... |
| 39 | 1 | ..... |
| 41 | 5 | ..... |
| 42 | 6 | ..... |
| 48 | 1 | ..... |
| 50 | 2 | ..... |
| 51 | 21 | ..... |
| 52 | 1 | ..... |
| 54 | 9 | ..... |
| 55 | 2 | ..... |
| 56 | 25 | ..... |
| 57 | 7 | ..... |
| 58 | 1 | ..... |
| 59 | 5 | ..... |
| 60 | 2 | ..... |
| 61 | 4 | ..... |
| 62 | 10 | ..... |
| 63 | 5 | 1 |
| 66 | 2 | ..... |
| 67 | 5 | ..... |
| 68 | 5 | ..... |
| 69 | 1 | ..... |
| 72 | 16 | ..... |
| 73 | 18 | 3 |
| 74 | 24 | 1 |
| 75 | 30 | 2 |
| 76 | 6 | ..... |
| 77 | 13 | ..... |
| 78 | 20 | 1 |
| 79 | 15 | ..... |
| 80 | 11 | ..... |
| 81 | 7 | 1 |
| 86 | 15 | ..... |
| 87 | 3 | ..... |
| 88 | 6 | ..... |
| 90 | 1 | ..... |
| 92 | 1 | ..... |
| 93 | 3 | ..... |
| 94 | 2 | ..... |
| 95 | 1 | ..... |
| 97 | 1 | ..... |
| N. 99 | 2 | ..... |
| 99 | 12 | ..... |
| 100 | 13 | ..... |
| 101 | 30 | 3 |
| 102 | 18 | 1 |
| 103 | 7 | 1 |
| 104 | 10 | ..... |
| E. 87 | 3 | ..... |
| S. 104 | 9 | ..... |
| 111 | 1 | ..... |
| 113 | 3 | ..... |
| 115 | 7 | ..... |
| 116 | 13 | ..... |
| 117 | 19 | 1 |
| 118 | 17 | 1 |
| 119 | 21 | 3 |
| 120 | 14 | ..... |
| 121 | 9 | 1 |
| 122 | 17 | ..... |
| 123 | 1 | ..... |
| 124 | 3 | 1 |
| 126 | 15 | ..... |
| 127 | 39 | ..... |
| 131 | 1 | ..... |
| 137 | 1 | ..... |
| 138 | 1 | ..... |
| 139 | 3 | ..... |
| 140 | 19 | ..... |
| 141 | 21 | 1 |
| 142 | 19 | ..... |
| 105 | 28 | 4 |
| 106 | 24 | 1 |
| 107 | 11 | ..... |
| 143 | 6 | ..... |
| 144 | 2 | 1 |
| 146 | 1 | ..... |
| 151 | 2 | ..... |
| 152 | 1 | ..... |
| 154 | 2 | ..... |
| 158 | 5 | ..... |
| 160 | 2 | ..... |
| 161 | 2 | 1 |
| 163 | 37 | ..... |
| 165 | 5 | ..... |
| 166 | 35 | 6 |
| 167 | 3 | ..... |
| 168 | 19 | 2 |
| 169 | 14 | 1 |
| 170 | 13 | 1 |
| 171 | 1 | ..... |
| 172 | 9 | 1 |
| 173 | 2 | ..... |
| S. 173 | 2 | 1 |
| 179 | 1 | ..... |
| 181 | 1 | ..... |
| 182 | 1 | ..... |
| 183 | 4 | ..... |
| 184 | 4 | ..... |
| 185 | 10 | ..... |
| 186 | 2 | ..... |
| 193 | 2 | ..... |
| 196 | 12 | ..... |
| N. 196 | 1 | ..... |
| 197 | 28 | 1 |
| 198 | 19 | ..... |
| 199 | 24 | ..... |
| 200 | 4 | 1 |
| 219 | 11 | ..... |
| 221 | 10 | 1 |
| R. 1 | 1 | 5 |
| 84 | 7 | ..... |
| 85 | 16 | ..... |
| Total.. | 1,231 | 56 |

**SECOND WARD.**

| Squares. | Houses. | Shops. |
|---|---|---|
| 202 | 1 | ..... |
| 206 | 1 | ..... |
| 210 | 2 | ..... |
| 211 | 4 | ..... |
| 212 | 2 | ..... |
| 213 | 1 | ..... |
| 214 | 34 | ..... |
| 215 | 4 | ..... |
| 216 | 18 | ..... |
| 218 | 16 | 2 |
| 220 | 13 | 1 |
| 222 | 10 | 2 |
| 223 | 13 | 1 |
| 224 | 26 | 4 |
| 225 | 27 | 3 |
| 226 | 24 | 1 |
| 227 | 14 | 4 |
| 228 | 11 | ..... |
| 229 | 2 | 1 |
| 234 | 1 | ..... |
| 238 | 1 | ..... |
| 240 | 1 | ..... |
| N. 242 | 1 | ..... |
| 242 | 2 | 1 |
| 243 | 4 | ..... |
| 245 | 7 | ..... |
| 246 | 4 | ..... |
| 247 | 18 | ..... |
| 248 | 11 | ..... |
| 250 | 44 | ..... |
| 251 | 4 | ..... |
| 252 | 37 | 3 |
| 253 | 44 | ..... |
| 254 | 57 | 5 |
| 255 | 11 | ..... |
| 256 | 25 | 1 |
| 257 | 18 | ..... |
| 258 | 39 | 1 |
| 259 | 3 | 2 |
| 278 | 3 | ..... |
| 279 | 1 | ..... |
| 280 | 3 | ..... |
| 281 | 25 | ..... |
| 282 | 26 | ..... |
| 283 | 16 | ..... |
| 284 | 11 | ..... |
| 285 | 13 | ..... |
| 286 | 29 | 2 |
| 287 | 17 | 1 |
| 288 | 41 | 4 |
| 289 | 27 | ..... |
| 290 | 34 | 6 |
| 291 | 31 | 7 |
| 292 | 21 | 2 |
| 293 | 48 | 4 |
| 294 | 4 | 1 |
| 295 | 1 | 1 |
| 302 | 1 | ..... |
| 303 | 1 | ..... |
| 312 | 2 | ..... |
| 313 | 11 | ..... |
| 314 | 1 | ..... |
| 315 | 14 | 2 |
| 316 | 16 | ..... |
| 317 | 26 | 2 |
| 318 | 12 | 1 |
| 319 | 32 | 1 |
| 320 | 20 | 3 |
| 321 | 25 | 1 |
| 322 | 20 | 4 |
| 323 | 22 | 2 |
| 324 | 13 | 3 |
| 335 | 2 | ..... |

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## EXHIBIT—Continued.

**SECOND WARD—continued.**

| Squares. | Houses. | Shops. |
|---|---|---|
| 337 | 1 | ..... |
| 339 | 1 | ..... |
| 340 | 10 | ..... |
| 341 | 25 | ..... |
| 342 | 8 | ..... |
| 343 | 22 | 2 |
| 344 | 22 | 1 |
| 345 | 26 | 1 |
| 346 | 17 | ..... |
| 347 | 32 | ..... |
| 348 | 34 | 9 |
| 349 | 17 | 2 |
| 350 | 12 | 5 |
| 363 | 1 | ..... |
| 394 | 2 | ..... |
| 417 | 8 | ..... |
| 419 | 11 | ..... |
| 440 | 2 | ..... |
| Total.. | 1,375 | 94 |

**THIRD WARD.**

| Squares. | Houses. | Shops. |
|---|---|---|
| 444 | 1 | ..... |
| 445 | 3 | ..... |
| 447 | 10 | 1 |
| 448 | 43 | ..... |
| 449 | 36 | 2 |
| 450 | 21 | 2 |
| 477 | 3 | ..... |
| 478 | 1 | ..... |
| 479 | 8 | ..... |
| 480 | 30 | ..... |
| 481 | 6 | ..... |
| 482 | 1 | ..... |
| E. 510 | 3 | ..... |
| 512 | 7 | ..... |
| 513 | 8 | ..... |
| 514 | 19 | ..... |
| 520 | 2 | ..... |
| 521 | 3 | 2 |
| 524 | 7 | 2 |
| 550 | 1 | ..... |
| 553 | 1 | ..... |
| 554 | 5 | ..... |
| 555 | 8 | 1 |
| 552 | 1 | ..... |
| 366 | 3 | 1 |
| 367 | 33 | ..... |
| 368 | 36 | ..... |
| 369 | 31 | ..... |
| 370 | 32 | 1 |
| 371 | 12 | ..... |
| 372 | 13 | ..... |
| 373 | 41 | ..... |

**THIRD WARD—continued.**

| Squares. | Houses. | Shops. |
|---|---|---|
| 374 | 45 | 1 |
| 375 | 4 | 4 |
| 376 | 11 | 2 |
| 377 | 42 | 5 |
| 378 | 63 | 6 |
| 379 | 31 | 4 |
| 380 | 26 | 3 |
| 381 | 16 | 3 |
| 382 | 9 | 6 |
| 396 | 2 | ..... |
| 397 | 8 | ..... |
| 398 | 5 | ..... |
| 400 | 15 | ..... |
| 401 | 42 | 2 |
| 402 | 16 | 1 |
| 403 | 32 | ..... |
| 404 | 14 | 3 |
| 405 | 23 | ..... |
| 406 | 17 | 5 |
| 407 | 20 | 5 |
| 408 | 21 | ..... |
| Res. 8 | Patent | Office |
| Res. 7 | Marke | t Ho. |
| 421 | 2 | ..... |
| 422 | 1 | ..... |
| 423 | 9 | ..... |
| 424 | 16 | ..... |
| 425 | 47 | 1 |
| 426 | 24 | ..... |
| 427 | 30 | 3 |
| 428 | 19 | 5 |
| 429 | 42 | 5 |
| 430 | 5 | 2 |
| 431 | 27 | 5 |
| 432 | 19 | 7 |
| Total.. | 1,135 | 90 |

**FOURTH WARD.**

| Squares. | Houses. | Shops. |
|---|---|---|
| 451 | 25 | ..... |
| W. 484 | 11 | ..... |
| 452 | 24 | 1 |
| 453 | 54 | 6 |
| 455 | 55 | 1 |
| 456 | 52 | 1 |
| 457 | 58 | 7 |
| 458 | 29 | 2 |
| 459 | 18 | 7 |
| 460 | 26 | 6 |
| 461 | 28 | 5 |
| 484 | 24 | 1 |
| 485 | 12 | 3 |
| 486 | 34 | 1 |
| 487 | 23 | ..... |
| 488 | 22 | 1 |
| 489 | 21 | 2 |

**FOURTH WARD—continued.**

| Squares. | Houses. | Shops. |
|---|---|---|
| 490 | 33 | 9 |
| 491 | 35 | 4 |
| B. | 47 | 12 |
| N. 515 | 4 | ..... |
| 515 | 12 | ..... |
| 516 | 56 | ..... |
| 517 | 44 | 4 |
| 518 | 52 | 5 |
| Res. 9 | ...... | 4 |
| 525 | 14 | ..... |
| 526 | 14 | ..... |
| 527 | 21 | ..... |
| 528 | 4 | ..... |
| 529 | 26 | ..... |
| 530 | 16 | ..... |
| 531 | 7 | ..... |
| 532 | 10 | ..... |
| 533 | 31 | 2 |
| Res. 10 | 66 | 4 |
| A. | 39 | 10 |
| S. 516 | 29 | 2 |
| 556 | 5 | ..... |
| 557 | 11 | ..... |
| 558 | 2 | ..... |
| 559 | 3 | ..... |
| 560 | 1 | ..... |
| 562 | 1 | 1 |
| S. 562 | 10 | ..... |
| 563 | 8 | ..... |
| 564 | 34 | 1 |
| 565 | 9 | ..... |
| 566 | 34 | ..... |
| 567 | 20 | ..... |
| 568 | 6 | ..... |
| 569 | 11 | ..... |
| 570 | 12 | ..... |
| 619 | 1 | ..... |
| 620 | 12 | ..... |
| 625 | 22 | ..... |
| 626 | 10 | ..... |
| 673 | 2 | ..... |
| 677 | 25 | ..... |
| 678 | 1 | ..... |
| 711 | 1 | 1 |
| 713 | 1 | ..... |
| 718 | 3 | ..... |
| 751 | 1 | ..... |
| 752 | 1 | ..... |
| 777 | 3 | ..... |
| 780 | 2 | ..... |
| 811 | 2 | ..... |
| 812 | 3 | ..... |
| 835 | 2 | ..... |
| 836 | 2 | ..... |
| 857 | 1 | ..... |
| Total.. | 1,326 | 103 |

**FIFTH WARD.**

| Squares. | Houses. | Shops. |
|---|---|---|
| 572 | 7 | 1 |
| Res. 11 | 31 | 5 |
| Res. 12 | 23 | 1 |
| 573 | 4 | ..... |
| 574 | ...... | 2 |
| 575 | 25 | ..... |
| 576 | 20 | ..... |
| 632 | ...... | 4 |
| 633 | 5 | ..... |
| 634 | 6 | ..... |
| 635 | 8 | ..... |
| 636 | 5 | 2 |
| 637 | 11 | ..... |
| 683 | 2 | ..... |
| 684 | 3 | ..... |
| 685 | 13 | ..... |
| 686 | 11 | ..... |
| 687 | 17 | ..... |
| 688 | 25 | ..... |
| 689 | 9 | ..... |
| 690 | 30 | ..... |
| 691 | 9 | ..... |
| 692 | 1 | 1 |
| 693 | 15 | 1 |
| 694 | 4 | ..... |
| 695 | 11 | ..... |
| 696 | 4 | ..... |
| 699 | 2 | ..... |
| 700 | 1 | ..... |
| 701 | 11 | ..... |
| 703 | 2 | ..... |
| 706 | 1 | ..... |
| 724 | 9 | ..... |
| 725 | 10 | ..... |
| 726 | 1 | ..... |
| 728 | 29 | ..... |
| 729 | 35 | ..... |
| 730 | 12 | ..... |
| 731 | 12 | ..... |
| 732 | 16 | ..... |
| 733 | 1 | 1 |
| 734 | 2 | ..... |
| 735 | 1 | ..... |
| 736 | 1 | ..... |
| 737 | 2 | ..... |
| 738 | 8 | ..... |
| 739 | 1 | ..... |
| 740 | 3 | ..... |
| 741 | 7 | ..... |
| 742 | 8 | ..... |
| N. 743 | 6 | ..... |
| 743 | 4 | ..... |
| 744 | 4 | ..... |
| S. 744 | 1 | ..... |
| 756 | 4 | ..... |
| 757 | 6 | ..... |
| 758 | 11 | 2 |

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## EXHIBIT—Continued.

| FIFTH WARD—continued. | | |
|---|---|---|
| Squares. | Houses. | Shops. |
| 759 | 9 | ..... |
| 760 | ...... | 1 |
| 761 | 5 | ..... |
| 762 | 12 | ..... |
| 763 | 2 | ..... |
| 764 | 2 | ..... |
| 765 | 2 | ..... |
| 766 | 5 | ..... |
| 767 | 4 | ..... |
| 768 | 1 | ..... |
| 769 | 5 | ..... |
| 770 | 12 | ..... |
| 771 | 7 | ..... |
| 782 | 1 | ..... |
| 783 | 7 | ..... |
| 784 | 10 | ..... |
| 785 | 3 | ..... |
| 786 | 8 | ..... |
| 787 | 20 | 1 |
| 788 | 4 | ..... |
| 790 | 7 | ..... |
| 791 | 9 | ..... |
| 792 | 12 | ..... |
| 793 | 13 | ..... |
| 795 | 3 | ..... |
| 796 | 8 | ..... |
| 797 | 17 | ..... |
| 798 | 8 | ..... |
| 799 | 17 | ..... |
| 800 | 5 | ..... |
| 801 | 3 | 1 |
| 802 | 10 | ..... |
| Total.. | 743 | 23 |

| SIXTH WARD. | | |
|---|---|---|
| Squares. | Houses. | Shops. |
| 813 | 3 | ..... |
| 814 | 1 | ..... |
| 815 | 1 | ..... |
| 816 | 3 | ..... |
| 817 | 7 | ..... |
| 818 | 7 | ..... |
| 819 | 2 | ..... |
| 820 | 4 | 1 |
| 822 | 2 | 1 |
| 823 | 4 | 1 |
| 824 | 9 | 1 |
| 825 | 16 | 1 |
| S. 825 | 18 | ..... |
| 826 | 2 | 1 |
| 837 | 2 | ..... |
| 838 | 1 | ..... |
| 840 | 3 | ..... |
| 843 | 6 | ..... |

| SIXTH WARD—continued. | | |
|---|---|---|
| Squares. | Houses. | Shops. |
| 844 | 7 | ..... |
| 845 | 10 | ..... |
| 847 | 8 | ..... |
| 846 | 11 | 1 |
| 849 | 4 | 1 |
| N. 853 | 4 | 2 |
| 865 | 1 | ..... |
| 867 | 6 | ..... |
| 868 | 7 | ..... |
| 872 | 1 | ..... |
| 873 | 3 | ..... |
| 874 | 3 | ..... |
| 875 | 2 | ..... |
| 821 | 12 | ..... |
| 863 | 4 | ..... |
| 876 | 9 | ..... |
| 877 | 22 | 2 |
| 878 | 28 | ..... |
| 879 | 3 | 2 |
| 880 | 4 | 3 |
| 881 | 25 | ..... |
| 882 | 12 | ..... |
| 898 | 1 | ..... |
| 901 | 1 | ..... |
| 903 | 27 | ..... |
| 904 | 34 | 1 |
| 905 | 24 | 2 |
| 906 | 28 | ..... |
| 907 | 15 | 2 |
| 923 | 1 | ..... |
| 924 | 5 | ..... |
| 925 | 1 | ..... |
| 926 | 8 | ..... |
| 927 | 2 | 4 |
| 928 | 20 | 2 |
| 929 | 14 | ..... |
| 930 | 21 | 1 |
| 939 | 2 | ..... |
| 940 | 1 | ..... |
| 944 | 2 | ..... |
| 945 | 1 | ..... |
| 948 | 2 | ..... |
| 949 | 13 | ..... |
| 950 | 10 | ..... |
| 951 | 7 | 1 |
| 952 | 7 | ..... |
| 953 | 10 | 4 |
| 962 | 1 | ..... |
| 966 | 2 | ..... |
| 969 | 1 | ..... |
| 973 | 1 | ..... |
| 974 | 9 | ..... |
| 975 | 16 | 1 |
| S. 975 | 7 | ..... |
| 976 | 15 | ..... |
| 977 | 24 | ..... |
| 978 | 4 | ..... |

| SIXTH WARD—continued. | | |
|---|---|---|
| Squares. | Houses. | Shops. |
| S. 951 | 2 | 1 |
| 994 | 2 | 1 |
| 995 | 5 | ..... |
| 996 | 9 | ..... |
| 999 | 10 | 2 |
| 1000 | 21 | 2 |
| 1001 | 4 | ..... |
| S. 1001 | 1 | ..... |
| 1010 | 1 | ..... |
| 1014 | 1 | ..... |
| N. 1017 | 1 | ..... |
| 1018 | 3 | ..... |
| 1019 | 3 | ..... |
| 1020 | 10 | ..... |
| 1021 | 5 | ..... |
| 1022 | 1 | 3 |
| 1023 | 1 | ..... |
| 1024 | 2 | ..... |
| 1025 | 1 | ..... |
| 1036 | 1 | ..... |
| 1043 | 6 | ..... |
| 1044 | 1 | ..... |
| 1045 | 4 | ..... |
| 1046 | 2 | ..... |
| 1047 | 1 | ..... |
| 1048 | 3 | ..... |
| 1066 | 3 | ..... |
| 1065 | 1 | ..... |
| 1075 | 1 | ..... |
| 1078 | 1 | ..... |
| 1079 | 2 | ..... |
| 1106 | 1 | ..... |
| 1115 | 1 | ..... |
| 1125 | 1 | ..... |
| 1128 | 1 | ..... |
| 1149 | 1 | ..... |
| Res. 13 | 5 | ..... |
| Res. 14 | 6 | ..... |
| R. 15, 16 | Market Ho. | |
| Total.. | 738 | 44 |

| SEVENTH WARD. | | |
|---|---|---|
| Squares. | Houses. | Shops. |
| Res. 3 | 3 | 1 |
| 231 | 3 | ..... |
| 232 | 1 | ..... |
| 233 | 1 | ..... |
| 263 | 12 | ..... |
| 264 | 16 | ..... |
| 265 | 3 | ..... |
| 266 | 18 | ..... |
| 267 | 29 | ..... |
| 268 | 7 | ..... |
| 267 | ...... | 1 |

| SEVENTH WARD—cont'd. | | |
|---|---|---|
| Squares. | Houses. | Shops. |
| 269 | 3 | ..... |
| 278 | ...... | 1 |
| 296 | 19 | 2 |
| 297 | 13 | 2 |
| 298 | 2 | ..... |
| 299 | 10 | ..... |
| 300 | 2 | ..... |
| 325 | 7 | 1 |
| 327 | 16 | ..... |
| 328 | 4 | ..... |
| 329 | 1 | ..... |
| N. 351 | 7 | ..... |
| 351 | 8 | ..... |
| 352 | 10 | ..... |
| 353 | 23 | 6 |
| 354 | 13 | ..... |
| 355 | 5 | ..... |
| 356 | 1 | ..... |
| 383 | 15 | ..... |
| 385 | 8 | 3 |
| 386 | ...... | 1 |
| 387 | 17 | 1 |
| 388 | 30 | 3 |
| 389 | 18 | 1 |
| 390 | 5 | ..... |
| On G. | 2 | ..... |
| Res. 2 | ...... | 1 |
| 409 | 1 | ..... |
| 410 | 1 | 1 |
| 411 | 8 | ..... |
| 412 | 3 | ..... |
| 413 | 11 | ..... |
| 414 | 9 | ..... |
| 415 | 3 | ..... |
| 433 | 1 | 1 |
| 434 | 11 | 1 |
| 435 | 12 | ..... |
| 436 | 9 | ..... |
| 437 | 17 | 1 |
| 438 | 12 | ..... |
| 439 | 1 | ..... |
| 462 | 23 | 1 |
| 463 | 10 | ..... |
| 464 | 5 | 2 |
| 465 | 18 | 1 |
| S. 463 | 12 | ..... |
| 466 | 8 | ..... |
| 467 | 2 | 2 |
| 469 | 4 | ..... |
| 473 | 4 | 2 |
| D. | 18 | 4 |
| 492 | 31 | 1 |
| 493 | 26 | 1 |
| 494 | 20 | 1 |
| 495 | 7 | 2 |
| 496 | 19 | 1 |
| 497 | 15 | ..... |

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EXHIBIT—Continued.

| SEVENTH WARD—cont'd. | | |
|---|---|---|
| Squares. | Houses. | Shops. |
| 500 | 5 | 1 |
| 501 | 22 | 1 |
| 502 | 15 | 1 |
| 503 | 19 | 1 |
| 504 | 6 | ..... |
| 505 | 1 | ..... |
| C. | 16 | 2 |
| 534 | 42 | 1 |
| 535 | 24 | ..... |
| 536 | 7 | ..... |
| 537 | 12 | ..... |

| SEVENTH WARD—cont'd. | | |
|---|---|---|
| Squares. | Houses. | Shops. |
| 538 | 25 | ..... |
| 539 | 12 | ..... |
| 540 | 7 | ..... |
| 545 | 20 | 1 |
| 546 | 4 | ..... |
| 576 | 2 | ..... |
| 577 | 8 | ..... |
| 579 | 10 | ..... |
| 580 | 16 | ..... |
| 581 | 2 | ..... |
| S. 581 | 1 | ..... |

| SEVENTH WARD—cont'd. | | |
|---|---|---|
| Squares. | Houses. | Shops. |
| 582 | 34 | ..... |
| N. 583 | 4 | ..... |
| 583 | 16 | ..... |
| 584 | 8 | ..... |
| 585 | 13 | ..... |
| 586 | 3 | ..... |
| 590 | 1 | ..... |
| 596 | 2 | ..... |
| 599 | 14 | ..... |
| 638 | 2 | ..... |
| 641 | 2 | ..... |

| SEVENTH WARD—cont'd. | | |
|---|---|---|
| Squares. | Houses. | Shops. |
| 642 | 3 | ..... |
| E. 642 | 5 | 1 |
| 651 | 1 | ..... |
| 653 | 1 | ..... |
| 660 | 3 | ..... |
| 663 | 2 | ..... |
| 664 | 2 | ..... |
| E. 664 | 1 | ..... |
| Res. 5 | 5 | ..... |
| Total.. | 1,058 | 55 |

JOHN SESSFORD.

DECEMBER 20, 1852.

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*Exhibit of the number of dwellings, &c., erected in the city of Washington within the year* 1852.

| Periods, &c. | BRICK DWELLINGS. | | | | | | | WOOD DWELLINGS. | | | | | | Total number of dwellings. | Shops, &c. | Public. | Running feet of brick pavement laid. | Estimated populat'n Dec. 31, 1852. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | On line of streets. | | | | Back from line. | | | On line of streets. | | | Back from line. | | | | | | | |
| Stories | 4. | 3. | 2. | 1. | 3. | 2. | 1. | 3. | 2. | 1. | 3. | 2. | 1. | | | | | |
| Total Dec. 31, 1848 | .... | 850 | 1,340 | 26 | .... | 290 | 3 | 63 | 2,659 | 217 | 6 | 583 | 113 | 6,150 | 390 | 89 | 176,196 | ........ |
| Erected in... 1849 | 12 | 32 | 24 | 1 | 5 | ...... | .... | 4 | 84 | 9 | .... | 13 | ...... | 184 | 9 | 17 | 6,322 | ........ |
| Do...... 1850 | 10 | 57 | 23 | .... | 6 | 18 | .... | 9 | 149 | 1 | .... | 16 | 3 | 292 | 25 | 24 | 6,768 | ........ |
| Do...... 1851 | 1 | 94 | 41 | .... | 2 | 4 | .... | 24 | 241 | 3 | .... | 42 | 1 | 453 | 28 | 44 | 17,657 | ........ |
| | 23 | 1,033 | 1,428 | 27 | 13 | 312 | 3 | 100 | 3,133 | 230 | 6 | 654 | 117 | 7,079 | 452 | 174 | 206,945 | ........ |
| *Erected in* 1852. | | | | | | | | | | | | | | | | | | |
| First ward | 2 | 11 | 7 | .... | .... | ...... | .... | 1 | 41 | 2 | .... | 2 | ...... | 66 | 3 | 1 | 3,185 | 7,303 |
| Second ward | 11 | 56 | 7 | .... | .... | ...... | .... | 11 | 25 | ...... | .... | 2 | 2 | 114 | 5 | ...... | 2,707 | 9,673 |
| Third ward | 4 | 24 | 8 | .... | .... | 4 | .... | 2 | 41 | 1 | .... | 9 | ...... | 93 | 2 | ...... | 3,102 | 6,792 |
| Fourth ward | 7 | 35 | 15 | 2 | .... | 3 | .... | 5 | 71 | 1 | .... | 17 | ...... | 156 | 4 | 1 | 1,659 | 10,323 |
| Fifth ward | .... | 6 | 4 | .... | 1 | ...... | .... | 2 | 25 | 3 | .... | 5 | ...... | 46 | 2 | ...... | 2,879 | 4,287 |
| Sixth ward | 1 | 4 | ........ | .... | .... | 1 | .... | ...... | 24 | 1 | .... | 3 | ...... | 34 | ...... | ...... | .......... | 4,292 |
| Seventh ward | .... | 10 | 12 | .... | .... | 6 | .... | 6 | 83 | ...... | .... | 6 | ...... | 123 | 3 | 1 | 2,702 | 6,669 |
| Total built in 1852 | 25 | 146 | 53 | 2 | 1 | 14 | .... | 27 | 310 | 8 | .... | 44 | 2 | 632 | 19 | 3 | 16,234 | 49,339 |

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*Estimate of the "cost of affording the cities of Washington and Georgetown an unfailing and abundant supply of good and wholesome water" by an aqueduct from Rock creek.*

| | | | |
|---|---|---|---|
| 1. *Retaining reservoir on Rock creek.* | | | |
| Grubbing and clearing | $1,000 | | |
| Deepening | 2,500 | | |
| | | $3,500 | |
| County-road bridge, crossing reservoir at Hoyle's farm— | | | |
| Mortared rubble masonry, 1,016 perches | 4,064 | | |
| Embankment, 444 cubic yards | 67 | | |
| Wooden bridge, 3 spans of 100 feet each | 6,200 | | |
| | | 10,331 | |
| Dam across Rock creek— | | | |
| Excavation of earth in foundations and waste-weir, 1,400 cubic yards | 420 | | |
| Excavation of rock in foundations and waste-weir, 2,069 cubic yards | 3,761 | | |
| Mortared rubble masonry in dam and wings, 6.526 perches, | 39,156 | | |
| Mortared face masonry in dam and wings, 1,417 perches, | 21,255 | | |
| Earth-filling back of dam, 19,680 cubic yards | 5,904 | | |
| Paving at lip of dam, 542 perches | 1,084 | | |
| Gate-house and fixtures | 4,000 | | |
| | | 75,580 | |
| 2. *The conduit bed.* | | | $89,411 |
| Grubbing and clearing | 771 | | |
| Mucking and benching | 1,645 | | |
| | | 2,416 | |
| Excavation of earth, 86,117 cubic yards | 18,085 | | |
| Excavation of rock, 22, 762 cubic yards | 40,972 | | |
| Embankment, and covering conduit, 80,915 cubic yards | 16,992 | | |
| | | 76,049 | |
| Tunnel, 1,530 feet long, excavation, 4,452 cubic yards | | 62,328 | |
| Walling and paving 50 cubic yards | 100 | | |
| Drains, roads, &c | 1,550 | | |
| | | 1,650 | |
| 3. *Culverts, bridges, and waste-weirs.* | | | 442,443 |
| 14 culverts, requiring excavation of earth in foundations, 1,877 cubic yards | 469 | | |
| excavation of rock in foundations, 1,373 cubic yards | 2,746 | | |
| bricks laid, 253,032 | 3,541 | | |
| mortared rubble masonry, 675 perches | 3,375 | | |
| stepped coping, 760 feet lineal | 380 | | |
| centring | 1,201 | | |
| | | 11,712 | |
| 4 bridges, requiring excavation of earth in foundations, 5,993 cubic yards | 1,199 | | |
| excavation of rock in foundations, 1,607 cubic yards | 2,411 | | |
| mortared rubble masonry, 16,004 perches | 95,214 | | |
| mortared cut masonry, 697 perches | 17,425 | | |
| coping 10,368 feet lineal | 10,368 | | |
| bricks laid, 1,344,740 | 18,827 | | |
| centring | 4,250 | | |
| asphaltum covering, 1,755 square yards | 1,755 | | |
| embankment over conduit, 1,787 cubic yards | 716 | | |
| | | 152,165 | |
| 3 waste-weirs | | 6,000 | |
| | | | 169,877 |

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## ESTIMATE—Continued.

| | | | |
|---|---|---|---|
| 4. *Conduit of brick.* | | | |
| In the tunnel, arch two feet thick, 1,530 feet lineal | | $18,360 | |
| Outside of tunnel, arch nine inches think, 18,568 feet lineal | | 74,272 | |
| | | | $92,632 |
| 5. *Distributing reservoir.* | | | |
| Embankment, 189,773 cubic yards | | 47,433 | |
| Puddling, 16,739 cubic yards | | 8,369 | |
| Broken stone, 10,744 cubic yards | | 16,116 | |
| Stone paving, 7,160 square yards | | 5,370 | |
| Concrete under brick paving, 2,865 cubic yards | | 10,028 | |
| Brick paving, 396,683 bricks | | 19,553 | |
| Influent and effluent gate-houses | | 3,000 | |
| Waste-weir, and pipes therefrom | | 3,000 | |
| Effluent pipe-vault, 230 feet long | | 3,000 | |
| Pipes, 2 of 36-inch diameter, each 350 feet long | | 8,400 | |
| 4 stop-cocks | | 2,000 | |
| Excavating for and laying brick sewer, 3 feet in diameter, 8,595 feet long, and refilling the trench | | 25,785 | |
| | | | 152,064 |
| 6. *Pipes and stop-cocks not common to this plan and those from the Potomac, including works for high service in Georgetown.* | | | |
| Pipe—a 30-inch main from the receiving reservoir to the intersection of Boundary street and Vermont avenue; thence along Vermont avenue to the intersection of K street north and 15th street west; thence along 15th street west to the middle of Pennsylvania avenue. From the intersection of High and Bridge streets, in Georgetown, to the middle of Lingan street, 11,699 feet | 105,291 | | |
| 11,699 feet of 12-inch main along the same line | 25,738 | | |
| | | 131,029 | |
| 4 stop-cocks of 30 inches | 1,600 | | |
| 4 stop-cocks of 12 inches | 280 | | |
| | | 1,880 | |
| 4,300 feet of 10-inch main for the high service of Georgetown | | 8,600 | |
| Pump-house and machinery for high service in Georgetown, | 10,000 | | |
| Reservoir for high service in Georgetown | 8,928 | | |
| | | 18,928 | |
| | | | 160,437 |
| Land damages, engineer services, and contingencies, 20 per cent. on estimate | | .......... | 161,373 |
| Total cost of aqueduct from Rock creek, with works for high service in Georgetown, including also the mains not common to this plan and those from the Potomac | | .......... | 968,237 |

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*Estimate of the "cost of affording the cities of Washington and Georgetown an unfailing and abundant supply of good and wholesome water" by an aqueduct from the Great Falls of the Potomac river.*

| | | | |
|---|---|---|---|
| 1. *Dam at the Great Falls, and work connecting it with the Maryland shore, viz:* | | | |
| Dam proper, (1,541 feet long,) 20,090 cubic yards of rock | | $40,180 | |
| 4,623 cubic yards of gravelling | | 1,849 | |
| Two abutments, with protection at the head of conduit, including stop-planks | | 4,500 | |
| Extension of rock protection to the canal, and protection of the canal bank | | 3,514 | |
| | | | $50,043 |
| 2. *Connexion between the dam and the pipe-chamber at the Great Falls, viz:* | | | |
| Excavation of the trench for the conduit— | | | |
| 7,500 cubic yards of earth | $2,250 | | |
| 13,723 ......do .....rock | 34,308 | | |
| | | 36,558 | |
| Brick conduit, 2,985 feet lineal, 9 inches thick | 13,432 | | |
| 946.... do.... 1½ brick thick | 6,338 | | |
| | | 19,770 | |
| Refilling trench, 21,223 cubic yards of earth and rock | 4,245 | | |
| Embankment not obtained from excavation, 3,809 cubic yards of earth and rock | 2,285 | | |
| | | 6,530 | |
| | | | 62,858 |
| 3. *Pipe-chamber, protection to and crossing the Chesapeake and Ohio canal, with pipes and gate-house, viz:* | | | |
| Protection to the canal between locks Nos. 18 and 19, 4,000 perches mortared masonry | | 16,000 | |
| Wall around pipe-chamber, 4,418 perches mortared masonry | | 17,672 | |
| Coping the wall around pipe-chamber, 1,000 feet | | 2,000 | |
| Preparation for crossing canal with pipe, pipe-chamber, and pipe-house | | 9,000 | |
| Five pipes, 210 feet each; 1,050 feet of 36-inch pipe | | 13,125 | |
| | | | 57,797 |
| 4. *The conduit bed, from the crossing of the canal to the distributing reservoir near Georgetown, viz:* | | | |
| Clearing and grubbing | 2,323 | | |
| Mucking and benching | 4,936 | | |
| | | 7,259 | |
| Excavation of earth, 198,298 cubic yards | 41,456 | | |
| Ditto ....rock...69,605....do | 125,051 | | |
| Embankment and covering the conduit, 320,300 cubic yards | 66,467 | | |
| | | 232,974 | |
| Five tunnels, 1,103¼ feet; in the aggregate, 3,883 cubic yards of excavation | | 54,362 | |
| Roads and drains | 9,000 | | |
| Walling and paving | 5,860 | | |
| | | 14,860 | |
| | | | 309,455 |
| 5. *Culverts, bridges, and waste-weirs.* | | | |
| 76 culverts, requiring 16,624 cubic yards of earth excavation | 4,990 | | |
| 9,376 cubic yards of rock excavation | 18,752 | | |
| 2,587,645 bricks laid | 36,227 | | |
| 6,851½ perches of mortared masonry | 34,257 | | |
| 4,712 feet of stepped coping | 2,356 | | |
| Centring | 8,739 | | |
| | | 105,321 | |

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ESTIMATE—Continued.

| | | | | |
|---|---|---|---|---|
| 3 bridges— | | | | |
| Excavation of foundations, 1,549 cubic yards of earth | $310 | | | |
| Excavation of foundations, 900 cubic yards of rock | 1,350 | | | |
| | | $1,660 | | |
| 9,910 perches mortared rubble masonry | 55,763 | | | |
| 650 do cut do | 14,964 | | | |
| 612 lineal feet mortared cut coping | 1,124 | | | |
| | | 71,951 | | |
| 1,863 perches dry rubble masonry | | 6,520 | | |
| 810,299 bricks | | 11,344 | | |
| Asphaltum covering over arches, 1,198 square yards | | 1,198 | | |
| Embankment at ends and over conduits, 3,842 cubic yards | | 1,168 | | |
| Centring | | 4,830 | | |
| | | | $98,671 | |
| Waste-weirs, 5, at $3,000 | | | 15,000 | |
| | | | | $218,992 |
| 6. *Reservoirs.* | | | | |
| 1st. Receiving and settling reservoir, Little Falls branch— | | | | |
| Grubbing and clearing | $1,000 | | | |
| Deepening, 12,500 cubic yards | 1,250 | | | |
| | | 2,250 | | |
| Dam—excavations of foundations, 27,531 cubic yards | 6,883 | | | |
| Puddling and gravel, 3,600 cubic yards | 1,440 | | | |
| Embankment not obtained from excavation, 25,655 cubic yards | 6,414 | | | |
| | | 14,737 | | |
| Timber laid, (in foundations.) 8,000 feet | 1,600 | | | |
| Concrete, 326 cubic yards | 1,180 | | | |
| | | 2,780 | | |
| Rubble masonry, 13,250 perches | 57,906 | | | |
| Cut masonry, 1,980 do | 29,700 | | | |
| Coping, 3,366 feet | 3,366 | | | |
| | | 90,972 | | |
| Stone and facines, 560 perches | 1,120 | | | |
| Paving at lip of dam, 200 perches | 400 | | | |
| Dry walls, 1,200 perches | 3,000 | | | |
| | | 4,520 | | |
| Gate-house and fixtures to connect with conduit | | 4,000 | | |
| | | | 119,259 | |
| 2d. Distributing reservoir above and near Georgetown— | | | | |
| Excavating trench for conduit along the reservoir bank, 11,994 cubic yards | $2,399 | | | |
| Replacing earth and covering conduit along the reservoir bank, 11,994 cubic yards | 970 | | | |
| Paved drain, in lieu of culvert, say | 631 | | | |
| | | 4,000 | | |
| Excavating trench for conduit at lower end of reservoir, 6,251 cubic yards | 938 | | | |
| Covering trench, 2,283 cubic yards | 228 | | | |
| | | 1,166 | | |
| Mucking, 24,200 cubic yards | 8,228 | | | |
| Puddle ditches, 18,184 cubic yards | 1,818 | | | |
| | | 10,046 | | |
| Excavation applicable to embankment, 73,067 cubic yards | 17,059 | | | |
| Embankment not obtained from excavation, 141,852 cubic yards | 47,284 | | | |
| | | 64,343 | | |

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## ESTIMATE—Continued.

| | | | | |
|---|---|---|---|---|
| Protection to banks— | | | | |
| Broken stone, 8,030 cubic yards | $12,045 | | | |
| Stone paving, 5,351 square yards | 4,013 | | | |
| Brick paving, 802,920 bricks | 11,246 | | | |
| Concrete under brick pavement, 1,670 cubic yards | 5,845 | | | |
| | | $33,149 | | |
| Influent and effluent gate-houses | 3,000 | | | |
| Pipe-vault at eastern end, 140 feet long | 1,500 | | | |
| Pipes, two, of 36 inches each, and two stop-cocks | 6,280 | | | |
| Pipe-drain at west end, 330 feet long, 12 inches diameter, with masonry walls | 1,650 | | | |
| One stop-cock | 70 | | | |
| Communication-pipe in division-bank, and one stop-cock | 2,900 | | | |
| | | 15,400 | | |
| Small reservoir on the heights of Georgetown, with pump-house and machinery | | 18,928 | | |
| | | | $147,032 | |
| *7. Conduit of brick.* | | | | $266,291 |
| 1st. 1,103 feet in the 5 tunnels, 2 feet thick | | | 15,442 | |
| 2d. 59,971 feet outside of the tunnels, 9 inches thick | | | 269,870 | |
| | | | | 285,312 |
| *8. Pipe into Georgetown, along Bridge to High street.* | | | | |
| 8,800 feet of 30-inch main | | 79,200 | | |
| 8,800 feet of 12-inch main | | 19,360 | | |
| 4,300 feet of 10-inch main, to Georgetown reservoir | | 8,600 | | |
| | | | 107,160 | |
| Stop-cocks: 2 of 30 inches | | 800 | | |
| 2 of 12 inches | | 140 | | |
| | | | 940 | |
| | | | | 108,100 |
| Land damages, engineer services, and contingencies, 20 per cent. on estimate | | | .......... | 271,770 |
| Total cost of aqueduct to the intersection of High and Bridge streets, in Georgetown, whence lines of pipes to supply Georgetown and the public buildings in Washington are common to all plans proposed | | | .......... | 1,630,618 |



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*Estimate of the "cost of affording the cities of Washington and Georgetown an unfailing and abundant supply of good and wholesome water" by an aqueduct from the Little Falls of the Potomac.*

| | | | |
|---|---|---|---|
| **1. *Preparation.*** | | | |
| Grubbing and clearing | | $600 | |
| Mucking, 10,975 cubic yards | | 1,097 | |
| Puddle ditches, 32,220 cubic yards | | 4,833 | |
| | | | $6,530 |
| **2. *The canal.*** | | | |
| Excavation carried into bank, 69,100 cubic yards | $23,033 | | |
| Embankment not obtained from excavation, 541,722 cubic yards | 260,861 | | |
| Raising the tow-path above guard-bank, 2,800 cubic yards | 700 | | |
| | | 294,594 | |
| Rock protection to banks, 65,304 cubic yards | | 65,304 | |
| | | | 359,898 |
| **3. *The dam.*** | | | |
| Rock dyke, 26,731 cubic yards | | 53,462 | |
| Gravelling, 8,088 cubic yards | | 2,426 | |
| | | | 55,888 |
| **4. *Guard-gate, revetment wall of guard-bank, and stop-gate.*** | | | |
| Guard-gate— | | | |
| Excavation in foundations—earth, 1,622 cubic yards | $324 | | |
| rock, 600 cubic yards | 600 | | |
| Grillage—timber foundations, 15,025 cubic feet | 3,756 | | |
| Concrete for foundations, 1,589 perches | 6,356 | | |
| Mortared rubble masonry, 11,236 perches | 67,416 | | |
| Mortared cut masonry, 730 perches | 7,300 | | |
| Earth filling, 2,800 cubic yards | 1,400 | | |
| 2 pair of lock-gates and 1 set of stop-plank | 1,400 | | |
| 21 sluice-gates | 4,260 | | |
| | | 92,812 | |
| Revetment wall— | | | |
| Excavation of foundation, and refilling part of same, 7,187 cubic yards | 2,516 | | |
| Foundation, concrete, 1,102 perches | 4,408 | | |
| Mortared rubble masonry, 8,995 perches | 53,970 | | |
| | | 60,894 | |
| Stop-gate, crossing the Chesapeake and Ohio canal— | | | |
| Sheet-piling and grillage of timber under foundation | 784 | | |
| Concrete foundation, 243 cubic yards | 972 | | |
| Mortared rubble masonry, 1,745 perches | 10,470 | | |
| Gates, paddles, and stop-plank | 500 | | |
| | | 12,726 | |
| | | | 166,43 |
| **5. *Wall for passing lock No. 5 of the Chesapeake and Ohio canal.*** | | | |
| Mortared rubble masonry, 1,428 perches | | 5,712 | |
| Dry rubble masonry, 278 perches | | 695 | |
| Bridge and feeder gates | | 300 | |
| | | | 6,707 |
| **6. *Culverts.*** | | | |
| Excavation of earth, 3,577 cubic yards | | 1,038 | |
| Excavation of rock, 3,223 cubic yards | | 4,834 | |
| Rubble mortared masonry, 8,804 perches | | 45,452 | |
| Rubble dry masonry, 1,349 perches | | 2,698 | |
| Embankment, 16,667 cubic yards | | 6,801 | |
| | | | 60,823 |

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## ESTIMATE—Continued.

| | | | |
|---|---|---|---|
| **7. *Bridge at the Little Falls, crossing the feeder.*** | | | |
| Cost | | | $5,000 |
| **8. *Pump-house, pumps, and stand-pipe.*** | | | |
| Pump-house and walls— | | | |
| Mortared masonry, 5,919 perches | $59,190 | | |
| Roof, gates, and windows | 8,000 | | |
| | | $67,190 | |
| Two pumps and turbine-wheels, with foundations for same | | 16,000 | |
| Stand-pipe, ¾-inch wrought iron, 92,000 pounds | 13,820 | | |
| Brick tower, 823,800 bricks | 11,533 | | |
| Iron stairs for brick tower | 1,283 | | |
| | | 26,636 | |
| | | | 109,826 |
| **9. *Mains from pumps to pipe-chamber, with stop-cocks and pipe-chamber.*** | | | |
| Two 36-inch mains, each 1,000 feet long | | 25,000 | |
| Four stop-cocks of 36 inches | | 2,000 | |
| Pipe-chamber | | 3,000 | |
| | | | 30,000 |
| **10. *The conduit line.*** | | | |
| Grubbing and clearing | $53 | | |
| Mucking and benching | 75 | | |
| Excavation of earth, 7,681 cubic yards | 1,882 | | |
| Excavation of rock, 1,065 cubic yards | 1,598 | | |
| Embankment and filling trench, 14,404 cubic yards | 2,724 | | |
| | | 6,332 | |
| One culvert, under the conduit line— | | | |
| Excavation of foundation—earth, 200 cubic yards | 60 | | |
| rock, 460 cubic yards | 920 | | |
| Arch, 105,000 bricks | 1,470 | | |
| Mortared masonry, 244 perches | 1,220 | | |
| Stepped coping, 120 feet | 60 | | |
| Centring | 400 | | |
| | | 4,130 | |
| | | | 10,462 |
| **11. *The conduit of brick.*** | | | |
| 4,954 feet | | | 22,293 |
| **12. *Reservoirs.*** | | | |
| Distributing reservoir above and near Georgetown— | | | |
| Excavating trench for conduit along the reservoir bank, 11,994 cubic yards | $2,399 | | |
| Replacing earth and covering conduit along the reservoir bank, 11,994 cubic yards | 970 | | |
| Paved drain in lieu of culvert, say | 631 | | |
| | | 4,000 | |
| Excavating trench for conduit at lower end of reservoir, 6,251 cubic yards | 938 | | |
| Covering trench, 2,283 cubic yards | 228 | | |
| | | 1,166 | |
| Mucking, 24,200 cubic yards | 8,228 | | |
| Puddle ditches, 18,184 cubic yards | 1,818 | | |
| | | 10,046 | |
| Excavation applicable to embankment, 73,067 cubic yards | 17,059 | | |
| Embankment not obtained from excavation, 141,852 cubic yards | 47,284 | | |
| | | 64,343 | |

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ESTIMATE—Continued.

| | | | |
|---|---|---|---|
| Protection to banks— | | | |
| Broken stone, 8,030 cubic yards | $12,045 | | |
| Stone paving, 5,351 square yards | 4,013 | | |
| Brick paving, 802,920 bricks | 11,246 | | |
| Concrete under brick pavement, 1,670 cubic yards | 5,845 | | |
| | | $33,149 | |
| Influent and effluent gate-houses | 3,000 | | |
| Pipe-vault at eastern end, 140 feet long | 1,500 | | |
| Pipes, two, of 36 inches each, and two stop-cocks | 6,280 | | |
| Pipe-drain at west end, 330 feet long, 12 inches diameter, with masonry walls | 1,650 | | |
| 1 stop-cock | 70 | | |
| Communication-pipe in division-bank, and 1 stop-cock | 2,900 | | |
| | | 15,400 | |
| Small reservoir on the heights of Georgetown, with pump-house and machinery | | 18,928 | |
| | | | $147,032 |
| 13. *Pipe into Georgetown, along Bridge to High street.* | | | |
| 8,800 feet of 30-inch main | 79,200 | | |
| 8,800 feet of 12-inch main | 19,360 | | |
| 4,300 feet of 10-inch main to Georgetown reservoir | 8,600 | | |
| | | 107,160 | |
| Stop-cocks—2 of 30 inches | 800 | | |
| 2 of 12 inches | 140 | | |
| | | 940 | |
| | | | 108,100 |
| Land damages, engineer services, and contingencies, 20 per cent. on estimate | | | 217,798 |
| Total cost of aqueduct to the intersection of High and Bridge streets, in Georgetown, whence lines of pipes to supply Georgetown and the public buildings of Washington are common to all plans proposed | | | 1,306,789 |

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*Estimate of the cost of mains and stop-cocks from the intersection of High and Bridge streets, in Georgetown, to the Capitol, Navy-yard, and other public buildings, applicable to any plan which may be adopted.*

| | | |
|---|---|---|
| 30-inch pipe from intersection of High and Bridge streets, along Bridge street to a point in line with the middle of Pennsylvania avenue; then, crossing Rock creek, to and along Pennsylvania avenue, 15th street, and Pennsylvania avenue, to the middle of 1st street east, 18,313 feet | $164,717 | |
| 18,313 feet of 12-inch main laid between the above points. 23,232 feet of 12-inch main laid as follows: From the middle of Pennsylvania avenue along 24th street to the Observatory. From the middle of Pennsylvania avenue up 8th street by the General Post Office to the centre of the Patent Office square. From the middle of Pennsylvania avenue up 4½ street west to the centre of Judiciary square. From B street south along 4½ street west to the Arsenal, at Greenleaf's Point. From the middle of 1st street east and Pennsylvania avenue along Pennsylvania avenue to middle of 8th street east, thence down 8th street east by the marine barracks to the Navy-yard, at the water's edge. | 91,399 | |
| 4,336 feet of 20-inch main laid as follows, viz: From the middle of Pennsylvania avenue down 4½ street west to the middle of B street south, thence along B street south to middle of 10th street west. From the middle of 10th street west to the Smithsonian Institution. | 21,680 | |
| | | $277,796 |
| Stop-cocks: 2 of 30 inches | 800 | |
| 14 of 12 inches | 980 | |
| 5 of 20 inches | 1,050 | |
| | | 2,830 |
| Crossing Rock creek with mains | .......... | 10,000 |
| Total cost of mains through the cities to the principal public buildings | .......... | 290,626 |

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*General summary of the estimate for an aqueduct from Rock creek.*

| | | |
|---|---|---|
| 1. Retaining reservoir on Rock creek, with road bridge over the reservoir, and dam across Rock creek | $89,411 | $89,411 |
| 2. The conduit bed—excavation, embankments, tunnels, &c | | 142,443 |
| 3. Culverts, bridges, and waste-weirs | | 169,877 |
| 4. Conduit of brick | | 92,632 |
| 5. Distributing reservoir | 152,064 | 152,064 |
| 6. Pipes and stop-cocks not common to this plan and those from the Potomac, including also works for high service in Georgetown. | 18,928 | 160,437 |
| Land damages, engineer services, and contingencies, 20 per cent. on estimate | | 161,373 |
| Total cost of reservoirs, including pump-house and machinery for high service in Georgetown | 260,403 | |
| Total cost of reservoirs and aqueduct to points whence lines of pipes to supply Georgetown and the public buildings of Washington are common to all plans proposed | | 968,237 |
| Add cost of mains and stop-cocks from the intersection of High and Bridge streets, in Georgetown, to the Capitol, Navy-yard, and other public buildings in Washington | | 290,626 |
| Total cost | | 1,258,863 |

*General summary of the estimate for an aqueduct from the Great Falls of the Potomac.*

| | |
|---|---|
| 1. Dam at the Great Falls, and work connecting it with the Maryland shore | $50,043 00 |
| 2. Connexion between the dam and the pipe-chamber at the Great Falls | 62,858 00 |
| 3. Pipe-chamber, protection to and crossing the Chesapeake and Ohio canal, with pipes and gate-house | 57,797 00 |
| 4. The conduit bed, (from the crossing of the canal to the distributing reservoir near Georgetown,) excavation, embankment, tunnels, &c | 309,445 00 |
| 5. Culverts, bridges, and waste-weirs | 218,992 00 |
| 6. Reservoirs, with pump-house and machinery, in Georgetown | 266,291 |
| 7. Conduit of brick | 285,312 00 |
| 8. Pipe into Georgetown, along Bridge to High street, with main from pump-house to high-service reservoir in Georgetown | 108,100 00 |
| Land damages, engineer services, and contingencies, 20 per cent. on the estimate | 271,770 00 |
| Total cost of reservoirs and aqueduct to points whence lines of pipes to supply Georgetown and the public buildings of Washington are common to all plans proposed | 1,630,618 00 |
| Add cost of mains and stop-cocks from the intersection of High and Bridge streets, in Georgetown, to the Capitol, Navy-yard, and other public buildings in Washington | 290,626 00 |
| Total cost | 1,921,244 00 |

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*General summary of the estimate for an aqueduct from the Little Falls of the Potomac.*

| | |
|---|---|
| 1. Preparation for the excavation and embankments | $6,530 00 |
| 2. The canal leading to the pumps | 359,898 00 |
| 3. The dam across the Potomac | 55,888 00 |
| 4. Guard-gate, revetment wall of guard-bank, and stop-gate, crossing the canal. | 166,432 00 |
| 5. Walls for passing lock No. 5 of the Chesapeake and Ohio canal | 6,707 00 |
| 6. Culverts under the canal | 60,823 00 |
| 7. Bridge over feeder at the Little Falls | 5,000 00 |
| 8. Pump-house, pumps, machinery, and stand-pipe | 109,826 00 |
| 9. Mains leading from pumps to pipe-chamber, with pipe-chamber and stop-cocks | 30,000 00 |
| 10. The conduit line | 10,462 00 |
| 11. The conduit of brick | 22,293 00 |
| 12. Reservoirs | 147,032 00 |
| 13. Pipe into Georgetown | 108,100 00 |
| Land damages, engineer services, and contingencies, 20 per cent. on the estimate | 217,798 00 |
| Total cost of aqueduct and reservoirs to points whence lines of pipes to supply Georgetown and the public buildings at Washington are common to all plans proposed | 1,306,789 00 |
| Add cost of mains and stop-cocks from the intersection of High and Bridge streets, in Georgetown, to the Capitol, Navy-yard, and other public buildings in Washington | 290,626 00 |
| Total cost | 1,597,415 00 |

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