

PRELIMINARY SURVEYS

FOR

PROCURING A SUPPLY OF WATER BY GRAVITATION,

FOR THE

CITY OF PHILADELPHIA,

FROM THE

PERKIOMEN,

BY

H. P. M. BIRKINBINE,

CHIEF ENGINEER.



PHILADELPHIA:

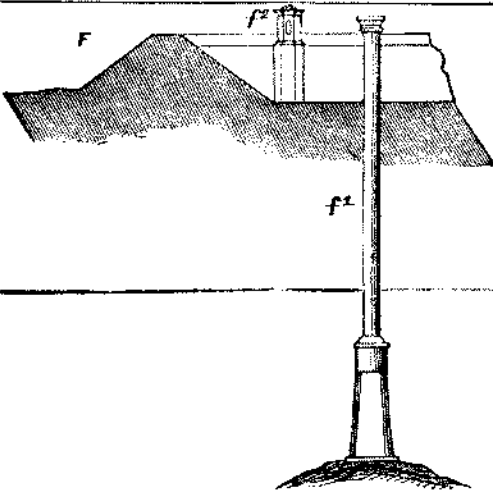
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1866.

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THE
PHILADELPHIA
WATER WORKS
H.P.M. BIRKINBINE
CHIEF ENGINEER
1865

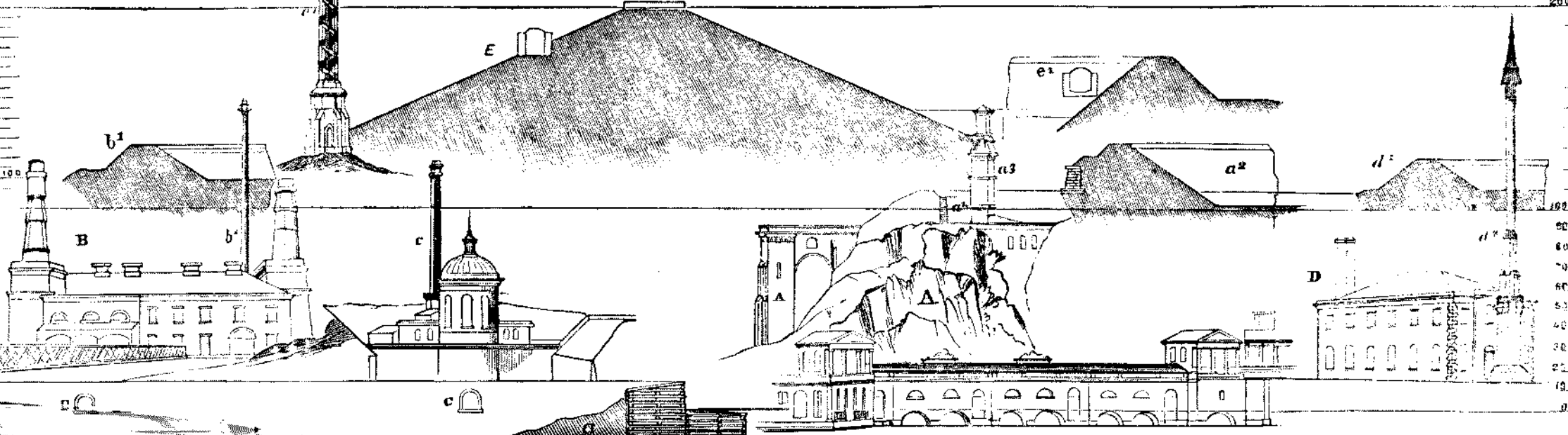


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PRELIMINARY SURVEYS

FOR A SUPPLY OF WATER FROM SOURCES BEYOND THE LIMITS OF
THE CITY.

In the first Report I had the honor of making to Councils, in October, 1858, their attention was drawn to the importance of looking for a water supply to other sources than the two noble rivers flowing past and through our City; not because the water in either is of inferior quality, but because so much objectionable matter is drained into them. As the City increases in population the sources of contamination are of necessity augmented, and no care or legislation can entirely protect the purity of these rivers, as all drainage naturally tends towards them.

The dam at Fairmount prevents the sewerage discharged into the Schuylkill below it from being carried above the Works, but there is a large and constantly increasing drainage into the dam itself. This has been referred to in former Reports. A portion of the sewerage entering into the Delaware is carried by the ebb and flow of the tide past the Works, and as a consequence, contaminates, to some extent, the water taken from it.

Pumping the amount of water necessary to meet the wants of this large City, requires a great deal of labor and a large expenditure of money. The City has now fifteen pumps propelled by water, and eight by steam. Two additional steam engines are in course of construction.

The Works supplying the City were constructed at different periods of time and for the purpose of furnishing the various districts now forming the consolidated City. The reservoirs are of

different elevations, and the distribution arranged simply with reference to the several districts they were intended to supply.

The engraving in the front of the Report exhibits the Works and Reservoirs of the consolidated City. The figures upon the right hand show the elevation above City datum, and those on the left, the elevation above Fairmount Dam.

The Fairmount Water Works is represented at *A*.

A section of the dam at *a*.

A section of Fairmount Reservoir at *a*¹.

A section of Corinthian Avenue Reservoir at *a*².

This Reservoir is connected with the Fairmount Works, and supplied by the pumps in the new mill house. The Water Tower, *A*, and Stand Pipe, *a*³, are used in connection with these pumps.

The Works at Fairmount were originally intended to supply the old City and the former districts of Southwark and Moyamensing.

In the old mill house there are eight double acting pumps, sixteen inches in diameter, propelled by breast wheels, and one by a turbine wheel. In the new mill house there are six double acting pumps, eighteen inches in diameter, propelled by turbines. The full capacity of both these Works, at ordinary stages of the river, is 28,000,000 gallons per day.

The Schuylkill Works, formerly the Spring Garden and Northern Liberties, are represented at *B*. The water is drawn from Fairmount Dam at *B*, and pumped into the Reservoir at *b*¹. These Works also supplied the former district of Penn. In these Works there is a Cornish pumping engine, thirty inches diameter of plunger, ten feet stroke; one condensing bell-crank engine, double acting pump, twenty-two inches in diameter, four feet stroke; and two beam condensing engines, double acting pumps, eighteen inches diameter, and six feet stroke.

These Works can supply 8,000,000 gallons per day, and may be forced to 10,000,000 gallons.

The Twenty-fourth Ward Works, formerly West Philadelphia, are

represented at *C*. These Works receive the water from Fairmount Dam at *c*, and pump into the stand pipe at *c*¹. No reservoir has been built for this district; one, however, is authorized, and will be commenced in the spring.

In these Works there are two Cornish Bull engines, plungers seventeen and a half inches in diameter, eight feet stroke. The works can supply 1,000,000 gallons per day, and may be forced to 1,500,000.

The Delaware, formerly Kensington Works, are represented at *D*. The water is taken from the Delaware river in front of the Works, and is pumped into the reservoir at *d*¹. These Works were also intended to supply the former district of Richmond.

In these Works is a high pressure engine, propelling a double acting pump, eighteen inches diameter, six feet stroke, and a condensing engine, propelling a double acting pump, nineteen inches diameter, six feet stroke. The capacity of these Works is 3,000,000 gallons, and they may be forced to 4,000,000.

The present supply of water is furnished at such various elevations, and the systems of distribution are from so many different sources, that it will be advisable to entirely abandon the old system, and adopt one that will command all of the City except the comparatively small districts, Germantown, Chestnut Hill and Roxborough. These portions of the City are so high that it would be impossible to arrange a system which would embrace them, without making the pressure upon pipes in the other portions of the City so great as to destroy them.

The Reservoir which is intended to supply these high districts is now in course of construction, and is represented at *F*. It is to be supplied with water taken from the Schuylkill, at Flat Rock Dam. The stand pipe for the Germantown Water Works is represented at *f*¹. It will be connected with this Reservoir.

Believing that there were sources within a reasonable distance, from which water could be supplied to the City, with the above

exception, at an elevation greater than any of the reservoirs now in use, you were urged, from time to time, to make the appropriation for preliminary examinations to determine this fact; and, finally, in the spring of 1864, \$3,000 were appropriated for the purpose.

The preliminary surveys authorized by ordinance of Councils, under date of April 15th, 1864, for the purpose of ascertaining the practicability of procuring a supply of water from sources other than the present, and beyond the limits of the City, have been carefully prosecuted, and examinations made of a number of streams within a moderate distance of the City.

The following have been examined, with a view of ascertaining the practicability of procuring a supply of water from them. With the exception of the Perkiomen, no actual surveys have been made, but the various streams have been carefully examined from their sources to their mouths, and all information within reach collected, as far as the moderate appropriation you made for this purpose would enable the Department to do.

CHESTER CREEK.

Chester creek has three principal branches, the northwest, west, and main. The northwest branch rises in West Chester borough, and flows for five miles in a southeasterly direction, joining the main branch at Cheyney's shops. The west branch rises in Concord township, Delaware county, and flows in a northwesterly direction for eight and a half miles, entering the main branch at Glen Riddle. The main branch rises in West Whiteland township, Chester county, and flows twenty-one miles in a southeasterly direction, through Chester and Delaware counties, entering the Delaware river at Chester.

This creek has a drainage area of seventy square miles, and furnishes power for thirteen grist mills, nine saw mills, eight woollen mills, six cotton mills, two paper mills, and two water,

works—total forty. The Water Works supply West Chester and the West-town Boarding School.

A dam from which water could be supplied to the City by aqueduct, could probably be made about six miles above the mouth of the creek, below the confluence of the main and west branches. Above this point there are thirty-two mills, and the creek has a drainage area of sixty-one square miles. The proposed site for a dam is fifteen miles in a direction east south-east from Broad and Market streets.

A supply of 50,000,000 gallons per day could be furnished from this source, but the region drained by it is highly cultivated and densely populated, and the naturally excellent character of the water to a large extent impaired; it receives all the drainage of West Chester, a large and flourishing town.

To utilize the amount of water, estimated as procurable from this and the other creeks mentioned, will require impounding reservoirs of sufficient capacity to store and keep back the storm, or flood water; to be used in seasons of drought, or when the creeks flow but a small amount of the average estimated.

RIDLEY CREEK.

This Creek rises in East Whiteland Township, Chester county, and flows for twenty miles in a southeasterly direction, through Chester and Delaware counties, entering the Delaware river one mile north-east of Chester. The creek has a drainage area of thirty-eight square miles, and furnishes power to seven grist mills, seven saw mills, seven woollen mills, two paper mills, two edge-tool works, and two drug mills—total twenty-seven.

A dam from which a supply to the City could probably be obtained, might be made at Media, six miles above the mouth of the creek. There are thirteen mills above this point, and the creek has a drainage area of thirty and a half square miles. This point is thirteen miles east south-east of Broad and Market streets.

From this source about 25,000,000 gallons per day could be procured for supplying the City. The country drained by this creek is of the same character as that drained by Chester Creek.

CRUM CREEK.

This creek rises in Willistown township, Chester county, and for eighteen and a half miles flows in a southeasterly direction through Delaware and Chester counties, entering the Delaware river eight miles below the confluence of the Delaware and Schuylkill rivers. The creek has a drainage area of thirty-eight square miles, and furnishes power to four grist mills, four saw mills, four cotton mills, two woollen mills, one paper mill, and one edge-tool works—total sixteen.

A dam from which water could be supplied to the City, could probably be made at the edge-tool works, six and a half miles above the mouth of the creek. Above this there are seven mills, and the creek has a drainage area of twenty-nine square miles. This point is ten and three-fourths miles east south-east from Broad and Market streets. The creek would afford about 20,000,000 gallons of water per day.

DARBY CREEK.

This creek rises in East-town township, Chester county, and for twenty-three and a half miles flows through Chester and Delaware counties in a southeasterly direction, entering the Delaware river at Tinicum Island, seven miles below the confluence of the Delaware and Schuylkill rivers. It has a drainage area of fifty square miles, and furnishes power to nine grist mills, seven saw mills, nine woollen mills, three cotton mills, and two shoddy mills—total thirty.

Ten and a half miles above the mouth of the creek, near Garrettsford, a dam could probably be constructed to furnish a supply to the City; above this there are twenty-three mills, and the creek has a

drainage area of thirty-seven square miles. This point is seven and a half miles east of Broad and Market streets. A supply of about 25,000,000 gallons per day could be procured from this source.

COBB'S CREEK.

This creek is properly a branch of Darby creek, but as the confluence of the two streams is at tide water, it is mentioned as a separate creek. It rises in Haverford township, Delaware county, and flows nearly south for eleven miles, entering Darby creek one mile below Paschalville.

The creek supplies power to eight woollen mills, two grist mills, two saw mills, two cotton mills, one paper mill, one forge, and one snuff mill—total, seventeen.

At Haddington, six miles from its mouth, a dam could probably be constructed to supply the city with water; above this place there are nine mills, and the creek has a drainage area of ten miles. This point is five miles east north-east of Broad and Market streets. From this source about 12,000,000 gallons of water per day could be procured.

An amount of water sufficient to supply a city three times the size of Philadelphia—say 100,000,000 gallons per day—could be procured from these five streams, viz: Chester, Ridley, Crum, Darby and Cobb creeks. They could all be brought in by gravitation, at sufficient elevation to supply any reservoir now in use in the City. The quality of the water is naturally unexceptionable, but the large population inhabiting the country drained by these streams, and the great proportion of the land under tillage, doubtless impairs the purity of the water. The value of property occupied or damaged, and the number of mill sites destroyed or injured, if a supply of water should be obtained from these streams, is a subject worthy of consideration; until, however, over 60,000,-

000 gallons of water are required per day, an amount double the the present daily consumption, these mill powers could be compensated by water spared from the store reservoirs.

Were there no other apparently more desirable sources, these would be recommended.

MILL CREEK.

This creek rises in Lower Marion township, Montgomery county, and flows in an easterly direction six and a half miles, entering the Schuylkill one mile above Flat Rock Dam. It has a drainage area of nine square miles, and furnishes power to one grist mill, two cotton mills, two paper mills, three woollen mills, three shoddy mills, one rolling mill, and one machine shop—total, thirteen.

One mile and three-fourths from the mouth of the creek a dam could probably be constructed from which a supply of water could be obtained. Above this point, which is seven and three-quarter miles northwest of Broad and Market streets, there are eight mills, and the creek drains an area of seven and a half square miles.

This stream I recommended to the district of West Philadelphia, as a source from which a supply of water could be procured, before the present Twenty-fourth Ward Works were constructed. It could have been brought in for about the amount the present Works cost; but the Committee of Councils of the then district of West Philadelphia, who were induced to visit the stream, thought it best to trust to a supply pumped by steam from the Schuylkill, rather than to one procured by gravity from this source.

GULF CREEK.

This creek rises in Frediffrin township, Chester county, and flows for six miles through Chester, Delaware and Montgomery counties, and enters the Schuylkill river just below Catfish Dam, at Conshohocken. It has a drainage area of seven and a half

square miles, and furnishes power for three woollen mills, one grist mill, and one saw mill—total, five.

A small dam could be constructed of sufficient height to supply the City, three miles from the mouth of the creek. Above this point, which is twelve miles northwest from Broad and Market streets, there are two mills, and the creek has a drainage area of five square miles.

EAST VALLEY CREEK.

This creek rises two miles northeast of White Horse Station, Chester Valley Rail Road, and flows for nine and a half miles in a direction east northeast through Chester county, entering the Schuylkill at Valley Forge, above Pauling's Dam. It supplies power to seven grist mills, four saw mills, one plaster mill, and one woollen mill—total, thirteen. It has a drainage area of twenty-one square miles.

A dam from which water could be delivered into the City, could probably be constructed four miles from the mouth of the creek. Above this site, which is eighteen and three-quarter miles northwest of Broad and Market streets, the creek has a drainage area of seventeen square miles.

These three creeks enter the Schuylkill from the west, above the Fairmount Dam, and are all too inconsiderable to require further notice as a source of supply for the City, even were they collected together.

The creeks entering the Schuylkill from the east are, with the exception of the Wissahickon creek, of little importance. They have, however, received sufficient attention to exhibit their value.

WISSAHICKON CREEK.

This creek rises in Montgomery township, Montgomery county, about one and a half miles southeast of Landsdale station, on the

North Pennsylvania Railroad, and flows for nineteen miles in a southern direction, through Montgomery and Philadelphia counties, entering the Schuylkill river about four and a half miles above Fairmount Water Works. The creek furnishes power to sixteen grist mills, six saw mills, three woollen mills, three cotton mills, two paper mills, one carpet manufactory, one oil mill and one print works,—total, thirty-three. The creek has a drainage area of seventy-eight square miles. 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, and below there are eighteen mills.

PLYMOUTH CREEK.

This creek rises one and a half miles northeast of Hickorytown, Montgomery county, and flows for five miles in a southern direction, entering the Schuylkill at Conshohocken. It has a drainage area of eight square miles, and furnishes power to one saw mill. The creek is about twelve miles north of Broad and Market streets.

SAW MILL RUN.

This creek rises near Springtown, Montgomery county, and flows in a westerly direction, entering the Schuylkill river at Norristown. It has a drainage area of five square miles, and furnishes power to two saw mills. The creek is fourteen miles northwest of Broad and Market streets.

STONY CREEK.

This creek rises in Worcester township, Montgomery county, and flows seven and a half miles in a southwestern direction, entering the Schuylkill at Norristown. It furnishes power to four grist mills, one oil mill, one clover mill, one machine shop, one plaster

mill and one woollen mill ;—total, nine. This creek is about sixteen miles northwest of Broad and Market streets. It has a drainage area of sixteen square miles.

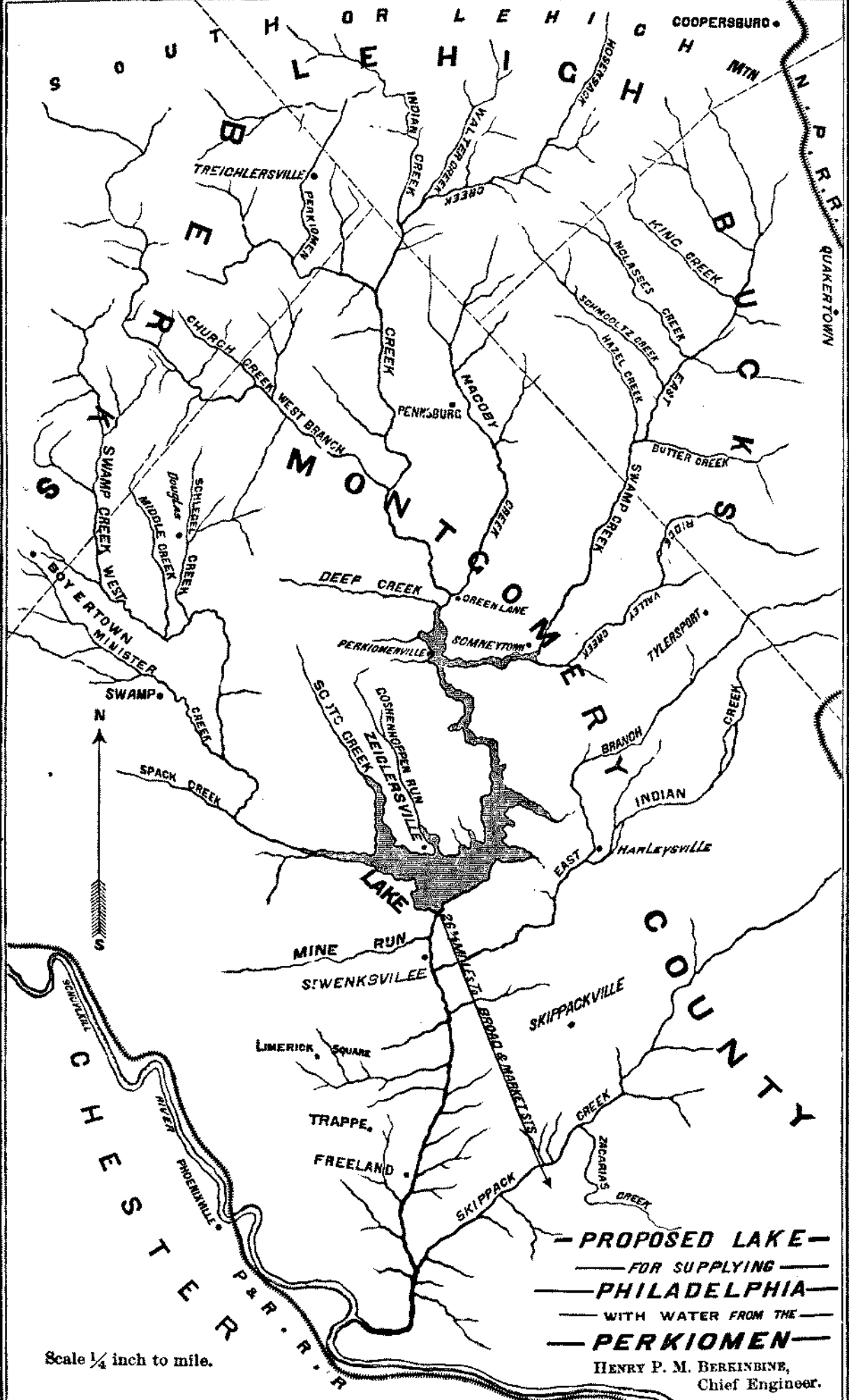
PERKIOMEN CREEK.

This is the next creek entering the Schuylkill from the east, and is one of the largest tributaries. The main branch rises near Peryville, Hereford township, Berks county, and flows through Berks, Lehigh and Montgomery counties, entering the Schuylkill about three miles below Phoenixville. It has a number of tributaries of considerable importance, (*see map*). The largest of these are Skippack creek, East Branch Perkiomen, Swamp creek, west ; Swamp creek, east ; West Branch Perkiomen, and Hosensack creek.

The creek and its tributaries have a drainage area of about three hundred and twenty-five square miles, and furnishes power to eighty-seven grist mills, seventy-two saw mills, twenty-one oil mills, eleven powder mills, four clover mills, four forges, two cotton mills, two fulling mills, one woollen mill, one paper mill, one gimlet manufactory ;—total, two hundred and six.

Eleven and a half miles above the mouth of the creek, and just below the confluence of West Swamp creek, is a site which seems admirably adapted for the erection of a dam by which to form a large lake, to furnish a supply of water to the City, by aqueduct. The level of the water of the creek here is 125 feet above that of the water in Fairmount Dam ; and a dam of 65 feet in height and 1100 in length, would back the water up the creek for over six miles, and form a lake having a surface area of about 1500 acres.

This point is twenty-six and five-eighths miles west of Broad and Market streets. The water from this lake can be delivered in the City at a head of 175 feet above the level of Fairmount Dam.



— PROPOSED LAKE —
 — FOR SUPPLYING —
 — PHILADELPHIA —
 — WITH WATER FROM THE —
 — PERKIOMEN —

HENRY P. M. BERKINBINE,
 Chief Engineer.

Scale 1/4 inch to mile.

PROPOSED PLAN

FOR

SUPPLYING PHILADELPHIA WITH WATER

FROM THE PERKIOMEN.

The most desirable mode of furnishing large cities with water, and that adopted wherever practicable, is, by gravitation, and from sources at a distance, beyond the deleterious influence of a city and its surroundings.

Boston, New York, Baltimore and Washington are supplied by this means, and all, except Washington, from comparatively small streams, by impounding the water in natural or artificial lakes, and drawing it from them as required.

The companies supplying the City of London with water from the Thames, were compelled by Act of Parliament to remove their works to a distance above the City, beyond the influence of its sewage, and to construct subsiding and filtering reservoirs. Notwithstanding the large expense incurred by these companies to procure water of a satisfactory character, surveys have been made for bringing a supply from the head waters of the Severn, a distance of one hundred and fifty-two miles, by constructing store reservoirs on its principal branches, and conducting the water to the city by aqueduct.

The plan proposed for securing a supply of water for Philadelphia from the Perkiomen, is similar to the above. It is proposed to construct a large store reservoir or lake at a suitable point on the stream, and to convey the water by an aqueduct from this lake to

a distributing reservoir located upon the higher ground in the northern part of the City, and connected by supply mains to the several centres of distribution of the present Works.

LAKE OR STORE RESERVOIR.

Between Swenksville and Zieglersville, the Perkiomen has cut a narrow passage through the trap hills, which cross the country at this point from east to west. These hills rise to from four hundred to five hundred feet above tide, and about three hundred and fifty feet above the creek. At this point it is proposed to construct a dam, for which purpose it possesses unusual advantages. The trap is forced up through the overlaying strata and crops out upon the surface, forming reliable foundations and abutments for such a structure. No danger need, therefore, be apprehended of the water finding its way through unseen channels, under or around the dam. It will only be necessary to construct the dam of sufficient strength and join it to the rock on the sides and bottom, to insure a structure that will never yield to any force that may come against it. A dam of any desirable depth may be constructed at this point, and a lake of corresponding area made.

A line of levels were run around what would be the surface of the water in the lake if it was raised sixty-five feet above the present level of the stream and two hundred and four feet above city datum. The water, at this depth, would cover an area of fifteen hundred acres. It is proposed to place the outlet so as to draw it down twelve feet. At this depth, the lake would contain over five thousand million gallons, an amount of water sufficient, if no water flowed into it from its numerous tributaries, to supply the present demands of the City for about two hundred days. A lake of double the storage capacity of this, could be constructed at this point, if desired.

If the water be made sixty-five feet deep it will overflow two grist mills, two saw mills, two powder mills, three oil mills, one woollen mill, one forge, one tannery and sixteen dwellings. Below

the proposed dam, there are ten grist mills, three saw mills and one oil mill. The amount of land overflowed would be fifteen hundred acres, much of it rocky and of comparatively little value for farming. The shores would be to a great extent precipitous and rocky.

The object of this lake is to impound the storm water, so as to supply deficiencies that occur in seasons of drought. It would not be of sufficient capacity to store all the surplus water, large as it is proposed to make it; even if increased in depth, so as to cover two thousand acres, other store reservoirs would be required, which could be constructed upon the different tributaries, as made necessary by the demands of the City.

The accompanying map of the Perkiomen exhibits the lake and the various streams that will be drained into it. The proposed dam is shown at *E*, on the cut in front of the report, and the distributing reservoir in the City which would receive the water from the aqueduct at *e*. It will be seen by the cut that the water in this reservoir will be at a greater elevation than in any other in the City, except the one in course of construction at Roxborough.

AQUEDUCT.

The means at the disposal of the Department were too limited to make surveys to indicate the line of the aqueduct. From a careful examination of the country laying between the city and the proposed lake, there appear to be fewer difficulties in the way than are generally found, and several routs appear to be practicable. This subject will require careful investigation, so as to select a rout best adapted for the purpose. An aqueduct twenty-four miles long, will, most probably, connect the lake with a suitable site for a reservoir in the upper part of the City. The aqueduct should be made of sufficient capacity to bring down the maximum amount of water that may be required.

RESERVOIR.

To perfect the plan of supplying the City, a large reservoir should be constructed capable of storing at least 1,000,000,000 gallons; no matter what plan of supply be adopted such a reservoir will be indispensable. The water from the Perkiomen could be delivered at an elevation fifty feet higher than the Corinthian Avenue Reservoir, and seventy-five feet higher than Fairmount. There are numerous localities in the northern part of the City adapted for such a reservoir. The reservoir directed to be constructed in the Twenty-fourth Ward could be supplied from the Perkiomen; and all the present reservoirs could be abandoned and the property put to other uses.

SUPPLY MAINS.

The Reservoir to be at sufficient elevation, will be located at some distance from the present centre of distribution, and it will be necessary to lay several lines of large supply mains. To furnish 75,000,000 gallons per day, four forty-eight inch mains leading from the Reservoir will be necessary; and as the demands of the City increase additional mains can be laid.

QUANTITY OF WATER.

In the absence of actual measurement of the capacity of the Perkiomen by gauging, which would require observations extending over several years, the following estimates of the quantity of water procurable from this source are substituted.

Twelve cities of Great Britain, supplied from impounding reservoirs situated on comparatively small streams draining areas of various extent, are given as follows:

Ashton,	Annual rain fall,	40 inches ;	of this,	384 is utilized.
Belfast,	"	"	32 "	" 522 "
Bolton,	"	"	50 "	" 619 "
Dublin,	"	"	45 "	" 500 "
Glasgow,	"	"	60 "	" 402 "
Greenock,	"	"	60 "	" 603 "
Huddersfield,	"	"	33 "	" 537 "
Liverpool,	"	"	55½ "	" 436 "
Macclesfield,	"	"	40 "	" 526 "
Manchester,	"	"	37 "	" 617 "
Oldham,	"	"	35 "	" 415 "
Paisley,	"	"	56½ "	" 548 "

The average rain fall upon the surface drained for the supply of the above cities, is 45.32 inches per annum, stored or utilized, .509 equal to 23.06 inches per annum. The amount of the rain fall utilized, would be greater, if the capacity of the several reservoirs were sufficient to retain a larger portion of the flood water, as in the case of Bolton, Greenock, and Manchester; these reservoirs are of larger proportionate capacity, and above sixty per cent of the rainfall is utilized. The Department are not in possession of sufficient data to make an analysis of the Works supplied by similar means, in this country.

No record could be found of the rain fall upon the country drained by the Perkiomen, probably, none has ever been kept. The Department have placed rain gauges at Trichlersville, at the foot of the mountains, near the northern boundary of the water shed; at Boyerstown, near the western boundary of the water shed; and at Zieglersville, near the site of the proposed lake. The Polytechnic College of Pennsylvania has also placed rain gauges on its farm, near the eastern boundary of the water shed. The records of these observations will form a reliable basis for future calculations. For present purposes, the careful observations of J. A. Kirkpatrick, A. M., of the rain fall in this city, reported in

the Journal of the Franklin Institute, are used. The average annual rain fall in Philadelphia for the past thirteen years, has been 45.436 inches, about the same as the average fall upon the surface drained for the twelve Works instanced above.

The amount of rain which falls upon the country drained by the Perkiomen, is no doubt greater than that which falls on this City. The stream rises in the South, or Lehigh Mountains; the first elevated land west of the Atlantic ocean. These hills rise to from 900 to 925 feet above tide, and are about 100 miles from the ocean. The amount of rain falling upon this elevated land is no doubt greater than upon the comparatively low position of the observer of the rain fall in Philadelphia, 60 feet above tide.

Above the site of the proposed lake the flow of the Perkiomen and its tributaries is rapid, and the surface of the country drained of such a character that the rain which falls upon it soon flows off. Water which finds its way into the earth, will most probably, all be stopped and forced up by the trap, which forms what will be the entire southern or lower boundary of the lake; the only loss, therefore, will be that absorbed by vegetation and by evaporation. The experiments made upon the amount of water evaporated, upon which calculations of this kind are usually based, are very unsatisfactory and variable. The Croton Board have caused a series of observations to be made, but these can not be applied in the present calculations. The amount lost by evaporation is generally over estimated. In this country it is no doubt greater than in Great Britain; but in the case of the Perkiomen, the loss by evaporation will be comparatively small, fully one-third of the surface drained by it is covered with forests, and likely to remain so, on account of its broken and rocky character, and a large proportion of the country under cultivation is kept in grass. On account of the great depth of water in the proposed lake, the evaporation from it will be comparatively small. The amount of rain-fall that can be utilized will, therefore, be at least as great as that of the Works of the twelve cities mentioned above.

An estimate of the quantity of water that may be procured from the drainage area of the Perkiomen, based upon the above data, will be found correct, at least sufficiently so for the purposes of this report.

The country drained by this stream, above the proposed dam, is about 220 square miles. Estimating the average amount of rainfall upon this surface to be the same as at Philadelphia, 45.43 inches, the amount that can be utilized will be 23.12 inches.

The quantity of water that can be collected and furnished from this source, if impounding reservoirs of sufficient capacity be constructed to store the storm or flood water, will be a daily average of 240,000,000 gallons; a quantity sufficient to supply to 4,000,000 of inhabitants, an average of 60 gallons of water each, per day.

Large reductions may be made to these estimates, and still a supply of water be procured sufficient for Philadelphia, for many years to come.

QUANTITY OF WATER REQUIRED.

When the Water Power Works at Fairmount were first started, their total pumping capacity, as projected, was 10,000,000 gallons per day; this it was supposed, would furnish an ample supply of water to the city and surrounding districts, even for a population greater than the present. The average daily amount of water furnished, has been as follows: in 1825, 1,280,700 gallons; in 1835, 3,364,625 gallons; in 1845, 6,142,654 gallons; in 1855, 11,700,786 gallons; and in 1865, 30,281,019 gallons.

The amount of water required per inhabitant, has steadily increased; in 1830 an average of $12\frac{1}{2}$ gallons per day was required, and in 1865, 41 gallons.

When water was introduced into New York by the Croton Aqueduct, in 1842, the capacity of the Works, as then completed, was 35,000,000 gallons per day; this, it was estimated, would furnish an ample supply for 1,750,000 inhabitants. In less than

twenty years from that time, the supply of water to New York was deficient, with less than one-half that number of inhabitants, and notwithstanding the large sums of money expended for increasing the capacity of the Works, they are not now equal to the requirements of that City, although nearly doubled in capacity.

With the growth of a city in extent and population, the dependence upon a water supply from sources beyond its limits becomes greater, and the necessity for a larger proportionate supply increases.

Should the demands of Philadelphia increase in the same ratio as during the last twenty years, the amount that will be required in 1875 will be about 75,000,000 gallons per day, and in 1885 150,000,000 gallons. A Works, therefore, projected to furnish the City for a reasonable length of time, say twenty-five years, looking forward to the same ratio of growth in population and corresponding demands for water, should have a capacity of not less than 175,000,000 gallons per day.

QUALITY OF WATER.

Specimens of water taken from the Perkiomen, at the site of the proposed dam, and submitted to Clark's soap test, were found to be 6.4 degrees of hardness, indicating the presence of a corresponding number of grains of mineral salts to the gallon. The water of the Schuylkill, in Fairmount Dam, by the same test, indicates 6.19 degrees. The water was taken from the Perkiomen in October, when it was at its lowest stage, and most probably flowed only spring water, as there had then been a long season of drought. Should the lake be constructed, the water it would contain would be largely the rain fall, drained from the surface, purer and much softer than spring water.

Water collected from surface drainage will be affected by the character of the soil it falls upon. The land drained by the Perkiomen is remarkably well adapted for collecting water, being composed almost entirely of trap and sandstone. The only minerals

found are lime, from eight to ten square miles, and a few deposits of hematite. The Perkiomen copper and lead mines are all south of the trap and below the area draining into the proposed lake. There are no manufactories which would impair the purity of the water, and the villages are all small. This region offers no inducements to manufacturers, nor is it likely ever to become thickly settled; it probably does not now contain a larger population than it did fifty years ago. There is, perhaps, one-third still in forest, and there probably never will be a less proportion. The soil is not valuable, and much that is now tilled would pay a greater return if planted with trees; a large proportion is kept in grass. This surface is, therefore, a most desirable one for collecting water. On account of the depth of the lake, and the large volume of water contained in it, the water would always be pure, bright and limpid, probably never made turbid by freshets in the streams flowing into it.

COST OF WORKS.

Without actual surveys and detailed plans and specifications, it is impossible to form an estimate of the cost of this work. The means at the disposal of the Department were not sufficient to do this, but, it is believed the object for which you made the appropriation has been accomplished, and sufficient information presented to satisfy you that the City can be supplied with an abundance of most excellent water from the Perkiomen.

DAMAGES.

It is always difficult to estimate damages, particularly where water rights are concerned, and care must be taken to procure such legislation as will protect the City against combinations and exorbitant charges. Most of the land which would be overflowed by the lake is of little value, a great proportion of it being rocky, and if offered for sale would probably not bring an average of

forty dollars per acre. Several of the mills which will be destroyed, are good and substantial buildings; it will be necessary to purchase all the mills and buildings that will be overflowed. Without locating the aqueduct it is impossible to form any approximate estimate of damages.

The mill-powers below the dam would not be injured until a large amount of water was taken for the City, say over 60,000,000 gallons per day. The effect of the lake in keeping back the storm water, would compensate to a great extent for the amount taken for the use of the City; a portion of that stored could be spared in seasons of drought and supplied to the creek as required. By constructing store reservoirs on the East Perkiomen, for the purpose of compensating the mills below, for water taken from the main stream, it will be a long time before any actual damage will be done. The mill powers would rather be benefited by having the flow of water more constant; but if the mills below could be purchased at a fair valuation, it would no doubt be better to do so, than to incur the expense of constructing compensating reservoirs.

For the purpose of comparison, the cost of the entire work is placed at ten million dollars; a sum certainly sufficient to purchase the necessary real estate, and to do the work in the best and most substantial manner, and pay all proper claims for damages; say for dam, damages, and all expenses at the lake \$1,000,000: Twenty-four miles of aqueduct, at an average cost of \$250,000 per mile, \$6,000,000: Store reservoir in the City \$1,000,000: Supply mains to connect with present Works \$1,000,000: Contingencies \$1,000,000. A survey of the route and detailed plans and specifications may make important changes in these estimates, but it is not probable that this gross amount will be exceeded. This contemplates Works that would furnish to the reservoir an average of 175,000,000 gallons per day, and distribute to the City 75,000,000 gallons.

ANNUAL EXPENSES.

The annual cost of supplying the City with water from the Perkiomen, estimating the Works to cost, as above, will be for interest, appropriation to the sinking fund, etc., eight per cent. and for repairs, management, etc., say \$52,000, making the total annual expense \$852,000, or \$11,360 per annum per million gallons, when a daily average of 75,000,000 gallons are supplied. When an average of 150,000,000 gallons per day are furnished, the expense will be \$6,000 per annum per million gallons. This, compared with the cost per million gallons of water supplied to other cities, by similar means, will indicate the economy of these Works. The water supplied to the City of New York by the Croton Aqueduct, cost \$40,000 per annum per million gallons. That supplied to Boston by the Cochituate Aqueduct, cost \$24,000 per annum per million gallons. That supplied to Albany, also by aqueduct \$28,000. In Great Britain: the water supplied to Liverpool is at a cost of £45,000 per annum per million gallons. Manchester is supplied at a cost of £34,000. The supply to London, by the proposed aqueduct, will be at a cost of £71,000 per million gallons, when the Works furnish a daily average of 120,000,000 gallons; and of £49,000 when their full capacity, 220,000,000 gallons per day is required.

When a comparatively small amount of water is required, it can generally be procured at a less cost by pumping, if the source be near at hand, than by going to a distance to procure a supply by gravitation. This City, up to the present time, has been supplied at a less cost by the pumping works than it could have been by bringing in water by gravitation from some of the sources indicated above; and were the character of the water now furnished perfectly satisfactory, the amount could be increased to 59,000,000 gallons per day, by pumping, at a less cost than by the proposed aqueduct, but, beyond that amount, it can be furnished at a less cost from the Perkiomen.

The water supplied in 1865 cost \$6,000 per annum per million gallons. Of this amount sixty-four per cent. was pumped by the water power at Fairmount. By erecting new Works the amount furnished from this power could be increased 10,000,000 gallons per day.

To furnish 75,000,000 gallons per day, by pumping, would cost as follows :—

30,000,000 gallons from the present Works, at \$6,000,	\$180,000
10,000,000 " additional from Fairmount water power, at \$3,000,	30,000
35,000,000 gallons from steam Works, at \$20,000,	700,000
	<hr/>
75,000,000 gallons, at a total cost of	\$910,000

To this must be added the cost of store reservoir and supply mains, the same as in the Perkiomen project, \$2,000,000; add interest, &c., \$160,000, making the total cost for a supply of 75,000,000 gallons per day, \$1,070,000, or \$14,266 per annum per million gallons. By comparing this estimate with the cost of furnishing the same amount by the proposed aqueduct, it will be seen that the aqueduct will save \$218,000 per annum, and when 150,000,000 gallons per day are used, it will be at a saving of \$1,510,000 per annum.

REVENUE.

When the prospective income for the water rents of the City is taken into account, the project of bringing in the Perkiomen loses much of its apparent magnitude. In 1825 the total amount received for water was \$27,299.18; in 1835, \$92,166.82; in 1845, \$135,465.37; in 1855, \$327,176.24; and in 1865, \$595,661.44. The revenue derived from water will no doubt be sufficient to pay all expenses as soon as the aqueduct can be built, and the profits would repay the total investment long before the bonds issued for

the construction of the Works would mature. When the City requires the full capacity of these Works, the annual net revenue from them, after paying all expenses, will be over four millions of dollars.

The Perkiomen possesses many advantages; in fact, all that can be desired; abundance of water of most excellent character, and in no danger of contamination, and a head sufficient for all parts of the City, with trifling exceptions. The entire work can be executed at a comparatively small cost. There appears, therefore, no necessity for looking to other sources.

Although the means at the disposal of the Department did not admit of the full investigation desirable, before recommending a project of such importance and magnitude, yet, with the information collected, I do not hesitate to urge upon you the adoption of the project, and would ask for the means of making the necessary surveys, plans and estimates for the work. Should you take the same favorable view of the project, immediate action will be necessary. A railroad is already located up the valley of the Perkiomen, which, should it be built as located, will interfere with the construction of the proposed lake. I would also remind you that to execute a work of this character will require a number of years after the necessary legislation is procured, the plans definitely arranged, and the location of the different parts fixed. I therefore respectfully suggest an appropriation of twelve thousand dollars, for the purpose of making the necessary surveys, plans and specifications.

HENRY P. M. BIRKINBINE,

Chief Engineer.