WATER SUPPLY

OF OUR

GREAT CITIES.

By REV. JOHN W. MEARS.

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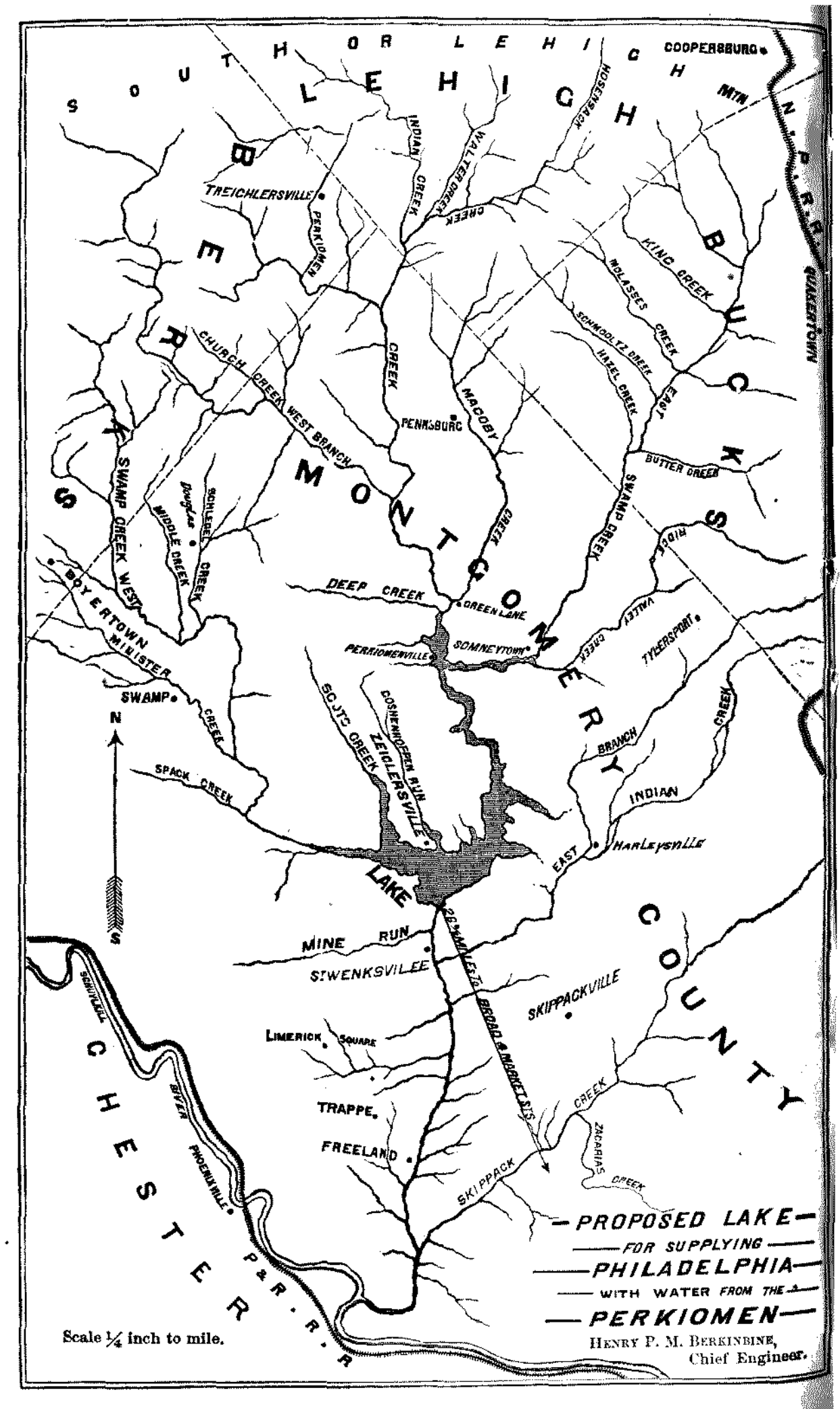
SOUTH MOUNTAIN
LEHIGH
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MONTGOMERY
BUCKS
CHESTER
COUNTY
COOPERSBURG
QUAKERTOWN
N.P.R.R.
TREICHLERSVILLE
PERKIOMEN
INDIAN CREEK
MOSELEM CREEK
KING CREEK
MOLASSES CREEK
SCHMOOLTZ CREEK
HAZEL CREEK
EAST BRANCH
PERKIOMEN CREEK
CHURCH CREEK
WEST BRANCH
PENNSBURG
MACOBY CREEK
SWAMP CREEK
BUTTER CREEK
MIDDLE CREEK
DEEP CREEK
GREEN LANE
SCHLEGEL CREEK
Douglass
MIDDLE CREEK
BOYERTOWN
MINISTER SWAMP
SWAMP CREEK WEST
PERKIOMENVILLE
SOMNEYTOWN
TYLERSPORT
VALLEY CREEK
SOUTH BRANCH INDIAN CREEK
ZEIGLERSVILLE
COSHENHOPPEN RUN
SPACK CREEK
HARLEYSVILLE
EAST BRANCH INDIAN CREEK
LAKE
MINE RUN
STWENKSVILEE
SKIPPACKVILLE
LIMERICK SQUARE
TRAPPE
FREELAND
SCHUYLKILL RIVER
PHOENIXVILLE
P&R.R.R.
SKIPPACK CREEK
ZACARIAS CREEK
N
S
Scale 1/4 inch to mile.
PROPOSED LAKE
FOR SUPPLYING
PHILADELPHIA
WITH WATER FROM THE
PERKIOMEN
HENRY P. M. BERKINBINE,
Chief Engineer.

THE WATER SUPPLY OF OUR GREAT CITIES.*

SCANTY SUPPLY OF LONDON—ITS BEARING ON PUBLIC MORALS

A subject so bound up with comfort, cleanliness, health, and good morals, as the abundant supply of pure water to our great and growing cities, will be regarded as not unsuitable for discussion in the columns of a religious newspaper. The painfully stinted supply doled out to the abject poor of London, undoubtedly forms a serious obstacle to their elevation in many ways. No one who informs himself of the facts in the case, as they have been stated by a writer in the last number of the *Edinburgh Review*, will wonder at the degradation, the drunkenness and the Sabbath-breaking, which accompany their poverty, and make it so hideous, and so hopeless. The very class of persons whose occupations render necessary a large amount of water to personal cleanliness; whose dwellings, from their crowded condition, most need frequent cleansings, to keep them from becoming like the dens and styes of beasts, are the most restricted in their use of the means of ablution. The inadequate supplies and the filthy condition of the water furnished to our captive soldiers in the South, during the rebellion, has been matter of just execration; but we must conclude, that the men who famished in the Andersonville pen, were no worse off for pure water, than are thousands of the poorer inhabitants of the great Christian city of London, at this day.

Our space does not permit us to present the dreadful facts as fully as we might wish. The best of the houses in these miserable neighborhoods are supplied with wooden cisterns, which, if regularly filled—about which there is some doubt—would allow each inhabitant an average of four gallons in twenty-four hours for all purposes. (In Philadelphia, the average to each inhabitant is forty-five gallons.) Moreover, nine-tenths of these cisterns are without covers, and one-

*Annual Report of the Chief Engineer of the Water Department of the City of Philadelphia, and Plan of Supplying the City with Water by Aqueduct from the Perkiomen, presented to Councils, February 15, 1866.

Edinburgh Review, April 1866, Art. "Water Supply."

half of them are so placed as to catch the foul drippings from the eaves of the houses, and are lined internally with scum and slimy vegetation. Not a few are so rotten that the finger can be pushed through them, and the contents of those that are tight, become every hour more offensive and unlike what water should be, for purposes of cleanliness and consumption.

Another mode of supplying these poorer quarters is by turning on water from the street pipes for a certain length of time every day. At that time, all who want water must be in attendance, with such articles as they can command. For *twenty minutes* a half-inch stream is allowed to run. "In the afternoon, those who pass that way may see, in looking up the narrow entrances of these courts, crowds of women and children, provided with bottles, pails, tubs, teakettles, broken jugs and other vessels. These people will tell you that they have not a drop of water in their houses. . . . At length the water issues from a lead pipe of not more than half an inch in diameter. So small is the stream, that it is difficult even for those who are provided with proper vessels to get what is wanted, and some are so ill off in this respect, that they are not able to collect more than a gallon of water. . . In some of the dark courts and lanes, pure water is as scarce as it is on board an emigrant ship during a long voyage."

Worse still, there are whole days in which there is absolutely not a drop of water to be obtained, and these days, of all others in the week, are those in which the abject poor would feel disposed and at leisure for some attempt at personal cleanliness. From Saturday afternoon at three o'clock, until Monday afternoon at the same hour, there are neighborhoods totally without a supply. Sometimes a whole court has to borrow from a "Public" at the corner. Three or four gallons of water must be made to last an individual, for every purpose, forty-eight hours! In a tenement neighborhood near Covent Garden, the poor creatures were described as actually famished for water in this Sunday drought. The premises belong to "eminent brewers"—men who not only convert much pure water into a means of dissipation, but who corrupt much more by the mere process of manufacture. Any one noticing the gutters near a brewery, flushed with turbid and offensive streams, may learn what poisoners of nature's beverage they are.

Who can doubt that there is a close connection between these facts, and the notoriously degraded condition of the London poor? Who can doubt that the squalor of their homes often drives them to the better conditioned gin shop; or, that when a healthful drink is al-

most impossible to be had, a stimulant is used in its stead? Who can avoid the suspicion that those "eminent brewers" already mentioned, stint their tenants of water, so that their appetite for beer may be kept at the highest available point? We believe it has long ago been settled, that an abundant supply of pure water greatly promotes temperate habits among the masses.

The relation of water supply to progress is shown in the fact, that the demand for water in our cities increases in a far higher ratio than would result from the increase of the population. "Not only does every additional person need a certain quantity, but every individual tends to require more water than any of his predecessors. The diffusion of care and cleanliness of body makes one man use perhaps twice as much water as any of his ancestors, and the more confidently men believe that cleanliness is next to godliness, the more ample will be their ablutions." Facts in regard to the amount of water used by former generations cannot be obtained; but we trace the effect of the increase "in the remarkable diminution in certain once prevalent diseases." In Glasgow, in 1838, twenty-six gallons a day was considered a liberal supply for each individual. In 1845 it rose to thirty gallons; in 1852 to thirty-five and thirty-eight gallons, and now, since Loch Katrine has been put to the practical purposes of a water supply, forty-five gallons are delivered, on an average, to every man, woman and child in the city. In London, the average is twenty-six gallons at the present time. In Philadelphia, in 1830, it was twelve and a half gallons; in 1861, it was forty-one gallons; it is now stated to be forty-five. Part of this increase is doubtless due to the increase of manufactories, requiring water for the generation of steam, and for a multitude of other purposes; but much is due to the increasing appreciation by individuals of the great comfort and moral value of an abundant water supply, when thus bountifully brought to their doors. They and their homes can be clean; it is their fault and their shame if they are not. A river of bright, pure water, poured in thousands of branches along every street and by every door, is a truly delightful persuasive to something very near akin to virtue. People yield to the persuasive; they luxuriate in the cheaply got cleanliness of their persons and homes. The filthier ones around them are shamed and stimulated. They, too, must have their share. And so the demand increases, and civilization and virtue are promoted in the action and re-action of increasing supply and increasing demand; it being difficult to apportion the praise accurately between the supply and the demand.

There is a great deal of cant uttered by infidel bigots and would-

be social reformers and materialist philosophers, upon the proper methods of ameliorating and elevating the social condition of the masses. Our missionary efforts, directed at the spiritual wants of these multitudes, are decried, and methods of outward improvement are extolled as worthy the first place in such undertakings. Let us not be loth to learn even from our enemies. Let us admit, that while myriads of the London poor have but two or three gallons of water apiece for all purposes, in one day, and on Sabbath none at all, or are supplied from filthy vats, little better than sewers, it is visionary to hope for great results from bare spiritual appliances. And it would be a legitimate and practical undertaking for the benevolent Christian men of the city, not only for Mr. Peabody, but also for the Bishop of London, and the multiplied evangelical organizations among churchmen and dissenters, to move earnestly for an increased water supply, as a powerful adjunct in the work of evangelization.

SUPPLY OF ANCIENT CITIES—JERUSALEM, ROME.

Even in ancient times, the supply of great cities with water was regarded as a matter of the greatest importance. The highest marks of engineering skill, and proofs of enterprise and liberality, appear in the arrangements made for this important end. In some instances, these water-works have quite outlasted any historical memorials which may have recorded their origin and described their character. There they stand, silent but overwhelming witnesses of a concern for the public welfare, and of skill and munificence, which we, in a more enlightened age, may copy with profit.

Jerusalem as the commercial, political, and religious capital of a nation which, at one time, obtained extraordinary power and prosperity, must at times have held an immense population. During the victorious reign of David and the golden age of Solomon, it is not unlikely that a million of inhabitants thronged the walls.* If we may trust Josephus, more than this number perished in the siege under Titus. The daily ablutions prescribed by their religion, and required in the services of the temple, must, in part at least, have made up for the absence of manufactures in the average daily demand for the water supply of each inhabitant. If that demand had equalled the present average supply for the inhabitants of London, (26 gallons,) the total average demand would have been, of course, twenty-six million gallons a day. This is just about the capacity of the Fair-

* Thomson, in "Land and Book," argues that scarcely one-fourth of this number could have regularly inhabited the city.—II., 590, 591.

mount Water Works in our city;* and it is a somewhat remarkable coincidence, that the celebrated pools of Bethlehem, otherwise called Solomon's Pools, have a capacity just about equal to that of the reservoirs on the top of Fairmount.

We copy the condensed account of these pools, constructed, in part at least, for the supply of Jerusalem, from "*The Bible in the Workshop.*"

"These remarkable reservoirs, of which there are three, are partly hewn out of the rock, and partly constructed of masonry. They are situated upon sloping ground, one above the other, each on its own level. They are of irregular shape and of different size, but each of very considerable dimensions. The measurements given by Dr. Robinson, who visited them, are as follows:—Lower pool: length, 582 feet; breadth, 148 to 207 feet; depth, 50 feet, and 6 feet of water. Middle pool: length 423, by 160 to 256 feet; depth, 39 feet, with 14 feet of water. Upper pool: length, 380 feet, by 229 to 236 feet; depth, 25 feet, with 15 feet of water. Their united capacity is therefore about equal to that of the seven reservoirs attached to the Fairmount Water Works in Philadelphia. They are so connected that only the surface water is allowed to flow off from the upper to the lower basin, thus allowing two opportunities for the impurities to settle before being drawn off for actual use. There are, indeed, conduits leading from each basin to the main aqueduct, so that, in time of scarcity, water from either basin could be procured. The embankment of the lower cistern is finished with a sluice, permitting the water to be drawn off occasionally. They are all lined with a thick layer of hard, whitish cement, and a flight of steps leads to the bottom of each. Not only do these cisterns remain, as a monument of the enterprise and skill exhibited by Jewish builders at an early age, but the aqueduct leading from them into the city of Jerusalem is still easily traced in the greater part of its course, winding through a very uneven country, sometimes above and sometimes below ground, until it crosses the depression on the western side of the city on a series of arches, and is finally lost in the ruins. Its length is estimated at from thirteen to fifteen miles. These remains are said to exhibit an acquaintance with hydraulics, which we could not have expected among Hebrew engineers. The stones of which the pipe is composed, are mortised together, with a fillet interposed to prevent leakage, and united with a cement so firm that they will sooner break than separate. The whole is covered with an arch or layer of flags,

* Preliminary Surveys in Mr. Birkinbine's Report, p. 4.

strengthened by the application of a peculiarly strong mortar, 'being endued with such absolute firmness as if it had been designed for eternity.'

"The age of these works is unknown. No distinct mention is made of them in the Scriptures. Tradition ascribes them, emphatically, to the time of Solomon, and numbers them among the great works of that most powerful and enterprising sovereign. No other period has been assigned to them. All agree that they are of great antiquity, and nothing conclusive is advanced to hinder our assent to the tradition."

In 1838, says Dr. Robinson, water was flowing in the aqueduct as far as to some distance north of Bethlehem, but did not reach Jerusalem.

The upper and lower pools of Gihon were constructed by Hezekiah; scarcely to make up for a deficient supply, for the population of Jerusalem was, at that time, doubtless, much smaller than in Solomon's time. Nor could the reservoirs at Bethlehem have given out, for very recent travellers* speak of having seen them full. Most probably, Hezekiah's object was to secure a water supply during invasions and sieges. For Milman must surely be mistaken in tracing, as he seems to do,† to the pools of Bethlehem, thirteen miles distant, the supplies of water "which enabled Jerusalem to maintain its thousands of worshippers at different periods, and *to endure long and obstinate sieges.*" An invading army could, without difficulty, have cut off that remote supply. The conduit from the upper pool of Gihon, into the city, cannot now be traced in all its course; but Dr. Robinson lighted upon a reservoir in the west of the city, still going by the name of "Hezekiah's Pool."

Thus, the Holy City was not unprovided for in this matter of the first importance to the general comfort, health and prosperity of a vast population. And part of the great and divinely supplied wisdom of Solomon was not inappropriately directed to this end. Our wonder and interest are increased, when we remember that these great works antedate the earliest aqueducts of Rome, of which we have any mention, nearly seven hundred years, and are still older than the oldest Roman works of which any remains can be traced. The oldest remains of these works belong to the aqueduct called *Anio Vetus*, which brought water from the Anio River, now the Teverone, thirty miles southwest of the city. It was erected B. C.

* Bausman, in "Sinai and Zion," p. 216, (1857,) and Thomson, "Land and Book," I., 422, (1857.)

† History Jews, I., 336.

273, seven hundred and forty years after Solomon's day. The Tiber, indeed, a much larger stream than its tributary, the Anio, flowed directly through the city of Rome; but, as the people of that city were either without the necessary machinery or engineering skill to give the water from that source the needed elevation, or because they saw that the trouble and expense would be too great, the Tiber was practically useless as a water supply. We say nothing here of its probable impurity. Hence, the Romans must seek a source naturally so elevated, as by the mere force of gravity, to distribute the water supply to every point of the seven-hilled city. The *Aqua Marcia*, a still greater work, nearly fifty miles in extent, drawing its supply from the same stream, but nearer its source, was built a century later. A considerable number of its arches are still standing. No less than *ten other aqueducts*, thirteen in all, are mentioned in the history of the water supply of Rome. Two of them, built under Caudius, A. D. 41–54, doubled the previous water supply. One of these, called *Anio Novus*, was a marvel of architectural grandeur. For six miles before reaching the city, it presented a continuous range of lofty arches, in some places 109 feet in height. Three other aqueducts, from different points, were united in the vicinity of the city, forming three separate water-courses, one above the other, and pouring their vast volume of water into a single reservoir in the city.

The Romans not only marked the lines of their conquests by splendid roads, but they bestowed even upon remote cities in their conquered provinces, the advantages of a similar abundant and steady supply of water. Nicomedia, Ephesus, Smyrna, Syracuse, Lyons and other cities, are mentioned in the list of places thus favored. In some cases, remains of these works are still standing. In Merida, Spain, there remain many piers belonging to two different aqueducts, some of them with three tiers of arches. The aqueduct at Segovia, in Spain, is one of the most perfect and magnificent works of art anywhere remaining. It is entirely of stone, and of great solidity; in places it is upwards of a hundred feet high, with two tiers of arches.

Returning now to London and modern times, we see this great city, with nearly three and a half million of inhabitants, embarrassed not only in the quantity, but in the quality, of her water supply. With five times the population of Philadelphia, she has, in the river Thames, "the great river" of England, a supply flowing over Teddington Weir, of just about half the volume discharged over Fairmount dam from the smallest of our two great rivers—the Schuylkill. She would literally threaten to drink up that "great river," were she not, in connection with fifty-six other towns upon its banks,

fast rendering it utterly unfit to be drunk. The degree of mineral impurity in 1854, was represented in figures as 15.52 degrees. It ranged in 1863–65, from twenty-two to sixteen degrees, there being an improvement latterly; arising, we suppose, from a change in the sources of supply of some of the companies. The organic impurity, although increasingly perceptible to the senses, is not represented in the analysis. The mineral impurity of the Schuylkill at Fairmount is put at six degrees; and our Chief Engineer is every year reminding the authorities in his reports, of the rapid increase of the sources of impurity to this river from the sewage of towns, and the filth of numerous factories of every kind, constantly multiplying on its banks.

As "the great river" of England is becoming hopelessly foul, and as artesian wells are totally inadequate to the wants of the city; as it is idle to look to surface drainage, or to streams in any of the densely populated regions around the city; as even the Severn River, in its lower course, is almost as bad as the Thames, the question forces itself upon the authorities and property owners of the great metropolis how this vital necessity is to be met? Is the growth of London to be arrested, and its population finally scattered; and shall those melancholy anticipations of the essayist, with his famous New Zealander, musing on the broken arches of London Bridge, already begin to cast the shadows of a cold reality upon the hearts of her surging and swelling millions? We seem to have found the limit of England's coal supply. About the time she has burned up all the coal she can come at, will her city populations have swallowed, or hopelessly corrupted, all the drinkable water within their reach?

English engineers are answering the question very hopefully for London and other great cities on the island. Far away among the remote and desolate hills of Northern Wales, where the damp winds from the Atlantic impinge upon the rocky walls, and first deliver their heaven-distilled treasures for the use of the inhabitants of earth, 171 miles from the half-famishing, half-poisoned millions of London, wise and skilful men have fixed the probable future location of the pure supplies which are to send health, comfort, and cleanliness through the streets of the metropolis. Here, the limpid streams which form part of the head waters of the Severn, are depended on to furnish two hundred million gallons per day, or fifty gallons to each of the present inhabitants, with the chance of increasing the supply as it may be needed. The total cost of these great works, with the long range of aqueducts, is put at £8,600,000—not an enormous sum, when the vast nature and utility of the enterprise are considered. A gala day, indeed, would it prove for London when such a gift was put in her

keeping; an omen of better days and of true advance to the corrupt, festering masses of her poorer population. Two millions of dollars worth of soap alone would be saved each year, by substituting the soft water of the hills for the hard water of the Thames River, in washing the clothes of the Londoners.

A truly grand and comprehensive scheme is at the same time broached by these English engineers, which proposes to supply Liverpool, Leeds, and a score of Northern towns, from one and the same undertaking. Copying, doubtless, the very successful experiment by which the pure waters of Loch Katrine are brought in profusion into Glasgow, these engineers propose to apply the pure and abundant waters of two lakes in Cumberland and Westmoreland to a similar source. The mountainous ranges of these counties face seaward, and the regions showed in the year 1845–53, the extraordinary average rain-fall of 140 inches per annum; *four* times the average in this vicinity. Over the area drained by these lakes, there should, therefore, be an average daily drainage, allowing for evaporation, of 550 millions of gallons. From this immense store, in positions elevated from 400 to 700 feet above tide, it would be a simple problem to furnish these low-lying towns with a daily supply of 131 million gallons in the aggregate. The cost of the combined works would be £12,000,000 sterling, the annual revenue being estimated to exceed interest and expenses of every kind.

A NEW SUPPLY FOR PHILADELPHIA—WHY WE MUST LEAVE THE SCHUYLKILL AND DELAWARE RIVERS.

The increasing impurity of the chief water supply of Philadelphia—the River Schuylkill—and the rapidity with which our rapidly growing population has been approaching the extreme limits of the capacity of the existing arrangements for a supply, have furnished frequent topics of warning and argument on the part of the Chief Engineer. His latest report warns us that the limits of the pumping machinery, theoretically, are passed, and that practically, we are in a precarious situation, depending upon the power of the machinery to withstand the strain of the excessive duty required of it, and upon exemption from such accidents as a serious break in the dam, &c. The theoretical limits of the machinery are 36 million gallons daily. In the hot spell of July last, as many as 40 million gallons were forced from the groaning pumps in a day. Our storage capacity is sufficient for but a *two days' supply*. Should we desire to increase our supply from the Schuylkill, it will not be practicable to give any great extension to the present cheap but wasteful methods of driving the

pumping machinery, now practised at Fairmount. Hence a radical change of the mode, as well as a great and permanent increase in the supply, must be provided for.

One would think that Philadelphia, lovingly begirt by two great rivers, of comparatively pure and soft water, rolling for miles by the foot of her wharves, need never be agitated by the question of a water supply. Here it is, in abundance, we imagine we hear thoughtless persons exclaim; what have we to do but to pump it up and drink it? The idea of going miles away from two such streams as the Delaware and Schuylkill, for a water supply for Philadelphia, seems to many a mere freak of engineering folly and ambition, not to say a scorning of the bounties of Providence.

Yet long ago, Rome abandoned the Tiber, and had recourse to its obscure tributary, the Anio; London is about giving up the Thames and going to the rivulets of Northern Wales; Glasgow has abandoned the river Clyde, and has tapped the little Loch Katrine; Paris, too, is leaving the Seine; Dublin is leaving the Liffey and the Dodder, and Manchester the Mersey. And the Chief Engineer of our water works proposes to leave both the Schuylkill and the Delaware behind, and to gather the supplies which are to suffice when Philadelphia requires six times her present demands, from a comparatively small and obscure stream, thirty miles away.

At least he is not suggesting innovations or trifling with established facts, in this serious matter of a water supply for a great American city, in generations to come. He is, in fact, conforming to a widely gathered experience, reaching as far back as 273 B. C., two thousand one hundred and thirty-nine years ago, when the Romans forsook the Tiber, flowing past their doors, and betook themselves for a supply to its tributary, the Anio—a stream which bears much the same relation to the Tiber as the Perkiomen does to our own Schuykill. He is but applying, with wise foresight, to our own prospective necessities, those valuable lessons which a dire experience has just now forced upon the engineers of the Old World.

Take the case of Glasgow for instance. Here is a city with a broad, deep, navigable stream of fresh water flowing like the Thames and the Schuylkill, through its centre. Pumping water works delivered the waters of the Clyde, for many years to the inhabitants. But the supply soon became inadequate; impurities accumulated; freshets filled the water with clay and moss; it was hard and unfit for washing; a multitude of plans was suggested for relieving the difficulty, one of which was carried into effect, and the southern half of the city was well supplied from the head waters of a small stream five miles dis-

tant. At length the pure, soft, and unfailing waters of Loch Katrine, thirty-five miles to the north of the city, were fixed upon by competent engineers as the proper permanent source of supply. The works were commenced in the spring of 1856. To give an idea of the extraordinary difficulties surmounted in accomplishing the work, we quote from the language of Mr. Bateman, the Chief Engineer:*

"It is impossible to convey to those who have not personally inspected it, an impression of the wild and beautiful district through which the aqueduct passes, for the first ten or twelve miles after leaving Loch Katrine. The country consists of successive ridges of the most obdurate rock, separated by deep wild valleys in which it was very difficult, in the first instance, to find a way. There were no roads, no houses, no building materials,—nothing which would ordinarily be considered essential to the successful completion of a great engineering work for the conveyance of water. The rock, when quarried, was unfit for building purposes; there was no stone of a suitable description to be had, at any reasonable cost or distance; no lime for mortar, no clay for puddle, and no roads to convey material."

Such an accumulation of grave difficulties must have led to the utter abandonment of the scheme, if interests less pressing than the supply of hundreds of thousands of human beings with water had been concerned, or if a mind of less capacity or genius for engineering than Mr. Bateman's had been charged with the problem. The result was, that the aqueduct assumed the form of an almost continuous tunnel. The rock proved extremely hard and difficult to work. At several points the progress did not exceed *three lineal yards in a month*, in each face of the opening, although the work was carried on day and night. The average progress through the mica slate was about five yards a month. In drilling the holes for blasting, a fresh drill was required for every inch in depth.

In March, 1860, the water was generally distributed through the city. Thus, in the face of doubts and distrust freely expressed, and of unparalleled difficulties, the whole works, involving an outlay of upwards of £900,000, and extending over thirty-four miles of country, were completed in less than four years. It is a work which will bear comparison with the most extensive aqueducts in the world, not excluding those of ancient Rome. Such difficulties were judged necessary to be overcome, in order to supply a city, lying on a navigable fresh-water stream, with water.

But London, in abandoning the Thames and the Lea, will be

* In "Papers read before the Institution of Engineers of Scotland on the Glasgow Water Works." P. 36.

obliged to undertake works many times the extent and the expense of these of Glasgow. We need not add to what we have already written on this part of the subject. The line of Aqueduct from the proposed basins or artificial lakes in Wales, is calculated at one hundred and seventy-one miles long, and the cost, when the works are completed, at between ten and eleven million of pounds sterling.

Such vast works being undertaken by cities, past which flow great streams of naturally good water, and such seemingly narrow sources of supply at a distance being exchanged for greater ones near at hand, may well relieve of all appearance of singularity the proposal of our chief engineer to abandon both the Schuylkill and Delaware rivers, and to have recourse to the trifling rivulet, Perkiomen.

Three conditions enter necessarily into the question of a water supply for a great city—abundance, purity, and cheapness. Abundance certainly we have at our doors. The rivers Delaware and Schuylkill could not only supply, but drench and drown a city equalling in population the combined totals of all the great cities of the world, for indefinite ages to come. So too would the Clyde have sufficed for Glasgow, or the Tiber for Rome, or the Seine for Paris, so far as the mere question of quantity is concerned. If, however, the abundant supply has become unfit for use, it must be allowed to roll on past our very doors untouched, while we look to remoter sources for the needed element. This is the fact in the cases named, and is tending to become so more and more. Rivers are the natural sewers of all thickly settled and agricultural regions. Into their channels, as to the lowest levels of the regions, drains almost everything that can take a fluid form. The better the habits of the people, and the stricter the sanitary regulations of the river-towns, the more foul becomes the condition of the river. Civilization and culture are incompatible with the drinkable character of river water.

The process of corrupting the waters of the river Schuylkill is steadily going forward with the increase of population and manufactures on its banks, and of tillage of the territory which it drains. It would be interesting to identify and combine, in one view, the various sources of impurity which discharge their corrupting contents into its channels, and make a sewer of that which is the very fountain of our life. We should have to commence with the sulphureous discharges which flow from the coal mines around its head-waters, in a vast and poisonous volume, destroying all the animal life within their reach. This source of impurity, however, is partially neutralized by a beautiful provision of nature. Just about seven miles above Reading, the bed of the river is crossed by an immense stratum of limestone, which

supplies a base for the action of the free sulphuric acid in the river, the resulting combination being the innocuous and easily deposited sulphate of lime. Yet, all traces of the acid do not disappear below the limestone. Even now, its presence may be detected in Fairmount dam. And if mining operations around the head waters of the Schuylkill continue to increase, the enlarged quantity of the acid may be expected to produce perceptible and deleterious results in the water as we drink it.

But there is no provision to neutralize the fast increasing sewage from large towns like Reading, Norristown, Pottsville, Pottstown, Phœnixville, Hamburg, and others; or from manufactories of every kind, including not only every sort of iron-works, but dye-works, chemical works, gas works, print works, paper mills, cotton and woollen factories, etc., etc., some of them discharging the most noxious and offensive matters into the waters. And not only the main stream, but every available tributary, as Wissahickon and Mill Creek, are thronged with these sources of impurity.* Not only the waste liquids, but all refuse matter from these establishments are either thrown directly into the river, or so placed as to be carried off at the first rise of the water. Many factories are located on the river-bank, expressly for the opportunity it affords of getting rid of their refuse matter.

And one of the guiltiest parties to the work of wilfully corrupting the stream, is the city itself which drinks it. Several *common sewers* in Manayunk open directly into the river, and the gas works in that district belonging to the city, is also permitted to give the same direction to its refuse. Even coal-oil refineries are tolerated as close to Fairmount as the foot of Girard and Columbia avenues.

Abandoning the Schuylkill as hopeless, and turning to the Delaware, we find a stream much more difficult to corrupt from its great size. Its waters do, indeed, already supply a portion of the city, and are at present drinkable and wholesome. If we abandon the Schuylkill, why not turn to the broad Delaware? So far as the existing quantity and quality are concerned, we might. And perhaps such a possibility as the corruption of the waters of that great stream, at any future time, is not to be regarded as of the slightest practical moment. But here enters the question of expense. The waters are here in abundance, indeed, but they must be distributed, and in order to be distributed, they must be elevated, and to be elevated they must be pumped. The expense of pumping so many million gallons of water a day to such a height, including interest on the cost of the works, is a simple problem, and has often been calculated. The Chief Engi-

* Preliminary Survey, pp. 10, 11.

neer, in his preliminary survey,* tells us that to supply seventy-five million gallons per day, (more than double the present amount,) by pumping, would cost over a million of dollars a year. Other considerations being the same, this question of expense would decide for or against pumping. It might appear advantageous, in a pecuniary point of view, to leave the pure and great stream at our doors, and to go many miles away, as did Rome and Glasgow, to the smaller source. GRAVITATION is the cheap substitute for pumping. Give us an elevated and abundant source of water, at a reasonable distance, that will distribute itself, without expense, when once brought into connection with our dwellings and places of business, and it actually becomes a matter of economy to go abroad for what seems so abundant, right at our doors. The longest way 'round is, in this case, the nearest way home. In short, the Delaware River, viewed as a water supply, is an elephantine gift, which we cannot control or utilize with any degree of economy. To procure it by gravitation, we should have to build an aqueduct a hundred miles long. The Chief Engineer shows us how, by leaving it and the Schuylkill thirty-five miles in the rear, he can supply us with seventy-five million gallons of pure water per day, at a saving of $218,000 per annum, as compared with pumping.

THE PERKIOMEN AS A SUPPLY FOR PHILADELPHIA.

As the Schuylkill river is growing more and more corrupt, and as either the Schuylkill or the Delaware water would have to be pumped by expensive machinery to make it available for distribution, the citizens of Philadelphia have no alternative in securing an abundant, pure, and cheap water supply for the future, but to abandon both these rivers, and look for a source as near at hand as practicable, from which, by gravitation, the needed amount may be procured.

Now, Philadelphia is highly favored in being almost entirely surrounded with a well-watered, rolling country, rising, in some directions, into heights far above the level of its built up portions. Streams of considerable volume rise in these high regions, and fertilize and give beauty to the picturesque valleys between. A dozen or more of these rivulets—they would be dignified as rivers, and their banks would be adorned by the castles of the nobility, and all the charms of poetic and classic imagery would be connected with them, if they were in England,—a dozen or more of them, tributaries of the Delaware and the Schuylkill, rise and flow in a course sufficiently near to the city to attract the eye of an engineer charged with the problem of supplying its population with water. Let us glance at these streams and test their capacities.

The Chief Engineer charges himself, in his preliminary survey, with

* Preliminary Survey, p. 26.

the examination of all of these streams, which seemed to promise any important results. Commencing with tributaries of the Delaware, his report embraces remarks and suggestions upon the head waters of the five familiar streams, whose mouths are successively passed as we descend from the mouth of the Schuylkill to the mouth of the Brandywine, viz., Cobb's, Darby, Crum, Ridley, and Chester creeks. They may all be classed together as of the same general character. With them, too, might be joined the classic waters of the Brandywine, which he does not mention. This stream, though further off in its general course than the others, yet stretches with its head waters far toward Valley Forge.

It is a stream naturally of remarkable purity and sweetness, whose qualities are well known and esteemed among the people and the manufacturers of Wilmington. Its waters might be reached and stored for the uses of our city at or near Downingtown. A stream so large and so available has obviously been left unmentioned by the engineer, on account of the vast manufacturing interests which would be destroyed by seriously diminishing the flow of its waters. But there is one objection alike applicable to the Brandywine and the five other tributaries of the Delaware, which have been mentioned; they all take their rise in Chester county, and from their sources to the points suitable for collecting their waters, they flow through some of the most highly cultivated and populous regions in the state or the country. Thus, one of the branches of Chester creek rises in the borough of West Chester, and receives all the drainage of that large and well-cleansed town; and all of them must, more and more, assume the characters of sewers of the populous and fertile districts, through which they flow. The insignificance of these streams, too, is seen from the fact, that if the head waters of all of them, except the Brandywine, were united in one engineering scheme, mentioned as practicable, but not recommended by Mr. Birkinbine, the resulting supply would be but one hundred million gallons per day—an amount for gathering which, we should hardly be justified in the great outlay required. If possible, we must build works which shall be sufficient for a generation or two to come; and it appears that if the demands of our city population for water increase for the next twenty-five years, at the rate they are now doing, we shall need at the expiration of that time, one hundred and fifty million gallons a day.

Passing now to the tributaries of the Schuylkill, and omitting the inconsiderable streams upon the western side, we come first to the romantic Wissahickon. This stream rises in Montgomery county, and after running a most picturesque course of nineteen miles southwardly, it enters the Schuylkill, four miles and a half above Fairmount dam.

The capacity of this stream alone is but little over one-fifth of that of the five united tributaries of the Delaware already described. There is little danger, therefore, that its attractions as a resort for pleasure-seekers, or as a seat of numerous mills and factories, will be interfered with. Three other streams intervene before we reach the largest tributary received by the Schuylkill in all its course; a stream larger than all of the five tributaries of the Delaware combined. This is the Perkiomen, which takes its rise far away in the hill country of Berks county, among the wild and romantic glens of South Mountain. Touching upon portions of Lehigh and Bucks counties, and traversing the northern portion of Montgomery county in its course, it empties into the Schuylkill, three miles below Phœnixville.

This is a stream of the most interesting character. Its course is mainly through a rough, unproductive country, until within six or seven miles of its mouth. The rocky character of its banks protects it from the disturbing effects of freshets. It was after a season of protracted, heavy rain, that we first visited this stream. A most excellent opportunity was afforded us, of contrasting the widely different effects of the freshet upon two streams in close proximity, but of widely different drainage. Our road lay across the Skippack, a large and sluggish tributary, which enters the Perkiomen near its mouth. This stream we found nearly the colour of chocolate. In a few moments we were crossing the main stream, on one of those magnificent stone bridges, which, after nearly a hundred years, remain the delight of the traveller and the engineer alike. The contrast in the appearance of the stream was really astonishing. There it flowed, comparatively bright and pure, innocent of all signs of freshet, save in the fulness and rapidity of its waters, limpid as those of a mountain torrent. The reason for the difference is obvious. The Skippack flows through a cultivated region, the geological character of which is the presence of red shale, while the water-shed of the main stream and higher tributaries of the Perkiomen is little cultivated, and is marked by hard sandstone and still harder trap-formation, the best guarantee in the world for the crystal purity of the water it retains.

It is, of course, *above* the mouth of this turbid tributary—to which we owe much of the discoloration of the Schuylkill during a freshet—that the works for the supply of the city are contemplated. The area of surface drainage upon which we should thus depend, and from which the creek and its tributaries would gather up the rain-fall, would be no less than two hundred and twenty square miles. Plant one limb of the dividers at the point of junction of Bucks, Lehigh, and Montgomery counties; extend the other limb westward, so as

nearly to reach Boyerstown; with this radius of about eight miles, the circle drawn around the point of junction of the counties named, will indicate, with tolerable accuracy, the section of country, including the corners of Berks, Montgomery, Lehigh, and Bucks counties, from which our city will draw the vital element so necessary to the wealth and prosperity of the prospective millions of its population. Compare these remote corners of territory with the districts through which flow the tributaries of the Delaware, already considered. A glance at the map will show that they are widely different in the single item of roads, being almost devoid of these means of communication; on the other hand, a perfect net-work of roads covers Chester county, in which all those six streams take their rise. Barren, rocky, and broken, these out-of-the-way sections are avoided by the great currents of population, and seem formed and located by the hand of Providence comparatively near to our doors, for the very purpose of treasuring up the dews and the rains; in diamond purity and healthfulness, for our use.

Now let a line be drawn from the centre of our imaginary circle, out toward the ocean—it will be seen that it may be extended due east, with room for a northward sweep, until it reaches the coast, without meeting any elevated land. Carry the outer end of the line downward, through ninety degrees of the compass, and you will find it still passing successively over tracts of low and flat country, over which the winds from the rainiest quarters, east, northeast, and southeast, can blow without interruption, and retain a large part of their stores of moisture, until they reach the hillsides and ravines of the South Mountain range, 900 feet above the tide. There they must yield up a portion of their treasures, and there the head waters of the Perkiomen are nestled, ready to receive their contents.

The most satisfactory way to ascertain the amount of water which the Perkiomen could be relied on to supply, would be to measure the stream at the point where it is proposed to gather its waters. But this is an expensive undertaking, requiring the construction of a dam —for which the funds have not been appropriated by the Councils— and years of observation. Recourse must, therefore, be had to a system of calculations based upon the average annual rain-fall over the region drained by the stream.

The rain-fall of this comparatively uninhabited region is unascertained, but we have every reason to suppose it much larger than in the level regions to the east and the south. However, Mr. Birkinbine, to be on the safe side, has taken the average ascertained fall in this city, for the past thirteen years, about 45½ inches per annum,

as the basis of his calculations for the Perkiomen region. The next step in the process is, to estimate the proportion of the rain-fall which actually passes into the channels of a stream, in a given territory. This is a very difficult point to settle. There are losses by evaporation and by absorption into the soil and the vegetation of the country. The water-shed of the Perkiomen is well wooded, and the evaporation is comparatively light; the banks are steep, and the flow of water into the channels is rapid and large; the character of the underlying rock is retentive, so that a large part of the rain-fall is doubtless utilized and brought into the stream. Taking the average of a number of observations made in connection with the actual water supply of twelve cities of Great Britain, as a certainly safe guide, Mr. Birkinbine allows for the loss of half of the rain-fall in the region by evaporation, &c.; the remaining half leaves us a body of water nearly two feet in depth, spread over the 220 square miles of country drained by the head-waters of the Perkiomen. A very simple calculation, then, brings us to the gratifying conclusion that there will be a daily average supply of 240 millions of gallons, which can be made available for the wants of the city; an amount sufficient to supply four millions of inhabitants with an average of sixty gallons of water each, per day.

How, now, shall we gather up and put into available form this body of water, which, at the depth of two feet, and covering over two hundred square miles of territory, is of no possible use to us, and which, coming sometimes in heavy storms, will hurry away from our reach, and in a few hours be irrecoverably lost? Here again Providence has been at work to aid us, in the configuration of the surface and the geological character of the region. If we take a position on the banks of the stream, at a point 26⅜ miles northwest of the corner of Broad and Market streets, we shall notice that directly across the path of the creek, enormous masses of trap-rock have been forced up through the surrounding strata of sandstone, forming a range of hills four to five hundred feet above tide, and three hundred and fifty feet above the bed of the creek. Through a gate or gap in these rugged hills, the Perkiomen has found its way into the more level country below. A survey of the region shows that these hills, stretching nearly due east and west, form the southern boundary of the available watershed of the stream; all the territory above them is of the geological character required for yielding pure water; below them an unfavourable change at once begins. An old copper mine, opened during the days of British rule, presents its mouth within a few rods of the southern face of the ridge, directly upon the bank of the creek.

Above the ridge, nothing more injurious than a small quantity of limestone and iron ore can be found. The Skippack Creek, the first large one below the trap, already furnishes a much deteriorated quality of water.

Now, when we remember that trap-rock is one of the most impervious of all geological formations to water, we see that both in location and texture, this ridge of trap is a natural dike, behind which the waters of the Perkiomen may be gathered; it being necessary for us only to supplement nature's work, by building a dam of sufficient height across the gap, through which the stream now flows. Had nature chosen to continue her trap-dike, without a break, across the country, we should have had a ready-made Loch-Katrine—a body of water, in fact, of nearly the same dimensions—within twenty miles of the city limits. She has come so near this beautiful and desirable result, as to invite us to complete her work, and Mr. Birkinbine proposes to the city to accept her invitation.

Running a dam across the gorge, say eleven hundred feet long, about the length of that at Fairmount, and sixty-five feet high from the lowest point or bed of the stream, we should soon collect a body of water covering an area of fifteen hundred acres. This lake would perform the part of an immense subsiding reservoir. Only the upper stratum of its waters, say twelve feet in depth, would be drawn off into the aqueduct. This twelve foot stratum, over an area of fifteen hundred acres, contains five thousand millions of gallons; a supply sufficient to last the city, at its present rate of demand, for two hundred days. Once full, there might be a drought extending through two thirds of the year, before the supply from this upper and purer stratum of the lake alone was exhausted. To-day, we have room for storing a *two days' supply* in our existing reservoirs.

Herewith we give a map, prepared by the department, of the proposed lake and immediately surrounding country. In its largest dimensions, the lake will be nearly six miles long and over one mile broad. The gorge in the trap-dike is at the point where the waters of the lake are represented as entering the main stream, flowing southward. The turnpike road, on the right bank, passes through the gorge, crosses what would be the bed of the lake at its deepest part, and rises to the level of the northern shore, at Zieglersville. The narrow arms of the lake would be navigable to a distance of over three miles from the dam on the western, and over eight miles on the eastern arm. If a small steamer were allowed to ply on its surface, as we believe, under proper restrictions it might be, excursionists might enjoy the novelty of a trip of the most romantic

character for over twelve miles, upon an inland lake, within thirty miles of their doors. Huge strata of trap and sandstone would frown from the hillsides and through the wild forests lining its shores. A single wooded island would rise gently upon its bosom, and palisade rocks, one hundred feet high, would loom up at different points on the long and narrow eastern arm of the lake. At suitable distances from the edge of the waters, summer residences of most desirable character might be built, and Perkiomen Lake might thus present a combination of useful and beautiful qualities, scarcely rivalled by any like body of water in the world.

And then, in years to come, when four or five times as great a population is comprised within our ample limits as at present; when Philadelphia has grown to the proportions which her favorable position, her manufacturing facilities, her healthfulness, good order and unyielding loyalty, promise to give her, and toward which she is moving with increasing energy and rapidity, Perkiomen Lake will be pouring through the proposed aqueduct, a daily supply of pure, undiscoloured mountain water, at the rate of sixty gallons for every man, woman and child, of the millions of inhabitants, every day of their lives; and the city will gather into the treasury, after interest and all expenses are met, and at rates not at all burdensome to the consumer, the enormous net revenue of over ten thousand dollars per day, or four million dollars per annum. The time might come when, with republican munificence, she could make her water supply almost as free to her citizens as the light or the air of heaven.

There was a discovery made and considerably noised abroad, some years ago, that Philadelphia is built upon gold. It was true, only the minute proportion of the precious metal in the soil would not pay the expense of extraction. Here we have a plan which is equal in money value, and infinitely superior in moral value, to the discovery of a real vein of gold running through the heart of the city; one which would contribute, if carried out, far more to the real prosperity of the city, and one, for the execution of which, posterity will be far more grateful to us of the present generation, than if we should transport a section of Montana territory to their doors—a plan for furnishing an unfailing supply of pure water at a trifling cost to the people. The general supply of the cities of Christendom with abundant and good water, might almost be accepted, especially in the light of Ezekiel's vision of the waters, (chapter xlvii.,) as a millennial trait. At any rate, we may fairly quote and apply the final clause of the ninth verse: "Everything shall live whither the river cometh."