REPORT

OF THE

WATER COMMITTEE,

COMPILED FROM THE VARIOUS DOCUMENTS, PAPERS AND REPORTS OF THE FORMER DEPARTMENTS AND THE PRESENT BUREAU OF WATER, RELATING TO A PROPER SOURCE OF

WATER SUPPLY,

WITH ACCOMPANYING SUGGESTIONS FOR THE

City of Philadelphia.

PHILADELPHIA:
DETRE & BLACKBURN, 35 NORTH SEVENTH ST.
1892.

REPORT

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WATER COMMITTEE.

Compiled from the various documents, papers and reports of the former departments and the present Bureau of Water, relating to a proper source of water supply, with accompanying suggestions for the City of Philadelphia.

HARRY P. CROWELL,
Chairman Sub-Com.

J. EMORY BYRAM,
JOHN MORRISON,
J. C. COLLINS,
JOS. F. PORTER.

We approve and recommend the following report of the Sub-Committee:

EDWARD W. PATTON, *Chairman.*

BEASLEY, C. OSCAR,
BRINGHURST, ROBT. R.,
BYRAM, J. EMORY,
COLLINS, JAMES C.,
CROWELL, HENRY P.,
FALBY, ANDREW W.,
FINLETTER, ROBT. W.,
FIRTH, THOMAS,
GREEN, B. J.,
HAGAN, JAMES,
HANIFEN, JOHN E.,
HART, SAMUEL,
HORR, R. C.,
KNIGHT, WM. R., Jr.,
McCLAIN, PENROSE A.,
MACKIE, WM. C.,
MILLER, HIRAM A.,
MORRISON, JOHN,
PORTER, JOSEPH F.,
SCHANZ, FRANK,
SEIBERLICH, SEBASTIAN,
TAXIS, JOHN O.,
THOMAS, B. S. C.,

RESOLUTION

Relating to the Water Supply of the City of Philadelphia.

Resolved, By the Select and Common Councils of the City of Philadelphia, that the Committee on Water be requested to perform the following duties:

1. To compile the various documents, papers and reports found in the Annual Reports of the former Department and the present Bureau of Water, relating to a proper source of water supply for the city, including the Schuylkill river and such other places as have been suggested in lieu thereof, *and make report thereof in printed form.*

2. To accompany their report with such a digest of the documents presented, as in their judgment will assist in an understanding thereof, together with such suggestions, as after consultation with the Mayor and the Director of the Department of Public Works will, in their opinion, aid in procuring for the city an adequate supply of pure water for the present and future.

3. The said Committee is requested to make its report not later than the first Thursday of September, 1891.

Your Committee having complied with the above Resolution, present herewith extracts from the following documents, papers and reports, obtained from the Water Department and other sources, touching upon the future supply.

Your Committee did not deem it necessary to comment on the reports published prior to 1871, as the subsequent reports embrace the same information, but submit herewith what is considered the most valuable extracts.

After a careful consideration of the accompanying reports, your Committee begs leave to submit the following:—

First.—The Source of Future Water Supply.

There is no necessity for the present generation to take into consideration any other source than the Schuylkill River, when it is shown, beyond a doubt, by all reports that the Schuylkill is the best source for the future water supply of the City of Philadelphia as to quantity and quality. The reports show that the minimum flow during the year of the greatest drought was 225,000,000 gallons in twenty-four hours. The water impounded in the dams and canals, from Flat Rock to and including Tumbling Run dams, would be sufficient to let down 75,000,000 gallons daily, for a period of sixty days drought, in addition to the natural flow of the stream. That quantity let down every twenty-four hours from the upper pools of the river, when the river is at its minimum flow of 225,000,000 gallons per day, would be equal to one-third of the entire natural flow at Flat Rock in times of drought.

The distance on the Schuylkill river from Fairmount to Mill creek, Schuylkill County, is 108.23 miles; the distance in miles of navigable pools or slack water formed by the dams in the river is 40.87 miles, and by the canal 44.48 miles. The total feeding capacity of all the dams on the Schuylkill river is equal to 4,452,612,000 gallons. Should the time arrive when the above quantity would be insufficient to supply the requirements of the City, the accompanying reports show that the Perkiomen can be damed up to hold a quantity equal to a feeding capacity of 194,000,000 gallons per day at Zieglersville (according to the estimate of R. Hering), which could easily be let into the Schuylkill and pumped into the different

reservoirs, without any other additional expense than the cost of damming same.

When both Schuylkill and Perkiomen fail to furnish the requisite quantity, the accompanying reports show that the Upper Delaware, Lehigh, or South Mountain recommendations can be resorted to and relied upon for a future supply, and could be used in conjunction with same.

To prevent waste of Water.

Your Committee recommends that action be taken at an early date to prevent the useless waste of water. Unless same is done it will be impossible to keep up the supply. San Francisco had trouble of a similar nature, which was overcome to a great extent by the introduction of meters.

The following article from the "*Argonaut*," San Francisco, March 2, 1891, is interesting:—

"The waste and excessive use of water was so great in 1887, that the company, after various experiments by a house-to-house inspection, without effecting any perceptible reduction, actively increased the use of meters; and while their use was a source of great irritation and annoyance, yet the result was that, in 1888 and 1889, the waste was sensibly checked, and the consumption kept within a reasonable margin, and it has so continued. It is evident from this testimony, that for the use of meters, the consumption of water, through waste and excessive use, would, by this time, have reached nearly 30,000,000 gallons per day (the present maximum capacity of the works), and this would have necessitated large expenditures to furnish a supply to keep pace with this extravagant use, and necessarily an increase of rates, which have thus been avoided.

"The present average daily consumption is about 22,000,000 gallons, and this, it appears, if paid for by meter measurements, at very low rates, would net the company about all the revenue desired. That amount of water, at nineteen and three-quarter cents per thousand gallons, would, if all paid for, net the company $1,585,925 for the year, a little more than the estimated receipts under the rates now in force.

"This makes it evident that, with the present meter rates at thirty cents per one hundred cubic feet, with the natural increase in patrons, taken into consideration, yielding a total estimated revenue of $1,580,000, that a large amount of water is wasted and excessively used, and corroborates the statements made by the officers of the company that the use of meters is not a source of revenue, but a necessary means of preventing undue waste."

Second.—The Purity of the Water.

It has been clearly demonstrated that if the water is taken from Flat Rock dam, a point above Manayunk, where the water becomes polluted by the drainage from the factories, houses, cemeteries and Park drives, it would greatly improve the quality of same in comparison with the present source, notwithstanding the completion of the intercepting sewer, which was built to convey the drainage from the manufacturing industries on the east side of the Schuylkill, from Manayunk to a point below Fairmount dam, but which failed to accomplish its purpose to a greater or less extent.

No provision has yet been made to prevent pollution from the west side of the river, which is very large at Pencoyd and worthy of special and immediate attention to prevent same.

Your Committee thinks the purity of the water could be still further improved by obtaining the supply from

Norristown dam and conveying same through conduits or aqueducts to the different pumping stations, thereby preventing the drainage from Norristown, Bridgeport, Spring Mill, Conshohocken and Lafayette.

In times of greatest drought the 75,000,000 gallons of water from the upper pools, coming from sources almost entirely free from pollution, would raise the standard of the stream as to purity very materially.

With regard to the comparisons that have been made of the samples from the Delaware and Perkiomen with that of the Schuylkill, the claims are in favor of the latter. Learned men have endeavored to show that the water of the Schuylkill is wholesome, and statistics prove that the death rate is low as compared with other cities. Much has been done to keep pollution away, and much more can be done.

To still further improve the quality of the water arises the question of filtration. This is a matter of vital importance and one which cannot be ignored. The citizens and consumers of water in this large city not only demand a full supply, but will insist that it shall be free from discoloration, and devoid of all impurities containing the germs of disease so detrimental to health. Recognizing the deplorable condition in which water is being supplied to the City, both in appearance and quality, we can see no permanent relief except in filtration. This must be of the best kind, both as to quality to be supplied and its standard of purity. This can be easily accomplished, so that after the first outlay filtration can be maintained at a nominal cost.

The several anaylses establish the fact beyond a doubt, that the water of the Schuylkill and Perkiomen sources suggested by your Committee, is equal to that of any other City, or to that recommended in any of the accompanying reports.

Your Committee, in accordance with the Resolution passed, waited upon his honor, the Mayor, and the Director of Public Works, and solicited their co-operation, having been informed that they would furnish a separate report of their own to Councils.

Your Committee understands that a proposition is in the hands of the Water Department to furnish the City with a full supply of pure water from dams to be erected, about thirty miles from Philadelphia, in New Jersey. Insomuch as the Water Department has not furnished your Committee with any information concerning same, they cannot comment on the matter.

Summary of the Different Recommendations for a Future Water Supply.

The first recommendation was a supply from the Wissahickon creek, but its flow is so small, as compared with the requirements, that it has been abandoned.

The second was the impounding dam at Flat Rock and pumping the water at that point by water power.

The third was to impound the Perkiomen at Schwenksville, and it was calculated that 180,000,000 gallons per day could be obtained by gravity.

The fourth was the Delaware projects, the most favored being the Water Gap scheme, *via* Point Pleasant, by gravity.

The fifth was the Perkiomen project to the Blue Mountains, *via* Green Lane.

The sixth is the Schuylkill Navigation Company's project.

The idea in recommending the Delaware and Perkiomen projects was to obtain a purer supply of water, but it is shown by the foregoing reports, that while the water may be better in some respects, in the main it is not so good as the Schuylkill water.

To go to the Water Gap or Lehigh Valley involves an outlay of from fifty to sixty millions of dollars, not taking into consideration the advance in prices of material, and the increase in the valuation of property to be condemned for that purpose. Another important item is the abandonment of the present water works which cost the City about ten millions of dollars.

The Point Pleasant and Perkiomen projects by themselves cannot be relied upon for a sufficient quantity of water. The Tohickon, at Point Pleasant, has an average daily flow of from 80,000,000 to 90,000,000 gallons, and the Perkiomen, at Green Lane, no more; the Perkiomen, at Schwenksville, could not be relied upon for a full supply.

To draw the water from the Delaware would be of no particular advantage, as it has not been proven that the water at Point Pleasant is any better than that of the Schuylkill.

HARRY P. CROWLL,
Ch'n. Sub-Com.
J. EMORY BYRAM,
JOHN MORRISON,
J. C. COLLINS,
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Statistics as follows.

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1. Population and consumption of water.
2. Increased daily consumption of water, estimated on supposed increase of population, allowing 140 gallons *per capita.*
3. Storage capacity.
4. Pumping capacity.
5. Minimum flow of the river Schuylkill, 1869 to 1891, duration of droughts, maximum consumption.

6. Water pumped and used for water power at Fairmount pumping stations.

7. Approximated cost of works.

8. Table of reservoirs and dams of the Schuylkill Navigation Company, with their capacity, etc.

9. Table of revenue and expenditures, showing profits.

10. Table of the estimated cost of the Delaware river and Lehigh projects.

Comments on the water supply of Philadelphia, by James Haworth. Pamphlets published in 1871 and 1878.

Report of the Commission of Engineers, in 1875, on the future water supply.

Papers by H. M. P. Birkinbine, in the years 1876, 1878 and 1879, on the rainfall of the Schuylkill basin and the future water supply.

Paper by James F. Smith, on the future water supply, with table of the drainage area of the Perkiomen Valley.

Paper by Chas. G. Darrach, 1879, on the water supply of Philadelphia.

Colonel William Ludlow, chief engineer, report for 1885, improvement of the present supply.

Reports of the progress of surveys for the years 1883, 1884, 1885 and 1886, by Rudolph Hering, assistant in charge.

Colonel William Ludlow, 1885, comments on the chemical report of Professor Leeds.

Report of the chemical investigation into the present and proposed future water supply, by Albert R. Leeds, Ph. D., 1883–1886.

Colonel William Ludlow, 1885, comments on the investigations of Professors Mallet, Wormley and Greene.

Report of chemical and microscopical investigations in relation to the present water supply, by Professors Mallet, Wormley and Greene, 1885.

Annual report of John L. Ogden, chief engineer, for 1886, report on investigation of sources of future water supply.

Address of Charles W. Dulles, M. D., 1886, on the Schuylkill river as a source of water supply.

Address of Dr. J. Cheston Morris, 1886, on the Schuylkill river as a source of water supply.

Annual report of the Water Department for 1890, with recommendations of the Mayor, Edwin H. Fitler.

The digest of the various reports is as follows, the information being given as nearly as possible, in chronological order:—

As early as the year 1793, efforts were made to secure a better supply of water, and in the same year Benjamin Franklin recommended the impounding of the Wissahickon and delivering the water to the City by gravity, and in his will, bearing date June 23, 1789, he set aside part of one hundred pounds to be used for that purpose.

In the year 1800, water works were erected in Centre Square, Broad and Market streets, which were discontinued in 1815, and taken down in 1820. Capacity, 200,000 gallons.

In 1815, steam works were put in operation at Twenty-second and Chestnut streets. Capacity, 840,000 gallons, and were abandoned in 1822.

Then followed the Fairmount Water Works and the City's present system of Water Works.

In 1858, efforts were again made to secure a better supply of water, on account of the amount of refuse in the river from Manayunk to below the dam. In the same year Mr. H. M. P. Birkinbine, Chief Engineer of the Water Department, urged that other sources than the Schuylkill be investigated, and made a preliminary report on the subject.

He considered the Delaware and the Lehigh at Easton, also, the Schuylkill above Reading, and rejected them as unsuitable, and recommended an examination into the small water sheds about the City.

In 1863, I. S. Cassin, Chief Engineer of the Water Department, in his annual report, likewise urged the necessity for securing a better supply.

In 1864, Mr. Birkinbine, again Chief Engineer, was granted an appropriation to make surveys for a water supply to be brought from beyond the limits of the City, which resulted in a reconnoissance of all the creeks and streams within a radius of forty miles.

The following year he submitted a report. He had examined the Chester, Ridley, Crum, Darby, Cobb's Mill, Gulf and East Valley creeks on the west side of the Schuylkill; and the Wissahickon and Plymouth creeks, the Sawmill Run, and the Stony and Perkiomen creeks on the east side.

The report gives the quantity of water available from each, the location of storage reservoirs, etc., and concludes with recommending a gravity supply from the Perkiomen, with a delivery into the City at an elevation of 175 feet above datum, from a storage reservoir to be located above Schwenksville; requiring a dam across the valley 65 feet high, which would impound the water from an area of 220 square miles.

The scheme is advocated with some force and supported by a large number of data, as far as they were available at the time. If sufficient storage capacity were provided, it was claimed that 240,000,000 gallons daily could be furnished to the City from this source.

In 1866, the Fairmount Park Commission was created to secure such lands along the Schuylkill and Wissahickon as might be necessary to prevent the pollution of both streams and to convert them into a public park. By this means it was expected to maintain the purity of the water supply.

On account of the objections that had been raised against the Perkiomen project by the Park Commissioners and others, Mr. Birkinbine, in his report to Councils for

the year 1866, again discussed the scheme and endeavored to answer the disputed points by giving additional facts.

From a number of comparisons with similar works, he confidently estimates the daily average supply from the proposed reservoirs at Zieglersville to be at least 150,000,000 gallons. He also states that the water in this basin cannot become stagnant on account of its size and depth, but that it will rather be improved by allowing the suspended matter to settle. He finally argues that the valley offers no inducement for factories, and therefore no elements for pollution of the water.

In 1867, a Special Committee of the Fairmount Park Commission, consisting of Fred. Graff, John C. Cresson, George G. Meade, Strickland Kneass and William Sellers, reported on the preservation of the purity of the City's water supply, with the conclusion that the Schuylkill river can be relied on for many years if proper means be taken early to guard it from pollution, especially by building an intercepting sewer from Manayunk to below the Fairmount dam, and if large retaining compensating reservoirs are built in the upper Schuylkill to supply additional water during drought.

By this latter means it was computed that the average flow of the river would give sufficient water power to raise into distributing reservoirs at Philadelphia over 116,000,000 gallons per day through the dry period of the year.

In the following year, 1868, a bill was presented to the State Legislature, providing for the maintenance of the purity of the Schuylkill river between Norristown and Fairmount. While pending, a memorial was sent to the same body by a number of manufacturers in Manayunk, protesting against the passage of this bill, and recommending a plan which, it was thought, would accomplish the object, namely, to supply the City of Philadelphia with water from Flat Rock dam, by means

of a conduit extending from this dam to the pumps at Fairmount.

From other quarters it was suggested, instead, to build an open canal along one or both banks of the Schuylkill, by forming an embankment in it, and thus carry the refuse water to below the dams, and use the river's water for the City's supply.

Owing to the opposition, the above bill did not pass; and neither of the projects were carried out.

For several years no action was taken in the matter of improving the quality of the supply. The increased quantity of water required was supplied by increased steam-power.

This action called forth a series of pamphlets from a citizen, James Haworth, who was eager to show that the City could be furnished with the required quantity at a much smaller cost by water-power, and suggested the construction of numerous impounding dams to store the water from heavy rains.

In 1874, Dr. William H. McFadden, then Chief Engineer of the Water Department, discussed the question of the future water supply. Eliminating from consideration the plan of bringing water from the Delaware Water Gap by gravity, on account of its cost, he also, for the same reason, regards it as folly to bring it from New Hope, a point that had been suggested. The Perkiomen scheme is not considered by him for want of the necessary data. Nothing, therefore, appeared to be feasible, but to continue to use the Schuylkill water. The question of raising it into reservoirs by water-power is answered negatively on the ground that it would require an extensive and costly system of compensating reservoirs and dams, and, quoting from the report to the Reading Railroad Company, by James F. Smith, in 1874, he concludes, that taking a most favorable view, the largest available amount thus to be secured would be 100,000,000 gallons

per day. Steam-power is therefore recommended as the most economical means of increasing the water supply for the immediate future. He urges a more careful study, however, into the best scheme for a more distant future.

The same report contains the results of a chemical analysis of the Schuylkill water and notes on its pollution, by Dr. Charles M. Cresson. His conclusions are, that the Schuylkill water would be sufficiently good for the City if the sewage entering below Flat Rock dam were intercepted, and the foulest sewerage entering above it purified before draining into the river.

In 1875, a memorial was presented to Councils by James Haworth on supplying the City with water from the Schuylkill and Wissahickon by water-power. It was accompanied by a paper from J. W. Nystrom, Mechanical Engineer, supporting the view that a judicious employment of water-power would render steam unnecessary for supplying the City with water.

From the variety of opinion entertained on this subject, and from the difficulties presented in clearly viewing the proper plan for the future supply, and therefore building present works in conformity thereto, but more especially from the urgent necessity of guarding against a water famine during the time of the International Exhibition, a Commission of Experts was appointed by the Mayor, in 1875, consisting of W. Milnor Roberts, William J. McAlpine, J. W. Adams, W. E. Morris, Solomon W. Roberts, and William H. McFadden, Chief Engineer of the Water Department, to whom the entire subject of the present and future supply was referred.

As to the latter question, the report of the Commission was unsatisfactory, from want of a comprehensive view of the question and a positive expression of opinion, due, no doubt, to the magnitude of the subject, and to the insufficient funds and time available for making the necessary inquiries.

The following propositions are discussed in the report of the Commission of 1875:—

1. The increase of minimum flow of the Schuylkill river by storing water in impounding dams.
2. Pumping with the power at Flat Rock.
3. Prevention of the pollution of the water pumped from the Fairmount pool.
4. Gravity supply from the Delaware Water Gap.
5. New Hope projects.
6. Scudder's Falls project.
7. Gravity supply from the Perkiomen.
8. Artesian wells.

Dr. McFadden, Chief Engineer of the Water Department, in his annual reports to Councils for the years 1877, 1878 and 1879, calls attention to this matter, and urges a study into a plan for an adequate future supply.

Mr. Birkinbine again contributed some information on the question, in several papers read before the Franklin Institute; one in March, 1876, on the "Rainfall in the Basin of the Schuylkill River," containing valuable and interesting data; another, in May of the same year, on the "Relation between the Rainfall in the Schuylkill Basin and the Water discharged at Fairmount."

In May and July of the year 1878, Mr. Birkinbine gives, in the Franklin Institute Journal, an extensive discourse on the "Future Water Supply of the City." He examines into the various schemes that have heretofore been proposed, and concludes, as formerly, by recommending the Perkiomen gravity scheme as the best and most economical one.

In May, 1879, Mr. Charles G. Darrach read a paper before the Engineer's Club of Philadelphia on the same subject. He endeavored to show that a supply by pumping is more economical than by gravity, until the quantity of water needed is 150,000,000 gallons per day, or about the year 1950.

In discussing the gravity schemes, he favors the Perkiomen, but instead of a dam at Schwenksville, as proposed by Mr. Birkinbine, he recommends an intercepting canal built around what would have been the edge of the lake, with dams on the cross valleys, to avoid the high dam at Schwenksville and the consequent flooding of the populated part of the valley.

In October, 1879, the future water supply of the City is discussed by Mr. James F. Smith, Chief Engineer of the Schuylkill canals. He states that the Perkiomen creek and its tributaries form the source from which the water for Philadelphia must eventually be brought, and gravity must be the mode of its conveyance. He criticises Mr. Birkinbine's plan, however, to the effect that the surface water at the proposed site for the reservoirs would be too low, except for the supply of the East Park reservoir and the basins below it. The location of Mr. Smith's line begins at Green Lane, where a storage reservoir is proposed, and extends from there to an elevation of 273 feet above City datum to a terminal basin situated in the City at an elevation of 249 feet.

In the following year, Mr. James Haworth issued another pamphlet, containing a report of the Philadelphia water supply, made to him at his request in 1878, by a commission consisting of Messrs. J. W. Nystrom, W. Barnet Le Van and William Dennison. The document was entirely of a private nature, and set forth the opinion that, with the aid of proper impounding dams, the entire supply for Philadelphia could be furnished for nearly a century to come by the water-power of the Schuylkill river below Roxborough pool.

In June, 1882, the Mayor was again authorized by Councils to appoint a Board of Experts, to report, among other matters, on what should be done for the future water supply of Philadelphia. The commission consisted of Messrs. E. S. Chesbrough, J. Vaughen Merrick and

Frederick Graff, in conjunction with the Chief Engineer, William Ludlow.

They recommended that a complete survey be made for the purpose of obtaining reliable data of the localities from and through which a pure and abundant supply could be obtained, the consideration of general legislation for protection of streams from pollution, and the adoption of measures for the prevention of waste.

In the following year, Councils authorized a survey of the water-sheds that would furnish an abundant supply of potable water, and Mr. Rudolph Hering, C. E., was placed in charge. Three parties were placed in the field, one to work up the topographical features of the Perkiomen, the other those of the Delaware project, and a third party to take charge of the hydrographic work. In addition, a careful reconnoissance was to be made of the Lehigh water-shed; also, a sanitary survey of the Schuylkill valley, and a geological survey of the respective water-sheds and of the territory over which the conduit lines were to pass.

The schemes that were investigated are as follows:—

Delaware river at Yardleyville, not favorably considered.
" " New Hope, " "
" " Lumberville, " "
" " Point Pleasant, considered the best.
" " Water Gap, " "

Perkiomen at Green Lane, considered favorably in conjunction with the Lehigh river, north of the Blue Mountains.

He favored the Point Pleasant scheme, as it is on a direct line to the Blue Mountains. He also favored the Perkiomen scheme at Green Lane, as it could be extended to the Blue Mountains. Both of these schemes, according to the report of the Commission of Engineers in 1875, would cost over $30,000,000.

The investigations were begun in May, 1883, and continued during the years 1884, 1885, and until July, 1886.

The amounts expended were as follows:—

During 1883, ...	$20,500 20
" 1884, ...	27,457 56
" 1885, ...	22,399 10
" 1886, ...	11,191 10
Total, ...	$81,547 96

Professor Albert R. Leeds, Ph. D., Stevens' Institute of Technology, Hoboken, N. J., made an exhaustive chemical investigation of the present and future water supplies, under the direction of Colonel William Ludlow, Chief Engineer of the Water Department, during the years 1883, 1884 and 1885. In his report of 1884, he classes the waters of the several streams in the following order:—

First.—The waters of the upper Delaware are pleasant to the taste, and ordinarily clear, transparent, and with little or no color. In this respect the waters of the Gap are especially noteworthy. Before reaching a final conclusion, it is necessary to determine whether the waters of the upper Delaware can be so protected that they will permanently retain their present excellence.

Second.—The Tributaries of the Delaware: The taste, color, and physical character of the waters in the Tohickon, the Neshaminy above the forks of the Big and Little Neshaminy, and in Mill creek, conform to the accepted standard of palatable waters.

Third.—The Perkiomen waters, taken as a whole, have afforded the least satisfactory results of those analyzed and reported upon in the present report. They are inferior in quality to the Delaware at Point Pleasant and the Schuylkill at Phœnixville.

Fourth.—The waters of the Schuylkill ordinarily contain much more solid matters in solution than those of the Delaware and the other streams examined.

In his report for 1885, he says:

"In the selection of a new water supply for the City of Philadelphia, the Blue Mountain tributaries of the Delaware and Lehigh rivers are to be preferred before all others. And whilst, of the Delaware river waters, those at the Water Gap are entitled to the first place, that gathered at Point Pleasant is uniformly wholesome, and of satisfactory purity and quality."

Colonel William Ludlow followed this investigation with another, independent of the Department reports, by Professors Mallet, Wormley and Greene, in the year 1885, in order to establish the purity of the Schuylkill waters.

In transmitting their report, he says:—

"The main points of the report are: First, that chemical analysis alone cannot be relied upon to establish the character of a water supply, as disease germs may exist and quite elude possibility of discovery by this means; secondly, the progressive deterioration of the Fairmount pool from Flat Rock dam to Fairmount, due to very apparent pollution going on within the limits of municipal authority; thirdly, the vital importance of excluding all sewage and foul drainage of any kind, and fourthly, the inferiority of the Shawmont (Roxborough) water to that taken from the Delaware at Lardner's Point.

These conclusions, with the exception of the last, have been frequently and fully set forth in the Department reports, although the exhaustive investigations which have been in constant progress during the past two years have not warranted me in asserting that the Schuylkill at its best point, viz., Shawmont, must be regarded as distinctly inferior to the Delaware, above Bridesburg.

In the same year (1885), the South Mountain Water Company submitted to Councils a proposal to lease the water plant of the City for a period of fifty years. The project was to supply the City from Perkiomen Valley, but when the facts were set forth in the Department reports indicating that the Perkiomen water-shed alone

might not prove adequate, the Company shifted its ground and boldly adopted the Delaware project as outlined in the Department reports.

In commenting upon this project, Colonel William Ludlow, then Chief Engineer, stated that the conduit proposed would not be adequate for the future supply, and that the Company would be compelled to build another and have it completed before the expiration of the lease. His calculation was that in 1920 the City would require an average daily supply of not less than 215,000,000 or 220,000,000 gallons.

In the spring of 1886, a meeting was held at the Continental Hotel, and a Committee was appointed to investigate the merits of the South Mountain scheme. On this occasion the adherents of the South Mountain Company presented to Councils a memorial, signed by some of the leading citizens, setting forth that the water supplied was not satisfactory.

It was found upon investigation that there were no grounds for the agitation, and Dr. J. Cheston Morris delivered an address before the water committee in support of his claims that the Schuylkill could be depended on for many years, and that it was a better original source than the Delaware.

Dr. Charles W. Dulles also delivered an address, repudiating the claims of the South Mountain Company that the Schuylkill was diminishing in its flow; and of Professor Leeds, that the water of the Schuylkill was inferior in quality to other sources. He made a comparison of the analyses made by Professor Leeds, and showed that while in some respects the water of the Schuylkill was inferior, in most respects it was superior to other sources.

Mr. John L. Ogden, Chief Engineer, in 1886, made a report on the water supply, and some of his remarks are noteworthy here:

He claimed that by building inexpensive dams on the mountain streams and by raising the existing dams, the

minimum flow of the Schuylkill and the available storage could be increased. By building storage basins within the City limits, part of the average flow could be stored to supplement the pumpage at low stages of the river. Should the entire maximum flow be pumped, the Navigation Company would be obliged to draw upon its storage reservoirs to meet the requirements of navigation.

As to the quality of the Schuylkill water, it is a mountain stream, possessing in a remarkable degree the means of self-purification. The action of the lime water of the lower tributaries upon the mine water is well understood. The main stream is broken by twenty-six dams and the small streams by at least an equal number. These greatly assist in the aeration of the water. The stream is generally clear, except after rain, when it becomes turbid. The Delaware and other rivers are no exception to this rule. This objection can readily be overcome by the completion of the proposed reservoirs, which will permit the pumps to be stopped after a storm until the river becomes clear, and also allow the first surface washings of the streets and roads to pass over the dam. The City can then be supplied with water entirely satisfactory in appearance, and the pipes will not become choked with sediment, as at present.

As to the Quantity of Water available of the Sources that have been Investigated.

No one has been able to predict, with any degree of certainty, the future requirements of the City of Philadelphia as to the quantity of water that would be needed, even at the present time. Perhaps James Haworth has estimated more accurately than any one else; his estimation was 160,000,000 gallons in 1898. Charles G. Darrach anticipated that it would be 104,000,000 gallons in 1910.

Colonel William Ludlow estimated that it would take 100 gallons a day *per capita*, and that by 1920 the demand would be from 215 to 220 gallons per day.

Our present requirements are over 150,000,000 gallons per day. In 1884 it was 73 gallons per head; in 1890 it was 136 gallons per head. Boston and New York, in 1884, furnished 90; Troy and New Haven, 100; Wilmington, 103; Milwaukee, 106; Chicago, 121; Buffalo, 130; Detroit, 144; Washington, 165, and Pittsburgh, 185 gallons per head.

As to the Quantity of Water available of the Sources that have been Investigated.

Wissahickon.—The report of the Water Department for 1866, says, that the drainage area above Bischoff's mill, six miles from the Schuylkill, is 55 square miles, and furnishes a daily average of 73,766,000 gallons.

Flat Rock.—The Commission of 1878, claimed that 180,000,000 gallons per day could be pumped by water-power, at this point, by building an impounding dam on the Perkiomen, which, together with the present, would be sufficient to the end of this century; that, if arrangements could be made between the City and the Reading Railroad Company for a lease of that ground and water-power, it would make the best water works in Philadelphia. The head of fall at Flat Rock is about double that of Fairmount, and free from tide-water. The Commission of Engineers of 1875 favored this idea, and recommended it as worthy of future consideration.

Perkiomen at Schwenksville.—Among all the projects for a future supply, this one received the most attention. It was first suggested by Mr. Birkinbine in 1865, and was favorably considered by the Commission of Engineers in 1875, and strongly advocated by James F. Smith, Chief

Engineer of the Reading Canals. Mr. Birkinbine calculated that by impounding the stream, a supply could be obtained by gravity of 200,000,000 gallons per day. The average flow at this point is estimated to be 240,000,000 gallons per day. The Commission of 1875 estimated the cost of gravitation plan at $12,000,000.

When the South Mountain Water Company proposed to lease the Water Works and supply the City from this source, Colonel William Ludlow set forth the facts that the Perkiomen water-shed alone might not prove adequate. Mr. R. Hering estimates the daily supply not quite 200,000,000 gallons.

Scudders Falls Project.—This scheme is to take the Delaware water at this point, situated two and one-half miles above Trenton, and was discarded by the Commission of Engineers of 1875 on account of its cost, which is estimated at $21,500,000. It requires the purchase of the Trenton water works, the erection of a low dam, the building of twenty-four miles of a large supply canal and seven miles of a conduit, besides pumping the water by steam-power at or near Lardner's Point.

Yardleyville Project.—This scheme is to take the Delaware water at this point, situated four miles above Trenton. It is above tide-water and above any serious source of pollution. It would be difficult and very expensive to build an aqueduct of masonry parallel with the river. The entire quantity would have to be pumped at that point. Such a scheme has therefore not been considered. The estimated cost, including capitalization, is $27,390,519, not including interest. This project allows of no extension. In case the water became impure, the whole line would have to be abandoned.

New Hope Projects.—Following up the river we find New Hope to be the next convenient place from which a water supply could be obtained. This project allows the water from the Neshaminy to be collected and delivered into

the aqueduct by gravity. Two projects have been suggested; a closed aqueduct scheme and an open canal scheme. The Commission of Engineers of 1875, in their report, say:—

"The project to obtain water from the Delaware at this point likewise meets with disfavor on account of its expense, the cost of the two alternate schemes being estimated at $23,000,000 and $22,500,000, respectively, to supply only 75,000,000 gallons per day. One plan is to raise the water at New Hope by steam-power, and thence carry it to the City in a high level conduit. The other is to purchase the Delaware Division of the Navigation Company's Canal, change it to a supply canal, and construct nine miles of new canal and seven miles of conduit, besides pumping the water by steam-power at or near Lardner's Point."

If an extension of the aqueduct should be desired, considerable portion would have to be abandoned.

Lumberville Project.—Above New Hope, the next practicable point from which the Delaware water may be taken is at Lumberville, 30.57 miles from Philadelphia. This project likewise allows the water from the Neshaminy creek to be collected into the aqueduct. The estimated cost is $20,258,667 for 210,000,000 gallons per day, not including interest. This scheme has the advantage that it lies in a direct line with the Water Gap project. No objection can be raised to it, except that it is more expensive than the Point Pleasant scheme.

Neshaminy and Tohickon Creeks.—The combination of these creeks is hardly worth considering as forming a scheme by themselves, because their combined water is less in quantity than the water from the Perkiomen basin, although the quality cannot differ very materially from it. But the location of a conduit bringing this water to the City would be identical with one bringing water from Point Pleasant and the Water Gap. It is

estimated that 181,000,000 gallons per day can be supplied from this source, and the cost, including reservoirs, is $14,551,662, not including interest.

Point Pleasant.—The length of the aqueduct would be 32.9 miles, starting at the proposed basin at Olney avenue. If the entire quantity is pumped the total cost is estimated at $20,000,000. If the Tohickon water is stored and turned into the aqueduct the cost will be somewhat reduced; another reduction can be made by storing and gathering the Neshaminy water.

The additional feature in favor of this project—that the height of pumping is reduced considerably below that of New Hope and Lumberville.

Point Pleasant to the Blue Mountains.—Portland is 47.20 miles above Point Pleasant, and the water could be obtained by gravity from this point, and the cost of the aqueduct from Point Pleasant to this point is estimated at $11,142,052. The river is considerably polluted here from the sewage from Stroudsburg, Port Jervis and a number of other towns above.

The cost of an aqueduct from Portland to Water Gap, with extensions to beyond Stroudsburg and Bushkill, furnishing 210,000,000 gallons per day, is estimated at $2,954,497, their aggregate lengths being 22.79 miles.

The total length of the aqueduct from Philadelphia to the Water Gap would be 102.89 miles, and the cost was estimated at $33,719,092 in the year 1885, not including land damages and cost of storage reservoirs.

Perkiomen Creek to the Blue Mountains.—The amount of water available from the entire water-shed has not yet been definitely ascertained, yet it will not fall far short of 200,000,000 gallons per day. The amount at Green Lane, including the East Swamp creek, would probably give about 100,000,000 gallons per day. The remaining quantity, on the basis of a supply of 210,000,000 gallons per day, would have to be obtained elsewhere, and the only

suitable locality lies in the Lehigh Valley north of the Blue Mountains. The entire quantity of water available from the head waters of the Lehigh river, north of the Blue Mountains and east of the river, can, by establishing storage reservoirs, be increased to over 450,000,000 gallons per day. The water is most excellent, and, from the fact that there are no inducements to either manufacture or agriculture, it is bound to remain so indefinitely. The disadvantages of the scheme are mainly the damages resulting from a serious diminution in the flow of the river.

Estimated cost of the Perkiomen aqueduct from Cambria basin to Green Lane, length 32.29 miles, capacity, 210,000,000 gallons per day, is $7,164,457.85.

Estimated cost of aqueduct from Treichlersville, in the upper Perkiomen Valley, to Aquanchicola creek, in the Lehigh Valley, length, 28.7 miles, capacity, 130,000,000 gallons per day, is $4,974,176.22.

Estimated cost of aqueduct in the Lehigh Valley, from Aquanchicola creek to Big creek, length 4.77 miles, capacity 130,000,000 gallons per day, is $863,581.10.

Estimated cost of aqueduct in the Lehigh Valley, from Big creek to White Haven, length 22.15 miles, capacity 130,000,000 gallons per day, is $4,786,844.39.

The total length of aqueduct from Philadelphia to White Haven is 87.91 miles, and the cost $17,789,059.56.

Cost for delivering 210,000,000 gallons daily.

Tohickon creek, by gravity, and Delaware river, at Point Pleasant, pumping by water-power, ...	$12,695,941
Northeast branch and Perkiomen, above Schwenksville, by gravity, . . .	13,674,493
Delaware river, at Lardner's Point, pumping by steam, ...	13,766,085

Delaware river, at Point Pleasant, pumping by water-power and steam, . . .	$15,475,262
Tohickon creek and Neshaminy creek, by gravity, and Delaware river, at Point Pleasant, pumping by steam, . .	17,174,998
Tohickon creek, by gravity, and Delaware river, at Point Pleasant, pumping by steam, ...	17,717,025
Perkiomen, above Green Lane, and Lehigh affluents, by gravity, ...	18,833,400
Delaware river, at Water Gap, by gravity, .	19,278,061
Delaware river, at Point Pleasant, pumping by steam, ...	19,622,543

The above does not include the cost of storage reservoirs and compensation for loss of water and land damages.

As to the Present Quality of the Water.

In 1886, Charles W. Dulles, M. D., delivered an address on the Schuylkill river as a source of water supply, and repudiated the claims of the South Mountain Water Company that the Schuylkill river was diminishing in its flow, and of Professor Leeds, that the water of the Schuylkill was inferior in quality to that of other sources. He goes over the figures of Professor Leeds' analyses to show that the water of the Schuylkill is better in most respects than the water of the Delaware. As a whole, he says, chemical analysis is unreliable and often cannot be depended on. That the figures given in the tables are misleading, and calculated to deceive one not accustomed to chemistry or to reading the tables.

On page 363, Report for 1886, Dr. Dulles, says:

"The whole column shows that the Schuylkill water at Spring Garden was never quite so good nor quite so bad as the Delaware water at the Water Gap or at Point Pleasant, while it was always better than that of the

Perkiomen. It was never quite so good or quite so bad as the Delaware water at Point Pleasant."

"Another important matter for chemical analysis is the amount of oxygen required to oxidize organic matter. This is one of the means of testing for organic impurity. The figures in regard to that show the worst for the Delaware at Point Pleasant, and next for the Delaware at the Water Gap."

On page 364, Report for 1886, he says:

"After studying these analyses, I do not hesitate to ask you to accept with me the opinion of the Citizens' Committee on the future water supply of the City of Philadelphia, in a memorial to Select and Common Councils of Philadelphia, dated November 30, 1886, viz.: 'We are satisfied that, although objections have been made to the water of the Schuylkill, it is chemically as pure as those which may be brought to the City from other points which are advocated.'"

Dr. Henry M. Chase, Civil Engineer, who examined the subject at the request of the Citizens' Committee, says:

"In regard to analyses, etc., I can only say, that as a whole they are quite favorable to the Schuylkill river water, and this I think would be the judgment of any unbiased person. In fact, the opponents of the Schuylkill find it necessary to repeatedly state that the analyses very curiously have failed to show the objectionable impurities, or words to that effect."

In another part of his address Dr. Dulles says:

"'The Schuylkill water at Phoenixville is admitted to be exceptionally pure, etc." 'I have gone over all the comparisons of Professor Leeds in his reports, and find enormous differences between the way he calculates his percentages and what seems to me the just way to do it.'"

On page 376, he says:—

"As to the reliability of chemical analysis, in determining the wholesomeness or unwholesomeness of drinking water, let me quote the opinion of Professor Nichols."

"'In the majority of cases, chemical examination cannot be relied upon as giving conclusive evidence as to the suitability of a water for drinking. If the water is grossly polluted, or is of exceptional purity, chemical examination can determine these facts; but, in a vast majority of cases, while chemistry may teach something and aid in the decision, it cannot teach everything, and it cannot decide. Various students of the matter of water-supply have formulated 'standards' which a water may not overpass. They are, however, only of relative value. Moreover, different kinds of water cannot be judged by the same standard—a fact that is often lost sight of.'" "And in another place he says: 'Chemistry does not give us the means of determining the amount of organic matter, or even of determining, in all cases, whether it is of animal or vegetable origin.'" Similar conservative opinions have been expressed by Professor Parks in his Manual of Practical Hygiene.

On page 371, Dr. Dulles says:—

"I trust I have not labored in vain in the attempt to show how unjust it would be to admit that chemical analysis alone could be used to condemn a given drinking water; but even if we were to grant this unfair assumption to anyone who might be tempted to 'vilify' the Schuylkill water, we need not fear that the concession would prove disastrous, for a careful study of the various analyses indicates, as I have shown above, that the Schuylkill river, at what is assumed to be its worst point, is in some important respects better than the Delaware river at Point Pleasant, and even at the Water Gap, and that in no respect does it fall below the proper standard of wholesomeness."

Professors Mallet, Wormley and Greene, say:—

"In the present state of chemical knowledge, it is only possible, and will probably always remain possible, to say after an examination, that the character of the water is

comparatively more or less open to suspicion, more or less likely to prove wholesome in use than some other water which has been examined in the same way. And, again, we cannot at present, on the basis of the most elaborate chemical, microscopical and biological examination, pronounce absolutely upon the wholesomeness or unwholesomeness of a sample of such water as is actually used by a large city population."

There are a large number of other quotations in the Annual Reports which would fill a large volume.

As bearing upon the comparisons instituted between the waters of the Schuylkill and Delaware rivers, the following letter, published in the *Public Pedger*, in December, 1886, is of interest:—

"*Upper Delaware Water not so very Pure.*"

MR. EDITOR:—"It is generally supposed that the water of the upper Delaware is pure and free from the adulteration of other streams of less magnitude, from which it is proposed to draw the future supply for the City.

"From personal observation, made between Stroudsburg and Port Jervis at intervals during the past fifteen years, I find that there is a noticeable change in the condition of the water, it being less pure than formerly.

"There are fifteen towns and villages along the Delaware, above the Water Gap, the most populous place being the city of Port Jervis, where the drainage from not less than two thousand dwellings and industrial establishments passes into the river. The water is unpalatable, and is not used by those having access to it. The route of a railroad along the river between Port Jervis and Stroudsburg has been surveyed, and in all probability will be built in the near future. With it would come an increase in the number of industrial establishments and other sources of

pollution to the river, which the City of Philadelphia could not prevent. During the months of July and August, thousands of female shad, which expire after spawning, float down the river; and during the past summer I saw the shores in places lined with their bodies in various stages of decomposition.

"Although to the eye the water of the upper Delaware is usually quite clear and transparent, it is, perhaps, not much purer than other proposed sources nearer home."

J. A. F.

"*Dulles.—Philadelphia, December 9, 1886.*" (*Contained in pamphlets, Water Department*).

Mr. John L. Ogden, Chief Engineer, says:—

"As to the quality of the Schuylkill, it is a mountain stream, possessing in a remarkable degree the best means of self-purification. The action of the lime water of the lower tributaries upon the mine water is well understood. The main stream is broken by twenty-six dams and the small stream by at least an equal number. These greatly assist in the aeration of the water. The stream is generally clear, except after rain, when it becomes turbid. The Delaware and other rivers are no exception to this rule. This objection can be readily overcome by the completion of the proposed basins, which will permit the pumps to be stopped after a storm until the river becomes clear, and also allow the first surface washings of the streets and roads to pass over the dam. The City can then be supplied with water entirely satisfactory in appearance, and the pipes will not become choked with sediment, as at present.

"With regard to the wholesomeness of the water, there are but two ways by which it can be determined—experience and chemical analysis. If judged by the former, the general health of the City is sufficient evidence thereof. Twenty per cent. of the deaths are of persons over sixty

years of age. If typhoid fever be caused by impure water, the deaths would be evenly distributed over the entire City, and the average the same each month. In the worst portions of the City and where the houses, as a rule, are not connected with the sewers, there are few cases. Along the Cohocksink sewer and its branches, the disease appears to be the most prevalent. Even Brooklyn, with one of the best supplies, is not exempt, and during certain months the victims of this disease are quite numerous. Colonel George E. Waring, in the Tenth United States Census Report states that the mortality of Philadelphia is one less in each one thousand persons than the City of London, two less than Paris, and seven less than New York."

"The other method generally adopted for ascertaining the purity of water is by chemical analysis, in regard to the value of which there are grave doubts. Experts differ as to the methods to be pursued, and the interpretation of the results obtained. In the majority of cases, chemical analysis cannot be relied upon as giving conclusive evidence of the suitability of a water for drinking or culinary purposes.

"To improve the water supply no expense should be spared, and all sewage should be excluded from the Schuylkill.

"As to the future supply, the present source can be depended on for supplying the city until the year 1910, and possibly longer. Experience proves the water to be wholesome, but it can and will be improved both in appearance and in quality."

General Louis Wagner, Director of Public Works, in his Annual Report for 1890, says:—

"Repeated analyses of the water, made by different experts, and without previous knowledge on their part as to where the water sent them came from, show no material

deterioration in its quality. They also prove, what has always been claimed, that the water is wholesome."

Advantages of the Schuylkill over other Sources of Supply.

Dr. J. Cheston Morris, says:—

"I advocate the Schuylkill as a better *original* source of supply than the Delaware from the quality of the water in the first place. This Schuylkill water, as Professor Cresson has so eloquently described in his pamphlet, has gone through a process of purification which renders it, at Phœnixville and Flat Rock dam, a phenomenally pure stream. Further on it is liable to more or less pollution. That pollution should be prevented, and I think it lies with you, as representing the power of the City of Philadelphia, to prevent it. I advocate the Schuylkill as a source of supply, for the reasons given in a paper read by me before the State Board in May last, and printed in the Annals of Health for December. I also advocate it from a comparison of the analyses of both the Schuylkill and the Delaware, frequently made and published in the Department reports.

"We are told that the whole supply of 200,000,000 gallons, which will be needed forty or fifty years hence, can be raised by water, and the rest by steam or gravity. We are more concerned with what can be done now, or in the course of a few years; and more than this, I submit, can be accomplished by the use of the Schuylkill Navigation's rights to water-power, namely, by constructing a dam (as proposed by Mr. E. F. Smith) to take water above Flat Rock dam to a point near the Wissahickon drive, and erecting there suitable turbines.

"But how to get possession of the works of the Schuylkill Navigation Company. What will they cost, and what will they be worth to the City? The present market

value of the $13,000,000 securities of the Schuylkill Navigation Company is less than $6,000,000. Among its properties are reservoirs containing, alone, water enough for six weeks supply of the City of Philadelphia. That is to say, suppose there was not a drop of water flowing over the dam at Fairmount, there would be water enough which could be brought down from the reservoirs now in possession of the Schuylkill Navigation Company to supply the city for six weeks—pure water and good water. Has a drought ever been known to last anything like that long? What doubt, therefore, can there be that these reservoirs even, as now constructed, besides others, the sites of which are controlled by them, would be capable of supplying all our needs?

"All these dams, reservoirs, and other property of the Schuylkill Navigation Company could then be had for $6,000,000. The alteration required to adapt them better for purposes of water conduit, including construction of new reaches of canal, paving and lining the sides, could be made, I am informed by competent engineering authority, for $2,5000,000 more, making a total cost to the city of $8,500,000. The annual expense of maintenance, obtained from official sources, are about $75,000. It will thus be seen, therefore, at a glance, how favorably this scheme would compare financially with the Delaware aqueduct schemes.

"If it was wise policy for the city, in 1819, to pay the Schuylkill Navigation Company $150,000, and to erect and maintain for the latter the Fairmount dam, for the sake of the rights thus acquired, would it not be equally wise policy now to obtain control of all the dams, reservoirs, water-rights and privileges of the company at far less the cost of their construction to-day? Nor would their usefulness diminish as time rolls on. They could be, and would become forever, an integral and useful part

of our water system, whatever unforseen changes time may bring.

"Then again we have heard much, and often, of the legal difficulties in the way of policing the Schuylkill and preventing its contamination by sewer and other pollution. *Well*, how much easier is this going to be in the case of the much longer Delaware? And how about the towns there? And, if this could be so difficult when the whole stream lies under the control of the State, *how much would the difficulty be when the rights and jealousies of three Sovereign States are involved?* I think this latter part of the problem has not been sufficiently noticed.

"And, now I want to call your attention to another point. We have our rights, as riparian owners, to take our water supply from the Schuylkill, and as long as we do so, we can maintain those rights as against anyone who might soil or make foul that water supply. But what will become of those rights if we abandon such use? Will not the Schuylkill become an open sewer? And which of us can calmly contemplate such a result? Which of us would like to walk, ride, or drive in our beautiful Park to inhale pestilential vapors from Fairmount dam.

"London allowed the fouling of the Thames to go on until it became well nigh impossible to remedy it. Let us beware how we allow a similar fate to overtake our beautiful Schuylkill.

"Another point is the disadvantage of deep reservoirs and long aqueduct systems. The impounded water is liable to become loaded with low forms of growth, and the waters of the Croton and the Cochituate have not improved under the process. If you draw water from the spigots in Boston (as well as in New York), you will find that there is 'an ancient and fish like smell' about it. If you try the water in New York you will find that it is not as good as our much-abused and sweet Schuylkill

water. If, however, you go to St. Louis, you will find that the water is white, almost milky, but pure and wholesome. It is not obtained from deep reservoirs and long aqueducts, but from the stream of the Mississippi. A large stream is, as Colonel Ludlow acknowledged, the best source of supply for a city."

THE PRESENT REQUIREMENTS OF THE CITY AND THEIR RELATION TO THE FUTURE WATER SUPPLY.

From the Department reports for the year 1890, it will be seen that more pumps and reservoir capacity are required, and in order to show the necessity for them, the following tables have been prepared:—

1. Population and consumption of water.
2. Increased daily consumption of water, estimated on supposed increase of population, allowing 140 gallons *per capita.*
3. Storage capacity.
4. Pumping capacity.
5. Minimum flow of the river Schuylkill, 1869 to 1891, duration of droughts, maximum consumption.
6. Water pumped and used for water-power at Fairmount pumping stations.
7. Approximated cost of works.
8. Table of reservoirs and dams of the Schuylkill Navigation Company, with their capacity, etc.
9. Table of revenues and expenditures, showing profits.

1. The average daily supply in 1890 was 141,639,749 gallons, and according to this increase it will be over 150,000,000 in 1891. This is a daily consumption of 136 gallons *per capita.* In 1854 it was 25 gallons; in 1868,

50 gallons; in 1880, 100 gallons. The rate of increase from 1850 to 1890 is as follows:—

	Percentage of Increase of Population.	Percentage of Increase of Water.
Decade from 1850 to 1860	.33	.326
" " 1860 to 1870	.19	.79
" " 1870 to 1880	.26	.59
" " 1880 to 1890	.23	.145

2. The anticipation for 1940 is about 400,000,000 gallons, according to the accompanying table, allowing 140 gallons *per capita.* Pittsburgh uses more water, and it is evident that the large consumption is due to manufacturing. If the present increase of consumption were to continue, it would require all the schemes combined to furnish water to supply Philadelphia, and then regardless of quality.

3. The present storage capacity is 869,288,814 gallons, and with the completion of the Roxborough reservoir it will be 1,000,000,000. Of this amount 93,328,000 is the capacity of the reservoirs furnishing Frankford, Belmont, Mt. Airy, Roxborough and Chestnut Hill—hardly two days supply. While for the City proper the capacity is 775,960,814, and if there were sufficient pumping capacity, and the reservoirs could be kept full, there would be a supply for one week.

4. The present pumping capacity is 183,040,000 gallons, and with the completion of the new pump under construction at the Southwark foundry, this capacity will be increased 26,000,000 gallons at Spring Garden. The city proper is dependent on the Spring Garden and Fairmount water works. The capacity of the Spring Garden works

is 96,000,000, and the water is pumped by steam. The capacity of the Fairmount water works is 33,290,000, and the water is pumped by water-power. The latter cannot be depended on during minimum flow or when the river is low, and 129,290,000 gallons, which is the capacity of both works, must be pumped by the Spring Garden works. The deficiency, after the new pump is placed in position, will be 7,290,000, to supplement the turbines at Fairmount. The past two or three years the flow in the river has been good, and the turbines have been kept running most of the time; but had there been a scarcity of water, they would have been useless, and a shortage in the pumpage would have ensued.

5. The table of minimum flow of the Schuylkill the past twenty years, shows that the least flow was 225,000,000 gallons for 96 days in 1881; 243,000,000 gallons, 66 days in 1879; 245,000,000 gallons, 211 days in 1874. In 1889, the minimum was 560,000,000 gallons for 15 days; and in 1890, it was 495,000,000 gallons for 194 days. The average minimum flow for the past twenty years, according to the table, is one month, and 323,738,445 gallons daily. The Department reports show, that the average flow of the Schuylkill river is 1,666,635,019 per day.

6. The amount of water required to run the turbines is thirty gallons to pump one gallon. When the water is low it is necessary to shut them down, thus cutting off 33,290,000 gallons capacity at Fairmount, and the Spring Garden works are not ample to meet the demand on them. These works are only one-fourth the capacity of the pumpage at both stations.

7. The approximated cost of the works erected since the year 1800 is about $7,807,263.16, including pumping mains. The cost of the works abandoned is $1,682,154. The cost of the works in operation at the present time is $6,125,108.21. The Fairmount Water Works cost $3,453,616.63, including dam and mains.

8. The storage capacity of the dams of the Schuylkill Navigation Company's plant is 595,269,000 cubic feet, which is equal to 4,452,612,000 gallons. The above storage is sufficient to let down from the upper river for the supply of the City 75,000,000 gallons of water per day for a period of sixty days drought, in addition to the natural flow of the stream. This amount with the least flow, 225,000,000, would make 300,000,000, or nearly the average minimum flow.

9. From the table of Revenues and Expenditures, it will be seen that the City has had a net profit over all expenses of $15,849,168.33 since the year 1855. Recommendations are made annually to set the surplus aside for the future requirements of the City. The surplus last year was $1,387,773.41, and every year it is increasing.

Population and Consumption of Water.

By John L. Ogden, C. E.

Year.	Total Gallons.	Average Daily Supply.	Consumption per Capita.	Population.	Percentage Increase of Population.	Percentage Increase of Water.
			Gals.			
1854	4,279,586,902	11,700,238	25	471,466		.13
1855	4,891,066,805	13,400,183	27	487,142		.13
1856	5,669,970,147	15,491,722	30	502,818		.16
1857	6,309,040,116	17,285,044	33	518,494		.11
1858	6,839,425,973	18,738,153	35	534,170		.10
1859	7,168,031,647	19,638,443	35	549,846		.05
1860	7,465,740,277	20,398,197	36	565,529	.33	.04
1861	7,596,087,978	20,811,200	34	576,378		.02
1862	7,932,886,423	21,733,933	37	587,227		.04
1863	9,498,775,141	26,024,041	43	598,076		.20
1864	9,307,007,849	25,428,983	42	608,925		.02
1865	11,052,569,184	30,281,011	49	619,774		.17
1866	10,654,345,470	29,189,987	46	630,623		.04
1867	10,863,421,498	29,762,798	47	641,472		.02
1868	11,985,178,883	32,746,390	50	652,321		.10
1869	12,414,752,336	34,013,020	51	663,170		.03
1870	13,402 811,272	36,720,030	55	674,022	.19	.08
1871	13,498,399,481	36,981,916	55	702,907		.07
1872	13,040,018,461	35,628,465	49	731,592		.03
1873	14,223,198,443	38,967,667	51	760,277		.09
1874	14,553,425,097	39,817,603	51	788,962		.03
1875	15,097,160,069	41,363,082	56	817,647		.04

Population and Consumption of Water.—Continued.

By John L. Ogden, C. E.

Year.	Total Gallons.	Average Daily Supply.	Consumption per Capita.	Population.	Percentage Increase of Population.	Percentage Increase of Water.
			Gals.			
1876	17,473,308,039	47,741,279	58	817,448		.15
1877	17,817,144,792	48,983,958	61	795,000		.02
1878	19,101,064,332	52,333,326	64	813,000		.07
1879	19,984,101,515	54,507,518	65	830,000		.04
1880	21,120,792,386	57,707,082	68	847,542	.26	.06
1881	22,721,014,838	62,249,355	71	869,000		.08
1882	24,691,440,430	67,647,782	76	890,000		.08
1883	25,284,957,251	69,273,856	76	911,000		.02
1884	25,495,179,353	69,658,969	74	932,000		.08
1885	25,165,020,072	68,945,260	72	953,000		.01
1886	28,658,966,569	78,433,289	80	975,000		.13
1887	32,426,779,765	88,840,492	89	995,000		.13
1888	37,068,763,428	101,280,774	100	1,020,083		.11
1889	42,518,919,781	116,490,191	113	1,032,000		.15
1890	51,698,508,699	141,639,749	136	1,045,396	.23	.21

	Percentage of Increase of Population.	Percentage of Increase of Water.
Decade from 1850 to 1860	.33	.326
" " 1860 " 1870	.19	.79
" " 1870 " 1880	.26	.59
" " 1880 " 1890	.23	.145

Increased Daily Consumption of Water, Estimated on Supposed Increase in Population, Allowing 140 Gallons per Capita.

BY JOHN L. OGDEN, C. E.

Year.	Population.	Daily Supply. Basis, 140 Gallons per Capita.
1890	1,100,000	141,000,000
1900	1,320,000	191,000,000
1910	1,584,000	241,000,000
1920	1,901,000	291,000,000
1930	2,281,000	341,000,000
1940	2,737,000	391,000,000

Your Committee thinks the above estimate is a much larger quantity than will be required.

If the present rate of increase of water consumption were to continue, it would require all the schemes combined to furnish enough water to supply the City of Philadelphia with water, regardless of quality.

Storage Capacity.

Name of Reservoir.	Date of Completion.	Height above City datum.	Capacity in gallons.
Fairmount Reservoir, No. 1	1815	94	26,350,800
" " " 2	1821		
" " " 3	1827		
" " " 4, Section 1	1835		
" " " 4, " 2	1836		
" " " 4, " 3	1836		
Lehigh avenue, Section 1	1852	114	26,394,000
" " 2	and		
" " 3	1871		
Spring Garden	1844	120	12,000,000
Corinthian	1852	120	37,341,400
East Park, Section 1	1887	133	62,737,632
" " 2	1888	133	306,400,622
" " 3	1889	133	304,736,360
Frankford	1877	167	36,046,000
Belmont	1870	212	39,758,000
Mount Airy	1851	363	4,546,000
Roxborough	1866	366	12,838,000
Manatawna tanks—2	1878	442	100,000
Chestnut Hill tank	1860	481	40,000
Total storage capacity			869.288,814

Pumping Stations.

Pumping Station.		Designated No.	Type of Engine.	Designed Capacity Gallons per Day.	Total.
Spring Garden.	Old Station.....	6	Simpson Com. Rotary..	10,000,000	
	"	7	Marine Com. Rotary...	20,000,000	
	"	8	Worthington Duplex..	10,000,000	
	"	11	Gaskill.....	20,000,000	
	"	12	Worthington Duplex..	6,000,000	
	New Station.....	9	" " ..	15,000,000	
	"	10	" " ..	15,000,000	96,000,000
Belmont		1	Worthington Duplex.	5,000,000	
"		2	" " ..	5,000,000	
"		3	" " ..	8,000,000	18,000,000
Roxborough.....		2	Worthington Duplex..	5,000,000	
"		3	" " ..	7,500,000	12,500,000
Roxborough Auxi'y		1	Knowles' Pump.....	500,000	
" "		2	" "	.....	500,000
Mt. Airy.....		1	Davidson Pump...	1,000,000	
"		2	" "	1,000,000	2,000,000
Chestnut Hill.....		1	Knowles' Pump.....	250,000	
" "		2	Worthington Duplux..	500,000	750,000
Frankford		1	Marine Com. Rotary...	10,000,000	
"		2	Corliss Com. Rotary...	10,000,000	20,000,000
Fairmount.	New House,.....	1	Turbine Wheels.....	2,000,000	
	"	3	" "	5,330,000	
	"	4	" "	5,330,000	
	"	5	" "	5,330,000	
	Old House.....	7	" "	5,100,000	
	"	8	" "	5,100,000	
	"	9	" "	5,100,000	33,290,000
Total number gallons per day.....					183,040,000

Minimum flow of the River Schuylkill, 1869 to 1890. Duration of Droughts, Maximum Consumption.

Year.	Duration of Minimum flow.	Total number of days during the year that no water flowed over Fairmount dam.	Minimum flow (approximate) of Schuylkill river at Fairmount in gallons per 24 hours.	Average daily pumpage in gallons per 24 hours, by all the pumping stations on the Schuylkill: Fairmount, Spring Garden, Belmont and Roxborough, during the month of maximum consumption of water by the City.
1869	80 days	No record	320,000,000	41,757,063, July.
1870	.....	"	325,000,000	46,008,735, "
1871	16 days	"	315,000,000	42,354,705, August.
1872	36 "	"	305,000,000	45,954,377, "
1873	.....	A few days	465,000,000	47,676,064, July.
1874	211 days	"	245,458,000	54,287,891, "
1875	22 "	"	300,000,000	51,249,917, June.
1876	45 "	91 days	255,000,000	57,175,346, July.
1877	.....	200 "	410,000,000	56,036,267, August.
1878	55 days	234 "	250 000,000	59,388,530, September.
1879	66 "	281 "	243,000,000	63,082,832, August.
1880	85 "	220 "	250,000,000	65,275,030, July.
1881	96 "	265 "	225,000,000	72,543,464, August.
1882	80 "	195 "	317,000,000	78,154,694, "
1883	28 "	231 "	291,000,000	83,121,658, July.
1884	57 "	227 "	302,000,090	79,644,129, August.
1885	45 "	251 "	225,000,000	81,449,488, July.
1886	68 "	221 "	246,000,000	91,210,072, "
1887	83 "	252 "	340,000,000	106,791,789, "
1888	49 "	226 "	438,000,000	117,291,017, June.
1889	15 "	97 "	560,000,000	119,166,413, September.
1890	14 "	194 "	495,000,000	150,176,770, "

The consumption of water is exclusive of water used for lockage at Fairmount Locks.

The minimum flow in the year 1874 covered a period between April 26th to November 23rd; in 1876 it covers a period between August 3rd to September 16th; in 1878, between August 30th to October 23rd; in 1879, between September 22nd to November 28th; in 1880, between August 19th to November 11th; in 1881, between August 16th to November 19th; in 1883, between August 14th to September 10th; in 1885, between August 20th to October 30th; in 1886, between August 18th to October 25th.

Water pumped and used for Power at the Fairmount Pumping Station.

Year.	Amount of water used to run Turbines.	Total number of gallons pumped at Fairmount.
1854	68,590,000,000	2,286,402,222
1855	83,640,000,000	2,787,736,850
1856	86,010,000,000	2,867,188,965
1857	91,793,000,000	3,059,797,730
1858	91,740,000,000	3,058,418,667
1859	101,700,000,000	3,390,271,757
1860	108,390,000,000	3,612,989,017
1861	111,960,000,000	3,731,785,628
1862	106,950,000,000	3,564,724,753
1863	167,610,000,000	5,586,712,091
1864	179,100,000,000	5,970,801,329
1865	212,460,000,000	7,082,015,640
1866	231,660,000,000	7,721,817,582
1867	239,700,000,000	7,990,416,594
1868	240,750,000,000	8,024,530,911
1869	224,700,000,000	7,489,611,069
1870	244,050,000,000	8,134,985,170
1871	264,660,000,000	8,821,728,593
1872	221,010,000,000	7,366,632,573
1873	261,510,000,000	8,717,538,594
1874	232,470,000,000	7,749,007,798
1875	239,820,000,000	7,994,234,254
1876	256,450,000,000	8,547,163,024

Water pumped and used for Power at the Fairmount Pumping Station.—Continued.

Year.	Amount of water used to run Turbines.	Total number of gallons pumped at Fairmount.
1877	283,760,000,000	9,492,419,433
1878	249,660,000,000	8,322,288,784
1879	218,340,000,000	7,278,357,488
1880	236,640,000,000	7,887,896,254
1881	227,250,000,000	7,575,326,689
1882	281,310,000,000	9,377,468,535
1883	292,710,000,000	9,757,096,729
1884	257,250,000,000	8,575,107,594
1885	205,410,000,000	6,847,346,991
1886	218,490,000,000	7,282,553,795
1887	303,180,000,000	10,105,736,633
1888	337,230,000,000	11,241,113,108
1889	342,420,000,000	11,413,386,469
1890	370,890,000,000	12,362,987,130

Approximate Cost of Works.

Name of Works.	Cost of Works.	Cost of Pumping Mains.	Remarks.
Centre Square Works	$657,398 91	Abandoned, 1815.	
Fairmount Steam Pumps	809,318 04	" 1822.	
Fairmount Water Works	3,299,262 63	$154,354 00	Including Fairmount Dam, etc.
Spring Garden	501,895 64	533,728 00	
Belmont, 24th Ward,	234,874 81	114,756 00	
Kensington	Unknown	215,448 00	
Frankford	657,307 04	218,760 00	
Chestnut Hill	37,520 99	5,262 00	
Mount Airy	16,085 33	21,371 00	
Roxborough	263,176 77	66,744 00	
Total	$6,476,840 16	$1,330,423 00	$7,807,263 16

The cost of Fairmount Water Works include the cost to 1872, and under the same heading the Pumping Mains to 1890, also includes cost of Fairmount Dam, etc.

Cost of building previous to consolidation at Spring Garden, unknown, and the cost is approximated.

The cost of the Kensington building is unknown.

Works that have been discontinued, Breast Wheels that have been removed, and Engines that have been replaced.

Centre Square, located Broad and Market Streets in 1801, discontinued in 1815, capacity,.....	200,000 gallons.
Steam Works, located at 22d and Chestnut Streets in 1815, discontinued in 1822, capacity,.....	840,000 "
Breast Wheels 1, 2, 3, located at Fairmount in 1822,	.....
" " 4, " " " " 1827,	1,340,000 "
" " 5, " " " " 1832,	3,000,200 "
" " 6, " " " " 1834,	3,400,100 "
" " 7, 8, " " " " 1843,	4,422,400 "
Turbine Wheels 1, " " " " 1851,	2,000,000 "
" " 3, 4, 5, " " " " 1867,	5,300,000 gals. each.
" " 7, 8, 9, " " " " 1862,	5,100,000 "
Engines Nos. 1, 2, located at Schuylkill, December 31, 1844, now at Spring Garden, capacity,	1,000,000 gallons.
Sutton No. 3, located at Schuylkill, May 10, 1849, now at Spring Garden, capacity,..... ..	1,000,000 "
Cornish No. 4, located at Schuylkill 1854, now at Spring Garden, capacity.....	2,000,000 "
Side Lever Cornish No. 5, located at Schuylkill, November 3, 1869, now at Spring Garden, capacity,.....	5,000,000 "

Table of Reservoirs and Dams of the Schuylkill Navigation Company above Norristown, with their capacity, etc.

No.	Local Name.	Character of Geological Formation.	Length of Pool in Miles.	Elevation above City Datum.	Feeding Capacity in Cubic Feet.
	Tumbling Run Reservoir, No. 1.....	Conglomerate and Red Shale.....	0.75	642.16	25,546,500
	Tumbling Run Reservoir, No. 2.....	" " "	1.00	688.87	39,865.500
14	Lord's Dam.....	Red Shale.....	2.375	427.73	14,000,000
15	Humel's Dam.....	"	1.00	403.78	3,484,000
16	Blue Mountain Dam.....	Second Great Sand Rock.....	1.613	384.57	32,535,000
17	Kernsville Dam.....	Slates	0 620	359.68	4,370,000
18	Herbine's Dam.....	Limestone	0.85	260.71	5,510,000
	Duncan Canal.....	"	2.66	259.21	3,550,000
19	Felix's Dam.....	"	3 621	231.03	54,152,000
20	Leize's Dam.....	"	1.75	216.22	28,090,000
21	Shepp's Dam.....	"	1.15	207.85	16,394,000
22	Kissinger's Dam.....	"	1.12	199.14	18,216,000
23	Poplar Neck Dam.....	Limestone, Sandstone and Conglomerare.....	2.555	179.64	40,605,000
24	Lewis or Big Dam.....	" " "	2.47	172.62	48,903,000
25	Vincent Dam.....	Red Sandstone.....	1 96	96.83	26,700,000
26	Black Rock Dam.....	Oclite or Black Rock.....	3.555	79.37	71,795,000
	Oaks Canal.....	" " "	3.64	78.02	4,800,000
27	Pawling's Dam.....	New Red Sandstone.....	1.888	61.62	34,328,000
28	Catfish Dam.....	" "	3.96	56.95	65,926,000
29	Norristown Dam.....	" "	3.34	51.90	56,508,000
		Total.....	41.877		595,269.000

Total feeding capacity, 595,269,000 cubic feet, which is equal to 4,452,612,000 gallons.

Table of Revenue and Expenditures, showing Profits.

Year.	EXPENDITURES.			Total Expenditure.	Total Revenue from all Sources.
	Annual Appropriation.	Special Appropriation.	Loans for Construction		
1855	$168,765 22	$79,460 87		$248,226 09	$382,036 72
1856	139,293 60	21,174 42		160,468 02	415,325 91
1857	177,502 04	23,150 96		200,653 00	425,778 31
1858	175,016 86	12,961 23		187,978 09	457,648 23
1859	194,828 44	30,258 59	$186,650 06	411,737 09	551,187 06
1860	193,555 24	4,767 45	54,209 85	252,532 54	558,531 53
1861	161,200 36	1,485 90	76,342 11	239,028 37	533,980 06
1862	156,408 08	20,863 61	40,694 49	217,966 18	545,793 06
1863	193,691 38	17,069 54	2,989 28	213,750 20	586,222 50
1864	253,975 75	10,380 85	15,393 72	279,750 32	623,647 79
1865	274,765 20	13,857 80	133,093 87	421,716 87	643,953 10
1866	267,425 25	10,572 53	453,086 18	731,083 96	682,412 34
1867	322,935 30	37,571 12	215,324 95	575,831 37	755,343 17
1868	301,845 27	86,777 44	413,844 75	802,467 46	795,560 45
1869	388,744 29	52,499 47	468,521 35	909,765 11	829,860 73
1870	445,949 54	2,657 29	695,448 67	1,144,055 50	947,330 78
1871	439,406 35	5,857 85	623,929 20	1,069,193 40	977,998 55
1872	471,219 80	10,218 35	582,138 13	1,063,576 28	1,075,203 47
1873	532,598 62	1,663 96	1,030,068 03	1,564,330 61	1,109,586 72
1874	688,006 89	2,518 92	534,576 27	1,225,102 08	1,261,011 55
1875	674,693 51	35,139 56	228,503 67	938,336 74	1,235,536 56
1876	713,518 08	11,189 83	376,375 96	1,101,083 87	1,252,014 92
1877	484,613 87	3,058 18	183,177 83	670,849 88	1,284,214 67
1878	414,955 45	3,770 66	63,946 38	482,672 49	1,416,645 85
1879	438,884 72	4,808 96		443,693 68	1,465,625 01
1880	386,962 12	2,568 14	1,170 35	390,700 61	1,484,357 06
1881	438,486 50	126,862 41	18,038 83	583,387 74	1,509,541 34
1882	564,044 34	53,834 02	43,080 09	660,958 45	1,516,904 64
1883	655,695 66	171,801 53		827,497 19	1,627,069 16

Table of Revenue and Expenditures, showing Profits.—Continued.

Year.	EXPENDITURES.			Total Expenditure.	Total Revenue from all Sources.
	Annual Appropriation.	Special Appropriation.	Loans for Construction		
1884	823,258 75	210,357 26		1,033,616 01	1,792,486 01
1885	865,808 84	36,122 65		901,931 49	1,826,164 04
1886	565,423 39	397,976 68		963,400 07	1,933,328 34
1887	911,947 37	90,464 04		1,002,411 41	2,030,434 61
1888	1,190,605 00	3,302 40		1,193,907 40	2,114,926 50
1889	1,299,591 09	14,915 01		1,314,506 10	2,241,999 85
1890	993,364 29			993,364 29	2,381,037 70
	$17,368,986 46	$1,611,939 48	$6,440,604 02	$25,421,529 96	$41,270,698 29
					25,421,529 96
					$15,849,168 33

Table of Revenue and Expenditures, showing Profits.

Year.	Total Expenditures.	Total Revenue from all Sources.	Surplus.	Deficiency.
1855	248,226 09	382,036 72	133,810 63	
1856	160,468 02	415,325 91	254,857 89	
1857	200,653 00	425,778 31	225,125 31	
1858	187,978 09	457,648 23	269,670 14	
1859	411,737 09	551,187 06	139,449 97	
1860	252,532 54	558,531 53	305,998 99	
1861	239,028 37	533,980 06	294,951 69	
1862	217,966 18	545,793 06	327,826 88	
1863	213,750 20	586,222 50	372,472 30	
1864	279,750 32	623,647 79	343,897 47	
1865	421,716 87	643,953 10	222,236 23	
1866	731,083 96	682,412 34		48,671 62
1867	575,831 37	755,343 17	179,511 80	
1868	802,467 46	795,560 45		6,907 01
1869	909,765 11	829,860 73		79,904 38
1870	1,144,055 50	947,330 78		196,724 72
1871	1,069,193 40	977,998 55		91,194 85
1872	1,063,576 28	1,075,203 47	11,627 19	
1873	1,564,330 61	1,109,586 72		454,743 89
1874	1,225,102 08	1,261,011 55	35,909 47	
1875	938,336 74	1,235,536 56	297,199 82	
1876	1,101,083 87	1,252,014 92	150,931 05	
1877	670,849 88	1,284,214 67	613,364 79	

Table of Revenue and Expenditures, showing Profits.—Continued.

Year.	Total Expenditures.	Total Revenue from all Sources	Surplus.	Deficiency.
1878	482,672 49	1,416,645 85	933,973 36	
1879	443,693 68	1,465,625 01	1,021,931 33	
1880	390,700 61	1,484,357 06	1,093,656 45	
1881	583,387 74	1,509,541 34	926,153 60	
1882	660,958 45	1,516,904 64	855,946 19	
1883	827,497 19	1,627,069 16	799,571 97	
1884	1,033,616 01	1,792,486 01	758,870 00	
1885	901,931 49	1,826,164 04	924,232 55	
1886	963,400 07	1,933,328 34	969,928 27	
1887	1,002,411 41	2,030,434 61	1,028,023 20	
1888	1,193,907 40	2,114,926 50	921,019 10	
1889	1,314,506 10	2,241,999 85	927,493 75	
1890	993,364 29	2,381,037 70	1,387,673 41	
	$25,421,529 96	$41,270,698 29 25,421,529 96	$16,727,314 80 878,146 47	$878,146 47
		$15,849,168 33	$15,849,168 33	

ESTIMATED COST OF THE DIFFERENT PROJECTS.

FROM THE REPORTS OF RUDOLPH HERING.

Point Pleasant via Storage Dam on Neshaminy Creek.

181,000,000 gallons daily from Neshaminy and Tohickon creeks, by gravity, including 25,000,000 gallons daily for compensation; 54,000,000 gallons daily from Delaware river, at Point Pleasant, pumped by steam.

Aqueduct, length, 33.09 miles,	$7,333,280
7 Reservoirs and 8,954 acres of land and buildings,	7,218,382
Cost of pumping plant,	500,000
	$15,051,662
Interest at 4 per cent. on the above is $602,066.48 per annum; for 40 years it would be	24,082,659
Capitalized cost of pumping,	17,174,998
Total,	$56,309,319

From Point Pleasant to Philadelphia Direct.

80,000,000 gallons daily from Tohickon creek, by gravity; 130,000,000 gallons daily from Delaware river, at Point Pleasant, pumped by steam.

Aqueduct, length, 33.09 miles,	$7,836,009
4 Reservoirs and 3,297 acres of land,	3,327,057
Cost of pumping plant,	900,000
	$12,063,066
Interest at 4 per cent., $482,522.64---40 years,	19,300,905
Capitalized cost of pumping,	6,808,959
	$38,172,930

From Point Pleasant to Philadelphia Direct.

200,000,000 gallons daily.

80,000,000 gallons daily from Tohickon creek, by gravity; 120,000,000 gallons daily from Delaware river, at Point Pleasant, pumped by water power.

Cost of Aqueduct, 33.09 miles in length,	$7,386,009
4 Reservoirs and 3,297 acres of land,	3,327,057
Cost of pumping plant,	1,084,500
	$11,797,566
Interest at 4 per cent., $471,902.64—40 years,	18,876,106
Capitalized cost of pumping,	1,603,375
	$32,277,047

Steam-power at Lardner's Point.

210,000,000 gallons daily.

Cost of pumping plant, ...	$1,250,000
Interest at 4 per cent., $50,000—40 years,	2,000,000
Capitalized cost of pumping, . . .	12,516,085
	$15,766,085

New Hope to Lardner's Point. Open Canal.

210,000,000 gallons daily. Steam-power.

Cost of Canal Aqueduct, ...	$6,232,953
Pumping plant, ...	1,250,000
	$7,482,953
Interest at 4 per cent., $299,318.12—40 years,	11,972,724
Capitalized cost of pumping, . . .	12,516,085
	$31,971,762

Yardleyville to Wentz Farm Basin.

Four 5 feet pipes, 210,000,000 gallons daily. By steam.

Cost of Aqueduct, 20.76 miles, ...	$8,845,565
Cost of pumping plant, ...	1,250,000
	$10,095,565
Interest at 4 per cent., $403,822.60—40 years,	16,152,904
Capitalized cost of pumping, . . .	17,294,954
	$43,543,423

New Hope to proposed Basin Twelfth Street and Olney Avenue.

Masonry Conduit, 12 feet diameter. Capacity, 210,000,000 gallons daily, by steam-power.

Cost of Aqueduct, 28.541 miles, . . .	$6,367,224
Cost of pumping plant, ...	1,250,000
4 per cent. interest, $304,688.96—40 years,	12,187,558
Capitalized cost of pumping, . . .	13,502,201
	$33,306,983

Lumberville to proposed Basin Twelfth Street and Olney Avenue.

Masonry Conduit, 12 feet diameter. Capacity, 210,000,000 gallons. Steam-power.

Cost of Aqueduct, 30.568 miles, ...	$6,720,148
Cost of pumping plant, ...	1,250,000
Interest at 4 per cent., $318,805.92—40 years,	12,752,236
Capitalized cost of pumping, . . .	12,288,520
	$33,010,904

Point Pleasant to proposed Basin at Twelfth Street and Olney Avenue.

Masonry Conduit, 12 feet diameter. Capacity, 210,000,000 gallons, by steam-power.

Cost of Aqueduct, length, 33.09 miles, .	$7,373,559
Cost of pumping plant, ...	1,250,000
Interest at 4 per cent., $344,942.36—40 years,	13,797,694
Capitalized cost of pumping, . . .	10,998,984
	$33,420,237

Delaware River at Point Pleasant to Twelfth Street and Olney Avenue Basin.

Masonry Conduit, 12 feet diameter. 120,000,000 gallons daily by water-power; 90,000,000 gallons daily by steam-power.

Cost of Aqueduct, length, 33.09 miles,		$7,373,559
Water-power, pumping plant,	$1,084,478	
Steam-power, pumping plant,	700,000	
		1,784,478
Interest at 4 per cent., $366,721.48—40 years,		14,668,859
Capitalized cost, pumping by water-power,		1,603,375
Capitalized cost, pumping by steam-power,		4,713,850
		$30,144,121

Gravity Supply from Neshaminy and Tohickon Creeks to proposed Basin at Twelfth Street and Olney Avenue.

181,000,000 gallons daily. 80,000,000 from Tohickon creek, 101,000,000 gallons from Neshaminy creek.

Cost of Aqueduct, length, miles,	$7,333,280
7 Reservoirs and 8,954 acres of land,	7,218,382
	$14,551,662
Interest at 4 per cent., $582,066.48—40 years,	23,282,659
	$37,834,321

GRAVITY SCHEMES.

Delaware Water Gap to Philadelphia Direct.

By gravity, 210,000,000 gallons daily from the Blue Mountains.

Cost of Aqueduct, 103.07 miles,	$21,482,558
Cost of Storage Reservoirs,	2,500,000
Interest at 4 per cent., $959,302.32—40 years,	38,372,092
	$62,354,650

Delaware River at Portland to Philadelphia Direct.

210,000,000 gallons, by gravity.

Cost of Aqueduct, distance, 80.287 miles,	$18,528,061
Cost of Dam and Inlet,	750,000
Interest at 4 per cent., for 40 years,	30,844,897
	$50,122,958

To Perkiomen Creek at Green Lane, and from Treichlersville to Big Creek, affluent of Lehigh River.

210,000,000 gallons, by gravity; 53,000,000 gallons from Perkiomen creek, at Green Lane; 36,000,000 gallons from East Swamp creek; 121,000,000 from Aquanchicola and Big creeks.

Cost of Aqueduct, distance Conduits, 87.91 miles,	$13,002,215
15 Reservoirs, Upper Perkiomen, and 7,630 acres land,	7,288,566
Reservoirs Lehigh Water-shed, not including land,	2,500,000
	$22,790,781
Interest at 4 per cent., $911,631.24—40 years,	36,465,249
	$59,256,030

Not including compensation for water right along Lehigh river.

Northeast Branch and Perkiomen Creeks, near Schwenksville, to the proposed Cambria Basin.

194,000,000 gallons daily, by gravity; 151,000,000 gallons daily from Perkiomen creek; 43,000,000 gallons daily from Northeast Branch.

Cost of Aqueduct, length, 26.69 miles, .	$6,534,230
12 Storage Reservoirs and 13,449 acres land,	9,765,714
	$16,299,944
Interest at 4 per cent., $651,997.76—40 years,	26,079,910
	$42,379,854

Not including cost of extra Basins in the City and compensation for loss of water below Schwenksville.

LIST OF PUBLICATIONS RELATING TO THE SUBJECT OF THE FUTURE WATER SUPPLY OF PHILADELPHIA.

1. Annual Reports of the Water Department from 1856 to 1882.

2. Reports of a special committee of the Commissioners of Fairmount Park upon the preservation of the purity of the water supply, October, 1867.

3. Proposition of certain manufacturers of Manayunk for supplying the City of Philadelphia with pure water, contained in a memorial to the State Legislature, February, 1868.

4. On the water supply of Philadelphia. Pamphlet by James Haworth, 1871.

5. Memorial to City Councils on supplying the City of Philadelphia with water from the Schuylkill and Wissahickon, by James Haworth, 1875.

6. On the water supply of Philadelphia. Pamphlet by J. W. Nystrom, 1875.

7. Report on the present and future water supply of the City of Philadelphia, made to Councils by a Commission of Engineers, 1875.

8. Rainfall on the Basin of the Schuylkill river. Paper by H. M. P. Birkinbine; Franklin Institute Journal, March and May, 1876.

9. Future water supply of the City of Philadelphia. Two papers by H. M. P. Birkinbine; Franklin Institute Journal, May and July, 1878.

10. The water supply of Philadelphia. Paper by Charles G. Darrach; proceedings of the Engineers' Club, Philadelphia, May, 1879.

11. The future water supply of the City of Philadelphia. Paper by James F. Smith; Franklin Institute Journal, October, 1879.

12. The future water supply of Philadelphia. Paper by H. M. P. Birkinbine; Franklin Institute Journal, November, 1879.

13. The Philadelphia water supply. Report of a Commission to James Haworth, 1880.

14. Report on drainage from the Falls of Schuylkill November, 1882, and on the pollution of the Schuylkill river, January, 1883, by Russell Thayer, Superintendent of Fairmount Park.

15. Report on the pollution of the Schuylkill river, etc., to the Commissioners of Fairmount Park, by Dr. Charles M. Cresson, January, 1883.

16. Potability of the Schuylkill water supply. Report to a Board of Experts, by Professor A. R. Leeds, January, 1883.

17. Report of the Philadelphia water supply, made to Councils, by a Board of Experts, October, 1882, and April, 1883.

18. Report of William Ludlow, Chief Engineer, for the year 1883: Preliminary remarks on the water supply of Philadelphia, page 2; defects of the present water supply, page 41; quality of the present supply, page 45; the waste of water, page 50; surveys for future water supply, page 60.

19. Surveys for the future supply. Report of progress during 1883, by Rudolph Hering, assistant in charge, page 263, report 1883.

20. Final report of the Board of Experts, dated April, 1883, on the future supply and on the reduction of waste, page 334, report 1883.

21. Report of chemical investigation, by A. R. Leeds, Ph. D., page 343, 1883.

22. The present water supply, by William Ludlow, page 38, report of 1884.

23. Charge of Judge Thayer, Commonwealth of Pennsylvania *vs.* Soulas, et al., *In re* Pollution of River Water used for Drinking Purposes. Page 59, report for 1884.

24. Survey for future supply, by William Ludlow, pages 68 to 85, inclusive, report for 1884.

25. Report of Sanitary Survey of the Schuylkill valley, by Dana C. Barber, page 247, report for 1884.

26. Report on the surveys for the future water supply of the City of Philadelphia, by Rudolph Hering, page 315, report for 1884.

27. Report on Sanitary Surveys of proposed future supply water-sheds, by Dana C. Barber, page 344, report for 1884.

28. Chemical investigation into the present and proposed future water supply of Philadelphia, by Albert R. Leeds, page 353, report for 1884.

29. Improvement of the present supply, by William Ludlow, Chief Engineer, page 37, report for 1885.

30. Report upon the water supply, by Professors Mallet, Wormley and Greene, page 55, report for 1885.

31. Remarks upon the chemical report of Professor Leeds, by William Ludlow, page 77, report for 1885.

32. The future supply, by William Ludlow, page 78, report for 1885.

33. South Mountain Water Company, by William Ludlow, page 84, report for 1885.

34. Address of William Ludlow to the County Medical Society, page 106, report for 1885.

35. Water supply in relation to Sanitation, by William Ludlow, March 30, 1885, page 119, report for 1885.

36. Report on the Plymouth epidemic, by William Ludlow, page 136, report for 1885.

37. Surveys for the future water supply of the city of Philadelphia, annual report of progress during 1885, by Rudolph Hering, page 309, report for 1885.

38. Final report of a chemical investigation into the present and proposed future water supply of Philadelphia, by Albert R. Leeds, page 379, report for 1885.

39. The present and future water supply, by John L. Ogden, page 26, report for 1886.

40. Report of hydrographic work in connection with future supply, by Amasa Ely, page 257, report for 1886.

41. Surveys for the future water supply, final report of Rudolph Hering, page 267, report for 1886.

42. Address of Charles W. Dulles, M. D., on the Schuylkill river as a source of water supply, page 347, report for 1886.

43. Address of Dr. J. Cheston Morris on the supply of the Schuylkill river, page 381, report for 1886.

44. Annual report of Edwin H. Fitler, Mayor, Bureau of Water, present storage capacity, pumpage and requirements, page 19, report for 1890.

45. Annual report of Louis Wagner, Director Public Works, for the year 1890, Bureau of Water, on page 74, shows operations for the past four years and improvements made, dwells on the waste of water, and suggests remedies; gives earnings, amount of water pumped, storage capacity, and amount of water required.

46. Annual report of the Bureau of Water for the year 1890, John L. Ogden, Chief Engineer, page 140, report for 1890.

47. Report of dydrographic work, by John E. Codman, page 331, report for 1890.

COMMENTS ON THE WATER SUPPLY OF PHILADELPHIA.

By James Haworth, 1871.

The importance of a cheap and permanent water supply to the manufacturing and domestic interests of Philadelphia is too obvious for discussion. The water famines of 1869 and 1870 gave proof of the utter inadequacy of our present resources, and of the incontestable necessity of an increased supply proportioned to the emergencies of our growing census. To subserve immediate wants new reservoirs of increased capacity have been ordered and are well under way, but they promise but a partial reliance for extended periods of time, even in the absence of protracted droughts; for although the population of the city doubles every twenty-two years, its water consumption doubles every fourteen. It would be idle, therefore, to limit to our present scale of wants any scheme of supply. Ephemeral expedients have been too frequently adopted already. A comprehensive policy is inexorably demanded; a policy which, in contemplation of the vast aqueous resources of the City, and of its well-measured necessities, should embrace all the conditions, both of economy and comfort, which, during an extended future, in any way relate to the subject. To reason understandingly upon the resources of the Schuylkill, its volume has been measured and found nearly equal to all the wants of the City for the next half century.

The present midsummer daily consumption is about 40,000,000 gallons, sometimes rising to 44,000,000. If 40,000,000 be taken as the average, in 1884 it will be 80,00,000 gallons; in 1898 it will 160,000,000 gallons; in 1912 it will be 320,000,000 gallons; in 1926 it will be 640,000,000 gallons.

Thus, in fifty-six years, the enormous volume of 640,000,000 gallons per day must be elevated to the reservoirs to subserve our midsummer necessities and prevent a water famine. But 440,000,000 gallons will be the maximum midsummer daily product of the river even when the channel is full. The river supply at this ratio will barely last forty-five years.

The present mode of pumping by water power is comparably the cheapest, and should not be abandoned except from necessity; but if the water gets very low, not only is the supply itself abridged but the wheels stand still. Steam at such times becomes indispensable. If, however, the channel of the river could be kept continually full, steam could be dispensed with, and a vast economy thus accomplished. The main object of these comments is to show that the channel can be kept full; and not only that it can be kept full, but that the policy necessary to keep it full is the very cheapest of all the expedients which have been proposed in this connection. The feasibility of the scheme, moreover, will become more apparent when it is remembered that for ten months in the year the natural supply is unfailing, and only flags during six or eight weeks of the hottest weather.

The scheme about to be proposed is a modification of a project of Mr. Birkinbine, late Chief of the Water Department. The project is to dam the Perkiomen (the largest tributary of the Schuylkill) at an indicated point, and thereby obtain an impounding reservoir of enormous capacity.

The defect in Mr. Birkinbine's plan, was the further proposition to bring this supply to the City by an expensive aqueduct, which not only would entail an enormous outlay, but could not drain its reservoir (65 feet deep) lower than twelve feet from the top. On the other hand, if, instead of an aqueduct, the water were gradually drained into the river as required, it would not only suffice to keep the channel full, but the reservoir itself could be drained to the bottom, if necessary, and utilized to its last drop. The advantage gained by this policy would not merely consist in saving the expense of the aqueduct, but, at the same time, economize the wasteful and unnecessary expense of filling the basins by steam. The basins of 1869–70, had a capacity only of a two days' supply when water was plenty and the works all in motion. During the droughts their contents were only a few hours' supply; and even this was liable to be exhausted by a great fire. The City, in fact, stood on the brink of disaster. An extensive conflagration and a high wind might have rendered it a second Moscow. To prevent such a calamity the feeble expedient has been proposed of introducing water meters, after the nature of gas meters, and of raising the price of water at least to the rate charged in other cities. This is a conspicuous manifestation of "Penny wisdom and pound folly." Water, on the contrary, ought to be cheap and lavishly abundant, and can and ought to be made so. It is the very life and hope of the City. An opposite policy would strike a death blow at the manufactures of Philadelphia, and sap the very foundations of her prosperity.

But assuming a perennial supply in the river by the aid of these reservoirs (which can be tapped whenever the river channel requires it), there are two modes of filling the basins:—

First.—By steam pumps, which make it cost $20 per 1,000,000 gallons, if raised to the necessary height of 160 feet, and

Second.—By water wheels, whose cost for the same height is less than $2 per 1,000,000 gallons.

The alternative, therefore, of employing steam or water power for this purpose would seem to offer very little basis for discussion. Their relative cost is nearly twenty to one in favor of water-power. Indeed, it would have been a wanton attack upon the treasury of the City to have proposed the former, but for the sudden paralysis of the water wheels by drought during the last two years.

If, notwithstanding a constant conflict with the tides, water can be elevated to the Fairmount basin for less than two dollars per million gallons by the aid of water-power, the same proposition is more than true at the Flat Rock dam, where there are no tides, and where the fall is twenty-four feet; indeed, one of the turbines now in use at Fairmount would pump four times the amount at Flat Rock, owing to this increase of head. Notwithstanding these incontestable truths, the whole volume of the river at that point, so far as the city supply is concerned, is running to waste. In superaddition to all other inducements to the use of the Flat Rock water-power and supply, is the fact of its vastly greater purity; nearly all the abominations which contaminate the river, as set forth by the official reports, being at or below Manayunk. Even after being used as power at Flat Rock, the same water would be none the less available a second time at Fairmount; in fact, the same quantity of water could do so largely an increased duty at Flat Rock that astonishment must arise at the reflection that no attempt to utilize this admirable power should ever have been made. This astonishment is enhanced by the further reflection that it is equally available at the terminus of the canal below Manayunk, some two miles nearer to the city, and might even throw its product into a basin south of the Wissahickon. In the full face of these propositions, five large and expensive steam pumping works have been established, and two

other, one of which is to be larger than all, are now under consideration. It would be an interesting question, therefore, to determine why turbines could not have been employed on the west side of the Fairmount dam, as well as on the east, and why steam should have been accepted in their place as an imperious necessity? The same remarks apply to Flat Rock. The heights adjacent to both these dams, on both banks of the river, afford every desired facility for basins upon commanding elevations which would subserve every public necessity. Those on the west of Flat Rock would dominate the entire habitable portions of the Twenty-fourth Ward. For the convenience of the more elevated parts of the Twenty-first and Twenty-second Wards, also sites for basins south of the Wissahickon could be selected where the natural surface is not only from a hundred and fifty to two hundred feet above tide, but far above the horizon of local consumption. By merely stretching dams across the embouchures of valleys on these elevations, natural basins could be completed for five or ten per cent. of the cost of ordinary construction.

Nature, with the most indulgent prodigality, appears to have laid out and designed the banks and channel of the Schuylkill for the very purpose here contemplated, in order to spare trouble to engineers and treasure to the city exchequer. Yet these eternal hills are repudiated, and the councils have now under consideration a scheme to erect two other basins, one of which is to be a vast artificial hill of an area of 106 acres, and at a cost of over two million of dollars, when a little way off the work is already virtually accomplished and waiting for us.

These proposed basins, moreover, must be supplied by steam. They are too remote from either of the dams to be conveniently filled by water-power. Every million gallons of their vast contents, therefore, will forever cost the City $20.00 instead of $2.00. Steam pumping machines

costing $2,500,000 are required for the purpose. The present supply of Germantown, owing to its increased elevation, costs the City $52.00 per 1,000,000 gallons. If pumped by water-power at Flat Rock it could be done for $6.00 or $8.00, notwithstanding its more than double height; and if pumped by water from the Wissahickon, could be procured at from $3.00 to $5.00 per 1,000,000 gallons, according to the quantity.

As time runs on, it might prove expedient to establish other feeders on the higher tributaries of the Perkiomen, or of the Schuylkill itself. They would not only supplement any possible deficiency of the first dam on the Perkiomen, but like that would serve to restrain the destructive force of freshets, and by retarding the current permit it to purge itself of mud and other impurities which constitute the only casual objection to its use. They would all, moreover, supply a water-power, which could be rented out to mills and factories, etc., in the City, where—costing the Department but $2.00 per 1,000,000 if pumped by water—it would rent for $10.00 for power. Many establishments now in Philadelphia are obliged to employ steam pumps in wells of their own, rather than pay a large price for the variable supply heretofore furnished by the City.

For all these shortcomings there is an easy and decisive remedy, and, strange to say, the most effective remedy is the cheapest. This vast economy is to be found in the exclusive employment of water-power for pumping purposes. No one denies that if this power is steady, constant and uninterrupted (even in time of protracted droughts), that it is incontestably the cheapest and best. The only difficulty has been to render it unfailing. As matters now stand, it is precisely in time for our greatest need that it fails. If such a disaster could be prevented, there would be heard but one opinion on the subject.

From the supposed impossibility, however, of its prevention, the use of water-power has been abandoned in despair and steam-power resorted to, which costs from ten to twenty times as much. It can very readily be shown, however, that at a very moderate expense the dams at Flat Rock and Fairmount can be kept breast-full during any drought, and accordingly that the use of steam for pumping purposes can be dispensed with. That expedient, as above mentioned, consists in the construction of one or more impounding dams on the Perkiomen, whose volume would be sufficient, if judiciously paid out in time of drought, to keep the river full.

As to the competency of the Perkiomen to supply the water required, there is no room for reasonable doubt. Although Mr. Birkinbine (possibly under a misapprehension of our views) asserts in the *Press*, of the 3d of July, 1871, that fifteen such dams as we propose would be requisite for the purpose. He nevertheless states in his annual report for 1866, p. 21, "that if additional reservoirs on the head waters of the same stream are employed, 240,000,000 gallons per day can be continually procured for the use of the City." This enormous daily supply he proposed to bring to Philadelphia by expensive aqueducts, estimated by him to cost from $6,000,000 to $8,000,000. The writer of this article, however, can prove upon Mr. Birkinbine's own data, that with the aid of these impounding dams on the Perkiomen, that same amount of 240,000,000 gallons per day could be pumped by turbines into the basins to the height of 160 feet if necessary, and (as before stated) at an expense (comprehending interest on the entire plant) not exceeding $2.00 per 1,000,000.

Every engineer is aware than an inverted syphon, if partially filled, will exhibit water at the same level in either arm. But although water will thus elevate water to the same point of gravitation, it will not pump it to this height without additional power. On the contrary,

two gallons, as a minimum, with the instrumentality of the best mechanism, must be expended in power to pump one gallon back to the same dam from which the power comes. This is also true for any height of dam. Accordingly, as the average height of the Fairmount dam (as between the high and low tide) is eleven feet, and as three feet must in all cases be deducted for friction and waste, if turbines be used, and four or more feet for breast and overshot wheels, we shall then have at Fairmount, for turbines, but eight feet of fall, which can be utilized as power. It will, as before stated, require two gallons of water to restore one to the dam by its turbine wheels. But the Corinthian avenue basin is 120 feet above the dam, or fifteen times higher than its available fall. It will, therefore, need thirty gallons, or 15×2, to elevate one gallon by the turbines to the Corinthian avenue basin. Mr. Birkinbine, however, thinks (and in his *Press* article says) that it will require only fifteen gallons for this purpose.

At Fairmount the tide interferes so much with the power of the turbines, that on an average from 35 to 40 gallons of water must be employed to pump one into the basins, the wheels for several hours making at tide, only from a third to one-half the number of their revolutions when at full speed. If Fairmount were 160 feet high from 45 to 50 gallons would be requisite for the same purpose.

Before relinquishing this subject, it may be well (in the interest of the City treasury) to reinforce what was previously advanced on the subject of prodigally expensive basins. It would seem to be little short of lunacy to spend two or more millions in the construction of artificial hills or basins whilst a series of natural basins, almost ready made, are now waiting in convenient places for use. Take, for instance, the valley of the rivulet entering the Schuylkill at the Falls, on the east side. An invaluable

basin (equal perhaps, to all the emergencies of the City for many years) could be there constructed by the cheap expedient of throwing a dam across the upper portion of it. Others to the south of this could likewise be constructed, as the river on both banks abounds in similar situations.

As a summary, then, of the foregoing views, it is asserted:

First.—That impounding dams as above stated would demonstrably suffice to supplement the short supply of the Schuylkill during the summer months, and thus render the use of its water-power available for pumping the city supply all the year round.

Second.—That the expense of these impounding dams would be inconsiderable, and would constitute the cheapest expedient beyond all comparison for keeping the city basins continually filled.

Third.—That the water-power of the Flat Rock and Fairmount dams is worth a million dollars a year to Philadelphia, and that it is a disgraceful exhibition of prodigality and ignorance to throw it entirely away, and then to resort to the most expensive of known substitutes in its place.

Fourth.—That the use of water-power, as above proposed, would furnish Philadelphia with a better quality of water than it now gets, in greatly increased volume, and at the low rate of $2.00 per million gallons, which would pay, not only all expenses of working and a full interest on the entire plant, but would furnish a large amount of water which could be rented out throughout the city at $10.00 per million gallons for the purpose of power, thus largely augmenting the business prosperity of the city, as well as its rental and revenue, from this department.

Fifth.—That the enormous sums spent and proposed to be spent upon new artificial basins, whilst natural basins,

almost completed and ready for use, are at the disposition of the city, are an utterly unintelligible departure from the dictates of municipal thrift, enlightened engineering, or official duty.

Sixth.—That the increased height of Flat Rock dam would give one turbine the effect of four at Fairmount, with the corresponding economy of one-fourth the cost of buildings and one-third the number of men; each turbine pumping twenty million of gallons per day, or about four times as much as the largest Cornish steam pumps at the Spring Garden works.

Seventh.—That in the distant future the water of the Delaware could be procured, if required, by the application of the same principles, giving Philadelphia the cheapest and most abundant water supply of any large city in the world.

JAMES HAWORTH.

REPORT OF THE COMMISSION OF 1878.

Showing that the Fairmount Water Works realize less than thirty per cent. of their proper effect; and even this after the machinery had been put in repair for the experiments of the Commission. (pp. 94 and 107).

A NEW PLAN FOR THE PHILADELPHIA WATER SUPPLY.

BY JAMES HAWORTH, 1878.

As the offspring of the facts brought forth by the accompanying report, the undersigned considers the following to be the most judicious mode of supplying Philadelphia with water:—

The City of Philadelphia can be furnished with 100,000,000 gallons of pure water, every day in the year, by adding to the present volume of the Schuylkill an occasional supply from a large dam, which could be constructed on the Perkiomen creek.

This supply, whenever required, could be run down its natural channel to the Flat Rock Dam, and from thence to a point nearly opposite Fairmount by a canal on the west side of the river.

The combined head at this place of the two falls (Fairmount and Flat Rock) would be 36 feet, and the pumps would have 24 feet less lift into the basins than at present from Fairmount dam. This head would be so powerful that the little seven feet turbine wheel, No. 1, now at Fairmount, would give a power of 1200 horse, and a daily pumpage (after deducting one-third for friction, etc.) of 40,000,000 gallons into the City basins, which will exceed the present daily average consumption of the City.

The present supply of Roxborough and Germantown from the Flat Rock Steam Works, which costs the City $60.00 per 1,000,000 gallons, could be derived from the Wissahickon, by water-power, at $2.00 per 1,000,000 gallons.

The aggregate cost of coal for the steam pumpage of 1879 was $65,000, which would pay the interest on the entire plant of the plan here recommended; while, at the same time, this plan would obviate the expense of the very costly sewer from Flat Rock to tide-water, which would be indispensable under the present system; which has since been built.

The cost of supplying water by the above plan, would only be about fifty cents per 1,000,000 gallons for running expenses, as the works would require but a small amount of machinery and but few hands.

This plan, instead of harming the power of the mills at Manayunk, will, on the contrary, maintain the power steadily through seasons of drought.

At present there is over 191,000,000 gallons basin capacity, and yet it may be said that little more than 100,000,000 gallons is ever stored. As will be seen, there is about 90,000,000 gallons storage capacity never used; and this does not look as if the City was short of storage basin room. When there is need of more storage capacity, we would recommend the building of a natural basin, on George's run, which is already surrounded on three sides by hills, and all that would be necessary to make a most efficient basin, would be simply to build a strong bank across the mouth of the ravine. Such a basin could be built (without either bricks or stone) to hold from 5,000,000 to 1,000,000,000 gallons, at an expense of from $20,000 to $30,000; whereas the Department want $900,000 to complete the East Park Reservoir. (Since finished.)

The Department have not at present any need of more basins, as those they have are not kept more than half

full, on an average, as will be seen by referring to pages 58, 59 and 60 of this report.

Having kept a close eye on this Department for many years, we have come to the conclusion that the Fairmount Water Works have not been supplying more than one-sixth of the water that they could have done (without any extra expense), whether the river was high or low, for the following reasons:—

1. The pumps are only pumping one-third of the water that they register, on account of their bad, leaky condition.

2. The turbine wheels are only run one-half of their proper speed, even when water is running to waste over the dam; and at other times, the Department allows the water to run to fearful waste through the wheels, when they are ostensibly stopped for want of water.

3. The wheels are systematically run at high tide, and stopped at low tide; when at high tide, those in the new wheel-house have only 108 horse-power, and at low tide, 250 horse-power per wheel; and those in the old wheel-house have at high tide, but 144 horse-power, and at low tide, 334 horse-power. This shows the immense difference of the power at high and low tides.

The above should be no secret, for any intelligent man can ascertain these facts, at any time, by going to the works with his eyes open.

JAMES HAWORTH.

Preface.

Oppressed with age and infirmity, the undersigned, through the accompanying report, takes final leave of a subject which has engaged his attention for many years.

The grave and long continued errors, which have pervaded the administration of the Philadelphia Water

Department, have caused him to feel it to be a duty to impart to the public the facts here set forth. Amongst the reasons which most urgently induced him to assume the great expense and trouble attending this subject, may be mentioned the following:—

First.—That the true condition of the water works would scarcely be revealed by any commission or investigation authorized by a political party, for the reason that the integrity of such a report would naturally be questioned.

Second.—That notwithstanding the expenditure of the city upon the commission of engineers of 1875, that commission failed to bring to light the errors, below detailed, as urged and specified before them by the undersigned, and even reported (page 23) that the Fairmount Water Works utilized sixty per cent. of their power, and ought to utilize eighty, whilst in point of fact, some of the wheels utilized but from fourteen to twenty-two per cent. and the others from twenty-two to twenty-eight per cent. only.

Third.—That for years an enormous volume of water has been observed to enter the flumes to the Fairmount wheels, while scarcely a perceptible current was visible where their pumps discharged into the basins—a fact ignored by the commission of 1875.

Fourth.—That the Fairmount water works have pumped less water, since the introduction of the six largest pumps, than before; their estimated capacity being 34,000,000 gallons, and their actual performance less than 23,000,000 per day.

Fifth.—That during the water famine of 1869, the water level in the Fairmount dam was drawn down three feet below its breast, thereby cutting off a supply of water from the pumps, and also stopping the navigation. Damages to the extent of a quarter of a million of dollars were thus entailed upon the city, together with the risk of a Chicago fire.

Sixth.—That during this water famine, the wheels were continually run at high tide and stopped at low tide, thus enormously diminishing their power and efficiency.

Seventh.—That the basins for long periods of time were kept but half filled and many citizens thus deprived of water; and, as a consequence, muddy water had to be used after every storm.

Eighth.—That neglecting to use the cheap water-power of the Schuylkill, expensive steam works were unnecessarily erected at Kensington, Frankford, Roxborough, etc.

Ninth.—That for the ten years prior to 1874 the City not only received no revenue from the Water Department, but lost the sum of $400,000 over and above all its heavy appropriations during that period.

The undersigned has long been of opinion (as is hereinafter demonstrated) that the water-power of the Schuylkill river, with the aid of proper impounding dams, can for nearly a century to come, furnish the entire supply of Philadelphia, and at the same time endow its treasury with an income of $500,000 per annum. The pamphlet published early in this year (1878), entitled "A Discussion of the Economic Value and Engineering Mismanagement of the Fairmount Water Works," will give his views more in detail on these points.

Under the existing system, the officials of the Water Department manifest no interest in the welfare of the City; nor does it appear in any way feasible to render their interests and those of the City identical, unless by consigning the Department to the control of a private company. Should the City thus be enabled to realize an abundant, cheap and permanent water supply, the most cherished hopes of the undersigned in this connection will have been accomplished.

JAMES HAWORTH.

Philadelphia, December, 1878.

REPORT TO JAMES HAWORTH, ESQ., ON THE WATER SUPPLY OF PHILADELPHIA.

SIR:—The Commission appointed by you to investigate the water supply of Philadelphia, has the honor to report that its labor is completed as far as the permission granted by the Water Committee of City Councils extended.

The interrogatories given in your letter of July 22, 1878, as well as your application to the Water Committee for permission to make experiments at Fairmount, did not include the steam water works, which you afterwards desired to be investigated; and which, although commenced, was not completed, because the Chief Engineer of the Water Department did not consider himself authorized to allow it, as will be seen in the correspondence embodied in this report.

This is to be regretted, because the investigation of the water supply cannot be rendered complete without that of the steam works.

The water in the Schuylkill river has been very low during this whole summer (1878), which has occasioned delay in finishing this report, as opportunity for experiment could be secured only from time to time according to the state of the river, when the works at Fairmount could be placed at the disposal of your Commission.

The General Superintendent of the works, Mr. Robert McFadden, as well as the engineers, Messrs. Joseph Moyer and A. C. Bonsall, are entitled to the thanks of your Commission for their unvarying kindness and courtesy in giving every facility for the accomplishment of its task.

The Chief Engineer, Dr. McFadden, was requested to appoint an Assistant Engineer of the Water Department to join your Commission and witness the experiments, which was declined, as no one connected with the water works appeared to take the slightest interest in the same. Your questions are printed in black italics, and the Commission's answers in roman letters.

In the organization of your Commission, it was solemnly agreed, according to your request, that no policy or etiquette should impair the integrity of its report, whatsoever interest it might affect.

In order to avoid confusion, it was further agreed, that in case of difference of opinion, each member of the Commission could append his individual ideas signed by himself. The few differences that have arisen, however, have finally been harmoniously reconciled, the result of which is that the Commissioners have the pleasure and honor of submitting to you herewith their unanimous report.

JOHN W. NYSTROM,
W. BARNET LE VAN,
WILLIAM DENNISON,
Commission.

TO JAMES HAWORTH, ESQ.,
Philadelphia, December 30, 1878.

(Most of the important points relating to the supply of water are embodied in Mr. Haworth's report. There are two or three papers which it might be well to copy).

Water-power at the Flat Rock Dam, or Manayunk.

Abstract of Report of the Commission, 1878.

The surplus water flowing over Flat Rock dam, above that consumed by the mills and canal, is about equal to

the overflow at Fairmount, because the water works consume about as much more water than the mills, as the supply from the Wissahickon, and the water-power at Flat Rock ought to be utilized for supplying the city with pure water.

All investigators of water in the Fairmount dam, in a sanitary point of view, agree that the impurities thrown into the river at Manayunk are very injurious. This serious evil can be avoided by pumping water from the Flat Rock dam for the city supply. There is an excellent location for water works between the canal and the river, a few hundred feet below the Falls, or near the second lock.

If arrangements could be made between the city and the Reading Railroad Company for a lease of that ground and water power, it would make the best water-works in Philadelphia.

The head of fall at Flat Rock is about double that of Fairmount, and free from tide water.

The dam between the guard lock and the second lock, would answer for the water works, and could easily be enlarged if necessary. In case all the water power now used at Manayunk could be rented for these water works, one or two mains, of not less than five feet in diameter, should be laid along the river to any storage reservoir provided therefor.

The plan you have suggested, namely, to raise and widen the canal from Flat Rock, and erect water works at the lower part of Manayunk, deserves consideration.

Thus Flat Rock and Fairmount Water Works would be sufficient to supply Philadelphia with plenty of water for a great many years to come, without the aid of steam pumping, as you have suggested.

Reservoir on George's Run.

Your Commission has examined the location referred to, and thinks it feasible to build a retaining wall or embankment across George's Run, at some point near the crossing of the proposed north Fiftieth and Dauphin streets, or above Bryn Mawr.

The ground appears to be favorable for retaining water, but your Commission has made no survey of the place, and can therefore not estimate the cost and capacity of such a reservoir.

Mr. James F. Smith, Chief Engineer of Schuylkill Canal, proposes to build water works on the west side of the Schuylkill below Flat Rock Dam, and lead the water to some storage reservoir on the hills, so elevated as to permit the water to be carried to Belmont, or any other reservoir on the west side of the river.

This proposition is similar to that previously made by yourself, namely, to build a retaining bank over George's Run, to form a natural basin for a storage reservoir.

There are several other locations on the west side of the river, where, as you have suggested, natural basins could be constructed high enough to supply Philadelphia with water pumped by water-power, either from Flat Rock or from Fairmount dam.

The plan you have suggested, namely, to raise the Delaware and Corinthian reservoirs for supplying Frankford with Schuylkill water by water-power would, no doubt, answer.

Frankford could be supplied direct from East Park reservoir; and, still better, from the proposed Cambria reservoir, which would be at least twenty feet higher.

The location of the proposed Cambria reservoir is marked with red ink, east of Laurel Hill, on the distributing map made by the Water Department and presented to your Commission.

Perkiomen Impounding Dam.

Abstract of Report made by the Commission in the year 1878.

The Commission of Engineers of 1875, estimated the capacity of an impounding dam on the Perkiomen, for the purpose of supplying Philadelphia with water by gravitation, and proposed to fix the water rise at seventy feet, with twenty-five feet to be drawn out, which would furnish 10,000,000,000 gallons of available water, exclusive of two feet in depth allowed for evaporation. The total capacity of this reservoir would probably be 20,000,000,000 gallons.

The water-shed of the Perkiomen is estimated at 220 square miles above the proposed dam, and the annual rainfall, 48 inches at 60 per cent., will be 28 inches available, or 109,000,000,000 gallons per year, which is a daily average of 300,000,000 gallons. The proposed dam is, therefore, much too small for its water-shed, but could be increased to, perhaps, double that capacity or more, by raising the dam sufficiently high to hold at least three-quarters of the annual rainfall, or say 80,000,000,000 gallons.

The height of 70 feet proposed by said Commission, was intended only for a dam to supply water direct by gravitation to the East Park Reservoir, and not for water-power at Fairmount Park.

The maximum capacity of the present water works at Fairmount is 35,000,000 gallons per day, with full water in the river, and the minimum capacity in the dry season is 16,000,000. Then for the full capacity of said work in the dry season 35.16—19,000,000 gallons per day must be pumped by storewater from impounding dams. With the present extravagant waste of water-power at Fairmount, 37 gallons for pumping 1, would require 37 x 19—703,000,000 gallons per day from impounding dams, and

80,000: 703—113 days supply from the Perkiomen. With properly proportioned pumps and turbines at Fairmount, and with the aid of the Perkiomen dam, the City could be supplied with at least 80,000,000 gallons of water per day the whole year round.

With adequate works at Flat Rock, this amount would again be more than doubled, or 180,000,000 gallons could be pumped per day by water-power alone.

Your Commission believes that the cheapest way of supplying Philadelphia with water in the future, would be to build water works at Flat Rock, and an impounding dam on the Perkiomen, which, together with the present, would be sufficient until the end of this century. In the year 1900, mains from the Perkiomen to Philadelphia will be required for supplying water by gravitation, 200,000,000 gallons daily.

Cost of Perkiomen Dam and Gravitation Supply.

From the Report of the Commission on Water Supply, 1878.

The commission of engineers of 1875, estimated the cost of an impounding dam on the Perkiomen, raised seventy feet, at $780,000. A dam to hold three-quarters of the annual rainfall would cost, perhaps, one million of dollars; it is, however, impossible to estimate the cost correctly without making a survey of the same.

The same commission estimated the cost of the gravitation plan at $10,000,000 for a daily supply of 100,000,000 gallons, and at $12,000,000 for 200,000,000 gallons daily.

Muddy Water.

The capacity of all the reservoirs, except the East Park, is 191,778,000 gallons, and, if the city requires 50,000,000

registered gallons per day, which is, perhaps, not more than 36,000,000 actual gallons, the required number of days will be 5.3 days, in which time the muddy water might pass. This, however, implies that all the water should be drawn out from the basins, which is not available, but three days might be allowed for stopping the pumps. With the aid of the East Park reservoir of 750,000,000 gallons, added to the other reservoirs, there would be 941,778,000 gallons, which could supply the city with water for ten days, without pumping.

Capacity of the Works.

Theoretical capacity of all the works, 127,042,288 gallons per twenty-four hours.

Practical capacity, 90,564,000 gallons per 24 hours.

The consumption, assuming the population of Philadelphia to be 820,000, consuming on an average 34,300,000 gallons per day, will make 42 gallons, or one barrel per head.

Hydrography of the Wissahickon.

The report of the Water Department for 1866, page 12, in the Appendix, says: "Water for supplying the city could be obtained at sufficient elevation ten miles above the mouth of the creek, and thirteen miles north of Broad and Market Streets. Above this point the creek has a surface drainage of forty-four square miles."

The drainage area above Bischoff's mill, six miles from the Schuylkill, is about fifty-five square miles, and with an annual rainfall of 46.5 inches, which, at 60 per cent. available, say twenty-eight inches, will make 26,873,259,600 gallons per annum, there would be a daily average of 73,766,000 gallons.

Suppose the Wissahickon to be dammed up to a twenty-five feet fall at Bischoff's mill, which is 114 feet above city datum, the dam would then be 131 feet above the water works erected here for supplying Mount Airy and Roxborough reservoirs, which are, on an average, 364 feet above city datum, or 233 feet above the proposed dam; there would then be required theoretically, 9.32 gallons of water to pump one into the reservoir, and, supposing the duty of the water works to be fifty-two per cent., then eighteen gallons would pump one into the reservoir practically.

Suppose the monthly percentage of rainfall to be as given on page 13, the hydraulics at Bischoff's mill would be, on an average, as in the following table.

The above table approximates the average hydraulics of the Wissahickon, without allowance for droughts, which would embarrass these works like those at Fairmount; but, by the aid of impounding dams and a storage reservoir, their supply could be made more reliable.

The plan suggested by you, namely, to build temporary water works on the Wissahickon, above the pier aqueduct, and connect them with the inverted syphon leading to Roxboro and Germantown, deserves consideration.

Relative cost of Steam and Water-Power.

What is the relative cost of pumping the City water supply by steam (as now practiced), or by water-power, at Fairmount and Flat Rock?

The cost of raising 1,000,000 gallons 100 feet high, at Fairmount, was $1.74 by the old breast-wheels, and averages $2.00 by the turbines. With interest on plant, the cost will be $11.70 for the water-wheels and about $14.00 for the turbines.

The cost of raising water by steam depends much upon the construction of the engines and boilers, and particularly upon the grade of expansion of the steam. The cost varies between $6.00 and $21.00 per 1,000,000 gallons raised 100 feet high, for running expenses.

With interest on plant, the cost of steam-power varies between $15.00 and $30.00 per 1,000,000 gallons raised 100 feet high.

In comparing the cost of steam-power and water-power for pumping, it will not be correct to base the calculation on running expenses and on interest on plant alone, because a steam engine does not last as long as a water-wheel.

The Fairmount breast-wheels lasted from 1822 to 1862, or 40 years. In this time many steam engines have broken down, were condemned, and new ones substituted; and there are now several steam engines standing idle, either unfit for use or too expensive to run.

In view of these considerations, your Commission thinks that steam-power costs ten times as much as water-power.

REPORT
OF
COMMISSION OF ENGINEERS, YEAR 1875.

June 5, 1875. In pursuance of an ordinance passed by Select Council (*Appendix No. 59*), entitled: "An Ordinance to appoint a Commission on supply of water for the City of Philadelphia.

In accordance with the foregoing ordinance, the following five Civil Engineers were appointed Commissioners by the Hon. William S. Stokley, Mayor of Philadelphia: W. Milnor Roberts, of New York; Wm. J. McAlpine, of Albany; Julius W. Adams, of Brooklyn; W. E. Morris, of Philadelphia; Solomon W. Roberts, of Philadelphia, who, in connection with Wm. H. McFadden, Chief Engineer of the Water Department, constitute the Commission.

From the report of the Commission aforenamed, the following extracts have been taken bearing upon the supply of water for the City of Philadelphia from the Schuylkill river, and also the comments and statements made in reference to other sources of supply.

On page 102:

Water-power of the Schuylkill River.---Fairmount Dam.

This structure was built to serve the double purpose of forming a pool for slack water navigation and furnishing power to drive the Fairmount pumps.

There is, therefore, a divided interest in the water and its use.

Page 103:

First.---By the decision of the Supreme Court of the State, the people upon its banks have the right to the water for the purposes of life, and the Navigation Company for transportation.

Second.---By agreement between the City and the Navigation Company, there is reserved to the use of the Company, the water necessary for the passage of boats through the locks.

Third.---The remainder of the water can be used by the City as power: *Provided*, That in using it the water is not drawn below the comb of the dam.

In the *Appendix* is a diagram, marked (*a*), that will explain the subject more fully.

By the contract beforementioned, the water was not to be drawn below the comb of the dam, marked in the drawing "Old Comb," or legal comb. If drawn below it, the City becomes liable to damages; if suffered to rise above it, the water ran to waste over it.

Page 105:

Daily flow of the river Schuylkill in the month of July was 249,000,000 gallons.

Page 110:

Pumping by Water at Manayunk, using the power of Flat Rock Dam.

It has been proposed that the city should lease or purchase the surplus water-power of the Flat Rock Dam, and use it for pumping into the East Park reservoir.

The total fall from the pool of this dam to that of Fairmount is twenty-six feet, and of this there is now available for power about twenty-two and a half feet, and with well constructed wheels eighty per cent. could be realized as useful effect.

At present seventy-two per cent. of this power is rented temporarily on short leases to different parties, for the sum of $33,443 per annum, and these leases can be terminated within twelve months, and probably might be transferred to the city upon fair terms.

At times of the minimum flow of the river, say for three months, this seventy-two per cent. of the water would raise into the East Park reservoir, through one pipe of four feet diameter, 20,000,000 gallons per day, and during the remaining nine months of the year, when the river is above minimum flow, and with proper arrangements for its use and application, it would raise about 27,000,000 gallons per day.

Page 111:

From the Flat Rock dam to the East Park reservoir the distance is nearly 30,000 feet, or about five and two-thirds miles, and the elevation of the reservoir above the pool is 104 feet.

It is not contemplated to take the water from the Manayunk canal to supply the pumps, but from the Flat Rock pool, and the above length of pipe is sufficient for both the pumping and the supply main.

To erect two turbine wheels, with pumps suited to the above purpose, with land and buildings, and to lay this four foot pipe would cost seven hundred and twenty-five thousand dollars ($725,000.)

To arrive at the value to the city of the water-power proposed to be leased, we will compare the cost of a year's pumping by water with that of pumping by steam. For this purpose we assume the cost of running the water-power machinery, including all repairs and renewals, at three cents per million gallons raised one foot high, and the cost of running the steam machinery, including repairs and renewals, at fifteen cents per million gallons raised one foot high, adding in each case to the elevation the head due to frictional resistance.

Cost of Water-Power.

Pumping 20,000,000 gallons per day, for three months, and 27,000,000 gallons per day, for nine months, from Flat Rock pool into East Park reservoir.

Running expenses, repairs and renewals, . .	$37,881
Rental, as above, ...	33,443
Interest upon cost of works ($725,000), . . .	43,500
Annual cost by water-power, ...	$114,824

As it is not necessary that the steam works should be placed at Manayunk, if built, they should be located at the Spring Garden Works, distant from the reservoir 2,000 feet, and having a four foot main and an elevation to overcome of 130 feet above Fairmount pool.

Cost of Steam Pumping.

To raise 20,000,000 gallons for three months, and 27,000,000 gallons for nine months, the machinery required, with buildings, including 2,000 lineal feet of four foot pipe, would cost $346,000.

Running expenses, repairs and renewals, . .	$183,049
Interest upon cost ($346,000), ...	20,760
Cost of pumping by steam, ...	$203,809
Deduct cost by water-power, ...	114,824
Difference in favor of water-power, ...	$88,985

Page 112:

To this it is proper to add something for the saving that would result in case of adopting the proposed water-power, by supplying Manayunk from the East Park reservoir, 135 feet above City datum, through the proposed

four foot main, instead of the Manayunk supply being pumped, as is now done, into the Roxborough reservoir, 365 feet above City datum, and then drawn down to the low level of the greater part of Manayunk.

About 500,000,000 gallons per annum are thus pumped at a loss of about $17,000 as compared with the water-power pumping.

In our opinion the rental of the 72 per cent. of the Flat Rock water-power and its application to pumping into the East Park reservoir would be justified.

This view is taken with the proviso that the Reading Railroad Company will favor the arrangement in accordance with the views expressed above; and also that a proper site can be obtained in Manayunk upon which to erect pumping works. The space required would not be large.

Page 113:

If this is not practicable, the suggestion of Mr. Smith to locate the works upon the west side of the Schuylkill is worthy of consideration, although it would probably involve the construction of a new dam and an expenditure of about $75,000.

The cost of pumping by the large pumps proposed to be used, and with the constant head here supplied would be less than at Fairmount, with its smaller pumps and variable head, though we have taken the cost at the latter as the basis of the estimated cost at Manayunk.

If this water-power be leased, the aggregate capacity, pumping by water, at the time of a full river, would be more, at present, and for some years to come, than the entire consumption of the lower system of distribution; therefore, to make the water-power more available, some of its pumps should be connected with higher systems,

or, water should be taken from the East Park Reservoir, and by a second lift raised by steam into those systems.

And even without the Manayunk power, it is worthy of examination whether such connection with the Fairmount pumps, and such second lift, may not prove to be advantageous.

Prevention of the Pollution of the Fairmount Pool, either by Sewer to Tide-water, or by a Pure Water Conduit from Flat Rock Dam.

Several measures have been proposed as preventives, palliatives or remedies, but little has been carried into effect, except the sewer on the west side of the river; the inflow of polluting matter still continues, being steadily augmented in volume, as the City grows, and even in a greater ratio.

Page 114:

The most prominent and the most effectual remedy hitherto advocated is by an intercepting sewer, from the upper end of Manayunk to tide water, below the Fairmount dam.

The construction of this sewer was recommended by a committee of the park commission in October, 1867.

In October, 1868, a report was made upon the subject by Mr. John D. Estabrook, addressed to John C. Cresson, chief engineer of the park. In March, 1870, another report was made upon the same subject by Mr. Estabrook, giving full details of the location and plan of the sewer, which was to be of seven feet diameter, and the cost was estimated to be about $1,000,000. If built, it would no doubt tend greatly to improve the quality of the water in the Fairmount pool.

If not built, there remains another way of securing, for a number of years, a water for the pumps purer than that now supplied from the Fairmount pool, namely, by a conduit from the Flat Rock pool, leading to the pumps at Belmont, Spring Garden and Fairmount.

We believe that the water of Flat Rock pool, at this time, is much more free from impurities than that of the Fairmount pool, and that for an undetermined number of years it may be used.

This conduit need not be quite so large as the sewer proposed in the last report by Mr. Estabrook.

If made 6½ feet in diameter, the proposed conduit, with the available fall, would furnish 70,000,000 gallons per day. This would be so much drawn from the water-power of Flat Rock pool.

In case the City shall decide not to build the sewer, we would recommend the immediate construction of the conduit, which would cost about the same as the sewer, namely, $1,000,000.

In case of the construction of this conduit, it would reduce the water-power of Flat Rock dam, that may now be leased, about 28 per cent. during the dry season, rendering the leasing of the same by the City less advantageous.

It is also to be borne in mind, that the City would probably be required to compensate the Reading Railroad Company for the water to be abstracted, or to furnish an equal quantity by means of compensating reservoirs.

Page 115:

Future Permanent Water Supply.

There are only two adequate sources of supply, namely, the Delaware and Schuylkill rivers, including their tributaries. At present the greater portion of the water fur-

nished is taken from the Schuylkill, and with the exception of that pumped by the Roxborough Works, situated on the pool of Flat Rock dam, the water from the Schuylkill is pumped from the pool of Fairmount dam.

There are two plans proposed on the Schuylkill: one which will continue to take the water from the main river, as at present; the other, the building of an impounding reservoir on the Perkiomen and a conduit to deliver the water by gravity.

On the Delaware several plans have been proposed. The Water Gap plan, by gravity to the City; the New Hope pumping and conduit plan; the New Hope canal and conduit plan; and the Scudder's Falls canal and conduit plan; the two latter requiring the water to be pumped up after reaching the City.

Water Gap Plan from the Delaware.

In order to obtain sufficient height on the river to allow the water to flow by gravity to the City into a proper distributing reservoir, it is necessary to take the water as far up the river as Belvidere, about 11 miles below the Water Gap, at an elevation of 232 feet above tide. The line would follow the river from Belvidere to New Hope (50 miles), and from there, by an interior route shorter than the river, reach the City in about 40 miles, making the entire length of the conduit about 90 miles. Our calculations show that the cost would not be less than $30,000,000, which renders its adoption inexpedient.

Page 116:

New Hope Conduit.

The water in the Delaware river, at New Hope, being only 48 feet above tide, it is impossible to obtain a gravity flow thence to the reservoirs of the City. The fall at this place

is not more than 6 feet, so that in the summer the water-power would be inadequate, and steam-power would be needed to raise the water into the conduit.

At present a portion of the water-power is in use raising water into the Delaware Division Canal, and an arrangement would have to be entered into giving the right to divert it.

The distance from New Hope to the East Park Reservoir, by a conduit route, is about 40 miles.

The estimated cost of a dam, bulkhead, etc., pumping machinery, steam engines, etc., pumping mains, and reservoir, and of conduit 40 miles long, is, in round numbers, ...	$13,000,000
Cost of pumping annually, $600,000, which capitalized, amounts to . .	10,000,000
Making total cost, including capitalization,	$23,000,000

which includes only a supply of 75,000,000 gallons per day.

Page 116:

New Hope Canal Project.

This scheme involves the purchase of 31½ miles of the Delaware Division Canal, and the change from a navigation to a supply canal, and other works.

Taking the water from the Delaware river, three miles above New Hope, by means of a low dam, where the water surface is now 55 feet above tide.

For these it would be necessary to purchase the canal company's water-power and 31½ miles of the Delaware division canal, and to obtain authority from the States of Pennsylvania and New Jersey to build the dam, etc.

The works would comprise a dam and bulkhead, three miles of river canal, changing 24 miles of navigation