BOARD OF ALDERMEN,

DECEMBER 28, 1831.

The Committee on Fire and Water presented the following Report, relative to introducing into the City of New-York a supply of pure and wholesome Water, accompanied with a Law asking power to raise money by Loan to execute said work, which were read, laid on the table, and directed to be printed, together (with such Documents as the Committee may deem necessary) for the use of the Members.

J. MORTON Clerk.

The Committee of the Board of Aldermen on Fire and Water, to whom have been referred various communications and resolutions on the subject of supplying the City with water,

RESPECTFULLY REPORT:

That they approach the subject as one of vast magnitude and importance to an already numerous and dense population, requiring our municipal authorities no longer to satisfy themselves with speeches, reports and surveys, but actually to raise the *means* and strike the spade into the ground, as a commencement of this all important undertaking.

Your Committee will not uselessly occupy your time in setting forth the advantages and necessity of this undertaking; they believe a great majority of the tax paying citizens are willing, and their representatives in the Common Council, ready

to concur in any plan which is feasible and within the reasonable ability of the city to execute. The duty of presenting such a plan, your Committee will endeavor to perform in as concise manner as the subject will admit, and without travelling over more than can be avoided of an already much beaten path.

The supplying cities with water for culinary purposes, for the extinguishment of fires, washing of streets and cleaning sewers, is no new undertaking. Taxes have been imposed and expenses incurred, more or less, in all cities for the obtainment of this not only comfort, but luxury, and not luxury, but necessity of life. The free citizens of Rome have left aqueducts not only in their own, but in their conquered provinces, as subjects of wonder and astonishment for even the present enlightened age; and how peculiarly appropriate is it that the American Republics should emulate Rome in her best days in works so emphatically beneficial to the whole people.

In modern times, at London, at Lisbon, at Versailles in France, and in still more modern, at Edinburgh in Scotland, and at Philadelphia in our own country, have been erected aqueducts highly creditable to the age, and contributing extremely to the health and comfort of their inhabitants. In our own city the subject has not been entirely at rest, for as early as 1799, an association of gentlemen was incorporated under the name of the Manhattan Company, for the purpose of supplying the city of New-York with pure and wholesome water; who have been more intent on making money by their banking operations, than accomplishing the avowed objects of their charter, and have left the city totally unsupplied with water which can be called pure and wholsesome; and even four-fifths of the paved parts of the city without *any supply* whatsoever; in fact, all those parts of their charter which authorise them to take and divert streams to the city or *to introduce* water, have never been used, or in any manner acted upon by this Company. The creation and existence of this monied incorporation will at least, it is hoped, be of this advantage—that it will prove, that the *comforts and necessaries* of life should never be

placed under the control of individual associations or monopolies, ever intent to comply with so much of their charters as will make for themselves good dividends, while they generally disregard all the beneficial objects which induced the Representatives of the People to create their incorporations.

In reference to this Company your Committee remark, that among the printed documents will be found an analysis of the Manhattan Water, by which it will appear that it is unfit for the use of man; that as to their carrying on their banking business, under a perpetual charter, on the ground of their rendering the city a valuable service, your Committee only wish to disabuse the Legislature as to the supposed worth of the consideration, and to leave to *their sense and judgment*, all which relates to *this part* of the subject.

In 1825 the Legislature created another Company called "*The New-York Water Works Company for the supply of pure and wholesome Water*"—which Company was to introduce their water from without the city, and their charter was to become void, unless they supplied the city before the first of January, 1832. This Company has also failed to comply with the condition of their charter, and it is now therefore void, and the field is left open, as it always should have been, free from legal embarrassments, to the public authorities of the city.

The first great desideratum is—

That the water to be supplied be pure and wholesome, not containing mineral or other impurities.

2d. That the supply be *full and ample*, for culinary purposes, for cleansing streets and sewers and extinguishing fires. As to how great this supply should be, we are taught by the experience of Philadelphia, were two millions of gallons are used per day. Their works can daily raise four and a half millions. The aqueduct at Edinburgh discharges 180 cubic feet per minute, which is equal to near two millions of gallons per day, for a population of 150,000.

3d. The supply to be made effectual in extinguishing fires, must be raised by a natural head or mechanical power, at least to the level of the tops of the highest houses.

Several plans have been proposed to produce the above desirable results; and although your Committee do not intend to express any definite or conclusive opinion, with a view to bind the Corporation as to the adoption of either, yet they feel bound to consider them all, and to show that at least one is within the reasonable ability of the Common Council to execute.

The first plan which they will consider, is the one for procuring water from springs on this island.

Your Committee will not say that numerous excavations would not produce a sufficient supply, but they do apprehend, that four millions of gallons (the supply the works should be capable of furnishing,) of pure water to be procured on the island by excavations, would be more expensive than the introduction of it from abroad. The well in 13th street gives, at its greatest yield, 20,000 gallons per day, and this experiment is considered very successful; yet it would require two hundred such wells with steam power at each, to supply four millions of gallons, and this supply likely to be effected by heat and drought, at periods when the greatest quantity is required. But a still greater objection arises from the fact that our island will be compactly built over, thereby diminishing the quantity, and destroying the purity of the water to be obtained from this source. This fact is founded not only in reason, but is taught by our experience; for many of the wells which formerly gave good water, have now become, by the extension of the city, noxious and unfit for use. We also add, that the New-York Water Works Company, subsequent to 1824, made repeated, and it is believed unsuccessful experiments, to procure water on the island.

All the other plans proposed, look to the springs and rivers of Westchester county for the supply.

The advocates for bringing the water from the Croton, base their argument mainly on the abundance of the supply to be obtained from that river. This important advantage must be yielded to the advocates of this plan, over that of all the others; and were it not for the distance which the Croton River lies from the city, it certainly would be the most desirable source whence to procure the supply.

Some of the advocates for Croton River propose that the water be carried along the Hudson, while others show perhaps a more feasible plan, by connecting it with the Sawmill Creek; but each of these plans growing out of the distance and the mountainous country through which you would have to pass, would be found more expensive than the procuring of the water from the source yet remaining to be considered, and in relation to which your Committee are united in opinion as to its being the least expensive and embarrassed with the fewest difficulties.

The river Bronx has its main origin in Rye Pond, a beautiful sheet of water with an area of two hundred and twenty acres, situate in Westchester, about thirty-four miles distant from the city, and discharges into Long Island Sound, through West Farms Creek.

Canvass White, Esq. in a report made to the Common Council in 1824, estimated the natural supply of the Bronx at three millions of gallons per day, in a dry season, and by a still more accurate measurement and survey made in 1826, for the New-York Water Works Company, he made the daily *minimum* quantity to be 4,302,720 gallons. Nature seems to have constructed Rye Pand, with its high hill embankments, for a beautiful reservoir to be made capable of containing even an additional supply of 7,000,000 of gallons by a short dam, at its outlet, raising the water ten feet higher, and there is on the spot an abundance of the best materials for the construction of the dam.

The Wampus Pond and the Byram Pond lie about north from the Rye Pond, and distant four or five miles; their natural discharge is into the Sound, through the Byram River, which, in part, passes through Connecticut. The water from these two last mentioned ponds furnish an additional daily supply of two millions, and might at a very small expense (as the Byram approaches Rye Pond within a mile and a half,) be conveyed into the Rye Pond, and made to mingle with the waters of the Bronx.

One mill and factory only are supported by the water of

the Byram, which rights would have to be extinguished, and perhaps some other privileges, before diverting the water of this river from its natural course. Several mill and factory privileges would have to be extinguished on the Bronx River.

On the plan here proposed, you can certainly procure the waters of Rye Pond, the Wampus and the Byram Ponds, with the waters as they increase from lateral sources, in the Bronx and part of the Byram River; to which may be also added the Saw-mill River, if ever wanted, which of itself supplies two millions of gallons daily, which it now discharges in the North River. And it should not be forgotten that this plan does not *exclude* procuring the waters of the Croton, if at any period of time they should become necessary for our city's use. An excavation might be made, and the water of the Croton introduced at the Wampus Pond, or an excavation might be made to intersect the line of the aqueduct, after it leaves the Bronx, in its route to the Harlaem River.

But no individual after examining the subject, will, your Committee think, doubt the sufficiency of the supply of the Bronx, with the ponds at its head, independent of the Croton and Saw-mill; if they do, they must disregard the opinions of Surveyors, who have made it their business to ascertain the exact supply these sources furnish.

As to the quality of the waters of the ponds referred to, and of the Bronx and Byram Rivers, your Committee concur in opinion with the gentlemen who have examined them, that they are pure and wholesome, possessing the quality usually described as soft. One branch of the Croton, it is said, is not entirely free from mineral substance, but the water of the Croton will not for centuries, if ever, be required.

Having considered and pointed out the source, the quantity and the quality of the water to be supplied the city, it but remains for your Committee to suggest the general outlines of the several plans which to them appear practicable for the introduction of this water.

The point at which it has been supposed it would be most advantageous to take the water from the Bronx, is near Under-

hill's Bridge, not far from Tompkins' Factory, a distance from Harlaem River of about thirteen miles. The country along the contemplated route is such, that it might easily be brought to a regular declivity for the base or embankment of any work which might be projected, and the head at the intersecting point of the Bronx and aqueduct is such as to allow eighteen inches in the mile for the whole descent to the Harlaem River.

The question first in order is, how this water shall be brought from the Bronx to the Harlaem River.

Three modes have been suggested; the one an open aqueduct with walled sides, or clay embankments and bottom. The ancient aqueducts were all open masonry, and supported by arches, and of this description is the work at Lisbon, which is supported on magnificent arches, one of which is two hundred and thirty feet in height. This work was completed about a century ago.

In support of the open aqueduct, with clay bottom and embankments, your Committee are referred to the modern work, introducing water into London, (where such a description of aqueduct is made for forty miles, of sixteen feet wide and five feet deep,) from the New River to Islington, on its way to London. But it is feared such an aqueduct might receive impurities in its passage down to the Harlaem River, though it is believed it would not be so much exposed, as that near London. But it is doubted if our winter climate is sufficiently mild to render this mode of bringing water practicable; yet the fact should not be lost sight of, that the rapidity with which this water will pass through the aqueduct on a regular inclined plane, would much diminish, if not entirely overcome all effects from frost.

The close tunnel of masonry has been the plan most generally approbated, but whether it or the iron pipes will be the plan eventually adopted for this part of the line, your Committee are at present unable to decide, and do not find it necessary to express, at present, an opinion in favor of the one or the other of these plans. In the valuable report of Mr. White referred to, he estimates a masonry tunnel of five feet diameter at but

$31,174 per mile, including all expenses ; if this estimate is correct, masonry would be the cheapest. The tunnel of masonry would have the advantage of being able to supply the greatest quantity which could ever be required. The cost of this masonry tunnel would be, at this estimate, $400,000.

The plan of iron pipes has many advantages over that of all others, though to have them cast in this country (it is feared,) would be very expensive, costing nearly double what they could be purchased for in Great Britain. The cost (including the expense of laying down,) of our twelve-inch pipes was about $10,000 dollars per mile. The expense per mile of American casting, for an average twenty-two inch diameter, (which it is believed would discharge near 2,000,000 of gallons daily,) would cost $30,000 at the American price; and the laying down is estimated at $10,000 per mile, or for the whole distance to the Harlaem River at about $500,000. If two lines of pipes should be required, it would make the expense near a million of dollars to bring it to the Harlaem River.

The two lines, it is believed, would discharge 4,000,000 of gallons; for though the distance is greater, and there woul not be the same head as at the Edinburgh works, (which daily discharge 2,000,000 gallons through a diameter, say twenty inches at the entering, and fifteen inches at the discharging end,) yet our line would not have the undulations of the Edinburgh line, growing out of a very uneven hilly surface over which it passes.

If the regular line of declivity should be found more expensive than has been supposed, the embankments and cutting could be avoided, and the same quantity of water introduced by a small increase in the size of the pipes, and following an uneven surface, the undulations of which would not, however, be great.

In favor of this plan of iron pipes, your Committee remark, that the city might be supplied although one line was out of order; an advantage of vast importance in reference to the wants and necessities of our city, when once dependent on such an establishment.

Having given the outlines of the expense and the different plans for bringing the water to the Harlaem River, the next cost to be incurred would be the passage of the river. If McComb's Dam was not used, then a bridge would have to be constructed, and probably also a dam, as the head for the water would have to be procured near there; and it has always been considered that the tide-water of the Harlaem might be used to lift the water, in whole or in part, into the proposed reservoir.

The expense of this bridge and dam has been estimated at $50,000. It would have the advantage of passing travellers, and if free of expense, it is probable that other advantages would accrue to the city, more than equivalent to the receipt of the tolls from the bridge.

Having shown the plans for introducing water on the Island, it is proposed to construct Store-housing Reservoirs on Harlaem Heights, with different compartments, both for the collection of water and the settlement of impurities, and that it should pass from one to another, until it is received in a pure state into the one, which will discharge it into the pipes to be brought to the city.

These Store-housing Reservoirs, it is proposed to extend over ten or fifteen acres of the Corporation land, between Yorkville and Harlaem, selecting a spot between the Third and Eighth Avenues, with a rock bottom and clay embankments. These grounds are one hundred and twenty feet above tide-water, thereby giving an ample head. These reservoirs may be formed at but little expense. We have the experience of our sister city, Philadelphia, (where their reservoirs are so constructed) as to this part of the work.

Your Committee estimate this excavation at $25,000, and the lifting power and machinery at $25,000 more.

From the Store-housing Reservoirs, three pipes of twelve inches diameter would, with the proposed head, bring to the city near 2,000,000 gallons daily, which would supply our present wants, and a fourth or fifth might be added, as the wants of the city increased.

The distance from the reservoir at Harlaem to the distributing reservoir at Thirteenth street, does not exceed four miles, and the expenses of each line would not exceed $10,000 per mile; the cost of these three lines of pipes would amount to $120,000. One of which lines to extend to the northern section of the city, and there to be connected with a distributing reservoir similar to the one in Thirteenth street, or immediately connected with the distributing pipes. The second to be connected with the present reservoir in Thirteenth street, and the third line to be led into the eastern section of the city.

Your Committee do not enter into a minute consideration of the expense of distributing pipes throughout the city; the expense of the seven miles of pipes now down, (generally of the largest class, for such purposes) has cost, including laying down, $65,800. Six-inch pipes can be laid at an expense including pipes, of $5000 per mile.

The injury to proprietors, and the taking of land and water rights, your Committee have not the means of estimating. The pipes as well as the tunnel, if the tunnel was used, would be completely covered, so that any agricultural purposes might be carried on over them, and no fences required; and when once down, they would not injure the fields, streets or roads. The owners of land about Rye Pond consented to the Water Works Company using the water, and making a dam at the outlet of the pond without charge, and the only injury would be to four or five mill-seats on the Bronx, where the water is used, and which might probably continue to be used during all the winter and wet part of the season, and still leave water enough for all our city purposes.

Your Committee think they have shown conclusively that this work is practicable, and within the ability of the Corporation in a moderate time to pay for; for the best judgment they can form (assisted by the opinion of Mr. Canvass White and Judge Wright, our Street Commissioners) is, that the expense of the work, including the extinguishing of rights, purchase of lands, mason work, tunnel, or iron pipes, connecting pipes from the store housing to the distributing reservoirs, re-

servoirs and distributing pipes through the city, will not amount to $2,000,000.

For this expenditure our inhabitants will have water pure and wholesome, not only as a beverage and for culinary and domestic purposes, but an ample supply for cleaning the streets and sewers of our city, and for the extinguishment of fires. And it must not be forgotten that the estimated loss by fire in the year 1828, was $600,000.

Your Committee are of opinion that the expense of this undertaking, the advantages of which will be lasting and permanent in their character, should be provided for by a loan, and they view the present or coming season as one at which this money can be procured at a low rate of interest, probably not to exceed four per cent., redeemable in thirty years. It would be well secured, as due from a city whose taxable property is rated at $125,000,000, and is worth much more. To provide for the $80,000 interest, supposing the expense to amount to two millions, we should have a fair charge on our present citizens.

It is believed that we have, or within a year or two will have, 35,000 houses and buildings, all of which are obliged to build and keep up cisterns, while may of our citizens purchase water, and all are at the expense of sinking wells and erecting pumps, at an average annual charge, including all these expenses, it is believed, of exceeding eight dollars per house. Now if we estimate that we can charge each house, on an average, four dollars, we have $140,000, nearly double the whole interest. If it should be thought that four dollars is too much for some houses, it may be remarked, that several families, in limited circumstances, generally reside in one house, and that this being the case, the landlord might well afford to pay four dollars, per annum; but as this calculation of four dollars per house, is an average charge, it will be seen that some houses can be charged more than double that rate, while the rate of others can be proportionably reduced.

We should have also what might be chargeable on livery stables, breweries, dying establishments, manufactories of all

kinds, making of mortar for building, and the supplying our shipping, to create a sinking fund for the final liquidation of the loan; and we should not forget that the income referred to is from nearly our present population, which is rapidly increasing, which increase the works would supply with little increased expense. The New River establishment at London charges all dwellings at the rate of five per cent. on the rent of the same, which appears to be a good criterion to regulate the charge, and this rate would produce a revenue to the city.

Your Committee have considered the description of the Edinburgh Water Works, (which they have procured from abroad, and to which they have referred,) as containing so much valuable information that they have caused it to be printed with the documents on the subject. It will be found that that city, not so populous nor so wealthy, it is believed, have overcome far greater obstacles than we have to contend with—having in one place passed for a considerable distance with their tunnel seventy or eighty feet below the surface, and at another place excavated a shaft through solid rocks six feet high by four and a half wide, for 700 feet, at some places at a depth of 120 feet below the surface, and have constructed a reservoir with an embankment of one hundred and twenty-four feet high. This work was finished in 1824, and is considered by the people of Edinburgh, and probably correctly too, as the most complete of all the modern works of the kind. Their success should urge us forward to the commencement and completion of the proposed undertaking.

Your Committee have also caused to be printed the Reports of Mr. White, referred to, and the opinions of our present Street Commissioners, each of which contain much valuable information, and from which many of the facts in this Report have been drawn. They also add to the printed documents, (that the Common Council may have the different views of gentlemen,) a Memorial and general statement from Francis E. Phelps, Esq.

In reference to the question as to who should superintend the works, your Committee are of opinion, that as the mem-

bers of the Common Council are constantly changing, that the execution of the plan should be entrusted to a Board of Commissioners, consisting of three persons, to whom a moderate salary should be paid.

They accompany this Report with the draft of a Law to be presented to the Legislature, to authorize the undertaking of this work, the appointment of a Board of Commissioners, and the raising by loan, two millions of dollars.

They offer the following resolution :—

Resolved, That the Common Council approve of the accompanying draft of a Law to be sent to the Legislature, and that this Corporation, on the passage of this Law, will undertake to supply the city with pure and wholesome water.

All which is respectfully submitted.

JAMES PALMER,
SAMUEL STEVENS,
WILLIAM SCOTT.

AN ACT,

Authorising the Mayor, Aldermen and Commonalty of the City of New-York to procure a supply of pure and wholesome water for the use of the said city.

The People of the State of New-York represented in Senate and Assembly, do enact as follows:—

1. The Mayor, Aldermen and Commonalty of the City of New-York, are hereby authorised to procure and introduce into the said city a supply of Water for the extinguishment of Fires, and for the domestic and other purposes of the inhabitants of the said city.

2. The said Mayor, Aldermen and Commonalty are hereby authorised to appoint three discreet persons to be called Water Commissioners, who shall receive such compensation for their services as the said Mayor, Aldermen and Commonalty shall deem proper, and shall hold their offices during the pleasure of the said Corporation. It shall be their duty to recommend to the Common Council the source whence the water shall be obtained, the description of works for the introduction thereof, to make the contracts, and generally to superintend under the direction of the Common Council, the executing of the whole plan for the introducing of water in the city of New-York.

3. The said Mayor, Aldermen and Commonalty, and all persons acting under their authority, are hereby empowered to enter upon and take possession of any land, to use any water, to make any survey, and to erect any works whatsoever, which they may deem necessary for the said purpose, and to agree with the owner or owners of any property which may be required for the said purposes or affected by

any operation connected therewith, as to the amount of compensation to be paid therefor to such owner or owners, and they shall have the like powers for the purposes of this Act, which by any former Act of the Legislature of this State have been granted to any person or persons, or body corporate, for the purpose of supplying the city of New-York or the inhabitants thereof with Water.

4. In cases of disagreement between the said Mayor, Aldermen and Commonalty, and the owner or owners of any property which may be required for the said purposes, or affected by any operation connected therewith as to the amount of compensation to be paid therefor, to such owner or owners, or in case any such owner shall be an infant, a married woman, or insane, or absent from this State, the Judges of the Supreme Court, or either of them, (not being an inhabitant of the said city,) may, upon the application of either party, nominate and appoint three indifferent persons to examine such property and to estimate the value thereof, or damage sustained thereby, and to report thereon to the said Court without delay.

5. Whenever such report shall have been confirmed by the said Supreme Court, the said Mayor, Aldermen and Commonalty shall, within four months thereafter, pay to the said owner, or to such person or persons as the said Court may direct, the sum mentioned in such report, in full compensation for the property so required, or for the damage sustained thereby, as the case may be, and thereupon the said Mayor, Aldermen and Commonalty shall become seized in fee, of such property so required, and shall be discharged from all claim by reason of any such damage, and they shall shall hold the lands and other property so taken, exempt from the operation of any statute of this State, authorising any other incorporation or company to take by process or otherwise, real estate, water or water privileges, for any purpose. And the said Mayor, Aldermen and Commonalty shall have the right to the use of the ground under any street, highway and road in this State, (on condition of their restoring the surface thereof to its original state, and repairing all damages,) which may be necessary to use in the introducing of water into the city of New-York.

6. If any person or persons shall wilfully do, or cause to be done, any act whereby the present Reservoir in 13th street, the Hydrants, Stopcocks or any work, materials, property, matter, or thing whatsoever, erected or used, or hereafter to be erected or used by the said Mayor, Aldermen and Commonalty, or by any person or persons acting under their authority, for the purpose of supplying water, shall in any manner be injured, such persons or persons shall be considered guilty of a misdemeanor, and liable to be imprisoned not exceeding six months, and fined not exceeding five hundred dollars, by any Court having jurisdiction thereof within this State.

7. The said Mayor, Aldermen and Commonalty are hereby authorised for the purposes of this Act, to raise money by loan, from time to time, and in such sums as they may by ordinances in Common Council direct, not exceeding Two Millions of Dollars in the whole, and to create a Public Fund or Stock, for the money to be raised, which stock shall be denominated the " New-York Water Stock," and shall bear an interest not exceeding five per cent. per annum, payable quarter yearly or half yearly.

8. The provisions of the Act entitled " An Act to regulate the Finances of the City of New-York," passed June 8th, 1812, which are not repugnant to any provision in this Act contained, shall apply to the said stock.

9. The money to be raised by virtue of this Act shall be applied by the Mayor, Aldermen and Commonalty to the purpose of supplying the said City of New-York with Water for the use of the inhabitants thereof, and the said Mayor, Aldermen and Commonalty shall have a right to dispose of the said Water at such rates and in such manner as they shall from time to time deem expedient.

DOCUMENTS

Accompanying the Report of the Committee on Fire and Water, relative to introducing Water in the City of New-York.

No. 1.

CANVASS WHITE'S REPORT.

To the Honorable the Mayor, Aldermen and Commonalty of the City of New-York.

GENTLEMEN,

Considerable time has elapsed since I had the honor of receiving a request from the Honorable Stephen Allen, late Mayor, to make an examination and estimate of the expense of furnishing the city with a copious supply of good and wholesome water. Agreeable to that request, I have made the necessary surveys, levels and examinations, to ascertain the practicability of the project. Ill health and other engagements have prevented my making a return of the result of my labors before this time.

I have extended my examinations to several routes and plans which are designated on the map accompanying this Report, and will be noticed separately.

It will be recollected, that I received directions from the Committee of the Corporation, to arrange my plans so as to have the water delivered into the city, at an elevation of thirty

feet above the Park, and in view of this object, the levelling was commenced in front of the City Hall, and continued along Broadway and Bloomingdale Road to 14th street, thence up that street to near the 5th Avenue; at the place the ground is elevated sufficiently high to form a Reservoir, from which the waters can be distributed to all the present populated parts of the city, also to a considerable district northerly. The Reservoir is designated on the map by No. 4. From this point the level was continued along the 5th Avenue, Cross Roads and 8th Avenue to McComb's Dam.

The intervening ground between the Reservoir and Harlaem Valley presents no obstructions to our pursuing the route through the 5th and 6th Avenues. Several other routes were examined, but the land was found to be too high, particularly through the 8th Avenue. From the dam the level was continued through the valley of Mill Brook, thence across a rocky ridge to the valley of Monmissina Creek, following up the valley to the source of the creek, which heads in a swamp, divide forming another outlet eastwardly. This route was followed to Bronx River; from thence the line was continued along up the river to Williams' Bridge, which is designated on the map. The water of the river was found to be eleven feet above the Park.

The Bronx River has long been looked to as a source from which a supply of water could be drawn for the use of the city, doubts having frequently been entertained as to the capacity of this stream for that purpose, but from partial measurement and observation, it may be safely stated to give 3,000,000 gallons daily during the dry seasons.

From Williams' Bridge the level and survey was continued to Rye Ponds, which are about thirty-four miles from the city by the route surveyed, and are the head of one branch of the Bronx. These ponds form two beautiful sheets of water, supplied principally by springs, and are admirably calculated for the formation of a reservoir, being principally rocky shores, and approaching near each other at the outlet of the smallest pond, which makes it very convenient to construct a dam and unite

the ponds. When thus united, and the upper pond raised about six feet, and the outlet lowered about two feet, they will afford 3,600,000 gallons per day for six months of dry weather, making allowance for evaporation. This added to the natural supply of the Bronx, as before estimated, will give a diurnal supply of 6,600,000 gallons; a quantity amply sufficient for double the present population.

It has been ascertained by experiments made at Philadelphia, that twenty-seven gallons per day for each person, is sufficient for the demands in summer, and this includes the amount used for all purposes of manufacturing by brewers, tanners, livery stables, and for washing the gutters, &c. Calculating from the above, we have an ample supply for the present population, and for the future increase of the city for some years. But in order to ascertain what further supply could be procured, the survey was extended from Rye Pond to Byram River in Connecticut; the route is designated on the map by a red line. This river can be easily turned into Rye Pond with little expense, being separated by a swamp and a ridge of gravelly soil, through which a tunnel has been constructed for the purpose of draining the swamp, and by this means the water is conveyed into Rye Pond, and in high floods some of the waters of Byram River pass through this artificial outlet.

The surplus waters of Byram River could be advantageously used, if required, to replenish the reservoir of Rye Pond, without any injury to the hydraulic works on the stream below the point of separation, but in order to effect this, permission must be obtained from the State of Connecticut. It is presumed that no difficulty need be apprehended on this point, for the land holders would be perfectly willing to have a canal through the swamp. If it should hereafter be found necessary the whole of Byram River should be purchased, although it is small at the point of intersection, and is estimated at only 2,000,000 gallons per day during the summer months, this stream heads in ponds which will serve as reservoirs; but as it is out of our State, and its common low waters being employed for hydraulic purposes, we shall not take it into account at this time, for a supply during the summer months.

A route has been surveyed from Bronx River to Saw-Mill River, near Union Church, and found practicable to turn the waters of that river into the Bronx at a moderate expense; the deepest excavations necessary between the two streams will be about eight feet; the route passes through a swamp, and is designated on the map by a red line.

The water of Saw-Mill River is estimated at 2,000,000 gallons per day. The country through which this stream passes, is well calculated to form reservoirs for retaining the flood waters until the dry seasons. I have not had an opportunity of sufficiently investigating this subject, but think an additional supply may be obtained by this means, equal to 1,000,000 gallons per day, making the whole supply within reasonable distance, and probably at command, exclusive of Byram River, 9,600,000 gallons per day; a quantity more than sufficient for 355,000 souls. The above quantities of water may undoubtedly be enclosed by means of reservoirs to 11,000,000 gallons.

No extraordinary drought has occurred since I have been engaged with these examinations, that would enable me to gauge the streams when yielding the least quantity of water, but I think sufficient allowance has been made for dry seasons.

Considerable time has been expended in examining the country for the purpose of connecting Croton River with Saw-Mill River, but no route has yet been found to accomplish this within any reasonable expense. The examinations have been extended as far up as Cross River, which unites with the Croton about thirteen miles from Sing-Sing, perhaps a route may be found to connect the Croton with Bronx or Byram Rivers; but if this cannot be effected, the Croton can be taken out at a sufficient elevation, and conducted along the bank of Hudson River to the city. This route has not been levelled, therefore no estimate has been made of the expense, as it is presumed that a sufficient supply can be had from the Bronx, much nearer, and of course at much less expense.

Having now established beyond a doubt, that a sufficient quantity of water for the present demands, and for a very con-

siderable increase of the city, is within reasonable distance and control, we shall next consider the several modes of conveying it to the several reservoirs.

PLAN FIRST.

The water can be taken from Bronx River, either at Williams' Bridge, or by constructing a dam across the river about one mile below, and turning the water up the outlet of a swamp, and from thence by cutting a canal through the swamp to the valley of Morrissinia Creek. The canal can be easily conducted along the valley to a ridge of rock, which must be passed by a deep cut of forty-five feet, or by a tunnel—the latter would be preferable. The distance through the hill at the point to be perforated, is about twenty-three chains. Some embankment will be necessary to extend the canal across the valley of Mill Brook to the west bank. It must then be conducted along steep sidelying ground, considerable part of which is rocky at McComb's dams. The water is there to be deposited in a small reservoir.

The canal from the swamp to McComb's dam, should be well lined or puddled, in order to prevent leakage, and the banks faced with stone walls, well laid without cement, the object of which is to contract the surface of the water, which will render the volume passing up liable to be obstructed by ice. The diminished surface should be added to the depth. The walls will also serve as a protection to the lining, and would be better if laid in cement, but it would increase the expense.

The route is designated on the map by a red line, with a profile of the ground corresponding to each mile, and is calculated to have a declivity of one foot per mile. The latter part of the route as before stated, passes along the side of a steep rocky hill, which will make it rather difficult to construct a canal, but presenting no obstacles which cannot be overcome. The distance from Williams' Bridge, is about five and a half miles, and by deducting the proposed declivity, will leave the

water at the termination of the canal, near McComb's dam, five and a half feet above the Park, and must be raised to the necessary elevation of fifty feet above the Park, which will make forty-four and a half feet to be raised by machinery to reservoir No. 1. Two methods only can be adopted to effect this object—one by steam power and the other by water power—the latter is considered preferable. Mr. R. McComb has constructed a dam and road bridge across Harlaem River, by which means the flood tides are kept at their common elevation between the dam and King's-Bridge, which forms an artificial pond about four miles in length, and at ebb tide can be used for pumping the water from the lower reservoir to the upper one, by means of water-wheels and forcing pumps.

The water of the pond is now only used for mills at the outlet near King's-Bridge. The quantity of water used by those mills does not appear to depress the pond very sensibly, and it is therefore presumed that sufficient water power can be obtained to answer the purpose. Objections have been made to tide power at this place, on account of the irregularity of the tides, occasioned by the wind when in a particular direction; but this, however, does not often occur, nor continue long at a time. The inconvenience arising from this can be in a measure remedied by extending a dam or mole of earth, faced with stone, from near the north end of McComb's dam, to the east shore of a bay which puts up some distance northerly into the main land; thus forming a pond containing a number of acres. The embankment should be provided with tide————and gates opening outwards, by which means the tide will be excluded, and the water from the main pond, after being applied to the wheels and pumps, can be kept at work during all times of tide, and the receiving pond will be discharged at every ebb tide.

Perhaps some difficulty will occur in forming the mole, owing to the depth of the mud which generally accumulates in marshes, and which will probably allow the embankment to settle below its surface. If this should be the case, an increased quantity of stuff will be required, which makes it difficult to

estimate the cost, as the depth of mud has not been ascertained, but the depth of water only has been taken. The moles, with tide gates, stone work, &c. is estimated at twenty thousand dollars.

The canal from Bronx River to the reservoir should be fenced. Stone would be the best, and through that country probably the cheapest. The banks should be planted with trees or shrubbery, which will have the effect of cooling the water in summer, and diminishing the evaporation. The expense of the canal is estimated at seventy-six thousand five hundred dollars, including the tunnel through the rocky ridge, stone walls, bridges, lining, &c.

A new dam and bridge must be constructed across Harlaem River, of substantial stone work laid in cement, with arches to allow the flood tides to pass into the ponds, and provided with tide gates; also arches for the purpose of drawing water from the pond for the use of the water-wheels attached to the pumps. It is necessary that the whole of the work should be done in such a manner as to require but little or no repairs. Cast iron water-wheels would perhaps be well calculated for this purpose; they have been adopted at several manufacturing establishments in this country, but as I am not sufficiently acquainted with the effects of salt water upon cast iron, I have therefore estimated the expense for wooden wheels. The expense of the bridge, dam, tide————mill-house and vice, depend in a great measure on the plan and style of the workmanship; but to complete them in the best and most substantial manner the expense is estimated at one hundred and fifty-five thousand dollars, including mains from the pumps to the upper reservoir.

It has not been thought necessary to give a minute description of the machinery necessary for raising the waters, as the extracts which will be given to the report of the Watering Committee of the city of Philadelphia, are deemed sufficient to convey all the ideas necessary on this part of the subject, and also all the information necessary connected with the cast iron pipes, &c.

The expense of reservoir No. 1, which is located on the

high land north of McComb's dam, and opposite to the small reservoir at the termination of the canal, is estimated at eight thousand dollars, though perhaps this estimate is rather liberal. The reservoir was calculated to contain about 4,000,000 gallons, and intended to be lined with stone laid in cement; this may not be found necessary, and perhaps the size of the reservoir will be found larger than necessary at that place.

From Reservoir No. 1, the water must be conveyed to Reservoir No 4, in cast iron pipes; and from all the examinations made on the Island, I am convinced that it is the only mode which can be relied upon, as combining utility and safety, and that pipes of thirty inches diameter, will be best adapted to this part of the works. The distance being so far that is necessary to make considerable allowance for friction. It has been before mentioned that a bridge should be constructed across Harlaem River, or McComb's dam rebuilt, which will afford a safe mode of passing the river with the pipes, by enclosing them in the roadway. From the bridge, the tubes can be laid along the 7th Avenue to near the high land, thence through one of the cross streets leading to 6th Avenue, thence ascending the hill to a sufficient elevation to form a reservoir, which is called No. 2. This Reservoir is not designated on the map, owing to the exact location not being on the ground: the distance will be about three miles from Reservoir No. 1, the pipes can be continued along 6th, or between 6th and 5th Avenues to sixty-ninth street, from thence along 5th Avenue to some convenient point, for another reservoir, No. 3, from which they can be continued along 5th Avenue, to Reservoir No. 4.

The reservoirs will be useful on several accounts, the surface of them can be raised to nearly the height of No. 1, which will allow the water to raise above the height fixed upon, when it is not drawn off by the conduit pipes leading from No. 4. The increase of height will be useful in case of fire, which is most to be apprehended in cold weather, and this is the time when the least quantity of water will be drawn off for other purposes. They will assist in relieving the friction of

the pipes, and they will also serve as receptacles for all foreign matter which may be floating in the water. The extra height of the reservoir has been taken into account in making the estimated expense. The form and size may be altered to conform to circumstances, and the expense increased or diminished. The three have been estimated at thirty thousand dollars. Reservoir No. 1 has an elevation of twenty-feet above the height required at the Park, for the purpose of overcoming the friction of the water in the pipes as much as possible, and to give a current which will ensure an abundant supply. The distance from Reservoir No. 1 to No. 4, is about 5¾ miles, and the expense for laying 30 inch pipes, with stop cocks, air valves, &c. is estimated at seventy-five thousand dollars, per mile, making for this distance, four hundred and thirty-one thousand two hundred and fifty dollars. From Reservoir No. 4, the waters may be conducted to the Manhattan Reservoir, in 22 inch pipes. The distance is about 3½ miles, and the expense is estimated at forty-one thousand six hundred and seven dollars per mile, which amounts to one hundred and forty-five thousand six hundred and seventy-four dollars and fifty cents. Two twenty-one inch mains will undoubtedly be necessary to convey the water from Reservoir No. 4, if it should be distributed among all the houses in the city, one branch leading down Broadway and the other down the Bowery.

RECAPITULATION OF EXPENSES.

From Bronx River to small Reservoir, . .	$76,500 00
Reservoir No. 1, ...	8,000 00
Mole, Tide Gates, &c.	20,000 00
Rebuilding Dam and for Mills, Pumps, &c.	155,000 00
Iron Pipes from Reservoir No. 1 to 4, . .	431,250 00
Three Reservoirs, ...	30,000 00
From Reservoir No. 4 to Manhattan Reservoir,	145,624 50
	$866,374 50
Add for contingencies, 10 per cent., . .	86,637 45
Total amount on Plan First, . . .	$953,011 95

PLAN SECOND.

The first part of this plan is the same as before described, until it passes the swamp at the head of Morrissinia Creek. The water can then follow the channel of the creek to near the rocky ridge, where it should be taken from its bed in a canal, and conducted to the ridge, which must be passed as before described, but the length of the tunnel will be a little increased, owing to the level falling nearer the base of the hill. From the tunnel the water will follow the bed of Mill Brook to an old dam near Devoe's house. The dam must be rebuilt and raised considerably higher than it was originally. From the dam the water must be conducted in a canal about fifty-five chains in length to McComb's Dam, and deposited in a small reservoir. This line from near Devoe's house, is designated on the map by a yellow line. On this plan, the water must be raised seventy feet to Reservoir No. 1, which being twenty-five and a half feet higher than on the first plan, will require a very considerable increase of power. The expense of this line from Bronx River to the reservoir at the termination of the canal, including clearing and enlarging the beds of the streams, bridges, &c. is estimated at forty-five thousand two hundred dollars, which makes the cost of this plan thirty-one thousand three hundred dollars less than plan first. But when we take into consideration, the additional height which the water must be raised, I think the first plan has the preference.

PLAN THIRD.

From the commencement of my operations, I have considered it of the utmost importance, that the city should be supplied with water without the aid of machinery, thereby avoiding all the perplexities and difficulties attending works of this kind. Water power is not as objectional as steam, on account of the great expense of the latter, but both should be

avoided if possible, in a work of so much importance to the inhabitants of the city; for if the supply should fail on account of unavoidable or unforeseen accidents to the machinery, the consequences might be extremely calamitous, situated as they are on an island surrounded by salt water, and as the wells now in use would undoubtedly be discontinued after the introduction of good water. It appeared to be the general sentiment of the Committee, that machinery should be dispensed with if practicable. Considerable time was therefore taken up in exploring the country for this purpose, commencing at Reservoir No. 1, following along the hills which descend toward Mill Brook and Morrissinia Creek, thence along the valley of Bronx River to Westchester Cotton Factory. The route is designated on the map by a blue line, with a profile of the ground. If this route should be adopted, it will vary a little from the exact course as laid down on the map, on account of an alteration contemplated in the level, for the purpose of giving a greater elevation to Reservoir No. 1, than was calculated when the line was surveyed, the object of which as before mentioned is to overcome as much as possible the friction of the water in the conduit pipes therein between Reservoir No. 1 and No. 4. but as the general character of the ground on the higher level corresponds with the line surveyed, no great difference will arise as to the expense, and in some places the line will be considerably improved. The distance is about twelve miles, and is calculated to have a declivity of one foot per mile.

The principal part of this route passes along sidelying ground, at different points rocky and broken and crossing some ravines, which will require considerable embankments; several culverts will be necessary to pass the streams and floods under the canal, but notwithstanding the roughness of the country no obstacle is presented which cannot be overcome.

It is proposed to take the water from the Westchester Cotton Factory Pond, the surface of which is 56 feet above the Park, but can be raised six feet higher by constructing a new dam above the present one; this will give an elevation of 62

feet, which will provide for the declivity of twelve feet. The distance which this line passes over an uneven rocky country, and a considerable part of it a dry gravelly and ——— earth, which renders something more necessary to prevent leaking and evaporation than a common canal, though constructed with the utmost care. It is therefore proposed to construct a brick tunnel the whole length, about five feet in diameter, the brick to be moulded to the proper form and dimensions, to be hard burnt and exposed to the operation of wet and frost during one winter previous to laying, as by this means the quality of the brick would be proved, and none admitted into the work except those that were perfectly sound. They should be well laid in hydraulic cement, and the outside plastered with the cement.

A canal or trench must be formed in the first place of sufficient capacity to receive the tunnel, including a foundation of stone properly laid to receive the brick work, and the whole should be placed sufficiently deep to prevent the action of frost.

The expense of this plan to deliver the water into reservoir No. 1, is estimated at $1,073,687 00. The amount appears large, but it is for a permanent work that is to endure for ages, without a constant tax for repairs.

RECAPITULATION OF EXPENSES.

From Cotton Factory Pond to Reservoir No. 1.	$1,073,687 00
Bridge across Harlaem River, . . .	83,750 00
Four Reservoirs, ...	38,000 00
From Reservoir No. 1 to No. 4, . .	431,250 00
From Reservoir No. 4 to Manhattan Reservoir,	145,624 50
	$1,772,311 50
Add 10 per cent. for contingencies, . .	177,231 15
Total, ...	$1,949,542 65

PLAN FOURTH.

The expense has been estimated for an open canal the same as on plan No. 1 for the route before described from Reservoir No. 1 to Westchester Cotton Factory, and by adding thirty-four thousand five hundred and twenty-four dollars to the first place, which will make $987,535 95, for this sum the water can be delivered into the Manhattan Reservoir without machinery. There may be a number of objections made to an open canal twelve miles in length, passing through so rough a country, but the estimates have been made to have the work constructed in the best manner that circumstances will permit. Some danger has been apprehended from the formation of ice on the surface of the canal, in such quantities as to check the current, thereby diminishing the supply; but by making it narrow and deep, this difficulty will probably be obviated. This plan is much the cheapest, but whether it is the best must be hereafter determined. Plan No. 2 can be accomplished for the least money, but is subject to too many contingencies. Another route was surveyed from Reservoir No. 1 to Saw-Mill River, and is designated on the map by a green line. This route was surveyed in anticipation of an additional supply to Saw-Mill River from Croton River, but on further examination towards the Croton this route was abandoned, on account of the scanty supply of water during the dry seasons, and the difficulty of increasing the quantity from other streams, and as the Saw-Mill can be diverted to the Bronx with but little expense, as before mentioned.

In all great public works something is necessary to be done, in order to collect facts and information from which a regular plan and system can be formed; I therefore consider the result of my labor as merely an outline for further investigation.

From all I can learn, we have no experience in the United States of supplying a city with water, that will apply to New-York.

The city of Philadelphia is the only one that has done any

thing of importance by which any weight can be obtained, and I must acknowledge myself under obligations to the gentlemen having charge of those works for much valuable information relating thereto, and shall take the liberty of making some extracts from the Reports of the Watering Committee.

"On the 19th of April, 1819, the work was commenced by Captain Ariel Cooly, with whom a contract was made for the erection of the dam, the locks and canal, the head arches to the race, and the excavation of the race from a solid rock, for the sum of 150,000 dollars."

"The whole length of the overfall of the dam is twelve hundred feet; the————dam two hundred and seventy feet; the head arches, which will presently be mentioned, one hundred and four feet, making the whole extent of the dam, including the water pier, about sixteen hundred feet, and backing the water up the river about six miles. The water power thus created is calculated to be equal to raise into the reservoir by eight wheels and pumps, upwards of ten millions of gallons; the lowest estimate of the quantity of water afforded by the river in the dry season is four hundred and forty millions per twenty-four hours, and as it is calculated, allowing for leakage, waste, &c. that forty gallons upon the wheels will raise one into the reservoir, the quantity raised would be eleven millions of gallons per day."

"On the east side of the river the whole of the bank was a solid rock, which it was necessary to excavate to the width of one hundred and forty feet to form a race as a site for the mill houses running parallel with the river. The length of the mill race is four hundred and nineteen feet, the greatest depth of excavation sixty feet, and the least sixteen feet. The gunpowder used alone cost the contractors upwards of $12,000. At the upper part of this excavation were erected the head arches three in number, which extend from the east end of the mound dam to the rock of the bank, thus forming a continuation of the dam."

"On the west of the excavation are erected the mill houses forming the west side of the race, which is supported on the

other side by the rock rising above it seventy or eighty feet perpendicular. The south end of the race is also of solid rock, and the mill houses are founded on rock, so that nothing can be contrived more secure in all respects."

"The race is about ninety feet in width and is furnished with water through the head arches, which allow a passage of water sixty-eight feet in breadth and six feet in depth, to which the race is excavated below the overfall of the dam, and of course room is allowed for a continual passage of four hundred and eighty square feet of water; these arches are on the north of the race and the mill buildings being on the west, the water passes from the race to the wheels which discharges the water into———The mill buildings are of stone, two hundred and thirty-eight feet long and fifty-six feet wide; the lower section is divided into twelve apartments, four of which are intended for eight double forcing pumps; the other apartments are for the forebags leading to the water wheels. The pump and forebag chambers are arched with brick, and are perfectly secure from the inclemency of the weather. Those now in use are kept warm by means of two large iron stoves heated to great advantage and economy with Schuylkill and Leheigh coal."

"It has been from the commencement determined for the present to erect only three wheels and pumps, which are now completed, and with them the most important parts of the duty of the Committee. The first of the wheels is fifteen feet in diameter and fifteen feet long, working under one foot head and seven feet fall. This was put in operation on the 1st of July, 1822, and it raises 1¼ million of gallons of water to the reservoir in twenty-four hours, with a stroke of the pump of four and a half feet, a diameter of sixteen inches, and the wheel making eleven and a half revolutions in a minute. The second wheel was put in operation on the 14th of September, and is the same length of the first, and is sixteen feet in diameter; it works under one foot head and seven and a half feet fall, making thirteen revolutions in a minute, with a four and a half feet stroke of the pump, and raises 1½ million of gallons

in twenty-four hours. The third wheel went into operation on the 24th December, 1822, and is of the same size as the second, and works under the same head and fall, making thirteen revolutions in a minute with a five feet stroke of the pump, and raises 1½ million gallons of water in twenty-four hours. It is not doubted that the second wheel can be made to raise an equal quantity, thus making the whole supply upwards of four millions of gallons in twenty-four hours."

"The wheels are formed of wood and put together with great strength, the shafts are of iron, weighing about five tons each. The great size and weight of the wheel give it a momentum which adds greatly to the regularity of its motion, so necessary to preserve the pumps from injury under so heavy a head as they are required to work, which is a weight of 7,900 lbs., the height ninety-two feet."

"The pumps are placed horizontally, according to a design of Mr. F. Graff, and are worked by a crank on the water-wheel, attached to a pitman connected with the———at the end of the slides; they are fed under a natural head of water, from the forebags of the water-wheel, and are calculated for a six feet stroke; but hitherto it has been found more practicable to work with not more than five feet. They are double forcing pumps and are connected, each of them to an iron main of sixteen inches diameter, which is carried along the bottom of the race to the rock at the foot of Fair Mount, and thence up the bank into the new reservoir. At the end of the pipe there is a stop cock, which is closed when needful for any purpose. The shortest of these mains is two hundred and eighty-four feet long; the other two are somewhat longer. The reservoir next the bank is one hundred and thirty-nine feet by three hundred and sixty feet, is twelve feet deep, and contains three millions of gallons; it is connected at the bottom with the old reservoirs by two pipes of twenty inches diameter with stop cocks. This reservoir contains four millions of gallons. All the waters being raised into the reservoirs one hundred and two feet above low tide, fifty-six feet above the highest ground in the city, is thence conveyed to the city,

in a mode which will be pointed out when the Committee speak of the iron pipes.

"On the 24th October, 1822, the steam engines were stopped, and it is believed will never again be wanted.

Expense of the present works, exclusive of iron mains of conduit purchases, of White & Gillingham,	$150,000
Erection of the dam locks, head arches, races and piers, including estimate of damage for overflowing by the dam,	181,000
Three pumps,	11,000
Mill houses, mills, and other work connected with them,	71,250
Iron raising mains,	4,480
New reservoir,	8,600
Amounting together to	$426,330

"A comparative view of the advantage of water power over steam power, will close this part of the Report."

"By an estimate made by Mr. Graff, and exhibited to councils with the report of the Committee on water power, on the 5th February, 1818, it appeared that the cost of working one steam engine and pump for one year was $30,858, and it has been found with this expenditure not more than 1,600,000 gallons could be raised in twenty-four hours. If therefore it were required at the same rate of expense to raise an equal quantity with that at present afforded by these wheels, the cost would be upwards of $70,000; but estimating the cost at only double that of one engine, it will amount to $61,716; from this is to be deducted the interest on the capital expended in erecting the water power and works, which was $426,330, and was principally borrowed at an interest of five per cent. and amounts to $21,316 annually, amounting together to $22,816, which being deducted from the sum of sixty-one thousand seven hundred and sixteen dollars, leaves a clear annual saving of thirty-eight thousand nine hundred dollars,

equal at an interest at five per cent. to a capital seven hundred seventy-eight thousand dollars. As before stated, it is not doubted that the water power is sufficient to work five wheels and pumps, in addition to the three in operation, which would raise an additional quantity more than six million of gallons, and estimating the saving on this quantity, and the same ratio as before stated, the amount will be $103,000, more than equal to a capital of upwards of two millions of dollars, and showing the whole saving or profit to be $142,000, a sum nearly double the amount of the city taxes, exclusive of interest on the city debt, which will soon melt away by the operation of the sinking fund, the uses and importance it is impossible sufficiently to value; the additional cleanliness of the city; the great advantages in cases of fire; the ornament of fountains in the public squares, so wisely provided by our great founder; the benefit to manufacturers, and the establishment of water power in the city for various purposes, may be named among the advantages of this new work, but above all, we are to place its effects in the health of a great and growing community, which of itself may justify a much greater expenditure. Necessarily connected with this subject, is a distribution of the water after it has been raised to the reservoirs. The former inadequate supply of water derived from the wooden pipes of the conduits from the Fair Mount, and the constant vexation and expense occasioned by the bursting of those in the streets, has long turned the attention of the Committee to the propriety of substituting iron pipes, but the experiments which had been made were not encouraging, and therefore it became desirable to get information from abroad. Several attempts were made without success, until the summer of 1818, when through a respectable house in London, Mr. I. Walker, an engineer of much eminence, made a report which was submitted to councils, with a report from the Committee on the 11th of November, 1818, and both were ordered to be printed.

At the same time some of the iron pipes were procured, and the information derived was so satisfactory, that it determined councils to commence the work of laying down a large

iron main from Fair Mount to the junction of Chesnut and Broad streets, an appropriation was made of $70,000 for this purpose at that time, and other appropriations equally liberal have since been added for iron pipes. I shall now make some extracts from the report of Mr. Walker, and then continue the extracts from the reports of the Watering Committee.

" In regard to the thickness of the pipes I may state generally, that three-fourths of an inch is quite sufficient for a pipe of twenty-two inches diameter; and as the tendency to burst decreases as the diameters of pipes of smaller sizes can hardly be cast too thin if they are sound, three-eights of an inch being upon the above principle, sufficient for a ten-inch, and three-sixteenths for a five-inch pipe, which is less than they can be cast with ordinary metal. Ample allowance is at the same time to be made for defects and inequalities in casting, but almost all accidents that have happened have been through faults in the pipes and not from their thinness. The pressure upon the square inch of a pipe with a head of one hundred and forty feet, is about sixty-two pounds, which is much less than one-tenth of a pressure which a good casting of one foot diameter, and a half an inch thick is capable of resisting; the tenacity of a square inch of the best cast iron having been found by experiment to exceed 20,000 pounds. The best preventive to accidents is to prove the pipes, particularly the large mains, before they are put down, which is easily done by means of a hydraulic press: the first cost of which is from thirty to forty pounds."

" The following is, I believe, a correct list of the average weights of pipes nine feet in length, of different diameters."

DIAM.	WEIGHT.			DIAM.	WEIGHT.		
Inches.	*Cwt.*	*qrs.*	*lbs.*	*Inches.*	*Cwt.*	*qrs.*	*lbs.*
2	0	3	6	10	6	0	24
3	1	0	20	11	6	3	27
4	1	2	12	12	7	3	26
5	2	0	19	16	10	2	0
6	3	0	0	18	12	3	27
7	3	2	16	20	15	0	0
8	4	0	7	22	17	1	12
9	4	2	27	30	25	3	26

" The pipes which are found to be the most convenient and best, are the spigot and faucet pipes. The joints are more easily made as well as more easily renewed or repaired in case of leakage. The depth and width of the faucet end for the different diameters of pipes, will be seen by the drawing. The spigot end is laid so as to go so far in, or give as much interlap as the faucet will admit, and blocked up so as to give nearly an equal width of joint all round, excepting where a small turn is intended, which is effected by an inequality of the joint, and which may be done safely, if at the most confined part sufficient width is left for the lead to meet around the pipe in a state of fusion, and to calk the joints."

" Previous to the use of spigot and faucet pipes, the injury by frost was often serious, by the unaccommodating nature of the flange joints. I have heard that of a principal main of one of the water works line breaking at the flange, and leaving an opening of upwards of an inch where flange-pipes have been continued in use. This evil has been remedied by introducing occasionally a spigot and faucet joints; but now that the flange joints may be said to be exploded, an accident from contraction is almost impossible, and the motion at each joint is so small that no leakage is likely to arise from it, particularly if the

joint is of lead, as the variation even between summer heat (80°) and freezing (32°) in a piece of iron nine feet long, does not exceed one-fortieth of an inch."

"The stop cocks are used for the purpose of shifting off the water from any part of the mains, for the purpose of repairs in case of accident, or when any part of the line requires to be extended. When the work is completed, all the mains will be united, thereby keeping up a constant circulation throughout the whole city, and by means of the stop cocks, any district may be closed without any inconvenience to others. Some improvement has been made on the construction of them in Philadelphia. Air valves are used for the purpose of preventing the accumulation of air in the elevated parts of the pipes, when they are laid undulating. The construction of them are simple. A valve opening downwards is furnished with a piece of cork, which by its specific levity, is raised or floated by the water, and kept close shut when the pipe is full; but when any air accumulates, it displaces the water and allows the valve to open and discharge the air, which would otherwise stop the passage of the water in such places as were elevated above a horizontal line.'

By the foregoing observations of Mr. Walker, it appears plainly that the difficulty experienced in London arising from the contraction of the pipes by frost, or low temperature of the water in winter, is now entirely remedied by the improved method of forming the joints. The same difficulty occurred in this country; which induced the Watering Committee of Philadelphia to send abroad for information, and the utility of the improvement has been demonstrated by the operation of several winters on the water works in that city. It may therefore be considered fortunate for the citizens of New-York, that sufficient experience has been acquired on this subject, to enable them to prosecute the plan now in contemplation, without the constant perplexities which have heretofore attended works of a similar kind.

"The straight pipes are made in lengths of nine feet each, with what are called spigot and faucet joints: other pipes of a

circular form to pass around corners, are made of different lengths as may be required, with easy turns by which it is obvious the passage of the water is much facilitated. A drawing of the different kinds of pipes is annexed."

"The laying of the pipes is very easy, care being taken to keep them firm in their bed. The hub or large end of one laps about four to six inches over the small end of the other, leaving a space of from one-fourth to one half an inch all around, which is first calked in with a ring of plaited hemp, to prevent the lead from running into the pipes. Then a pair of nippers with a joint in the lower part to fit all round the pipes, and having an opening on the top for the lead, and another for the escape of the air, which will be shown on the annexed drawing, is affixed next to the opening on the outer part of the pipe, so as to prevent the lead coming out in front, which is further secured by a ring of clay outside of the nippers, and formed into a cap at top into which melted lead is poured, forming a ring of lead three or four inches in depth. When the lead is cold the clay and nippers are removed, and it is then upset by a hammer and chissel, which completes the joints."

But when required by families, manufactories or for other purposes, to be more convenient they are compelled to pay such prices as shall be fixed by the Watering Committee and to be at all the expense of taking it from the mains.

Dwellings, Manufactories and Institutions supplied with the Schuylkill Waters, for the year 1823.

192	Horses,	$1 00	$192 00
65	Houses in Courts,	2 00	130 00
6	Do. do.	2 15	15 05
16	Do. do.	2 50	40 00
401	Baths in the city,	3 00	1203 00
19	Do. do. county,	4 50	85 50
3758	Dwellings, Schools, Churches, &c.	5 00	18790 00
5	Dwellings,	6 00	30 00
3	Bakehouses,	7 00	21 00
103	Dwellings in the county,	7 50	772 50
24	Hatters, &c.	8 00	192 00
5	Hydrants, Pumps, Vinegar Yard, &c.	9 00	45 00
81	Inns, Stables, Banks, &c.	10 00	810 00
8	Soap Factories, Dyers, &c.	12 00	96 00
12	Dyers, &c.	13 00	156 00
54	Distilleries, Soap Boilers, &c.	15 00	810 00
32	Sugar Houses, Distillers, &c.	20 00	640 00
1	Hatter,	17 00	17 00
1	Hydrant in Shield's Court,	22 00	22 00
1	Do. Braner's do.	20 00	20 00
2	Livery Stables, do.	24 00	48 00
16	Sugar Houses, Hatters, Inns, &c.	25 00	400 00
11	Soap Factories, Dyers, and Prisons,	30 00	334 00
2	Breweries,	34 00	64 00
6	Tan Yards, Stables & Manufactories,	35 00	210 00
7	Breweries, Stables, Dyers, &c.	40 00	280 00
6	Breweries, Hospital, Dyers, &c.	50 00	300 00
2	Breweries,	59 00	118 00
1	Do. do. do.	70 00	70 00
1	Do. do. do.	100 00	100 00
1	Bath House,	80 00	80 00
1	Alms House,	100 00	100 00
			$26191 05

The whole expense of the water works has been defrayed by the City proper, containing a population of about sixty-thousand. And to which the above statement principally applies. The districts containing a population about equal to the city, are now making arrangements to take the water, and as they have borne no part of the expense, they will undoubtedly be required to pay a considerable tax, which will very much improve the income from the water rents.

The city has probably expended more than a million dollars in experiments and expedients previous to the adoption of the present plan. The expenses up to the present time, may be safely stated at one and a half million dollars. The recent funds have been obtained on loans at five per cent. and the interest paid by a general tax on the property included with the tax for other incidental expenses of the city.

The city of New-York, with double the population of Philadelphia, may be equally as well supplied with good water, for about the same sum that has been expended by that city, including the distribution of the water in iron pipes; but this estimate does not include the purchase of the Manhattan works, nor the damages for water rights, mills, lands, &c. for which expense, I have no————for calculating, but presume it will not be very serious, when compared with the vast importance of the object.

I have noticed by a circular from the Superintendent of the Manhattan Water Works, in answer to a number of queries, that considerable difficulty exists in this present plan of operations to enforce strict regulations, particularly as to the waste of water. I shall add this document, for some statements are made, giving information which I think will be useful to be connected with this report. It will be seen by the remarks of the Superintendent, the difficulty and imposition to which a private company is liable. But these difficulties can be obviated by the City Corporation; and with judicious management, the water works can be made a productive source of revenue. All which is respectfully submitted.

CANVASS WHITE,

New-York, January 28th, 1824

No. 2

BENJAMIN WRIGHT'S REPORT.

To the Honorable the Mayor, Aldermen and Commonalty of the City of New-York.

GENTLEMEN,

In obedience to a request from your honorable body communicated to me by Stephen Allen, Esq. late Mayor, in November last, desiring me to assist Canvass White, Esq. with my advice and counsel, as to the best method of supplying the city of New-York with plenty of good water. I beg leave to make the following

REPORT.

That I have examined and duly considered the subject, and endeavoured to bring all the experience and practical knowledge I have been able to collect, which can in any way be brought in aid of the project. I find, however, very little has been done in the United States, worthy of great praise, except in Philadelphia, and there the localities are so entirely different, that what experience can be gained from their operations, applies chiefly to the manner of distributing the water when once brought into the city.

In a project so important and desirable as giving to the city a copious and abundant supply of good water, we should not only look to the present age, but to the extent which the imagination can reasonably give to the future population of this great commercial emporium ; and also, to such additional supply of water as shall be found necessary, should the present sources be found hereafter insufficient.

Keeping these preliminaries in mind, and learning from Mr. White that his instructions were, SO TO FORM HIS PLAN OF CONDUITING THE WATER TO THE CITY, THAT IT COULD BE RAISED TO AN ELEVATION OF THIRTY FEET ABOVE THE PARK, WITH A VIEW TO THE USE FOR EXTINGUISHING FIRES, I set out with Mr. White, the first week in this month, and made an excursion into the county of Westchester, to examine the Bronx River, Rye Ponds, Byram River, and Saw-Mill River.

The Bronx River has for a long time, been looked to as the source in the first instance, for water; and after looking at that stream, and also at Rye Pond, we passed on to Byram River and Saw-Mill River, both which streams had been previously ascertained by Mr. White could be easily turned into the Bronx; for a more particular detail and account of these streams, I refer to Mr. White's Report.

Mr. White had previously examined to find whether the Croton River could not be brought into the head of Saw-Mill River; in this he was unsuccessful, and it was our intention to have examined to see whether Croton River could not in some way be turned into the head of Bronx or Byram River, and thereby forever secure a resource, if wanted for any event, required by time or circumstances—bad weather prevented this being done.

Considering the Bronx, as before observed, the course from which a present supply could be had, we obtained all the information we could, to find the quantity of water it would give in its lowest state, at or above the place where it is proposed to take it from its bed without machinery, and convey it the city. The result of these examinations Mr. White has also communicated in his report. I will, however, observe that I believe if Rye Pond is six or eight feet, and held as a reservoir to be used in drought, there may be safely calculated a daily supply at all times, equal to five millions of gallons or more; a quantity ample for all the wants of the city for many years to come.

Durability and permanency should be primary objects in all works of this nature; the more expensive at first, they are in

the end cheapest. In this we have a strong instance in point in a neighboring city ; where I am informed nearly one million of dollars has been expended in projects to supply it with water, before the present useful and praiseworthy plan was adopted and carried into effect.

Of the several plans proposed by Mr. White, that one which proposes to bring the water from the Bronx, near the Westchester Cotton Factory, without the aid of Machinery, appears to me to have a decided preference. After having raised a dam across the Bronx at that point, to convey the water from thence in a tunnel of masonry, to a reservoir near McComb's Bridge, and from thence by cast iron —— passing into and out of several reservoirs on Manhattan Island. All which is calculated to preserve the water more pure and cool, to prevent evaporation, and secure it against any obstruction by severe and long continued frost.

An open canal has been proposed through that part in Westchester county, as being cheap ; to this it is objected, that much of the water taken from the Bronx would be lost by evaporation, and more by filtration, and in severe and long continued frost the passage of the water would be obstructed. And it is certainly advisable to take all precautionary measures to secure and pass safely to the city what is taken from the Bronx, and permit what is not wanted to pass down the bed of the stream to the hydraulic works below.

It has been believed by well informed men, that an open canal might be brought upon in high level over Harlaem River, and made to approach near the present built part of the city. An examination of irregularity of surface on Manhattan Island will show difficulties in such a project, owing to the ledges of rocks, but more so to the low ground which crosses the island in several places with less elevation than the Park ; making high and long embankments necessary, which would interfere with and obstruct streets and houses, and in short could not be kept at an elevation to raise the water the height required at the Park.

If the project spoken of as the best, should be once carried

into effect, the reservoirs as proposed by Mr. White will cause a deposit of all impurities taken up by freshets, and deliver the water to the city pure, cool, and good at all times. If well executed, it will require little or no repairs, and will lay a permanent foundation for a supply of water in abundance for the present and future ages.

Respectfully submitted,

BENJAMIN WRIGHT.

New-York, January 28th 1834.

No. 3.

EXTRACTS

FROM MEMORIAL OF FRANCIS E. PHELPS.

To the Honorable Common Council of the City of New-York.

YOUR petitioner respectfully represents to your honorable body, that it has been for a long time contemplated to furnish the city of New-York with a supply of pure and wholesome water; but, from various causes, the execution of the work has been delayed until the wants of the community render it necessary something should soon be done. True it is, to the rich it is not a matter of necessity, their means enabling them at all times to provide a supply of pure water; but to the poor, who are compelled to make use of such as may chance to be near them it is an object of immense importance, inasmuch as the loss of health and the sacrifice of comfort, result from the use of impure and unwholesome water. Independent of any considerations of this kind, there are numerous advantages to be obtained, so obvious to the mind of every one, that your petitioner will not go into detail on the subject, but proceed to examine some of the various plans or modes which have been suggested for the accomplishment of the object.

In the accompanying paper marked D, is the outline and estimate (so far as can be made without actual survey) by which it is proposed to vary from the plan suggested by the Engineer of the New-York Water Works Company, and

bring the water the whole distance from Rye Pond through a twenty-eight inch cast iron pipe. The estimated cost would be about $2,592,000.

The paper marked E, contains the plan and estimate for bringing the water of the Croton River to the city by canal, and also by a cast iron pipe. The cost of the canal would not be less than $1,834,200. Of the cast iron pipe $3,059,800.

In the paper marked F, it is proposed to bring the water from the Passaic River, taking it either at Paterson or some place above, and bringing it in cast iron pipes across the bed of the Hudson River. The estimated expense of this mode would be about $1,932,263.

The paper marked G contains the proposition of your petitioner, in which he suggests the practicability of furnishing a full and complete supply of pure, wholesome and cool water, for a sum not exceeding $793,000.

Your petitioner believes the above to be the principal practicable plans for supplying the city with water, from sources without the limits of the Island of Manhattan. Suggestions have been made by several scientific gentlemen, some of them members of your honorable body, proposing to procure a supply from the island. The importance of the subject, and the reasonable nature of these suggestions, would seem to call for an examination in relation to the quantity and quality of the water, and practicability of the plans proposed.

Aware of its importance, your petitioner has devoted considerable time and attention to the subject, and has become thoroughly convinced the city of New-York can be supplied with an abundance of pure and wholesome water, for the sum named in G, and a trifling annual expense.

The precise expense of the mode suggested by your petitioner, cannot be ascertained until accurate surveys have been made. The expense of these surveys will be moderate; but still too great to warrant individual expenditure, where public favor might transfer to another the ultimate reward. Your petitioner would therefore suggest to your honorable body, the expediency of referring to a Committee, the examination of the

various plans which have been suggested, as also the one named by your petitioner.

As in duty bound, will ever pray,

FRANCIS E. PHELPS,

D.

In this plan it is proposed to bring the water from Rye Pond directly to the city through a twenty-eight inch pipe, communicating with one or more reservoirs, but discharging the water directly from stop cocks and fire plugs. A dam across the outlet of Rye Pond, it is thought, will increase the quantity sufficient to supply at least two hundred thousand inhabitants. The expense of this mode will be

For 30 miles of cast iron 28 inch main pipe, including expense of transportation, &c. at $74,522,	$2,235,660 00
Dam at the outlet of Rye Pond,	1,150 00
Distributing water in the city for 200,000 inhabitants, including all south of 19th street,	231,367 00
Add contingencies, 5 per cent.	123,908 85
	$2,592,085 85

E.

Two plans for bringing the water from the Croton River in the vicinity of Sing Sing have been suggested; the first by closed canal (an open canal being objected to, from its liability to receive impurities from the country through which it passes) —the other by cast iron pipes, as in D. No correct estimate can be made without survey, but the cost could not be less than the closed canal described in the Report to the Water Works Company. The precise distance is unknown, but cannot be much less than thirty-six miles. To gain a sufficient elevation,

the water should be taken into the iron pipes at least eight, and probably ten miles from the Park. The cost of the closed canal would be,

For 28 miles of closed canal, at $30,000,.....	$840,000 00
8 miles 28 inch cast iron pipe, at $74,522,	596,176 00
Distribution below 19th street, including Hydrants, ...	231,367 00
Add contingencies, 10 per cent.	166,754 30
	$1,834,297 30

The cost of the cast iron pipe would be,

For 36 miles of cast iron pipe at $74,522, ...	$2,682,792 00
Distribution below 19th street, as above,..	231,367 00
Add contingencies, 5 per cent.	145,767 95
	$3,059,866 95

F.

It is proposed in this plan, to bring the water in cast iron pipes from the Passaic River, at some place above the falls at Paterson. The pipe to be laid across the bed of the North River with the assistance of a diving bell. To take the water at the most convenient point; the distance from the Park would be about nineteen miles. The cost of this route may be estimated—

For 18 miles of 28 inch iron pipe, at $74,522,...	$1,341,396
Pipe and laying across the bed of the river,.	183,840
Distribution below 19th street, ...	231,367
Add contingencies, 10 per cent.	175,660
	$1,932,263

The objections made to this plan are—1st. The impurity of the water.—2d. The source being within the jurisdiction of another State.—3d. And the continual danger of rupture of pipe on the bottom of the river, from drawing of anchors.

G.

It is proposed in this plan, to furnish the city a quantity of water, not exceeding one hundred thousand gallons per hour, or two millions four hundred thousand gallons per twenty-four hours. The water to be delivered at any place within one mile of the City Hall, at the discretion of the Common Council. The water to be pure and cool at all seasons of the year, and to be furnished with sufficient power to elevate the jet from the main pipe at least forty feet perpendicular. It would be proposed in distributing the water, to have one or more jets in each of the public squares, particularly in the Park, Bowling Green, Battery, &c. Also to provide an abundance for the Fire Department, and for washing the streets in dry weather. The reservoir in 13th street can be supplied from this source, and will be eminently useful in case of a sudden or extensive fire.

The expense of this mode will not exceed $793,000, including every expense, with the exception of distribution, and a contract can be made for the delivery of the water within two years from the completion of the surveys.

FRANCIS E. PHELPS.

New-York, May 17th, 1830.

No. 4.

To the Honorable the Corporation of the City of New-York.

GENTLEMEN,

The subscriber, who is President of the New-York and Sharon Canal Company, believing that your honorable body is desirous of obtaining all the information in your power on the subject of obtaining a supply of water for the present necessities, and of making ample provision for the future wants of your city, has been induced to lay before your honorable body, the facts contained in this memorial.

In the year 1823, a number of gentlemen in the counties of Dutchess, Putnam and Westchester, by the aid of your honorable body, obtained an act of incorporation from the Legislature of the State of New-York, to make a navigable canal from the western boundary of the State of Connecticut to the City of New-York. The bill for the act of incorporation which passed the Legislature, was drawn by an agent of your honorable body, and secured for the use of the Canal Company, all the waters on the route of the proposed Canal, with a view of furnishing a supply for the city of New-York. For some reasons unknown to your memorialist, your honorable body has since declined taking any part in the promotion of the object contemplated by the act of incorporation.

Your memorialist would further state, that the said Canal Company, soon after their incorporation, made thorough and expensive surveys of the country lying between the State of Connecticut and the City of New-York, and particularly of that portion of it below the Croton River, and it has been ascertained that that river can be carried into the City of New-York, and that without it, a supply which shall be adequate to

the present and future wants of the city cannot be obtained. The Canal Company, by the misconduct of their first President, and by the failure of a number of the Directors, and by being involved in an expensive law suit, which has not yet terminated, have been prevented pursuing the objects contemplated by their act of incorporation, but have by no means abandoned it.

The Directors of the Canal Company are somewhat divided as to the route which the Canal shall pursue; whether it shall go directly to the City of New-York, or follow the course of the Croton River to the Hudson; and their determination of this question will, in a great measure, be influenced by the course which your honorable body shall pursue in relation to the subject.

A thorough examination of the country has shown the only route which can be taken, to carry the Croton River into the City of New-York, and to take with it all the waters in the neighborhood.

If a conductor should commence at Cross River, at such an elevation as that the waters of the Croton could be hereafter introduced when it should become necessary, and should follow the route which has been accurately surveyed by the Canal Company, to a point a little north of McComb's Bridge, and the waters which could be collected on the route, be there emptied into a large and deep reservoir, at an elevation sufficiently high to conduct them from that place to any part of the city, an adequate supply for all present purposes could be obtained, and hereafter, as the wants of the city should increase, the aqueduct could be extended upon the same level to the Croton.

The practicability of this project has been ascertained by the surveys above mentioned, and the immense utility and importance of its accomplishment, will be obvious to every observer of the wants of the city.

Your memorialist has not been invested with any authority by the Canal Company, to make any proposition to your honorable body. There can, however, be no doubt that the Company

will consent to such a modification of their Charter, as will enable your honorable body to carry into effect the foregoing plan, upon receiving an adequate compensation for the relinquishment of their privileges, and with a view to bring the subject before your honorable body, your memorialist has been induced to detail the facts stated in this memorial, and would respectfully recommend their consideration to your honorable body.

CYRUS SWAN.

New-York, April 19*th*, 1830.

No. 5.

REPORT OF CANVASS WHITE,

Of January 9th, 1826.

To the Directors of the New-York Water Works Company.

To supply the city of New-York with good and wholesome water, is an undertaking of great public importance, and has been a subject of discussion for many years.

Although much has been written, yet nothing effectual has heretofore been done towards accomplishing this important and desirable object.

The delay may be attributed to a want of confidence in the success of the enterprise. Works of a similar kind have generally been accomplished by the capital and enterprise of public spirited individuals, aided by acts of incorporation. The distribution of the water, which has heretofore been the most complicated and difficult part of the work, has by recent improvements, been rendered easy and simple, so that there can be no longer any doubts as to the practical result.

Having heretofore been employed by the city to explore the adjacent country, with a view of ascertaining if a sufficient supply of good water, for domestic consumption, could be obtained, my attention at that time was directed to the Bronx, Byram, Saw-Mill, and Croton Rivers, also Rye Ponds.

Although the examination did not extend as far into the country as was desirable, yet they were sufficient for the information then required.

I examined and reported several routes and plans for conveying the water of the Bronx to this city, some of which

depended on raising it to a sufficient elevation by tide power at Harlaem River; but any connexion with machinery is objectionable, when it can be avoided. Therefore I have carefully surveyed the country, and extended the examinations from Rye Pond to Byram Pond, Wampus Pond, and the adjacent country, and particularly examined Bronx, Saw-Mill, Byram, Cross and Croton Rivers, Tisco, Peach and Long Ponds, and a number of small streams connected with them. The long drought of the past season has been favourable for gauging the streams and ascertaining the quantity of water that may be depended upon during similar seasons.

The country has been examined with a view to connect Cross River (being a part of the Croton) with the Bronx, and also to connect the main Croton with the Bronx. But the intervening ground is found to be too high and rocky, to accomplish this object.

Saw-Mill River can be easily turned into the Bronx through a Ravine near Union Church, but on gauging the stream, it was found to be so reduced in consequence of the drought, that no reliance can be placed on it for any part of the supply.

My examinations have resulted in a full conviction that a successful plan can be adopted by the Company, which is to take the waters of Bronx River, the main sourse of which is Rye Pond.

The water is of a superior quality, and is fit for all domestic purposes. It is the opinion of many that the Bronx is wholly inadequate to supply the city at those seasons, when the greatest consumption will be required. This question may be considered as put fairly at rest; for by the repeated trials made during the driest part of the last season, near the point proposed to take the water from the river, the minimum quantity or flow was found to be 4,302,720 gallons every twenty-four hours.

The supply can be increased by lowering the outlet of Rye Pond four feet, and raising the pond six feet above its present level, by making a dam across the outlet.

The banks are very favourable; the rocks approach near to each other, and almost form a natural dam.

The shores of the pond are also favourable, being principally rocky. Very little injury would be done to the land on the borders of the pond, the owners of which have no objection to its use; and have already entered into contracts to grant to the Company the right of so doing. By this arrangement an accession of ten feet on the surface of the pond will be at command, and may be considered as a part of the permanent supply, without interfering with the natural flow of the pond.

The accession of water to the pond will amount to about 775,000,500 gallons on the ten feet depth of its surface thus acquired.

Connected with this a dam may be constructed to cross the outlet of Little Rye Pond, into which Great Rye Pond discharges itself, and raised to a level with the upper pond, which will give an additional quantity of about 89,000,000 of gallons.

Surplus water may be drawn from these ponds, which will furnish a daily supply of 4,798,000 gallons, supposing a drought to continue six months in a year.

No allowance is necessary to be made for leakage, or evaporation. By adding the natural flow of the Bronx to the quantity which can be procured from the ponds, in the manner above proposed, there will be a daily supply at all seasons of the year, of 9,100,000 gallons.

If we allow twenty gallons for the consumption of each person daily, we shall have a supply for a population of 450,000 inhabitants; the allowance of twenty gallons will be ample to cover the quantity that may be required for factories and other purposes.

From the above, it appears that the Bronx, without the aid of reservoirs, will furnish a supply for a population of 215,000; and by the aid of reservoirs, a supply may be furnished to the city for years, without injury to the factories and mills on the Bronx.

In order to guard more fully against long and severe drought, it is proposed to make a reservoir of Byram Pond, in case the same shall at any time be required, similar to Rye Pond, which can be easily done by lowering the present outlet, and erecting a permanent dam across it; the water is soft and pure.

This reservoir, with little expense, may be made to contain about 789,000,000 gallons, in addition to the usual quantity in the pond. Byram Pond is the head of Byram River, although Wampus Pond is the principal source. Byram Pond lies much higher than Rye Pond, and a communication can be easily made between them, distant about six miles, principally over bottom lands.

It is proposed to cut a small independent canal, so as to divert the reserved waters only, thereby avoiding any interference with the water rights, mills, &c. on Byram River. Conditional contracts have been made with the owners of the land bordering on the pond, for the privilege of converting it into a reservoir.

The plan finally to be adopted, for conveying the water to the city, is of considerable moment to the Company, and particularly so to the community. An open canal will be the least expensive, but very objectionable on account of the water being liable to become turbid during rains, and the quantity of foreign matter that would necessarily collect in it. It must pass along side-lying ground, sometimes near farm yards and dwellings, and must receive the wash from the higher grounds in many places. The same objection may probably be made by some, to the natural stream, but it does not apply in this case, for the Bronx is generally bounded by woods or meadow lands, and the impurities brought down from the adjacent hills are deposited on the bottom lands, before reaching the stream.

Another objection to an open canal, is the liability of having the supply of water interrupted by the ice during the winter, if not entirely stopped by the formation of anchor ice, which would cause the water to flow over the banks of the canal, and follow the natural channel of the stream.

There are many other objections that may be made to an open canal, which have induced me to recommend a plan by which the water can be conveyed free from all obstructions or objections.

The water can be taken from the Bronx at Underhill's Bridge, about two miles above Mr. Shaw's Cotton Factory,

and conveyed in a stone or brick tunnel, forming a closed canal, laid in hydraulic cement, to Harlaem River. The canal or tunnel will pass along the ravine of the Bronx, about eight miles; thence westerly to the ravine of Morrissinia Creek, passing along the declivity of the hills about two and a half miles, to a point where the lines divide, (as shewn on the map) one to McComb's Dam or Bridge, near the termination of the 8th Avenue, both offering about the same facilities. The selection will depend on some circumstances, to be taken into consideration hereafter.

On the route to Cole's Bridge, the canal will terminate near Mrs. Morris', about three fourths of a mile from the bridge. The canal to McComb's Bridge will terminate on the hill near Harlaem River.

The line of canal which has been marked out on the ground, and laid down on the maps, herewith submitted, has a declivity of eighteen inches in a mile—and the surface of the water at the extremity of the canal or tunnel, will be at least forty-five feet above the Park.

A reservoir will be necessary at the termination of the canal, or tunnel, at which the iron pipes for conveying the water to the city, will commence.

In order to pass Harlaem River, it will be requisite to construct a permanent stone bridge, which will answer the double purpose of supporting the pipes and forming a good highway. A sufficienth depth of earth should be placed on the arches, to protect the pipes against frost; this precaution will be necessary with all the pipes, which should be placed about four feet below the surface of the ground.

In making an estimate of the expense for constructing a brick tunnel, I procured the data for the calculation, from the work of a similar kind in the city, but thinking the estimate too large, I have been more particular on this point. By noticing the fine quality and workmanship of the bricks made at Philadelphia, I engaged Mr. Samuel Fox to make four parcels of sample brick, (which are deposited in the office,) of different sizes, for the purpose of ascertaining the best form and size, by

actual experiment. They are moulded to form an arch of five feet in diameter, each brick is a segment of a circle, and when put together with hydraulic cement, will form a very perfect work.

It will probably not exceed three years, to get the work in a state to produce a revenue.

The quantity of materials to be procured, particularly the cast iron pipes, must take up considerable time. Heavy contracts of this kind cannot be urged beyond a certain extent, without incurring a heavy extra expense, and in all probability there will be a depreciation in the price of some of the most expensive materials; it would, therefore, be prudent not to make large contracts at first, but only sufficient to insure the steady and regular progress of the work.

The length of the tunnel will be about thirteen and a quarter miles, and it is estimated to cost $31,174 per mile, which includes all the expense connected with that part of the work; making a reasonable allowance for the land transportation of the materials from the landing places to the line of the tunnel. It will be necessary to lay about nine miles of twenty-four inch pipe; they will probably weigh from 17 cwt. to one ton each, and the length generally adopted is nine feet; and by putting them together, they overlap six inches, which will make six eundred and twenty-one pieces to a mile. Allowing them to weigh one ton each, at $70 per ton, they will cost $43,370 per mile, exclusive of the expense of laying; this has been found by experience to add fifty per cent. to the cost of the pipes.

This increase of expense is occasioned by the quantity of lead required in securing the joints, digging and regulating the ground, transportation of the pipes from the nearest landing places, &c. which will make the expense of laying one mile amount to $65,205.

The expense of a bridge across the Harlaem River will depend on the location; if McComb's dam should be taken, the present superstructure must be removed, and the work commenced on the foundation, at low water. Another position may be selected for the bridge, which would be between Cole's and McComb's, and very convenient for the works of the

company; the expense about the same as Cole's bridge; and would have an advantage over the others, by not interrupting the travel while the bridge was building, and would avoid a clashing of interests hereafter, in consequence of breaking up the road-way to repair the pipes, or to lay new ones.

From Harlaem River the best route appears to be through the Third Avenue; the undulations of the surface are less on this than on any of the other avenues; and the ground in many places on the side of the avenue is favorably situated for constructing large reservoirs for containing many days' supply of water; which, in case of a large draught of water, in consequence of fires or other causes, will allow the water to keep up a head sufficient for all the requisite purposes of the city, and render the supply sure in case of accident to the pipes between the reservoirs; and would be useful in rendering the water more pure, by giving it an opportunity to settle.

The particular form and construction of the reservoirs, and their location, as well as several other subjects connected with the work, will be communicated hereafter.

The estimated expense for delivering the water into a reservoir within the city, will be as follows:

For 13¼ miles closed canal or tunnel, at $31,174 per mile,	$413,055 50
Bridge over Harlaem River,	45,000 00
Nine miles 24 inch pipes, at $65,205 per mile,	586,845 00
Four reservoirs,	38,000 00
	$1,082,900 50
Add for contingencies 5 per cent.	54,145 00
Distributing water in the city,	187,954 50
	$1,325,000 00

Making altogether $1,325,000, exclusive of the sums which may be necessary for purchasing water rights on the Bronx, and to pay damages to those whose lands the tunnel shall pass through. From the purchases already agreed to be made, it

is not believed that all subsequent ones will exceed $125,000.

The population of the city of New-York amounts to 170,000 persons. Allowing six persons to a family, it will make 28,333 families that may require a supply of water.

The foregoing estimate of main pipe for the nine miles, carries it to the Park, and allows for several angles to connect with the reservoirs.

The expense of distribution, as set down, I believe more than ample.

Before closing this report, I must beg leave to express my acknowledgments to the inhabitants of Westchester county, for the information and assistance they have afforded me in my examinations and surveys, and who have uniformly evinced the strongest desire that the work should be carried into full and successful operation.

I do therefore report it as my decided opinion—

1st. That it is practicable, and in the manner above stated, to introduce into the city of New-York an abundant supply of pure and excellent water.

2d. That the same can be done at a moderate expense, compared with the public utility of the measure, and

3d. The foregoing estimate of costs and expenses, I believe to be over, rather than under, the probable amount.

Respectfully submitted,

CANVASS WHITE, *Engineer.*

New-York, Jan. 9th, 1820.

The subscriber having examined the ground and had explanations from Mr. White on all the particular details, upon which he grounds his calculation of expense in the foregoing report, I do hereby express my full confidence in the ample and liberal estimate made by him, and believe the work may be accomplished, for the sum he has stated, with the most perfect prospect of success.

BENJAMIN WRIGHT

New-York, Jan. 14th, 1826.

At a meeting of the Directors of the Water Works Company, Jan. 16th, 1826,

Resolved, That the Report of the Engineer be published for the information of the stockholder and the public.

BENJAMIN WRIGHT, *President.*
E. E. WEED, *Secretary.*

The maps are at the office of the New-York Water Works Company, and open to the inspection of all persons.

No. 6.

ANALYSIS OF THE MANHATTAN WATER.

The sample was obtained from the pump at the works before its entrance into the cistern, sp. gr. 1011.

One wine quart was slowly evaporated to dryness. The dry mass weighed 31.45 grains, equal to 125.80 of solid matter in the gallon, consisting of

Muriate of Soda,.....	45.20
Muriate of Magnesia,.....	40.
Sulphate of Magnesia,.....	6.
Carbonate of Lime with a little Carb. of Magnesia,..	12.80
Sulphate of Lime,.....	4.
Extractive Matter with Combined Water, ...	17.80
	125.80

GEORGE CHILTON.

November 25, 1831.

No. 7.

ACCOUNT OF THE WATER WORKS

FOR SUPPLYING EDINBURGH WITH WATER.

The works connected with the supply of water, may be conveniently divided into three parts. 1. Crawley Spring, and the adjoining building for collecting its water, which we shall call the Fountain head. 2. The Compensation Reservoir on Glencorse Burn, for storing up the flood waters, to be given out during the dry season, as an equivalent to the mills for the loss of the spring. 3. The Aqueduct pipe, commencing at the Fountain-head, and extending to Edinburgh.

CRAWLEY SPRING.

Let us suppose a person to set out from Edinburgh with the view of visiting the works.—Proceeding by Hillend and Howgate, after he has passed nearly a mile beyond the latter he enters a very sweet little valley in which Glencorse Burn flows. Down on his left hand about one hundred paces from the road, he observes a building of hewn stone, without windows, and covered with flags. This is the Fountain head. Crawley Spring is situated about two hundred yards west from this. It issues from a bank of gravel at the upper edge of the small meadow, at several spots within a few yards of one another. The water rushes out at the rate of more than sixty cubic feet (370 ale gallons) per minute; it is comparatively cold, having a temperature of 46°; and the supply is not much diminished during the droughts of summer—all proofs that it comes from a considerable depth. The water is

uncommonly pure, containing, according to Dr. Hope's analysis, only five and a half grains of foreign matter in a gallon, or one part in 10,500. The matter consists chiefly of carbonate of lime, with very minute quantities of muriate of soda, sulphate of lime, and sulphate of magnesia, all substances perfectly harmless. The original produce of the spring was much smaller, but it was increased by opening up the ground above and below it to some depth. The success of this operation induced Mr. Jardine to carry a trench or large tunnel at from ten to forty feet below the surface, up the middle of the valley, parallel to the burn, for about half a mile. The ground consists of a deep bed of gravel, through which the waters of various lateral springs percolate, and glide into the tunnel, the bottom of which is flagged, while the sides are built without lime, to let the water pass through. The tunnel terminates about half a mile below the Compensation Reservoir. Certain pieces of masonry consisting of large flag stones level with the surface of the ground, which may be observed near the side of the road, are the shafts or pits for descending into it for the purpose of ventilation and cleaning. By these operations the produce of the spring has been increased three-fold. It now averages about 180 cubic feet, or 1100 ale gallons per minute. When we visited the works in the middle of September, the long tunnel yielded about twice as much water as the proper Crawley Spring. The water of the latter seemed to be perceptibly colder to the touch than that of the tunnel.

The Fountainhead, as we have already shown, is of hewn stone, arched within, and roofed with flags, and it has a large door in each end. Its floor is entirely occupied by a stone cistern, (except a narrow path round its margin) six feet deep, about forty-five feet in length, and fifteen in breadth. Opposite the western door will be observed two small doors sunk below the level of the ground. These are openings into the two tunnels which convey the water into the cistern. The tunnel nearest the high bank conveys the water of Crawley Spring—the other conveys that of the smaller springs already described. You hear the water constantly pouring into the cistern. On

the south side of the Fountainhead, at the west end, will be observed a trap door, beneath which also the ear will generally detect the sound of falling water. This is the outlet for conveying the waste water to Glencorse Burn. When the springs yield more than is wanted, the excess is made to flow off by a lateral opening from the southern tunnel, so that the whole produce of the northern tunnel, that is, of the proper Crawley Spring, goes always into the cistern, and only as much is taken from the other as may be required—though, in point of fact, we believe both are equally good. For the purpose of cleaning the cistern, there is also a direct opening from its bottom into this waste outlet. At the east end of the cistern is the head of the line of pipes which convey the water to Edinburgh. It is material to observe that not one drop of the water of Glencorse Burn or the Compensation Reservoir is, or can be, conveyed to Edinburgh. There is in fact no apparatus for conveying it. The whole is derived from the large and small springs we have mentioned.

COMPENSATION RESERVOIR.

The reader must now accompany us to the Compensation Reservoir, a great and admirable work of its kind. Quitting the Fountainhead, we proceed westward about a quarter of a mile along the common road, and exactly at Glencorse Bridge we turn off to the right, and travelling up by the side of the Burn for more than half a mile, we come to an embankment with a large and beautiful sheet of water above it. The valley at this point is contracted by the neighboring hills to a narrow gorge about 100 yards wide. Across this gorge a bank of earth has been raised about 450 feet thick, horizontally at the base, and about 120 feet high. To obtain a secure foundation, it was necessary to remove the porous gravel to the depth of fifty feet, till the solid rock was laid bare from side to side. It is a curious fact, though not new to geologists, that the surface of the rock thus exposed, was furrowed with channels running horizontally in the direction of the valley, shew-

ing that powerful currents had flowed here before the great bed of gravel was deposited. This removing of the gravel was a work of great labor and difficulty, in which two years were expended. To make the bank perfectly water tight, a bed of puddled clay, sixty feet thick, extends from side to side, and is carried up from the bottom nearly to the top. This forms the central part of the embankment; and before and behind it is placed a mass of earth, making up the mound to the thickness we have mentioned. The upper face of the embankment and the margin of the lake to some distance on both sides of it, is paved with causeway stone, which gives it a neat and clean appearance. The lake formed by the embankment is three quarters of a mile long, and covers about fifty acres. Its depth is, when full, sixty feet at the lower end. An eliptical tunnel of hewn stone, is carried through the embankment a few feet from the bottom, to afford a passage for letting out the water in proportion as it is wanted. The stone tunnel, however, does not pass through and through. As the bank of soft puddled clay in the middle would have afforded an insecure foundation for masonry, the tunnel is continued through it by a cast metal pipe of thirty inches diameter. Two cast metal pipes of a foot diameter, fitted with sluice cocks, join into the end of this large pipe, and deliver the water at the back of the bank, where it may be seen pouring down in a cascade about ten feet high. By means of a ladder we descended upon the two pipes, and walked upon them some yards up the interior of the tunnel. In this cavity the reverberating noise of the falling water is peculiarly grand and striking. Though the stream of water issuing from the pipe appears scarcely thicker than a man's leg, it rushes with such rapidity under the superincumbent pressure, that it forms immediately a considerable rivulet. At the height of sixty feet from the bottom of the lake, there is a waste weir, or open canal, lined with hewn stone, for carrying off the surplus waters during extraordinary floods. With admirable taste, this canal has been carried forward nearly two hundred yards, and made to discharge the current over a precipice seventy feet high. Dashing from

point to point of the rocks, the stream forms a sheet of foam as white as snow from the summit to the bottom. Its site is chosen most judiciously. At a turn of the road it bursts upon the eye at once, in front of the spectator, and at the distance of a furlong. If visited during a great flood, there is no doubt that this fall would be a finer object than some of those which our virtuosos travel a hundred miles to see. Close beside the waste weir, but about ten feet lower, there is another tunnel of hewn stone with two sluices. The use of this is to carry off the the surplus flood waters, if from an accumulation of ice or any other accident, the waste weir should be blocked up. This tunnel (when used) delivers its water over the broken surface of the rock also, and forms another beautiful fall about forty or fifty feet north of the first one.

We should have mentioned that the natural cavity in which the bank or mound is placed, is of a funnel shape, being narrower behind and wider before: and the embankment itself has the form of a wedge lying on its side, presenting its thick end to the stream. Hence the force of the water tends only to compress its parts more firmly together. The back of the embankment is covered with good soil, and bore this season a crop of oats, which had a very singular appearance in such a situation.

In explaining the use of the Compensation Reservoir, we must first give an account of an artificial stream, carried along its north and east side, and kept entirely separate from it, the use of which would puzzle a common observer. It is necessary to premise, that all the springs in the valley rise on the north and east side. The average produce of each of these springs or streamlets during the summer half year, was carefully ascertained by measurement. A small weir or damhead was then made across each, of hewn stone, and a narrow plank placed on it, operating like a sluice, and turning all the water when the streamlet is in its usual state, into the artificial rivulet, by which it is conducted *past* the great Compensation Reservoir, and thrown into the bed of the Burn below. The weir or sluice is of such a size as to turn aside *only the ascer-*

tained ordinary produce of the streams, and when this is exceeded, as happens when heavy rains fall, the *surplus* flows over the weirs, and falls into the great Compensation Reservoir. Thus it will be understood, that all the *ordinary produce* of the streams in Loganhouse Valley, falls into Glencorse Burn below the reservoir, and goes to the mills as it did originally, and it is *only the flood waters* that are collected in the reservoir. This simplifies the arrangement with the millers, and obviates any cavils they might raise as to what the streams really yield. They receive the produce of the streams above the reservoir exactly as they did before it was formed; and out of the *flood waters* which are stored up in the lake, the Company have merely to give them an equivalent for what the Crawley and adjoining springs discharge into the Fountainhead—which can be at all times easily ascertained. Accordingly, the quantity spouting from the pipes in the elliptical tunnel behind the embankment, is meant to be equal to what the great pipes convey to Edinburgh. The square channels of hewn stone in the bed of the artificial rivulet, are measures for ascertaining the quantity of water conveyed, and the wooden ones in the channel of the rivulet below the dam serve the same purpose.

THE AQUEDUCT PIPE.

The aqueduct which conveys the water from the Fountainhead to Edinburgh is about nine miles long, reckoning to Queen street. The elevation of the stone cistern in the Fountainhead, where the aqueduct pipe begins, is as follows:

Above the sea at Leith, ...	564
Above Prince's street at the Mound, . . .	360
Above Reservoir at Heriot's Hospital, . .	270
Above ditto, Castlehill, ...	230
Above the lowest point to which the pipe descends in its course, namely, at Libberton dams, .	350

The distance from the Fountainhead to the Castlehill Re-

servoir in a direct line, is six and a quarter miles; by the line of developement, or that which the pipe follows, it is nearly eight and a half miles. After the pipe leaves the Fountainhead, it passes down the valley by the east side of the Burn, about a mile, till it comes to Milton Mill. It then strikes eastward to the point where the Pennycuik Road joins the Peebles Road, near the seventh milestone from Edinburgh. From this point it passes along the line of the Peebles Road by Straiton, Burdiehouse, St. Catharines, Libberton Dams, to the Grange Toll, crossing the road five or six times, but seldom running at a distance of more than one hundred yards from it on either side. A little without the Grange Toll it leaves the line of the road and passes on the west side of it to the meadow. It is continued obliquely across the meadow upon a basis of masonry raised above the surface, and covered with three feet of earth. It then enters a tunnel, which proceeds northwestward under the grounds of Watson's and Heriot's Hospital, passing near the west side of the latter, at the depth of about seventy or eighty feet below the surface. It then crosses the Grassmarket west of Heriot's Bridge, and enters another tunnel at the Castle Wynd. This last tunnel is rather a singular work. It is about six feet high by four and a half wide, and passes obliquely through the solid rock of the Castlehill, from a point near the foot of the Castle Wynd, to another point at the west side of the Mound below Ramsay Gardens. This subterraneous passage is about seven hundred feet, or one furlong in length. It descends gradually to the north, passing under the reservoir at the depth of one hundred and twenty feet, and is continued by a tunnel of masonry along the Mound to Prince's street, and thence onward to Queen street. The tunnel, though cut as we have mentioned out of the living rock, (sandstone) was made at the moderate expense of five pounds per fathom of length, including the laying of a bed of masonry for the pipe. It was found that the eighteen hundred or two thousand feet of pipe saved, rendered this a more economical mode of carrying the aqueduct to the New Town, than by taking it round the Castle. There is besides, the advantage of a greater discharge of water when the pipe is comparatively short and straight.

From Heriot's grounds a branch pipe passes off eastward to supply the southern districts of the town, and another comes up to the reservoir on the west side of the Hospital. A third ascends from the mouth of the tunnel along the side of the Castlehill to the reservoir there; and various branches pass off to other parts of the town.

It is to be observed, that a pipe coming from the reservoirs at Heriot's Green or the Castlehill, will carry the water no higher than the level of these reservoirs, but a branch from the main pipe has the pressure of the Fountainhead behind it, and easily makes the water ascend, not only to the top of the highest tenements in the town, but even to the upper flats of the barracks in the Castle, which are still nearly one hundred feet below Crawley Spring.

The pressure which the current of water exerts at the distance of eight miles from the Fountainhead, though its force is greatly relaxed by the partial escape of the water through various branches, is beautifully shown in the reservoir at Heriot's Green. A pipe is brought from below here of the full size of fifteen inches. Its mouth points upwards; and to close it effectually, and prevent the efflux of water, requires a pressure on the valve of a ton. This is applied by a series of cast metal plates, twenty in number, lying above one another, and each weighing about a hundred weight. They are kept in their position by an iron pin passing through a hole in the middle of each. When the plates are reduced to fifteen or sixteen, (three fourths of a ton) to allow water to flow into the reservoir, the force of the water makes this great mass play up and down, somewhat like a cork in a spouting fountain. But were the escape of the water by branch pipes prevented, we know from calculation, that the pressure would raise a mass ten times as great.

The pipes which compose the aqueduct, vary from twenty to fifteen inches diameter, are in lengths of nine feet, and are joined by spigot and faucet. This means, that about four inches of one end of each pipe is made wide enough to take the end of the next pipe within it—the wide or *recipient*

end being called the *faucet*, and the other or *intrant* end, which has the common diameter of the pipe, being called the *spigot*. The mode of joining is this: the small end being put into the large one as far as it will go, a piece of rope-yarn is driven in between the enclosed and enclosing ends. An iron hoop is next clasped round the joint, leaving a small open space within all round, and the joinings are made tight with clay. Melted lead is then poured through an opening in the hoop, and forms a sort of ring round the joint, into which it is driven firmly by a staving chisel, the rope-yarn preventing any of the lead from passing into the cavity of the pipe. In this way the joints are made perfectly tight, and yet give no obstruction to the flow of the water. The pipes are from half an inch to one and a quarter inch in thickness, a great strength being required in the latter and lower stages of the aqueduct, where the pressure is great. They are nine feet long when joined; and of course the aqueduct which, reckoning to Queen street, is nine miles in length, is composed of about five thousand individual pipes. The cost of these pipes alone was between £40,000 and £50,000, or nearly £5,000 per mile. At the present price of cast iron, it would have been probably a full third more.

The pipes were all proved before they were laid, by being made to bear a pressure equal to that of a column of from three hundred to eight hundred feet of water. This is rather a curious process. The pipe is filled with water and plugged up firmly at both ends, except that a communication is left through one end with a small forcing pump. It may probably remain for days in this state without the smallest leak appearing; but after you have worked the forcing pump a few minutes, and created a pressure perhaps equal to ten or twenty tons upon every part of the pipe, you are surprised to see the water transude at one or more points, and if the casting has been very faulty, it probably bursts asunder. In either case the pipe is useless. It may be observed, that from the very small elasticity of water, the actual rending of the pipe is not attended with any danger. It is of some value to engineers also to

know, that the shaking or dinneling of pipes by carting, even without actually producing rents, tries the soundness of the casting in a very effectual manner; and that of two similar parcels of pipes equally well cast at first, that which has been carted twenty miles before it was proved, will exhibit a greater number of defective pipes, than that which has been proved at the manufactory. Hence pipes should always be proved at the place where they are delivered—not where they are made.

Care was taken in laying the aqueduct, that it should form no sharp angles or sudden bends—as these diminish materially the rate of discharge. It begins with pipes of twenty inches interior diameter, and gradually diminishes to a size of fifteen inches. It scarce requires explanation, that as the aqueduct descends farther below the Fountainhead, the motion of the water is more and more accelerated by the superincumbent pressure, and that a fifteen inch pipe in the last and lowest stage of the aqueduct, will deliver as much water as one of twenty inches (that is nearly double the size) in the first and highest. The line of the aqueduct, considered with reference to a vertical plane, has neither a constant nor a uniform descent, but undulates considerably. There is a constant but varying descent from the Fountainhead to Burdiehouse. Here it rises a little, and then descends rapidly to Libberton Dams, where it is carried along an artificial embankment, thirty or forty feet above the natural surface of the soil. From this point it ascends to the high grounds behind Grange House; then declines gently to the Meadow, and continues declining to Heriot's Hospital, the Grass-market, and Prince's street. It may be proper to mention, that the aqueduct pipe is always covered with three feet of soil or more, to keep it out of the reach of frost and agricultural operation—that where it is laid at a depth not exceeding twelve or fifteen feet, it is simply covered with the earth, but where the depth much exceed this, a tunnel of six feet in height, with shafts for descending, has generally been built over it, that access might be had to the pipe afterwards for repairs without much digging. Ther

is a tunnel of this sort about a mile long across the ridge at Milton Mill.

The following are the distances and levels of the various portions of the ground, reckoning from the Fountainhead. They are taken from the Report published in 1813, and are expressed in feet; but it is to be observed that the pipe undulates less than the ground, a part of the inequalities having been got rid of by cutting tunnels and raising embankments.

	Dist.	*Aggregate Dist.*	*Fall or Rise.*	*Fountainhead.*
To Noblehouse Road, ...	5830	5,830	11,6	11,6
To a point a little beyond the 5th milestone from Edinburgh, ...	9385	15,215	30,6	42,
To the south corner of the Park of St. Catharine's, ...	9245	24,460	93,8	135,8
To Libberton dam's bridge, ...	8100	32,560	247 Rise.	382,8
To Crouch's Nursery, ...	6623	39,183	73,8 Rise.	309,
To Castlehill Cistern, ...	5254	44,437	78,5	230,7

Thus the length of the aqueduct pipe is 44,437 feet, or eight and a half miles; but if we reckon to Queen street, where its proper termination is, the entire length is very nearly nine miles. Of these nine miles, the portion of the pipe's track tunnelled through the natural rock from the Meadow to the Grass-Market, occupies about nineteen hundred feet; and the seven hundred feet tunnelled through the Castlehill added to this, makes half a mile, besides the tunnel at Milton Mill. We have mentioned that the size of the pipe varies from twenty inches to fifteen; and it may be proper to add, that its contraction is progressive from the Fountainhead, the size never being enlarged again after it has been diminished.

The pipe delivers about one hundred and eighty cubic feet per minute at present—and hence we find by calculation, that

the water travels at the rate of about two miles per hour where its motion is slowest, that is, in the parts of the pipe where it is ascending, and where the pipe is necessarily full. Of course the water passes from the Fountainhead to Edinburgh in four hours or less.

The cost of the Compensation Reservoir, Fountainhead and pipes, including value of ground, tunnelling and laying, but excluding all the smaller branches and service pipes in Edinburgh, has been about £145,000, as stated in the evidence given last summer before a Parliamentary Committee. The works were begun in the latter end of 1819, and were finished at Martinmas, 1824.

The Company, however, looking forward to the progressive increase of the town, secured under their Act a right to the property of the Black Springs. The produce of these, together with the other springs in the valley of Bavelaw Burn, which is about one hundred and twenty cubic feet per minute, will increase the new supply to three hundred cubic feet, or eighteen hundred and forty ale gallons per minute; and the present aqueduct has been made sufficiently large to convey the whole of this quantity. The Black Springs four in number, are situated entirely on the northwest side of the Pentland Hills, two miles south from Currie, at the height of eight hundred and fifty-four feet above the sea, and it is rather a remarkable fact, that this great mass of hills is traversed by a ravine (at the east end of the Black Hill) so deep, that not only the Black Springs, but those of Bavelaw and Liston Shiels, and even Bavelaw Burn itself, could be carried quite across the chain, and made to discharge their waters into the Esk. About three and a half miles of additional pipe, but of a smaller size, would be required to conduct the waters of the Black Springs to the present Fountainhead at the Crawley Spring, and about six and a half miles, if those of Liston Shiels are brought at the same time. When this is done, a new Compensation Dam will be constructed on Bavelaw Burn, at the point where it is joined by the Stream Burn, to store up the flood waters for the use of the mills on the water of Leith; and a part of the

water used in Edinburgh will then have travelled in pipes the astonishing length of fifteen miles.

Mr. Telford computes that a full supply of water for a town requires nine gallons for each inhabitant. The supply by the old works (which we have not thought it necessary to describe) is only about three and a half gallons a day for the present population of Edinburgh and Leith; by the old and new works together, it is about fifteen gallons a day, or two thirds more than Mr. Telford's calculation. In this statement, the present population of Edinburgh (including St. Cuthbert's Parish) and Leith, is assumed to be 153,000, of whom 23,000 in the country parts are supplied from wells, springs or rivulets.

Our narrow limits compel us to pass over a multitude of details which would be necessary to give a complete idea of these works—by far the greatest and most perfect of the kind ever constructed. Among scientific men who have examined them, we believe there is but one opinion as to the consummate skill with which they have been planned and executed by Mr. Jardine. The merit of success in his case is so much the greater, because the hydraulic works of this description, previously formed, were generally so imperfect as to teach the engineer nothing but a distrust of the principles on which their efficiency depended. It required a scientific head as well as a skilful hand to bring a work attended with so many difficulties to so successful a termination. What he wanted himself, he has now furnished to those who come after him—a model, which at once exemplifies the most advantageous construction of such hydraulic works, and affords data on which the engineer may in future safely found his calculations.

Edinburgh, October 19, 1825.