ANNUAL REPORT

OF THE

CHIEF ENGINEER

OF THE

Philadelphia Water Department

FOR

THE YEAR 1883

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1884.

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PHILADELPHIA WATER DEPARTMENT

FOR THE YEAR 1883.

Presented to Councils April, 1884.

PHILADELPHIA:

1884.

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Joint Standing Committee on Water.

For the year commencing the first Monday in April, 1883.

Select Council.

JOHN K. CUMING (*Chairman*),
Charles H. Banes,
Thomas Green,
William Thornton,
George R. Snowden,
John Brady,
John H. Graham,
Philip Mitton,
Joseph B. Van Dusen,
John J. McDevitt,
Albert A. Ardis,
George W. Hetrick,

WILLIAM B. SMITH,
President of Select Council.

Common Council.

John Bardsley,
Henry Clay.
James McCormick,
George H. McCully,
Charles Roberts,
John T. Strickland,
J. Raymond Claghorn,
John M. Walton,
Alexander Reinstine,
Charles Lawrence,
John Smethurst,
Samuel R. Marshall,

WM. HENRY LEX,
President of Common Council.

Personnel of the Water Department.

CHIEF ENGINEER.

WILLIAM LUDLOW.

Assistant Engineers.

JOHN L. OGDEN, CHAS. G. DARRACH,
WM. P. OSLER, LLOYD BANKSON.

Draughtsmen.

John E. Codman, C. O. Lindroth, T. Mellon Rogers.

General Superintendent.

JOSEPH J. de KINDER.

Chief Clerk—J. T. HICKMAN.
Assistant Clerk—L. L. Dean.
Clerk to General Superintendent—John A. Hayes.
Pipe Recording Clerks—William Whitby, Allen J. Fuller.
Pipe Inspector—Theo. S. S. Baker.
Time Clerk—William J. Innes.

Telephone Operators.

Day—Martha Whittingham. *Night*—George Weikman.

Registrar.

A. N. KEITHLER.

Registrar's Chief Clerk—Wm. J. Halliday.

Cashier—John F. Scheidt. *Permit Clerk*—E. S. Higbee.

Registering Clerk—A. Buckheister.

Receiving Clerks—George S. Macauly, Chas. D. Birney.

General Clerks.

Joseph Fisher, Chas. L. Hayden, John M. Stacker,
W. W. Widdifield, Chas. H. Russell,
Kennedy McNeal.

Chief Inspector—Thomas Orr.

Inspectors.

Edw. D. Thomas, Edw. M. Rowe, William Erwin,
Wm. H. Hergesheimer, Wm. A. Agnew, Henry Marshall,
Lewis Obermiller, James Carr, S. D. Woodington,
Jas. H. Graham, Thomas Shaffer, James Cameron,
John Simon.

Superintendent of Shop—JAMES F. NEALL.

Clerk to Superintendent of Shop—Chas. K. Adams.

Purveyors.

First District, John H. Holmes,	Office, 11th and Wharton streets.
Second District, David A. Craig,	Office, 918 Cherry street.
Third District, Chas. J. Lowry,	Office, 1420 Frankford avenue.
Fourth District, John Montgomery,	Office, Corinthian ave. and Poplar st.
Fifth District, Henry Dawson,	Office, Lyceum Building, Roxborough.
Sixth District, David B. Morrell,	Office, Town Hall, Germantown.

Purveyors' Clerks.

Samuel Moore, George B. Bunn, Henry R. Wildey,
Arthur B. Cook, Charles H. Fletcher.

General Foremen.

First District, James Humes. *Second District*, Michael Young.
Third District, Daniel Ahern.
Fourth District, George W. Showaker. *Fifth District*, Charles Franks.
Sixth District, George W. Jones.

Foremen of Repairs.

First District, W. Wellington. *Second District*, Joseph Bryan.
Third District, Wm. Magee. *Fourth District*, James Hutchinson.

Engineers at Pumping Stations.

FAIRMOUNT—*First Engineer*, Joseph Moyer.
Second Engineer, Robert K. Matlack.

SPRING GARDEN—*Engineer in Charge*, A. C. Bonsall.
Assistant Engineers, David Pyke, Wm. Wakefield.

BELMONT—*Engineer in Charge*, Christian Bezold.
Assistant Engineers, Abram Stott, John E. Smith.

ROXBOROUGH—*Engineer in Charge*, William H. Smith.
Assistant Engineers, Lewis Culp, Joshua Bartley.

MOUNT AIRY—*Engineer*, Archibald Weir.

CHESTNUT HILL—*Engineer*, James McClennahan.

FRANKFORD—*Engineer*, Charles Douglass.

KENSINGTON—*First Engineer*, D. B. Perkinpine.
Second Engineer, William Kiner.

Foreman Carpenter—Henry Guest.
Foreman Bricklayer—Frank A. Mooney.
Foreman Stone Mason—Crawford Lukens.
Foreman Rigger—James Forrest.

REPORT

OF THE

CHIEF ENGINEER OF THE WATER DEPARTMENT.

PHILADELPHIA WATER DEPARTMENT.
March 1, 1884.

To the Select and Common Councils
of the City of Philadelphia.

GENTLEMEN:—I have the honor to present herewith the Annual Report of the operations of the Water Department for the year 1883.

Owing to the nature of my engagements in Washington at the time when Councils did me the honor of placing me in charge of this Department, I was unable to report at Philadelphia until the 12th of March, 1883, and the operations of the first three months,—although necessarily included in this Report,—should, therefore, be considered as having been conducted under the direction of my predecessor, Dr. William H. McFadden.

During the remainder of the year the work of the Department was continued with unremitting activity until the close, and in some important respects,—particularly in connection with the re-inspection of the City, upon which the revenues of the current year depend,—the work was so considerable as not to have been completed until about the end of January of this year, and time has not permitted the earlier preparation of this Report.

Very respectfully,
WILLIAM LUDLOW,
Chief Engineer.

PRELIMINARY REMARKS.

In March, 1883, the condition of the Water Supply to the City of Philadelphia was such as to give cause for grave apprehension. The growing pollution of the Schuylkill River, from which the greater part of the supply is derived, in conjunction with the rapid diminution of its minimum flow (from five hundred million gallons in 1816 to less than half this amount in 1874), were circumstances of such serious import as to have attracted marked attention more than twenty years ago. Not merely were the efforts of the successive Chief Engineers of the Department, and others both interested and competent, directed to urging remedial measures and a search for other sources, but in 1875,—public attention having been powerfully attracted to all matters relating to the well-being of the City by the approaching celebration of the Centennial,—a Commission of eminent engineers was summoned to consider the entire subject of the present and future supply, with special reference to immediate needs. The Report of this Commission, which contains information and recommendations of the greatest value, based upon conscientious and protracted investigation by men of ability, has been before the community for nearly nine years, during which the discussion of the subject, both in journals and in scientific reports and papers, has been actively maintained; and yet, with the exception of some additions to the pumping machinery and the construction of the Wentz Farm Basin, little has been done to carry out the suggestions then made. The Commission represented the value of storage and subsiding basins, but the East Park Reservoir still lies an empty waste. They pointedly referred to the danger of drinking polluted water, and published analyses to show the steadily increasing deterioration of the Schuylkill; but the intercepting sewer from Manayunk to Fairmount is yet to be constructed, and even the sewage flowing past the Spring Garden Station still enters the stream, apparent to every sense. The contents of Gunner's Run,—an open sewer in Kensington, charged with the foulest matters,—were industriously pumped into the Lehigh Basin, and thence distributed to a large and helpless population. Changes were recommended in the Fairmount machinery which would increase the capacity from thirty-five to fifty million gallons daily, but the pumpage now is about the same as then. The Pipe Bridge across the Wissahickon, through which the Roxbury engines force the water for the supply of Germantown and Mount Airy, still has but one sound member;—the other spans the valley, rent and useless. These are all points earnestly adverted to by the Commission, whose labors and recommendations, supplementing those of others, have, by some strange lethargy, been rendered futile. While favoring, upon the basis of the information before them, one of the several projects which had been proposed for the future supply, the Commission urged the necessity of full and accurate surveys, and the collection of reliable data, from which the subject could be intelligently considered and thoroughly studied; but nothing whatever in this entirely rational direction was accomplished.

In 1882, by the imminent prospect of a water famine, public attention was again aroused to the constantly increasing evils to which the community actually and prospectively was subject, and another Board of Experts, composed of gentlemen well known for their scientific attainments and personal acquaintance with the subject, charged with the duty of ascertaining what should be done for the present and future supply of the City. In October, 1882, the Board presented a preliminary report. They state that their examination revealed a condition of affairs which would not justify delay in taking action—that the greater part of the machinery in operation was driven to its utmost capacity, that at two of the most important Stations there were no spare engines, and two others were dependent upon a single engine each, that during the year 1883, an area containing two-thirds of the population would fail in Summer to receive an adequate supply, and that in 1884 there would be a general shortage throughout the City.

The Board stated that four new engines, aggregating a pumping capacity of forty-seven and one-half million gallons daily, were imperatively needed to avert this probable catastrophe during the Summer of 1883, and that two of them, if immediately contracted for, might be got into operation by June, 1883, and the others in August. The cost of these engines with the necessary houses, boilers, mains, and appliances, was estimated at about $425,000. The Board further urged the speedy completion of the East Park Reservoir, the construction of a new Basin on the high ground near Thirtieth and Cambria streets, and the enlargement of that at Mount Airy; and recommended that of the total amount (between two and three million dollars) required for the reservoirs, about $650,000 should be made available for expenditure during 1883, with increasing appropriations for the two years following; further, that complete surveys for a future supply should be immediately begun, and, considering the lapse of years before any practical results could be secured in that direction, they urged the vital importance of immediate measures to protect the intakes of the several stations from the large and constantly increasing amount of offensive sewage that enters them.

Notwithstanding these startling warnings, and the impressive statement of facts upon which they were based, and notwithstanding, too, that in the month of January following, the Schuylkill itself—as though determined to arouse attention—assumed a most noisome and intolerable condition of offensiveness, the recommendations of the Board awakened no response until early in April, 1883, when the final report was submitted. In this report, the Board (with which—having meanwhile assumed charge of the Department—I had the honor to be associated, both in its deliberations and in the preparation of the report,) renewed generally its previously expressed recommendations, and appended a table showing that with an actual steam pumping capacity of seventy-four millions daily and an estimated delivery of five millions from the

Fairmount Turbines during low river, the Department would probably be able to furnish but seventy-nine millions to meet a possible maximum demand of one hundred millions—and in case of the failure of the largest engine, the deficiency might reach a third of the greatest demand.

Having before it a statement of the sums which, to the amount of $525,000, had, by the action of Councils, been made available for new works in addition to that required for the ordinary operations and maintenance of the Department for the year 1883, the Board considered what would be the most advantageous disposition of this sum. Their conclusions were, in brief, that two fifteen-million gallon engines, with houses, boilers, mains, etc., should be constructed at the Spring Garden Station, at an estimated cost of $263,500; that at the Roxborough Station, a seven-and-one-half-million gallon engine, with mains, boilers, etc., should be built, at an estimated cost of $62,000, and at the Frankford Station, a ten-million gallon engine, which would cost about $50,000. A distributing main needed for Germantown would cost $70,000, and the surveys for future supply would require for this year $20,000, leaving a balance of $59,500—$39,500 of which should be expended for indispensable repairs to Buildings, Grounds, and Reservoirs, and the remainder—$20,000—be held as a Contingent Fund for the general or special needs of the Department.

The allotment to Buildings, Grounds, and Reservoirs, was necessary by reason of the fact that these were known to be in bad, and in some cases, dangerous condition, and the regular Annual Appropriation Ordinance had authorized the expenditure of but $18,500 to cover items, specifically designated, whose total amounted to over $54,000.

The annual Contingent Fund was regarded as indispensable to provide for unforeseen emergencies and variations of cost.

Having thus allotted the sum available, according to its best judgment, the Board renewed its recommendations that the additional facilities for the storage of water be provided as soon as possible, and discussed the question of future supply. This resolved itself into two aspects; one, the necessity for accurate and complete surveys, which had been entirely lacking in the past, and the other, the desirability,—in view of the long period that must elapse before new works could be constructed,—of ascertaining as thoroughly as possible to what extent the increasing pollution of the Schuylkill could be controlled by engineering works and legislative enactments, and the river be in some measure restored to its pristine condition of comparative purity and wholesomeness.

This brief statement of the results of the more important investigations into the affairs of the Department, seems requisite to a proper understanding of its condition in the spring of 1883, and a suitable introduction to the account of the operations of the year.

STATEMENT OF MEANS AVAILABLE AND EXPENDITURES.

The means at the disposal of the Department for expenditure during the year, are set forth in detail in the appended report of the Chief Clerk. They were, in brief:—

1. The annual appropriation to the Water Department, Ordinance approved December 30, 1882	$611,292 00
2. Appropriation from the surplus of 1880 and 1881, Ordinance approved March 24, 1883	250,000 00
3. Appropriation from the surplus of 1882, Ordinance approved March 30, 1883	210,000 00
4. Appropriation for extension of Works at Mt. Airy, Ordinance approved January 31, 1883	2,822 24
5. Appropriation of balance of certain loans, to be applied to beginning the construction of the proposed Cambria Basin, Ordinance approved June 27, 1883	2,994 39

6. Appropriations for the repayment of over-paid water rents	2,249 93	
Total appropriations		$1,079,358 56
The total was reduced as follows:—		
1. To repay over-paid water rents	$2,001 32	
2. To pay deficiencies for 1881 and 1882	16,655 39	
3. For compensation of experts	6,000 00	
4. By transfer to the Highway Department	3,000 00	
5. By balance merging, December 31, 1883	4,474 83	
		$32,131 54
Leaving as the sum actually available during the year		$1,047,227 02
Of this there was expended:—		
For maintenance, supplies, repairs, etc	$633,040 27	
For new Works	169,800 21	
Total expended		$802,840 48
Leaving a balance on hand, December 31, 1883		$244,386 54

This balance is held to discharge contract and minor liabilities, as follows:—

1. New engine and boiler-house at Spring Garden Station	$26,928 00
2. New engines at " "	41,000 00
3. New boilers at " "	50,650 00
4. Adjustment of excavation contract, " "	8,109 21
5. New engine at Roxborough Station	25,920 00
6. New engine at Frankford Station	34,000 00
7. New boilers at "	26,680 00
8. New engines at Mt. Airy Station	2,753 02
9. Pipes and castings	24,939 68
10. Beginning work on Cambria Basin	380 70
11. Repayment of over-paid water rents	2,321 58
12. Sundry small balances	704 35
	$244,386 54

Amount paid for new work in 1883	$169,800 21
Due under contracts	240.979 91
Total	$410,780 12

ACTUAL OPERATIONS.

The work to be done with the means available, arranged itself under several heads, somewhat in the order of their relative importance.

1st. Repairs to existing plant.

2nd. Preparations for, and making of, contracts for new plant.

3rd. Reorganization of the *personnel* and methods of the Department.

4th. Re-inspection of the City, to ascertain and collect its proper revenues, and to restrict waste and peculation.

5th. Investigation into the condition of the Distribution System generally.

6th. Organization and Direction of parties for Surveys for Future Supply.

These were all undertakings of considerable magnitude, and while some naturally took precedence, under the pressure of circumstances, it was necessary, if anything of value was to be accomplished during the year, to begin them all without loss of time.

Repairs to Plant.

The imminent danger of a failure to meet the imperative requirements of the City during the rapidly approaching Summer, demanded that the pumping plant should be put in as efficient condition as circumstances would permit, with the least possible delay, and to this end the examination, repair, and adjustment of the defective machinery and appliances were at once begun.

The Report of the General Superintendent, in part details the work at the several stations, but it is impossible, in an account covering the operations of a year, to summarize with more than an approximation to completeness, the very great labor involved in this.

From the singular condition of decrepitude into which the Department had fallen—owing to causes which it is not requisite now to discuss—the necessary repairs, as they were undertaken at each station, at the more obvious points, extended until they became general. The Engines and Boilers were nearly all in a more or less defective, and in many cases, dangerous, condition. The intakes had not been cleaned for many years, and the suction wells were full of débris that frequently obstructed the pumps.

The Buildings were generally in a very dilapidated state, a condition of affairs which, from every point of view, is disadvantageous. In the first place, it destroys the appearance of the station and seriously impairs its efficiency. To neglect needed repairs as they develop is, in the end, to incur much greater expenditure, to say nothing of the risk of serious accident.

But perhaps most important of all is the depressing effect upon the *morale* of the employés. Discipline, order, and efficiency cannot be imposed upon men working in the midst of dirt and disorder, and, as every manufacturer knows, the greater the attention to systematic good order and cleanliness, and the more complete the arrangements for the comfort and convenience of the men, the better work will they do. From the money point of view alone, it is a good investment. Furthermore, there is a certain responsibility attaching to the management of the public works of a city, which requires that it should be in no respect inferior, and, if possible, exhibit a better system and efficiency than that of private establishments, both because the people who defray the cost of the service are entitled to an economical use of the public funds, which are heavily drawn upon for many other purposes, and because the city works are open to examination, and subject to public approval or condemnation.

Of the repairs at the several stations, I shall, in this report, refer only to the more important.

The FAIRMOUNT TURBINES have less than half their proper efficiency, wasting large quantities of water, and wearing themselves out more rapidly from the existence of their own defects than from their legitimate work. The roof above them had for years been leaking rain and silt, and the engine rooms looked as though they had been submerged by a freshet. The head gates were in many cases past operating, and could not be moved.

This Station was, however, less important in Summer than others, since the low water would stop the wheels in any event, so that no attempt was made at the formidable work of overhauling the Turbines.

In other respects, the condition of affairs was improved by replacing the Asphalt with a Granolithic roof, covering the brick pavement with Neufchatel, rebuilding the gates, thoroughly cleaning the station, and minor repairs.

The old Engine, No. 2, which for years had been useless, was taken out and sold.

At SPRING GARDEN is concentrated the largest plant, both in number and capacity, and the station is additionally important as supplying a large population direct from the pumps, without the intervention of a reservoir. A failure of the engines meant a total deprivation of water for a large district, including the Twenty-eighth, Twenty-ninth, and portions of the adjacent Wards, having a population of over one hundred thousand—with all the inconveniences, loss and danger that this condition of things would imply.

Two of the oldest Engines, Nos. 4 and 5, over-head and side-lever Cornish, are very extravagant in the consumption of fuel, and are not, for our purposes, worth the cost of retaining in service.

No. 6, Simpson Compound, was in fair condition; so, also, was No. 8 Worthington, which exhibited its good staying qualities during the Summer, with only an occasional halt.

The largest Engine, No. 7,—Cramp & Sons',—had never been put in good condition in its seven years' service, and, although designed as a twenty-million gallon engine and readily capable of that work when properly handled, had never pumped over seventeen and a half millions, and was rated in the Department at fifteen millions. Time did not admit of thoroughly repairing it, and the situation had to be accepted. It ran, with occasional halts, until late in the Summer, when the cracks in the housings,—which, from defects in adjustment, had existed for years,—began to look dangerous, and a fortnight's time was taken to stay and brace them. New housings were made and put in late in the year, and the Engine can now pump twenty-two millions against two hundred feet elevation without difficulty.

The roofs over the boiler room were raised for light and ventilation. Closets and bath-rooms for the men, and a small storehouse were constructed. The only convenience heretofore, was a small building on the hill, at some little distance from the station. It was therefore but little resorted to, and in consequence, the grounds adjacent to the buildings were in a very objectionable condition. In addition to this, the open sewer flowing past the building, emitted the most nauseous odors, which, at times, occasioned sickness among the employés. This is now covered in with a temporary wooden trunk, open at the bottom.

At BELMONT the plant consists of three Worthingtons, none of which was in good condition. Both Nos. 1 and 2 had cracked cylinders, which were repaired, and a new one for No. 2 was made ready for an emergency.

The submerged main leading from the Belmont Basin past the Belmont Station and under the river to near the Spring Garden Station, for the supply of the high levels of the Twenty-eighth and Twenty-ninth Wards, had broken at the deepest part of the river, at some indeterminable period in the past, and a large volume of water escaped when admitted. It was as thoroughly repaired as practicable at the time, and the broken joints encased in a heavy jacket of iron, bound with straps and secured with steel bolts. This held through the Summer, and on several occasions,—when from one cause or another the Spring Garden Engines were stopped,—maintained the supply to the eastern high levels which otherwise would have entirely lost it. The repaired section broke again December 4th, and the main is at present out of service, but will be thoroughly and permanently repaired this Spring.

The arrangement of the mains at the Belmont Station needs amendment. At present No. 1 pumps direct to the basin through a main of its own. Nos. 2 and 3, when they pump to the basin, are compelled to do so through the upper part of what further down becomes the submerged main leading to the east bank of the river. If, therefore, any draft is made to the eastward, the two engines pump up against the backward movement of the water, occasioning great confusion and excessive local pressure, with corresponding loss of efficiency. It was this defect, in conjunction with the heavy blows simultaneously given the submerged main by the action of the Cramp Engine at Spring Garden pumping into the other end of it, that developed the nearly explosive pressure which broke the steel bolts and split open the iron jacket at the break.

This point was at the deepest part of the river, where the static pressure alone, due to head of water, was considerably in excess of ninety pounds, and where two lengths of pipe made an angle with each other up-stream, both horizontally and vertically, straining open the joint, which was unsupported. The evidence is to the effect that the leak had existed for a considerable time.

The Engine House roof was opened at the top for much-needed light and ventilation, and a bath and dressing room for the men constructed in the rear.

The Station had no means of lighting other than hand lamps, which, aside from the danger from their use, smoked the walls and machinery. After advertisement, a sixty-light Edison Electric plant was put in at a total cost of $2,650, exclusive of the foundation for the engine and dynamos, and steam connection from the boilers.

This light has given great satisfaction, although an undue number of the lamps burned out by reason of the current having been set too high. The full account of this installation is given in the General Superintendent's report.

The work of the other stations, which were all in need of repair, was the occasion of less solicitude by reason of the smaller requirements more nearly approximating their capacity to meet them.

At the ROXBOROUGH STATION,—supplying Manayunk, the Falls of the Schuylkill, Germantown and Mt. Airy,—the No. 1 Cornish was in fair condition, although an extravagant and ponderous machine to operate. The No. 2 Worthington had for a long time been in need of a thorough overhauling. Repairs were made, and the engine was operated during the Summer.

At the FRANKFORD STATION,—which, in connection with the Wentz Farm Basin, supplies Frankford and the adjacent population in the Twenty-third and Twenty-fifth Wards,—the No. 2 Worthington, a small two-million gallon engine which had seen hard service at other points, was overhauled, ready for an emergency.

No. 1 Cramp 10-million gallon engine was all through the season in a dangerous condition, owing to its having been operated without proper adjustment, and at great disadvantages. Working only in the day-time to the Wentz Farm Basin, it was made to meet the necessities of the case by unremitting watchfulness, and occasionally an all night's work at repairs,—and was also kept going when the repairs to the basin necessitated constant pumping.

At the KENSINGTON STATION,—which pumps to the Lehigh Avenue Basin (formerly called "Fairhill,"—a name which should be retained,)—it was necessary to practically rebuild the air pumps of No. 3 Worthington, which, after thorough repair, did good work throughout the year.

Nos. 1 and 2 are engines of antiquated type, and in such condition as not to be worth repairing or retention. They were run during the Summer as necessity compelled.

The water pumped at this station, notwithstanding the urgent representations of its evil quality, was still taken from the end of the wharf, where it was contaminated both by the general sewage of the river, and, on the ebb tide, by the contents of Gunner's Run, otherwise called the Aramingo Canal.

The only improvement to be made at first was to cease pumping during ebb tide, and take the water only on the flood. Later, a wooden trunk four feet square was laid to mid-channel of the Delaware, and the water taken thence was much improved in quality and appearance. As elsewhere shown, however, the Kensington Station must be abandoned as a source of water supply, and no repairs were therefore made beyond those necessary to a temporary use of the station.

The MT. AIRY STATION is designed to supplement the supply to Mt. Airy and the vicinity, by drawing from the main through which the water is pumped from the Roxborough Station to the Mt. Airy Basin, and forcing it into the supply mains at an increased pressure. The station is built on a level below that of the water in the basin, which is the cause of certain disadvantages, more particularly referred to in the Report of the General Superintendent.

The two engines which constitute the equipment, have a capacity of one-million gallons each, and having been tested in actual service, are found to require certain alterations to improve their operation. In case of a failure of the Chestnut Hill Supply, arrangements have been made so that the Mt. Airy Engines can be put on this duty, as well as their legitimate work.

The CHESTNUT HILL STATION was purchased by the City in 1873, from the old Water Company, and the pumping and distributing plant will require considerable modification to adapt them fully to the increasing requirements of the district supplied.

The RESERVOIRS are, without exception, in need of considerable repairs and improvements. In works of this character, constituting a prominent public feature, it is not enough that they should be maintained in the most efficient condition;—some attention is properly due to their appearance. Not only has their cleanliness been neglected and the apparatus pertaining to their use been allowed to deteriorate,—but the greater number are unsightly and forbidding in appearance, and in consequence affect injuriously the value of properties in their vicinity.

The reports of the Superintendent and of Mr. Ogden, Assistant Engineer, show their present condition, and the lapse of years since they were cleaned. An analysis of the subsided muds shows that the material is of the most deleterious character, and in a highly concentrated form. It is proposed during the year to empty and clean them, making necessary repairs, and taking measures to protect the outer slopes and otherwise improve their condition.

The Wentz Farm Basin,—the banks of which had slipped in September 1882, and which, ever since its construction, had leaked to a greater or less degree,—was drawn down, the banks rebuilt and sodded, the brick floor repaired and a portion of it adjacent to the inner slope covered with a coating of cement extended up the bank some 12 feet. The stop house, which was in a bad condition and leaked freely, was also repaired.

The main difficulty with this basin is in the character of the material of which the banks are built, and the absence of sufficient suitable clay puddle to make the floor and walls water-tight.

It may, in the end, require considerable expenditure to remedy these defects of original construction.

During the year 1884, the general repairs to plant must be continued. There is an almost total absence of proper feed and blow-off arrangements. Grate-bars for burning pea coal have been ordered, and will be used this year. Feed heaters and improved safety valves will be provided. Many of the boilers will probably be condemned by the close of the season, and must be replaced.

As soon as the new engines now constructing are in service, those which have been under steam for a long period at great disadvantage, will be thoroughly overhauled and repaired,—in especial the No. 1 at Frankford, and No. 2 at Roxborough.

With the steam engines in good condition, no apprehension need be felt for the summer, and the Fairmount turbines can be taken down one by one, and necessary repairs and improvements made.

Much remains to be done, but the greater part of what is necessary can be completed by the close of the year, with the funds now available.

It is proper to say, that to the unwearying energy and intelligence of the General Superintendent, Mr. de Kinder, is largely due that rapid improvement in the practical working of the service at the stations, which enabled the Department, with crippled machinery, to meet the heaviest demands ever made upon it, and to carry the City through the Summer without serious loss or inconvenience to the citizens.

Tests of Coal.

The Water Department is a purchaser of coal to the amount of twenty-five or thirty thousand tons annually. The coal bills for 1882 were for 28,395 tons, costing $124,525, and for 1883, 27,486 tons, costing $117,874.

During the past year it was possible to effect a considerable economy, and at the same time increase the average steam pumpage during the Summer months, by improved discipline and better firing; but circumstances did not admit of such general modifications as were required to secure the large saving to be made by buying a less expensive coal than the Egg,—which has been in use for several years, and for which the 1883 Contracts had been made.

In anticipation of the new Contracts for 1884, experiments were made at Belmont to ascertain what would be the probable result of reducing the size, and perhaps of changing the character of the coal burned. The results of this are stated in a table accompanying the Superintendent's Report.

The tests were made under the immediate supervision of Mr. Lloyd Bankson, Assistant Engineer, and carefully conducted. The last column of the table shows the relative economy, taking into consideration both steam-making capacity, and the price of the coals tested.

The Contracts for 1884 were therefore made for Pea coal, and the necessary changes effected in the grate bars of all the boilers in use in the Department.

These alterations will be completed in March, and for the remainder of the year, Pea coal only will be used, with a probable saving of $25,000 or $30,000.

It may be possible to take still further steps in this direction, and the investigation of the subject will be continued until all the conditions have been fully ascertained, and the best results secured.

The Telephone Service.

As was anticipated, this has proved itself to be an indispensable adjunct to the practical working of the Department.

Formerly, the watchmen at the Basins had no other means of notifying the Pumping Stations of the condition of affairs than to leave their posts and do so in person, and the Stations were in partial communication, only, with the Main Office, by means of a Telegraph System of obsolete type, which was more often out of order than in working condition.

A Central Station (connected, also, with the general system of the City) was established at the Main Office, and an operator is in attendance, day and night. By means of five separate circuits, every Basin is connected with the Station to which it is auxiliary, and every station with the central one.

In addition, the Purveyors' Offices are all in communication with the Main Office, so that at any time of the day or night, reports can be made, and instructions promptly issued.

The Basins and Stations make regular hourly reports, so that the engines can be started or stopped, as occasion requires or circumstances indicate, and in case of accident, remedial measures can bé directed and begun without loss of time.

In this connection it should be observed, that an important advantage could be frequently secured in case of large fires. For example,—in the high district covering the Twenty-eighth and Twenty-ninth, and portions of adjacent Wards, which constitutes the large area dependent upon direct pumpage from the Spring Garden Station, between ten and four o'clock at night, the consumption of water is much less than during the day. It follows, therefore, that the engines are run at a lower speed. If now, a large fire should occur, and the Department were notified promptly by telephone, the pumping engines could be run up again, in a comparatively short time,—say 20 minutes or a half hour,—and largely increase the delivery of water to the Fire Engines. In many cases, the effect of this increased pressure might result in a large saving of property.

In case of fire in other portions of the City as well, benefit might result from a notification to the Department. The Purveyors' Offices could be called up, and the prompt opening or closing of a few stops would in many cases increase or concentrate the delivery to the endangered locality.

With the City so inadequately protected from fire as it is, and the Fire Department so dependent for its efficient working upon the Water Department, no means, however slight, should be neglected, of increasing the chances of saving life and property.

This suggestion has heretofore been made, officially, to the Fire Commissioners, but not acted upon.

CONTRACTS FOR NEW PLANT.

The appended Schedule is a condensed statement of the Contracts made for new Engines, Boilers, and Buildings, giving the names of the Contractors, dimensions of Plant, and cost.

In general, the recommendations formulated by the Board of Experts in April were followed, although certain variations therefrom were made, as upon the whole seemed judicious.

The specifications were carefully prepared, and the contracts made—after due advertisement—with the lowest responsible bidder whose proposals were in conformity with the requirements.

The general design of the new engine and boiler house at the Spring Garden Station was prepared in the Department, and the working drawings—covering details and architectural features—were made in the office of Mr. Jos. M. Wilson.

It was desirable that Mr. Wilson's skill and cultivated judgment should be consulted in this, as the building stands close to the Park Drive, and will always be a prominent feature.

It is believed that, while the means available for the purpose did not admit of an elaborate or expensive construction, the building will be such as to fairly harmonize with both its purpose and surroundings.

The site for the building was excavated out of the rocky hill adjacent, and its construction, as well as the draining and cleaning of the forebay, awaited the completion of the excavation work. The contract fixed the date of this at September 1st, and as by the 11th the contractors had made comparatively little progress, the work was taken from them, and completed by the Department at their expense.

The two Worthington Engines for this station will be capable of pumping 15 million gallons each, in 24 hours, to the proposed Cambria Basin, at an elevation of 165 feet above City Datum; and the pumping mains will be so arranged as to deliver to the East Park, Cambria, or Spring

Garden Reservoirs, or to pump directly into the distributing mains of the high levels of the Twenty-eighth Ward.

The ten Steel Boilers for the service of the engines are of the marine tubular type, internally fired, with Fox's corrugated furnace flues. It was intended to make use of two of the Frankford boilers, but as these are needed at the Roxborough Station two others must be purchased.

All the buildings at the Spring Garden Station will be furnished with an Electric Light plant, which has been tried at the Belmont Station and found to have great advantages—economical and otherwise—over lighting by gas.

A new Coal Bin will shortly be constructed, as well as a Storehouse to serve as a general depot of supplies for the Department.

In completing the equipment of the station, a second conduit from the river to the forebay is nearing completion. The difficulties in construction were seriously increased by the existence of a heavy timber trunk which had formerly done duty as a conduit, and been abandoned. To save time, and the expense of constructing a new brick conduit on uncertain foundations, two lines of iron pipe 48 inches in diameter were substituted.

The open sewer which flows past the station, emitting the foulest odors, will shortly be covered in with a temporary wooden structure, to conceal in some measure, its offensiveness; but the prolonged retention of so obvious and flagrant a pollution of the Fairmoumt pool, seems simply inexcusable, and until the City shall cease to be one of the principal offenders against its own laws, as well as those of nature and common sense, it will be useless as well as unjust, to attempt the enforcement of them upon others.

The interlacing and cross-connections of the numerous pumping mains back of the Spring Garden Station, which have been made from time to time to meet temporary requirements without reference to any general or intelligible system, has reached such a condition of complication as to be fairly dangerous.

Not only is the working capacity of the several engines reduced by the insufficient dimensions and absence of directness in the pumping mains, but the adjustment and alteration of the numerous stops and valves is in itself a work of much labor and uncertainty, giving cause for constant apprehension of accident.

It is quite necessary before the heavy Summer duty of this station shall begin,—when the demand for water is largely increased and the Fairmount Turbines fail to deliver their proper amount by reason of low water in the river,—to effect a thorough re-adjustment of the mains. This is likewise required in order to connect the two new engines with the supply system; and also because of the new Boulevard to be constructed from Girard avenue, past the station, and over the Reading Railroad, necessitating the alteration of the position of the mains to avoid burying them.

The Roxborough Worthington is now under steam at the station, in the position originally designed for it when the station was built. It will be able to deliver 7½ millions of gallons daily, to the Roxborough Basin.

The Frankford engine is of a type hitherto unused in the Department, although other of the Corliss pumping engines have been used with success in the New England States and elsewhere. It will be of the same capacity as the present Frankford engine, viz., ten million gallons daily to the Wentz Farm Basin, which has an elevation of 167 feet above C. D., and is distant about four miles from the station.

The boilers hitherto in use were constructed for a working pressure of 60 pounds only. It is recognized that a considerable economy of fuel can be attained by the use of higher pressures, and both the present and the new Frankford engine are of types that admit of the application of these. It was determined, therefore, to construct four new steel boilers of the same type as the new ones for Spring Garden, but calculated to work with a steam pressure of 100 pounds instead of 60. The Corliss engine is arranged for this, and the necessary modifications of the Cramp engine now in service offer little or no difficulty. A comparison of the useful effect of the higher pressures will be carefully made.

The four boilers hitherto in use at Frankford will all be transferred to Roxborough as soon as the new ones are delivered.

A new coal bin is immediately required at Frankford, and will be constructed this spring.

Following are descriptions of the new Spring Garden engine house, and the new engines and boilers.

New Engine and Boiler House at Spring Garden Station.

The new building stands on the north side of the forebay, with a total frontage of 166 feet southward, and 58 feet on the river end, and is built of Hummelstown brownstone, brick, and terra cotta, with a light, double corrugated galvanized iron roof, supported by wrought iron trusses.

The engine house, 58 feet square, adjoins the River Drive, with south and west fronts of similar construction.

It has a batired plinth of brownstone, 5 feet in height, and is surmounted by an ornamental lantern 18 feet square.

The boiler house, 48 by 110 feet, is separated from the engine house by storerooms and offices, and has a louvre with swinging windows overhead. The arrangements for light and ventilation throughout are good.

The stack stands in the rear of the boiler house. It is 16 feet square at the base and 100 feet in height, with wrought iron cap and railing at the top.

NEW PUMPING ENGINES.

STATION.	KIND.	Number.	Diam. H. P. Cylinder.	Diam. L. P. Cylinder.	Diam. Plungers.	Diam. of Piston and Plunger Rod.	Stroke.	Capacity. Gallons per stroke.	Piston Speed per Minute.	Capacity in gals. per 24 hours, corresponding to Piston Speed.
SPRING GARDEN......	Worthington Compound Duplex— H. R. Worthington, New York.....................	2	38-in.	66-in.	37-in.	5-in.	4-ft.	885	110-ft.	15,000,000
ROXBOROUGH...........	Worthington Compound, Duplex— H. R. Worthington, New York.....................	1	38-in.	66-in.	26-in.	5-in.	4-ft.	433	110-ft.	7,500,000
FRANKFORD..............	Horizontal Compound, Double, Corliss Type— R. Wetherill & Co., Chester, Penna...............	1	30-in.	54-in.	20-in.	$3\frac{11}{16}$-in.	3-ft.	192	250-ft.	10,000,000

Steel Boilers at Frankford and Spring Garden Stations.

Ten at Spring Garden; four at Frankford.

Constructed by Edge Moor Iron Company, Wilmington, Del.

Marine return tubular, internally fired, cylindrical; 11 ft. 6 in. diam.; 10 ft. 10 in. long.

One cylindrical steam drum (3 ft. 6 in. x 12 ft. 6 in.) for each pair of boilers.

Two furnaces to each boiler—Fox's corrugated steel—3 ft. 7 in. greatest diameter, 8 ft. long, with 188 lap-welded, wrought iron tubes (3 in. x 8 ft.) for each boiler.

Heating surface of furnace	136 sq. feet.
Heating surface of back connection	134 sq. feet.
Heating surface of tubes	1,180 sq. feet.
Heating surface of front of boiler	45 sq. feet.
Heating surface of side and back	56 sq. feet.
Total heating surface	1,551 sq. feet.
Grate surface	42 sq. feet.
Ratio of grate to heating surface	1—36.93

Statement of Contracts for New Work.

Henry R. Worthington, two 15-million gallon engines at Spring Garden station	$81,000
Henry R. Worthington, one 7½-million gallon engine at Roxborough	36,000
Robert Wetherill & Co., one 10-million gallon engine at Frankford	44,000
Edge Moor Iron Works, eight steel boilers at Spring Garden	50,650
Edge Moor Iron Works, four steel boilers at Frankford	26,680
Thomas Gamon, engine and boiler-house at Spring Garden	46,496
Wm. H. Green, five 48-inch stop valves	3,800
Gloucester Iron Works, two 36-inch check valves	1,300

Two flanged and curved pipes, at 3¾ cts. per lb.

R. D. Wood & Co , pipe, 48-inch and 36-inch, at $1\frac{369}{1000}$ cts.; and 16-inch and 12-inch at $1\frac{436}{1000}$ cts. per lb.

Gloucester Iron Works, breeches pipe, at $5\frac{2}{10}$ cts., and 6-inch pipe at $1\frac{52}{100}$ cts. per lb.

A. H. McNeal, 48-inch and 36-inch special pipe castings at 3 cts.; 16-inch and 12-inch special pipe castings at $2\frac{6}{10}$ cts. per lb.

Edward T. Niven, lead, at $4\frac{36}{100}$ cts., and $4\frac{39}{100}$ cts. per lb.

Operations of the Shop.

The work of the Department Shop, on Cherry street, near Ninth, is given in the Report of the Superintendent.

The establishment is a valuable adjunct to the Department, both in respect of convenience and economy, but its usefulness is restricted by the lack of space, of light, and of proper tools.

The combining of the Second Purveyor's Office and Yard with the Shop, is the cause of great inconvenience to both.

When the Kensington Station shall have been abandoned as a Pumping Station, as it will be this year, it might—with great advantage—be converted into an enlarged Shop. The local facilities for land and water carriage, its central position with reference to the corresponding class of industries, its nearness to other establishments with which the Department has frequent business, combine to indicate the desirability of converting the Kensington Station into a Shop. The buildings, steam-power, and floor space required are there, and the only expense attending the alteration would be that needed to make the transfer, and to properly equip the new shop with appliances and tools.

REORGANIZATION OF THE DEPARTMENT.

In a business so extensive as that of the Water Department, involving the collection and expenditure of large sums of money, as well as engineering work of considerable magnitude and interest, it is essential that the methods of administration should be as simplified and thorough as possible.

With a system clearly defining and enforcing responsibility, individual defects are readily discovered and corrected, and the work of the Department can be increased or diminished as occasion requires, without embarrassment or confusion.

To this end, however, authority must flow from above down-ward through the successive grades of employés, its limits for each being clearly fixed and adhered to; accurate records must be kept of all transactions, and accountability be rigidly enforced at every stage. From this point of view, the organization and methods of the Department were found defective in several important respects, the more obvious being the lack of necessary records in the main office, and of proper accountability in ordering and disposing of supplies.

It soon became evident, also, that there were both an excess of employés of the lower grades, and an insufficiency of those with higher functions through whom the various branches of the Department business must be supervised and conducted.

At the pumping stations, the absence of order and the looseness of discipline were marked. The engineers, assuming that they were so disposed, could not enforce their orders, and the subordinates, who were in most cases entirely too numerous, attended to the work in their own way, and were present or absent very much at their convenience. The results were manifest in much disorder and waste; while bad firing and cleaning ruined the boilers, wasted the coal, and furnished insufficient steam to the engines, whose efficiency was still further reduced by needed repairs not having been attended to, and by the use of improper lubricants. The pumpage accounts are based upon the recorded revolutions of the engines in connection with the volume of water corresponding to each stroke. It was ascertained that when the engines were not performing their duty, the relief valves were at times opened, reducing the load on the engines, and thereby making a show of pumpage without delivering the full amount to the basins.

At one of the stations, at least, the counters registering the number of strokes were sometimes worked ahead by hand.

At the Spring Garden station, tramps slept on the boilers in consideration of throwing coal into the furnaces, and the Kensington station was a common loafing place for the neighborhood, where fishermen dried and mended their nets, and boys ran riot.

In stating these typical facts, it is intended to convey the idea only, that the laxity of supervision and discipline enabled the defective work of the stations to be in part concealed by derelict employés, and responsibility for shortcomings averted.

The root of the evil must undoubtedly be looked for in the fact that other considerations than those of the effective working of the Department, crippled authority and made the enforcement of discipline impracticable.

The correction of these evils was effected by giving full authority and support to the Engineer in Charge, and holding him strictly responsible for the carrying out of his instructions. If then found unable to accomplish this, he was removed.

The enforcement of discipline at first developed opposition. At Spring Garden, where the largest number of men is employed, the discharge of several superfluous and inefficient men,—among them some who supposed themselves possessed of "influence,"—caused a mutiny. The men drew the fires and nearly all abandoned the Station. The Fourth of July was selected for this demonstration, for the reason that new men could not be secured on that day. Fortunately, the basins were full, and by the next morning new employés were at work. Finding themselves superseded, the better men made excuse that they had been misled, and pleaded for re-employment. There was no further trouble in this direction. The number of employés on the salaried roll whose services were unnecessary, was found to be thirty, and the corresponding net reduction of the salary list of the stations and grounds, amounted to over $18,000.

On the other hand, Councils authorized the employment of two Assistant Engineers of lower grade; an Engineer in Charge; two Draughtsmen; two Clerks; several Storekeepers and six additional inspectors.

In the Registrar's Office the additional assistance was especially required, as the records of water appliances upon which the collections are based, were known to be defective. A general inspection of the city had not been made in many years, and then but loosely, by leaving printed schedules of appliances to be filled up by householders. Even assuming that this had been honestly done, the Inspectors had not subsequently given that attention to their duties which was indispensable to have the records keep pace with building operations and other changes.

A re-inspection of the whole city was therefore necessary, and to effect this within the year, so that correct bills could be made out for 1884, would require the unremitting industry of a considerable force. The valuable results of this work are elsewhere reported.

To secure economy and responsibility in the purchase and use of supplies, all requisitions were submitted directly to the Chief Engineer—by the Purveyors, through the Assistant Engineer in charge of the Distribution System, and by the Engineers at the several Stations through the General Superintendent,—and nothing was ordered without the personal approval of the Chief Engineer.

A system of requisitions and receipts fixed responsibility at every point, and made it possible to trace a purchase from requisition to delivery, and final expenditure.

The weighing scales at some of the stations had been out of order for years, and the receipts for coal upon which payments were made, were practically based upon the bills. The consumption of coal per day was necessarily estimated only. This was remedied by repairing the scales, and requiring every pound of coal and ashes to be actually weighed into and out of the station, and recorded.

Small store-rooms were constructed at each of the more important stations, and a store-keeper employed whose business it was, in addition to acting as Clerk and Telephone Operator, to receipt for and issue, under the direction of the Engineer in Charge, all the small stores at the station.

Daily reports, covering the work at each station and in each Purveyor's District, were directed. The watchmen at the Basins report by telephone every half hour, day and night, to the Pumping Stations, and the Stations every hour to the Main Office, at Thirteenth and Spring Garden streets.

The Superintendent makes a daily report of the work of the preceding day, and other reports, weekly and monthly, are submitted by all assistants in charge of work, covering the entire operations of the Department,—the number of employés of each grade, how employed, etc.

With regard to the services of employés of all grades, they were given clearly to understand that the efficiency of the Department would be the first consideration,—that removals and changes would not be made without due cause, that every man should stand upon his own merits, and that his continuance in employment would depend upon the need of his services, his qualifications for the position occupied, and the faithful and satisfactory discharge of his duties.

I am glad to say that at the present time, while many improvements remain to be effected, the Department is in good working condition. The employés, as a rule, feeling that their future depends upon themselves, discharge their respective duties with interest, emulation, fidelity, and courage, working harmoniously for the benefit of the service and its improved efficiency and usefulness.

RE-INSPECTION OF THE CITY.

This work, which engaged a considerable number of employés for a period of several months, viz.: from August, 1883, to February, 1884, was a sufficiently important feature of the year's operations to justify special mention.

The methods of levying household water charges, vary in different cities. In some the bills are based upon the ratable assessments,—in other words the rental derived from the property is adopted as a measure of water charges. In others, the dimensions of a dwelling are taken as a basis,—its breadth upon the street, and the number of stories of which it is composed. In others again the actual amount of water furnished, as measured by meter, is charged for.

In Philadelphia the household water bills have always been made out from a record of the number and character of the appliances in use, in accordance with a schedule of charges, irrespective of the amount of water taken, or of the number of occupants.

These several methods have their respective advantages and disadvantages. That of actual measurement is undoubtedly at once the most equitable, convenient, and direct, but is open to the objection that the bills would be paid by the occupants of the premises, instead of, as now, by the owner, and therefore it might tend to effect an undesirable economy among that class of population which should be encouraged to make the freest use of water in their dwellings.

The "ratable assessment" and "dimensions" plans are artificial means of averaging charges which, in individual cases, are manifestly unequal.

The Philadelphia plan, on the whole, seems fairly satisfactory. It is true that the number of appliances in a dwelling is no measure of the amount of water used, but as the multiplied modern plumbing fixtures may be fairly classed as luxuries, their number indicates what the owner of the house is willing to pay for, and whether few or many, no restriction is placed upon the amount of water legitimately used.

As at present provided for, the Philadelphia system involves the serious disadvantage of domiciliary visits of inspection by employés of the Department, which must, of necessity, be a greater or less source of annoyance to the inmates. This could be almost entirely obviated by such legislation as would practically enforce a notification to the Water Department of all alterations in the plumbing. This matter will be hereafter adverted to more fully.

Examination of the Records of the Registrar's Office made it clear that the charges entered upon the books were, to a great extent, imperfect. No general inspection of the city had been made for many years, and the work of the Department Inspectors had not been in all cases carefully or conscientiously performed.

As a rough experimental test of this, an accounting was ordered of the actual number of bars and horse troughs in the city, to each of which is made a special charge of $10 per annum.

These two were selected for the reason that both possessed a certain character of obviousness that challenged attention, and in fact made it somewhat difficult to overlook them.

It appeared, nevertheless, that in one of the districts the Inspector had succeeded in accomplishing this to the number of over 100, and in some of the other districts to a less degree.

It was evident that to systematize the work of the Department, and in especial to ascertain in each case what should be the annual water charges in order that the City should receive its proper dues without discrimination in favor of or against individuals, a general re-inspection of the city was necessary.

The undertaking was certainly a formidable one, especially as it had to be completed, or nearly so, within a year, in order that the corrected bills for 1884 could be prepared by February 1st.

The detailed statement of the results of this work cannot be presented in this Report. It was completed late in January, and the making out of the bills and receiving moneys for 1884 have left the Registrar without opportunity to thoroughly compile and collate the information. This will be fully stated in the annual report for 1884.

The number of properties examined was in excess of 160,000, and in some cases a re-inspection was necessary where errors and omissions had occurred.

There were very numerous changes, making the rents in some cases less, but, as might be expected, in the greater number, larger. The total increase of the revenue, due to the re-inspection, cannot yet be given. In many Districts the increases were heavy, in others, slight.

On Spruce Street, taking that as an illustration, the average increase due to the additional number of appliances disclosed by the re-inspection, is about 14 per cent.

Were this average applicable to the entire city, the increased revenue to the Department would amount to about $225,000.

The actual amount collected this year may, however, fall short of this, for the reason that the general average may be less, and further, because many of the manufacturing establishments have taken advantage of the reduction, by ordinance dated Feb. 9, 1884, of the charge for water registered by meter, from $1.00 to 60 cents per thousand cubic feet, to have meters applied to their supply pipes, and payments made according to the amount actually used

Payments by meter are made at the end of each quarter, and therefore the meter charges for the last quarter of the year will not appear in the receipts previous to Jan. 1, 1885. The equalization of this will, of course, be evident in the year following.

The re-inspection has been as thorough as possible, and actual tests have shown it to be gratifyingly accurate on the whole.

Frequent attempts were made to bribe the Inspectors, but these were, it is believed, in very few cases successful.

To the Registrar, Mr. Keithler, and his assistants, is due high commendation for energetic and faithful discharge of an arduous, and, in several respects, an unpleasant task.

The cost of the re-inspection in excess of the ordinary expenses of the Registrar's Office, was $10,353.03.

SURVEYS FOR EXTENSION OF RESERVOIR CAPACITY.

The accompanying Table shows the capacity of each Reservoir now in service, the area and population dependent upon each, and the number of days' supply contained therein.

It will at once be seen that with the exception of the Wentz Farm and Belmont Basins—which are larger in extent and less drawn upon than the others—the number of days' supply ranges from 1⅓ days in the Spring Garden and Corinthian Basins to 4 days in the Lehigh avenue, or, as it should be called, the Fairhill Basin.

There is, therefore, practically no reserve storage at all for the main portion of the City, and the water pours through these basins without opportunity for subsidence or purging itself of impurities.

For the large district covered by the Twenty-eighth, Twenty-ninth, and portions of the adjacent Wards, including a rapidly increasing population, of probably 130,000, with numerous large manufacturing establishments, there is no reservoir whatever, nor is it possible from any of the existing basins (including the East Park Reservoir, supposing that to have been completed), to distribute water to the higher elevations of the area described. The supply is, therefore, derived directly from the pumps, with all the entailed disadvantages.

The most favorable point at which to construct a reservoir for the high district is in the vicinity of Thirtieth and Cambria streets, upon an elevated ridge which commands the surrounding country, and where a basin of 210,000,000 gallons capacity has been projected, with a surface elevation of 166 feet above City Datum. This height would be ample to supply all the City to the East and South, whether directly or through the intermediate basins—Spring Garden, Corinthian, and Fairmount; and, furthermore, the necessity for the construction of this Reservoir is greater than for the completion of the East Park—notwithstanding its grand capacity of 700,000,000

—by reason of the inferior elevation (133 feet, C. D.) of the latter, which will not admit of its supplying more than a small marginal area of the high district.

An additional argument for the construction of the Cambria Reservoir, if any be needed, is that whether the future supply be derived from a reformed Schuylkill, from the Delaware River or from Perkiomen Creek, the Cambria Reservoir will constitute a convenient and natural terminal and distributing point, whence the other reservoirs may draw their supply.

Upon representation of these facts by the Department, Councils passed Ordinances, approved July 7, and November 14, 1883, appropriating the necessary lands, and sought means to make pecuniary provision for beginning the work.

Of the funds appropriated, a large portion, derived from the balance of a Park Loan, was decided to be inapplicable to this purpose, and, therefore, nothing more could be done than to make the careful surveys and examinations necessary to a thorough investigation of the site, preliminary to the consideration and preparation of the working plans.

The Department, upon the basis of the ascertained data, is now prepared to begin work upon this basin whenever the necessary funds shall be provided. The cost in round numbers will amount to about $500,000, exclusive of the cost of the site, for which additional provision must be made. This matter is now in the hands of the City Solicitor, for the conduct of the proper legal proceedings to determine the price per acre which the city should pay.

It should be said that if the labor of the House of Correction be employed upon this work, a large saving in cost would be effected, and it would seem obvious that since the inmates of that institution are maintained by the taxation, direct or indirect, of every citizen of Philadelphia, the most natural and proper use that could be made of their time and labor would be in the construction of great public works, whose cost—which must also be defrayed out of general taxation—would be thereby correspondingly diminished. Arrangements to this effect were discussed with the Managers of the House of Correction, and the practical details adjusted, but the lack of funds prevented any action.

Surveys were also made for the extension of the Mt. Airy Basin. This reservoir, to which the water is forced from the Roxborough Station, supplies the rapidly extending Germantown District. The basin holds at present a supply of about two and one-half days only, and it is highly desirable that the additional available ground to the eastward be secured before it shall have still further advanced in price.

There is no doubt whatever of the necessity for enlarging the basin, and the sooner steps are taken to secure the site and begin the work of excavation, the sooner it will be completed and the less the ultimate cost, which, as now estimated, exclusive of land damages, would be about $225,000.

Another new reservoir site is required for the distribution to Manayunk and the Falls of Schuylkill. At the present time these points are supplied from the Roxborough Basin, having an altitude of 366 feet above City Datum. In consequence of this, not only are the local pressures in the two places named much greater than occasion requires—thereby calling for more costly plumbing than would otherwise be necessary—but the considerable expense is incurred of pumping the Schuylkill water to the great and unnecessary height, only to let it run down again to near the river bank.

Other things being equal, the cost of pumping is in direct proportion to the height to which it is pumped, and were a basin of suitable capacity constructed at some point west of Manayunk, and at an elevation of,—say 180 feet, the pressure would be ample and half the cost of pumping would be saved. No surveys have yet been made for such basin, nor has any site been selected. A preliminary investigation of this matter will be made during the ensuing season.

It is probable, also, that in the near future a storage basin will be needed at Chestnut Hill, as well as an enlargement of the visible supply and of the pumping machinery.

The completion of the East Park Reservoir is called for by several considerations of importance. It is designed as the storage reservoir for all that area now supplied from the Spring Garden, Corinthian, Fairmount, and Lehigh Avenue or Fairhill Basins, which its surface elevation of 133 feet will enable it to feed.

The present combined capacity of these basins is about 100 million gallons, and the population supplied is about 700,000. At 70 gallons per day per head, therefore, there is only about two days' supply in store, or at 40 gallons per head, three and one-half days'.

The East Park Basin with its capacity of 700 millions, will increase the storage to about 25 days supply, which is not in any sense more than a moderate and safe allowance.

The advantages of possessing this storage capacity are several. In the first place, security against the results of accident is obtained. Secondly, the water will have an opportunity to settle, and measurably clarify itself. Thirdly, it will enable the Department to stop pumping when the river is muddy, and let the successive freshets pass without taking up the dirty water. Fourthly, it will permit of the more constant use of the Fairmount wheels, which now are frequently stopped even when the river is high, because, the basins being full, there is no place to store the water.

The East Park Reservoir has cost in round numbers 1¼ millions, and as much more will be needed to complete it.

THE REVENUES OF THE DEPARTMENT.

The Registrar is charged, under the direction of the Chief Engineer, with the collection of all the revenues of the Department, with the exception of those claims for frontage which remain unpaid for four months from date of laying the pipe, and which, upon due certification from the Chief Engineer, the City Solicitor institutes legal measures to recover.

There has also been, heretofore, a certain amount received in the office of the Chief Engineer, from bills for work done by the Department, such as putting in fire attachments and other special constructions and repairs properly charged to private persons, but I could see no good reason for continuing the practice of receiving money in my office, and therefore had these, as well as all other Department bills, receipted by the Registrar.

The report of the Registrar, herewith, contains a full exhibit of the collections for the year 1883. It will be seen that while there is a decrease in the collections of delinquent rents and penalties, due to their having been more closely brought in for the last two or three years, there is a large increase in the regular collections for the year.

The total receipts for 1882 were $1,516,904.64, and the probable receipts for 1883, as previously estimated by the Chief Engineer, were $1,425,000. The actual receipts for 1883 were $1,627,069.16, exceeding the estimate by $202,000, and the receipts of 1882 by $110,000, so that the books of the Department, notwithstanding the expenditures for 1883,—1,047,227.02,—were considerably larger than usual, show an excess of receipts, or a gross profit for the year's business of $579,842.14.

For the year 1884, the general re-inspection of the City which has been made will still further increase the revenues by an amount which cannot be certainly determined until the close of the year. The preliminary examination of the books, as made up upon the basis of the re-inspection, shows an apparent increase over the year 1883 receipts of some $233,000, of which the larger part will certainly be realized, although reductions will no doubt be made upon affidavits as to the non-use of appliances.

It is probable, therefore, that my estimate of last September to the Controller, of a revenue for 1884, of $1,750,000 will prove to be approximately correct. It seems quite certain that it will not fall short of $1,700,000, although it must be observed that a number of large consumers have taken advantage of the reduced rate of water measured by meter, to be transferred from the regular rates to the meter account. It results that, as the meter accounts are payable quarterly, the receipts for the concluding quarter of the year will fall into the first quarter of 1885, and will, therefore, not appear in the reported receipts for 1884, although properly belonging there.

Should the revenue reach the sum of $1,750,000, a comparison of this sum with the total appropriations for the current year ($813,385) will show a surplus for the year 1884, of $936,615.

The following is a general statement of the entire receipts and expenditures of the Department since its organization in 1854 to the close of the year 1883, a period of twenty-nine years.

GENERAL STATEMENT OF THE COLLECTIONS AND EXPENDITURES OF THE WATER DEPARTMENT SINCE ITS ORGANIZATION IN 1854.

Total Collections, 1855 to 1882, inclusive	$25,343,252 08
Total Expenditures, 1855 to 1882, inclusive	17,190,896 00
28 Years' Surplus	$8,152,356 08
Total Collections, 1873 to 1882, inclusive	$13 535,438 32
Total Expenditures, 1873 to 1882, inclusive	8,061,116 15
10 Years' Surplus	$5,474,322 17

Collections for 1882	$1,516,904 64
Expenditures for 1882	660,958 45
Surplus for 1882	$855 946 19
Collections for 1883	$1,627,069 16
Expenditures for 1883	1,047,227 02
Surplus for 1883	$579,842 14
The Receipts of 1883, as estimated by Chief Engineer in 1882, were	$1,425,000 00
Collections for 1883	1,627,069 16
Excess	$202,069 16
Estimated Collections for 1884	$1,750,000 00
Appropriations for 1884	813,885 00
Estimated Surplus	$936,615 00

The total profits since consolidation are nearly eight and three-quarter millions, and for the past eleven years there has been an average Annual Surplus of over $550,000, equal to 66 per cent. of the expenditures.

Whatever may have been the causes of the extraordinary and prolonged neglect and consequent dangerous decadence (elsewhere adverted to) of a service established for the benefit of the citizens, and holding such intimate relation to the comfort, health and prosperity of the entire community, the above statements from the records of the Department make it sufficiently evident that a lack of funds properly and equitably applicable to its necessary support and enlargement, in proportion to the growth and requirements of the City, was not among them. It is probable that investigation would, without much or any difficulty, discover these, and establish their close connection with certain erroneous principles, misdirected economies, and radical defects of administration.

The business of supplying water to the citizens is no necessary municipal function or obligation. It might with entire propriety have been relegated, as in many large cities, to a chartered company, with careful stipulations as to the percentage of profits, and rigid provisions for penalties in case of inadequate or unsatisfactory service.

The City, however, has voluntarily chosen to engage in this business on its own account, and by Ordinance has created a monopoly, by forbidding others to compete therein. This assumption of an extraneous function cannot, however, relieve the City from the natural and equitable obligations thereby incurred, but on the contrary imposes additional and weighty responsibilities. As a vital need, whether for daily domestic uses, for manufacturing purposes, for protection against losses by fire, or for the conservation of the public health, there is no requirement which approaches in urgency the demand for an ample supply of wholesome water, and yet, as has been shown, the City has permitted the service to languish until not only is the quality of the water unsuitable and its quantity insufficient, but there was danger that a large portion of the City would be deprived of its supply altogether.

The appropriations for necessary improvements were withheld year after year, while the heavy Annual Surplus collected from citizens was used for other and less important improvements.

It would seem clear that until the Water Supply of Philadelphia is such as a City of 1,000,000 souls,—the second in population and the first in manufacturing importance in the United States,—should have, there can be no application of the Water Revenues so just and so judicious as their expenditure for the imperative requirements of a service upon which the well-being, comfort and prosperity, individually and collectively, of the community, is wholly and without alternative, dependent.

DEFECTS OF THE PRESENT WATER SUPPLY.

The Distribution System.

With the substantial addition of the new Pumping Plant which is now under construction and which will be available for service during the ensuing season, the Department will be able to pump up a daily average of 90,000,000 gallons, should so much be required, and as the minimum flow of the Schuylkill is not less than 180 or 200 millions, there is no doubt of the ability of the Department to pump a full supply for the City.

Leaving aside, for the present, the question of quality as affected by sewage and other contaminations, the most serious defects of the present system are found in the absence of adequate storage capacity and the lack of proper means to distribute the water to the several portions of the City, and the improvement of these constitute, at the present time, the most urgent need of the Department.

In my remarks upon the Extension of Reservoir Capacity, I have called attention to the inadequate provision for storage, by reason of which the water, being in constant movement through the basins, has little or no opportunity to free itself of even the grosser impurities, and is delivered to the consumers in pretty much the same condition as it came from the river.

It is only the Wentz Farm Basin supplying Frankford and the vicinity, and the Belmont Basin supplying West Philadelphia, that exhibit any proper proportion between their capacity and the daily draught, and it may be said that while the large area north of Spring Garden street and west of Ninth street has no reservoir at all, the remainder of the City is not much better off.

The works especially needed to amend this condition of affairs, with reference to the main City, are the construction of the new Cambria Basin of 200,000,000 gallons, with a surface elevation of 165 feet above City Datum, and the completion of the East Park Reservoir, with its 700,000,000 capacity, and elevation of 133 feet.

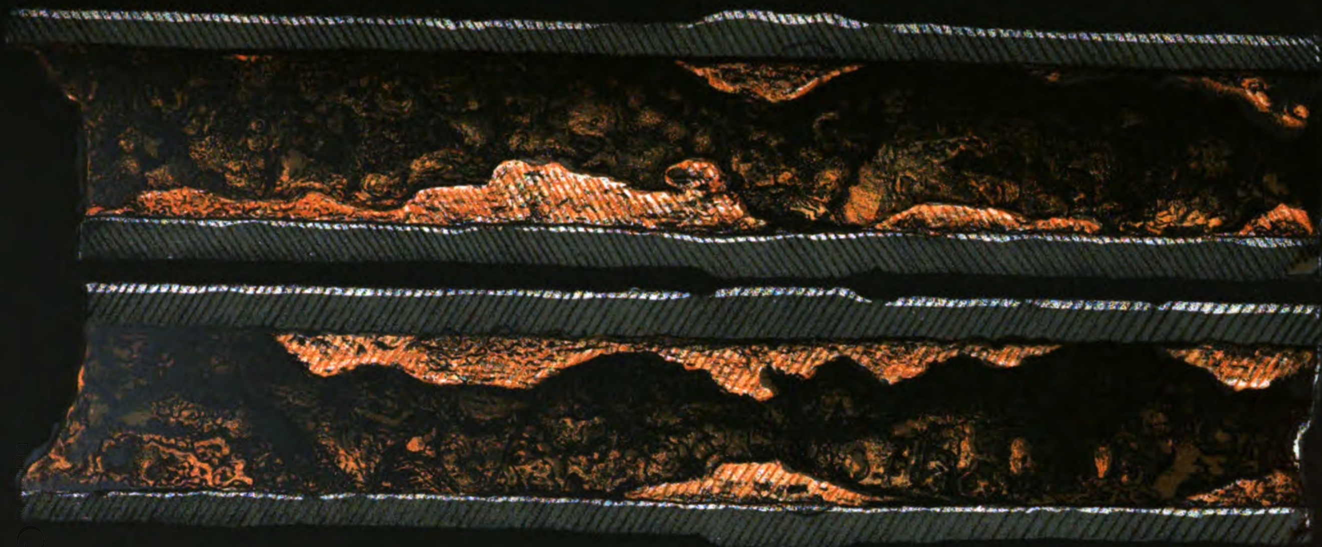
It will take about three years to complete these two works, at an estimated cost of over $2,000,000, and until then there can be no escape from the disadvantages now endured.

An even more important matter, however, is that of the distributing mains and pipes.

Previous to Consolidation, in 1854, the Districts of Spring Garden, Northern Liberties, and Kensington had their own supply systems, and Germantown and Chestnut Hill were served by private companies. The original Station at Fairmount and the Fairmount Basins then supplied, as now, the old City lying between Vine and South streets, and the Districts of Southwark and Moyamensing below. All these systems later came under the management of the consolidated City Government, but the original disadvantages of inadequate distribution facilities, and the absence of unity of system, have never been fully removed. To illustrate this subject without unduly extending the statements in regard to it, it may suffice to take the condition of affairs in the old City proper as typical of all. Within these limits, viz.: from Vine to South streets, and between the two rivers, there are at present in service about 490,000 feet of water pipe, laid at different periods, as shown in the following table.

It will be seen that most of these pipes are of great age and small dimensions,—150,000 feet or 30 per cent. being less than six inches in diameter, and over 90 per cent. of the total having been in the ground from 30 to 60 odd years.

Experience has shown that, under ordinary circumstances, naked iron pipes such as were formerly laid, become, to a considerable extent, obstructed by the accumulation of rust and sediment in the interior, and that in a period of from 10 to 20 years this obstruction will become so serious as to nearly or entirely close the pipes. This, as a matter of fact, is known to be the case with by far the larger proportion of pipes now in service less than six inches in diameter, and the accom-



SUPPLY PIPE TO 1716 18 20 22 & 24 CATHARINE ST

panying drawing is intended to illustrate the interior condition of the tube, and the extent to which the obstruction proceeds.

The Department has a number of striking examples of this effect, and the drawing was made from a longitudinal section of a two-inch pipe which had been in the ground for about 24 years. The opening available for the passage of water would not admit the tip of the little finger.

It is manifest that pipes in this condition are almost useless, and in particular for fire purposes are of no value whatever. The sole remedy is to replace them with larger pipes, which, coated inside and out with a protective covering of asphalt, will last for many years.

In addition to the necessity of replacing the ancient and small pipes, is that of laying larger mains,—and the deficiencies in this respect are serious. There are many portions of the City to which, in the Summer, little or no water is delivered, for the reason that the mains are of such inadequate capacity that the water is all drawn from them before reaching the end.

My letter of last August to the Controller, explanatory of the estimates,—which is appended to this Report,—as well as the Report by Mr. Ogden, the Assistant Engineer in immediate charge of the Distribution System, throw much light on this subject; and while the entire ground is not covered nor the subject fully treated, enough is shown to illustrate its importance and convey some idea of the expenditures which will be necessary to fully meet imperative requirements.

It is necessary to bear in mind that the Fire Department, however efficiently organized, is helpless without an abundant supply of water flowing freely to the hydrants, and this can only be secured by having in the principal streets, mains of adequate dimensions and suitably connected with the supply pipes and with each other.

I have been enabled, by the kindness of Mr. Lorin Blodget, to collect some data in regard to the value of property at risk from fire in the Old City. The Fifth and Sixth Wards, in especial, are heavy manufacturing districts, and contain valuable stores of merchandise. East of Ninth street, and between Vine and South streets, Mr. Blodget calculates that there are not less than $100,000,000 of active merchandise at risk, and by examining the assessment of properties and making due deduction for the value of the ground, I have computed the total value of perishable property exposed to danger of fire within the old City limits as approximately $250,000,000. To protect values of this extent, the means available are absurdly inadequate. There are about 800 fire plugs, of which one-half are of an obsolete pattern, and 100 are attached to old pipes of 4 inches diameter or less, from which the Steam Fire Engines cannot get enough water to do any service.

It is unfortunate that the elevation of the Fairmount Basin —94 feet above City Datum—is quite insufficient to give a proper pressure at the hydrants. This defect, for the present, cannot be amended, but it is intolerable that the supply should be destroyed altogether by the retention in service of appliances which a generation ago were unsatisfactory, and which to-day are practically useless.

It is essential that a Department having such close relation as this to general and individual interests, should assiduously and faithfully keep pace with the growth and improvement of its City, and to accomplish this there must be wise prevision of the needs of the immediate future, in order that when the demand shall be made there may be no hesitation or delay in meeting it.

This is a matter of such very great importance, and one in which every inhabitant of the City—whether a property owner or not—is so deeply interested, that I may be pardoned for some urgency in pressing it upon the attention of Councils.

The Quality of the Present Supply.

As previously indicated, it may be considered that with the Delaware on one side and the Schuylkill on the other, there need be no question as to the possibility of procuring an ample supply of water, and were the means of distributing it suited to meet the necessities of the city, the serious aspects of the case would be resolved into the single question of quality.

Of the six principal Pumping Stations, two take water from the Delaware River and four from the Schuylkill River.

The peculiarities of the Kensington supply have already been adverted to. The Delaware, along the city front, is the recipient, sooner or later, of the sewage refuse and street washings of a city area occupied by a population probably exceeding 800,000. These waste matters are borne up and down by the tides, and usually pass and repass the city several times before taking their final departure. Under these circumstances, whatever may be the volume of the stream, it is by necessity polluted, and is not suitable for immediate and habitual daily use.

In especial is the vicinity of the Kensington Station marked by an accumulation of the foulest materials. Its central position insures its getting the full benefit of all the city sewage, and, in addition, the Aramingo Canal—an open sewer of large dimensions and choked with filth—discharges in its immediate vicinity. The water taken thence is utterly unfit for human consumption, and the construction last Summer of a wooden trunk to mid-channel, is but a temporary device to mitigate the evil until such time as a connection can be made from the Stations on the Schuylkill to the Lehigh Avenue Basin.

The other Delaware Station—that at Lardner's Point, one mile above Bridesburg, from which the supply of Frankford and the vicinity is derived—has characteristics so much less objectionable, that few complaints are made of the quality of the water. Nevertheless, since the flood tides sweep upwards for five hours twice in 24 hours, with an average velocity of 1½ miles an hour, the general sewage of the city is carried some distance above Lardner's Point, and in particular, that from

Frankford Creek—which is the sewer for that district—is taken up stream for several miles, to return on the succeeding ebb.

As the ebb tide runs but two hours longer than the flood, it is during this interval only that the river may be considered free of the city sewage and contaminated only by that which we derive from the several cities above.

The Lardner's Point supply, therefore, must be viewed with suspicion as undoubtedly containing a considerable amount of diluted and partly oxidized sewage, and cannot be considered as an acceptable or satisfactory source for the future.

The condition of the Schuylkill supply is the important one, and a considerable body of facts regarding it is furnished in other portions of this Report, particularly the paper of Dr. Leeds on the chemical investigation, and Mr. Barber's tables on the physical and sanitary features.

The Schuylkill, above Fairmount Dam, is the natural sewer, first and last, for a population of 350,000, largely engaged in manufacturing, and whatever may be the varying judgments of physicists as to the power of a running stream to purge itself of foreign contaminations, it is very certain that the river itself has, from time to time, furnished the most convincing evidence of its inability to digest or dispose of the extraneous and injurious matters discharged into it.

The character of the pollutions is as diversified as the occupations of the people. Sewage, chemicals, wool-washings, dye stuffs, butcher and brewery refuse—there is almost nothing lacking—and the most singular feature of the case is that the worst and most deadly contaminations are those which enter the river within the city limits and under the control of the municipal authorities. The circumstance has this advantage, that matters can be amended whenever the city shall choose to exercise her powers, and the construction of the intercepting sewer on the east bank, from Manayunk to Fairmount, will no doubt be of great utility.

It should not be believed, however, that the sewer,—even should it accomplish all that it is designed for,—will be able to do more than a part of the work. There will still be the entire pollution of the stream above the Flat Rock Dam to prevent or neutralize, the waters of the Manayunk Canal to purify, and the Wissahickon and other streams to regulate, and in addition there will remain sources of contamination within the limits of the Fairmount pool itself, that are not the less deadly because they are concealed from view and escape direct observation.

The movement of ground water is, in general, slowly towards the river, and it will be years before the sewage-saturated soil underlying a long inhabited area, and filled with cess-pools, can free itself from poisons.

In particular is there a subject from which sentiment and the imagination alike recoil, but to which the Engineer, in the interest of the public health, is forced to allude. Civilized communities have for generations recognized the danger to the living from the presence of the dead, and decreed that no well be dug in the vicinity of their last resting place, nor any water taken thence, lest the potency of lethal matter slay the living. The thought is one which cannot now be pressed, but it is necessary to suggest it, that the gentle souls who lie at rest, and who on earth would have shrunk from the thought of injuring any living being, may by some means be spared becoming a peril to their descendants and successors.

Aside from the Engineering and other means of modifying the contaminations of the Schuylkill, involving years for their accomplishment, it must be said that little can be done to purify it. It is true that filtering the water will remove the visible impurities, and if thoroughly done, will render it a bright and sparkling fluid pleasing to the eye and generally acceptable to the palate, but the impurities thus removed are the least harmful of those contained in the water, and in reality, the river when muddiest from a recent freshet, is probably in its most wholesome condition, since it then contains the largest percentage of fresh water and the least of foreign matters. It is in Summer, when the movement of the stream is the gentlest and the waters the most pellucid, that the largest proportion of dangerous contaminations is held in solution, and these the ordinary methods of filtering are powerless to remove. It is true that the passage of water through a mass of spongy iron has been found to oxidize in part the organic matter, but the cost of inaugurating a plant of this sort, or any filtering appliances such as are used in Europe, on the scale necessary to purify the water supply of Philadelphia, is too formidable to contemplate unless all other means of procuring a better supply shall prove impracticable. When all was done, the organic matters would still remain, and it is these which constitute the real danger. It is known that the germs of cholera, of typhoid fever and other diseases, although their real nature or function can only as yet be guessed at, may be carried by water which to every sense is pure, and that these germs may entirely escape detection by the most subtle analysis, while existing in a condition of the deadliest activity and only awaiting admission to a living organism to develop their latent morbific energy. Against this danger science has no absolute specific, although the boiling of water is supposed to destroy the germs.

By far the most practicable and effective means of improving the present supply would be the completion of the East Park Reservoir, into which the water would be pumped when in its best condition, and drawn out for the supply of the smaller basins after having had from two to four weeks in which to deposit its sediment and rid itself of at least the grosser impurities.

The use of well water within the inhabited area of the City should be absolutely prohibited. Nothing is more deceptive than the cool sparkling water drawn from a well or spring which is the out-flow of a water stratum into which cess-pools or foul deposits discharge; but there are numerous wells, even in the old part of the City which are in daily use. Ignorance is responsible for this in part, and habit, in part. Again a vicious economy will sometimes induce people to continue the use of wells, and thus avoid the cost of introducing water-pipe in the street and the payment of water charges. Councils might well make provision for these cases by ordering the filling up of all wells and cutting off all sources of supply which analysis should show to be prejudicial to the public health, and requiring all houses and blocks of houses now built or in process of construction, before being occupied by tenants, to be connected with the City mains, whenever it is practicable to do so.

Much has been said of the possibility of procuring a supply from Artesian Wells or other ground sources, but while it is entirely possible that there may be a water stratum of sufficient purity and volume to answer a part, at least, of the requirements, there is always danger of pollution from increase of population and an uncertainty with regard to the future, both in quality and quantity, that would make it injudicious to depend solely upon such sources.

The water in the wells sunk into the water bearing rock on the elevation upon which it is proposed to build the Cambria Basin, is shown by analysis to be of exceptional purity, and would no doubt suffice for the time and for a limited supply, but the future extent and requirements of the City are entirely out of proportion to such insufficient and unreliable sources, and as works of the magnitude required need years for their construction, it would not be worth while to waste time and money in the effort to utilize them. It can be proved that the waters of a swiftly flowing stream, thoroughly exposed to sun and air, are superior in purity and wholesomeness to all other sources, whether gathered from the Heavens above or from the Earth beneath, and it will be time enough to undertake the task of sucking from the ground a supply of 100 or 200 million gallons per day, such as Philadelphia will need for the future, when investigation shall have proved the impracticability of drawing from a nobler source which can be traced and protected, from its birth on the mountain top to its final utilization.

THE WASTE OF WATER.

The importance of this subject in its relation to the question of Water Supply has, until within comparatively a few years, been almost ignored, especially in cities having a public service.

As the appliances for delivering water failed to meet the rapidly increasing consumption, and even the sources themselves became inadequate to furnish the enormous amount which was apparently required, the attention of the City and Department officials seems to have been directed solely to multiplying pumping machinery, the construction of new aqueducts and reservoirs, and the search for new sources whence an increased volume could be derived.

The advantages, and even necessity—according to modern domestic, sanitary, and industrial needs—of an ample supply is obvious, and those charged with the responsibility of its maintenance were quick enough to realize this, but while noting the fact that the demand had increased in a much greater ratio than the population, and the total amount per capita had attained proportions exceeding the bounds of possible utility, in few cases does it seem to have been thought necessary to investigate the disposition made of the water, or to definitely ascertain what proportion of the total pumpage was really utilized, and what was entirely wasted.

The practical ignoring of the subject may be, in the main, attributed to the fact that with a population habituated to the freest use of water, any attempt to limit or restrict the consumption, would, in all probability, arouse opposition, and perhaps affect unfavorably those holding official positions.

Of late years, however, the development of cities and the increasing consumption of water have, by the apparent exhaustion of the available sources, in many cases directed attention to the subject of waste, and commanded consideration of its extent and the means of checking it. In a few cases, also, while no deficiency of supply was threatened, an intelligent study of the subject and constant effort towards effective and economical administration had the same effect.

In Philadelphia, notwithstanding the annually increasing danger of a water famine, the matter seems to have been quite overlooked, or, if observed, no attempts were made to apply remedial measures.

In the investigation of this subject it is desirable, first to define what is meant by waste, and then to ascertain, as clearly as may be, what amount, per capita, should be considered an ample supply. Having fixed a standard, any amount less than this might be regarded as a deficiency, and anything more, as waste.

By waste, then, is meant the water which, having been pumped into the reservoirs and distributing mains, escapes thence into the sewers, the ground, or the street, beyond the possibility of utilization, without having performed in its journey any useful function or service whatsoever. In this sense it will be seen that the restriction of waste, so far from being a restriction of supply, is a positive addition thereto, for by so much as the useless expenditure of water is prevented, by so much is the amount available for useful purposes increased.

The cost to the city of pumping and distributing water which is wasted, is precisely the same as for water which is usefully employed, and it follows that with waste prevented, the expense of the Department is decreased and its service improved. It must be understood, therefore, that the prevention of waste is designed to give a more ample supply for all requirements, and to admit of the use of the water for the proper flushing of sewers,—for which no provision is now made,—and for public drinking fountains and ornamental purposes, the lack of which in Philadelphia impairs both its appearance and the comfort of its inhabitants.

In general, waste may be classified under three heads:

First, leakage from the pumping or distributing mains or reservoirs. The amount of this, with good administration, is comparatively small, as precautions are taken to make the reservoirs tight, and the mains are carefully laid and are much stronger than is needed to withstand the actual pressures to which they are subjected.

Second, loss from defective service pipes and faulty plumbing appliances. The waste from this cause is very large, as plumbing work in Philadelphia has not been subject to any real supervision, nor is there any effective discrimination between good and bad workmanship, or much attention to making repairs when needed.

Third, loss from careless or wilful opening of taps and faucets. It is this cause to which, perhaps, the largest part of the waste is due, and which would not exist if consumers were as careful in the use of water which is paid for at an annual rental, as of gas for which they pay by the cubic foot.

In fixing the standard of an adequate supply, it is necessary to rely upon the experience and statistics of cities where the subject has been carefully investigated, and in especial those in which the local conditions are, as nearly as may be, analagous to our own.

The European cities, in general, are content with a daily supply which we should consider absurdly inadequate — as Vienna and Berlin, with a daily allowance of 15 or 18 gallons, or St. Petersburg with 22 gallons. In Paris, however—where, although the domestic use is limited, large amounts are used in keeping the streets clean—the daily consumption is about 42 gallons per capita. In the principal cities of Great Britain the supply averages from 35 to 40 gallons per head; and in London, which, in its general features, approaches perhaps more nearly than any other to those of Philadelphia, the daily supply is about 31¼ British, or 37½ United States gallons.

On the whole the English engineers estimate that 35 United States gallons per head of population is an ample supply for all purposes, domestic, industrial, sanitary, and protective, and this estimate is justified by the experience of American cities in which the matter has been intelligently investigated. Prominent among these is Providence, a city having a large population, as well as extensive manufactures, where for several years past the average supply has been from 30 to 35 gallons per head.

In Boston, where the water question has occasioned great anxiety, as the consumption had reached and overpassed the capacity of the plant to meet it,—it has been clearly shown by actual tests, that of the former 95 gallons per head, at least 50 per cent was wasted. Similar estimates are made by the New York engineers, where again the increasing demand is in excess of the capacity of the Croton aqueduct, and the problem of the future is a pressing one.

In general, in all the American cities where the subject has been examined, the estimates of waste are from 25 to 75 per cent. of the total supply. It may be assumed then, with much confidence, that 40 gallons per day per head of population is an ample amount for all purposes, and an estimate of the magnitude of the waste in Philadelphia may be reached by comparing this figure with the average daily pumpage.

The total pumpage for the year 1883 was 25,182,775,641, which gives a daily average of about 69,000,000, equivalent to very nearly 70 gallons per day per head. It may, therefore, be considered that of these 70 gallons, 40 gallons, or 57 per cent. are used, and 30 gallons, or 43 per cent., are wasted, and these proportions cannot be far from accurate.

The loss is a formidable one from any point of view, and especially was it evident last summer, when the pumpage in one day exceeded 100,000,000 gallons, that if by any means the waste could be checked, the amount saved might be sufficient to avert disaster when the sole dependence, the steam-pumps, were in an unreliable, and, in some respects, dangerous condition.

An attempt was therefore made both to remedy the evil in part, and to collect data for the ascertainment of its causes and amount, and in this, valuable assistance was rendered by the Bell Waterphone Company, who had, with much success, used their methods and appliances in Cincinnati, and who tendered their services gratuitously to the Department, with the expectation of illustrating its practicability and value.

The instrument used resembles an ordinary telephonic receiver, and simply magnifies sounds transmitted to the diaphragm. In service it is attached to a steel rod, which is inserted in the stop-box over the service stop at the curb, and resting upon the cock, transmits to the ear the sound of water passing in the pipe. The examinations were made between the hours of 11 P. M and 4 A. M., when the occupants of dwellings were presumably asleep. If any flow of water was detected, the inspector made a note of the premises in his book, and visited the house during the following morning. The results of the trial with this apparatus are given in the accompanying table. The district examined lay between the two rivers and from Vine street to Washington avenue. It will be seen that of 12,000 stops examined, the sound of running water was heard at 3,631,—over 30 per cent of the total. In 302 of them the day inspection failed to reveal a cause, which was, therefore, either an underground leak or the use of the water appliances by the inmates during the night. The remaining causes were all either the wasteful running or leakage of openings from the pipes, and some approximate computations of the loss of water due to these will be useful, both to illustrate its amount and to support the conclusions already reached.

From the actual tests it was found that a horse-trough, water closet, or hydrant running full head under a pressure of 13 pounds would discharge 5 gallons in one and half minutes, or 4,800 gallons per day; and a washstand, urinal, fountain, or faucet would flow a gallon a minute, or 1,440 gallons per day. With 20 lbs. pressure, which is about the city average, these amounts would become respectively 6,000 and 1,800 gallons.

In the 12,000 inspections there were 428 water closets, 249 hydrants and 32 horse-troughs running,—a total of 709,—which, at 13 lbs. pressure, would discharge over 3,400,000 gallons per day. There were also 153 wash-stands, 148 urinals, 3 fountains, and 9 faucets,—a total of 313,—which would waste

RESULT OF NIGHT INSPECTIONS

WITH THE

BELL WATERPHONE,

From May 4 to September 15, 1883.

EXAMINATIONS Between the hours of 11 P. M. and 4 A. M.	Between Vine and South Streets and Delaware and Schuylkill Rivers.	Between South Street and Washington Avenue and Delaware and Schuylkill Rivers.	TOTALS.
Stops tested with waterphone	9,012	2,988	12,000
Number at which water was running	2,382	1,249	3,631
Water-closets found running	419	9	428
Washstands " "	152	1	153
Urinals " "	148	0	148
Hydrants " "	215	34	249
Fountains " "	1	2	3
Faucets " "	0	9	9
Water-troughs " "	20	12	32
Stops leaking	1	3	4
Water-closets leaking	98	2	100
Faucets "	69	726	795
Hydrants "	1,060	929	1,989
Wash-paves "	44	3	47
Service-pipes "	383	33	416
Urinals "	9	0	9
Washstands "	203	0	203
Places where water was heard running at night, but not in the day-time	276	26	302
	3,098	1,789	4,887

448,000 more. Deducting proportionately the 302 cases where it might be that the appliances were in legitimate use at the time of the inspection,—the total waste due to running of the remainder is 2,740,000 gallons per day.

For the sake of being entirely within probabilities, it may be assumed that these appliances, not being fully open, were discharging only about one-half of this,—the amount would then be 1,370,000 gallons. If now a moderate estimate of the average waste due to the 3,563 leaking and defective appliances be added of, say 100 gallons each,—and some of them will waste many times this quantity,—we have a total waste of 1,726,000 gallons per day.

The 12,000 stops examined are considerably less than one-fifteenth of the total number in the City. The aggregate loss, therefore, from this cause alone, is probably in excess of 25,890,000 gallons per day. To this loss is still to be added the large amount wasted in manufactories. In many of these, while the quantity actually used is very great, the waste is equally so from allowing the water to run during the day when not required, and especially at night when work is suspended. In some of these the flow of water is never stopped, and I have known a mill which had shut down at 3 o'clock on Saturday afternoon, to waste a full stream from a four inch pipe until work began again on Monday morning. The quantity escaping from this pipe alone was probably not far from 500,000 gallons in 24 hours.

It may be safely assumed that the loss from this cause is not less than 20 or 25 millions per day, which, added to the domestic waste, gives a total of 45 or 50 millions. This computation was made at a time of year when the pumpage was from 85 to 95 millions daily.

In Winter, while the waste is little less in the business establishments, in dwelling houses it is diminished unless it be in very hard freezing weather, when the fear of bursting pipes induces the cautious householder to protect himself against a plumber's bill by keeping the water in constant flow at the expense of the City, and to the detriment of his neighbors' supply.

Another considerable source of waste is the indiscriminate and illegal use of the fire plugs, which seem for some reason to be considered the property of everybody, and to be used for all purposes, without reference to the inscription on each that forbids its use without a permit, under penalty of $5.00.

Economically considered, the waste of water—of which enough has been said to indicate its magnitude—is of much importance. If, for example, it could all be stopped and the pumpage restricted to a sufficient amount only, the annual coal expenditure by the Department of, say $130,000, might be reduced to $80,000, and a yearly saving effected of $55,000. Fewer employés would be needed at some of the Pumping Stations, and the wear and tear, and consequent repairs and renewals of the boilers and machinery would be reduced in proportion with the pumpage.

On the other hand, the saving of water would effect general increase of pressure, and enable the water to reach the upper stories of houses to which it is now a total stranger.

A few figures as to cost may be of use. Comparing the total number of buildings with the total revenues of the Department, it may be said generally that the average charge per building is $10.00 per annum. A dwelling which pays $15.00 may be considered fairly well equipped with plumbing conveniences.

At the rate of charge for water by meter, viz.: 60 cents per thousand cubic feet, or 8 cents per thousand gallons, a house paying $10.00 per annum is entitled to, say 17,000 gallons, or, if it pays $15.00, to 25,000 gallons, and these amounts are in reality much in excess of those actually drawn, even by persons who use it lavishly.

A hydrant in the yard, or a horse-trough in the street, will run about 6,000 gallons daily, and in three or four days therefore, will waste a year's supply for a family.

A wash-stand or faucet will flow 1,800 per day, and exhaust in ten or fifteen days respectively, the entire amount needed by a family for a year. The mill pipe before mentioned will, in one day, waste enough water to supply from 20 to 30 families through the entire year.

From the sanitary point of view, the stoppage of that large portion of the waste which is due to leakage or flowing pipes, hydrants, wash-paves, or horse-troughs, is highly desirable.

The Department is almost daily in receipt of complaints of water flooding cellars and sapping foundations, which investigation shows proceed in the majority of cases from willful or careless waste by neighbors.

Aside from the injury to property, the close relation of certain forms of disease to a saturated dwelling site, is well understood, and no sanitary engineer or physician will hesitate to condemn the continuance of practices involving evils of such serious extent. Among the minor though quite obvious of them is the frequent sluicing of sidewalks, which, with a mistaken idea of cleanliness, is really an unmitigated nuisance. The brick pavement is saturated, and beneath it the soil in which the house stands, and the surplus water flowing down the gutter supplies the one element needed to convert the street dirt collected under the hot sun into putrescent matter emitting the poisonous germs of disease.

For every reason then, economic and sanitary, the prevention of waste is desirable, and while the accomplishment of this must be a work of considerable time, requiring both additional legislation, and to a certain extent the education of the public mind to make it effective, no time should be lost in taking the necessary preliminary steps.

The remedial measures may be classed under several heads, viz.: Instrumental determination, Domiciliary inspection, Regulation of plumbing appliances, and Infliction of suitable penalties. These must all be employed conjointly.

For the waste in large establishments—manufacturing and others—I know of no remedy at once so just and so effective as recording meters, by which the actual amount of water consumed, usefully or otherwise, is definitely ascertained and charged for.

For private houses, the Waterphone, or some similar contrivance, in conjunction with inspections, has shown itself to be of use, but if the Water Department is to perpetually maintain a conflict with defective appliances, a considerable increase of force will be required. In this direction legislation is needed, both to restrict waste and protect the public health.

The relations of the Water Department to the plumbing business are extremely intimate. It is upon the plumbing appliances in a house that the water charges are made, and any defect or changes therein affect the revenue of the Department. They should, therefore, be strictly regulated by law, and the possibility of bad or dishonest work prevented. Furthermore, the work of the plumber is a matter of life or death to the inmates of a house.

Civilization, while it has enhanced the comforts of life in this respect, has introduced into our homes a most deadly enemy unless due precautions are taken to control it. The plumber, therefore, should be a workman sufficiently intelligent and conscientious, and versed in his art, to be trusted with a matter of such vital importance, which, furthermore, should not be left to his sole discretion, but be supervised by some competent authority under regulations established by law.

At present, the legislation bearing upon this subject is exceedingly defective, and the example of other cities should be followed in procuring as speedily as may be, more effective administration for the protection of the public health against the fatal effects of ignorance and dishonesty.

With all its fortunate conditions, climatic and local, the expansion of its population and the intelligence and good conduct of its citizens, Philadelphia has a higher death rate than London, notwithstanding the greater age of the latter, its population of four millions to Philadelphia's one, and the average of eight persons to each house against less than six in Philadelphia. To a great extent this relatively high death rate is chargeable to the diseases known as zymotic, and classed as preventable, viz.: typhoid fever, diphtheria, scarlet fever, *et al.*

Philadelphia kills one person in a thousand more than London. In all, the lives of more than 1,000 persons are uselessly sacrificed every year, and the health of thousands more impaired. The causes of this are a sewage polluted soil, bad water, defective sewerage, defective highways, and defective plumbing. The responsibility for these things does not rest with the people, who cannot be expected to fully appreciate or understand them, but upon those whose business it is to know and whose duty it is to make them plain, and to indicate and provide the proper remedies.

SURVEYS FOR FUTURE WATER SUPPLY.

The increasing pollution of the Schuylkill, whence the main Water Supply of Philadelphia is derived, and in particular the occasional exacerbation of its unwholesome symptoms to the degree of rendering it totally unsuitable for ordinary purposes, have been already referred to, but the discussion which for a generation has been maintained with more or less earnestness and intelligence, has resulted only in confusing the subject with multiplied and variant suggestions, and in the absence of exact and carefully determined data, could not in the nature of things reach definite conclusions.

Not only has the quality of the water itself been the subject of dispute, but the widest diversity of opinion has been expressed as to the means best adapted to amend existing evils and to make suitable provision for the future.

It seems strange that, in a matter of such vital economic and social importance, this very contrariety of opinion should not have called attention to the one essential point, which had, moreover, been urged by competent advisers, viz.: The necessity for such thorough scientific investigation based upon the actual ascertainment of facts, as should eliminate doubt, and simplify the consideration of the problem by clearly determining its real conditions.

Sooner or later all cities are brought face to face with the water problem, and even when it has been thought that a solution has been reached, the development of industries and the growth of population out-run the provision which it was believed would suffice for long periods, and call for constant watchfulness and care to meet the growing demands.

In the case of Philadelphia, the problem—notwithstanding an apparent simplicity of conditions—is more than ordinarily complex. The Schuylkill brings the water to the heart of the City, and even furnishes the power with which to pump it, and it was therefore natural and proper enough to regard it as the main reliance. But the valley of the Schuylkill has peculiar features. At its source, the water—to a large extent the drainage of the coal measures—is charged with the acids resulting from the decomposition of the iron pyrites, and this excess of acid is still further increased by the great development of the mining industries. Farther down, the affluents drain a limestone region, and the commingling of the acid and alkali tends to neutralize both and to impart a certain degree of potability to the stream. As was pointed out long since, the water of the Schuylkill is an artificial product, depending for its quality upon a nice balance of chemical constituents, the undue preponderance of either of which would injuriously affect its use—the acid by destroying boilers and water-pipes, the lime by causing scale and rendering the water too hard to be acceptable.

This chemical balance has been hitherto sufficiently well maintained to give no great cause for complaint, but the pollution of the stream by the growing population and industries of the valley, has become a most serious feature.

The Schuylkill is the natural drainage outlet and sewer for the entire region traversed by it, and unless means can be found and applied to effectually cut off or thoroughly neutralize the multiplied sources of pollution, it is hopeless to consider it available in the future for drinking purposes.

To accomplish this, however, both legislative action and costly engineering works will be required, and the discussion of these must be deferred until the investigation now in progress shall have fully disclosed their character and extent.

Leaving aside the Schuylkill proper, it then remains to consider whether or not one or more of its affluents could be made to meet the necessary requirements. Of these, the Perkiomen alone is of such character as to promise good results, and in consequence the project of impounding the Perkiomen waters and bringing them to Philadelphia by a gravity conduit has heretofore presented itself as a plausible one, and been urged with more or less earnestness. In the absence, however, of such acurate data as must be obtained, it has been impossible to do more than accept estimates and opinions as a basis of argument, and there now appears good reason to believe that in respect of both quantity and quality, the Perkiomen supply would prove deficient.

Should it result that neither the Schuylkill nor its main affluent can be securely relied upon for the future, the Delaware must be considered, and this aspect of the case has hitherto been scarcely more than glanced at. Numerous suggestions have been made, but again the lack of precise and authentic information has crippled investigation and made discussion futile.

The estimated cost of every one of the Delaware projects has been so large as to discourage their consideration, but if the best results are to be attained, the investigation must be made.

For a gravity supply, the Delaware water must be taken somewhere in the vicinity of the Gap, since it is not until that point is reached that the elevation of the stream is sufficient to give the necessary fall. For a supply by pumping to a conduit, points nearer by offer themselves. The Delaware, too, has affluents which might be impressed into service, at least to diminish the necessary pumping.

A third possible source is the Upper Lehigh, whose waters in respect both of purity and altitude, present most favorable conditions, although the distance is great and the minimum flow less than is required for a full supply.

The ideal source is one whose swift waters, drained from a wilderness barren of mines or agriculture, and which the laws of nature will effectually guard from defilement by population or industry, can be diverted from the living reservoir of their rocky channel, and through an aqueduct of reasonable length, be delivered to the city receiving basins, as limpid, palatable, and free from contamination as when tumbling freely in their native bed.

Of all the sources available, the Upper Lehigh comes nearest to this standard, and the Upper Delaware,—whose greater flow is ample for all needs,—comes next.

It happens, however, that ideals are rare of attainment, and in the present case, economic considerations intervene to counsel caution, and compel the fullest and most careful investigation before a decision be made, but it cannot be denied that Philadelphia, with all her fortunate conditions, is doubly favored in having at her command, whenever she shall choose to claim it, a superb source of Water Supply which for generations to come will fulfill every requirement.

In investigating the Delaware project, some unexpected features were developed. It was necessary in running the conduit lines to the Gap, to take advantage of the valley itself to pass the South Mountain, and in doing this, Point Pleasant,—about half-way between Trenton and Easton, and 30 miles from Philadelphia,—was readily seen to be the most advantageous point at which to reach the valley. The conduit line to this point proved to be much more favorable than was anticipated, largely reducing previous estimates, and furthermore, the quality of the water in the Delaware at Point Pleasant was found to be extremely good,—better, in fact, than that of any of its affluents,—and almost comparable with the water of the Gap.

The Conduit line to Point Pleasant intercepts the Pennypack and the Big and Little Neshaminy, and when nearing the Delaware valley taps also the Tohickon. It results from this combination of circumstances, that the Delaware Project might be considered as terminating temporarily at Point Pleasant, where pumps could lift the Delaware waters to the conduit and send them in to the Wentz Farm and the proposed Cambria Basins at an elevation of 165 feet. Furthermore, the waters of the intercepted affluents could be used to decrease the pumpage, and in fact for the greater part of the year, would, in all probability, furnish the full amount required.

An aqueduct Northward from the Wentz Farm Basin would therefore come almost immediately into service by bringing in the supply from the several streams as they were successively reached, and the Point Pleasant Pumping Station would continue to furnish any amount of excellent water while the construction of the conduit should be proceeding towards the Gap.

The unexpected purity of the Point Pleasant water is due to two causes: First, the considerable aeration and consequent purification the Delaware waters are subjected to by flowing swiftly in a natural channel, and over numerous riffs and rapids; and secondly, the partial exclusion of the low water drainage of the Lehigh by means of the canal on the right bank of the Delaware, which absorbs the Summer flow of the Lehigh when it is most highly charged with the sewage of Easton, Bethlehem, and other cities in that valley.

The problem of the Future Supply of Philadelphia therefore, presents itself under three aspects:

First—The practicability, the requisite means, and the cost of redeeming the Schuylkill, and so effectually guarding it against future pollution as would justify the City of Philadelphia in depending upon the use of its waters for domestic and manufacturing purposes.

Second—The determination of the quality and quantity of the waters that can be reliably obtained from the valley of the Perkiomen; and,

Third—The cost and other particulars of the Delaware project—accepting Point Pleasant as a half-way station, and looking to above the Gap for a gravity supply.

As an alternative to this, the excellent suggestion is advanced by Mr. Hering, of bringing the waters of the Upper Lehigh into the Upper Perkiomen—thereby increasing the quantity and improving the quality of the latter.

It will be seen by any one conversant with the subject, that it has grown to great, and it may be said, unexpected proportions. The area of country to be examined, whether by accurate surveys or reconnaissances, is larger than has ever been attempted in this country; and, in this connection, a comparison of the necessary extent of the Philadelphia surveys with those made by other cities, will be instructive.

New York, with a topographical area to be covered of about 2,000 square miles, of which 100 were mapped and 250 were carefully reconnoitered, has, since 1875, spent an average of over $30,000 annually, or about $250,000.

The Baltimore surveys cost about $15,000, but only the Gunpowder project, which has since been successfully completed, was seriously considered, and the length of the conduit was seven miles only.

In Boston, the areas surveyed were about 50 square miles, and examinations were made of a total of about 5,500 square miles. The length of conduit line was 15¼ miles. The investigation occupied about three years, and cost $60,000.

The Philadelphia investigation will require careful surveys of about 468 square miles, conduit lines about 183 miles, and a general examination of about 6,500 square miles.

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The work which has so far been accomplished is excellent in character, large in amount, and economical in cost; and it is of the greatest importance that it should be carried to completion with the parties now fully equipped and trained to their work.

The total expenditure that will be required cannot yet be determined. The investigation, owing to an unexpected balancing of various advantages and disadvantages, physical and economic, has assumed proportions that were not at any time heretofore contemplated. But it is work that is absolutely essential to an accurate and reliable solution of the problem, and I feel no hesitation in saying, that whatever necessary expenditures are incurred will be amply repaid in the end.

The expense of maintaining and supervising the work is about $2,500 per month, and this year will probably see the greater part of the field work fairly advanced to completion.

The results are too important, and the consequences of a failure to obtain all necessary information would be too serious to allow me to feel any hesitation in asking for such funds as may be required to complete the investigation.

The accompanying reports from Dr. Leeds and Mr. Hering furnish a full account of the operations under their respective directions, and contain information of the greatest interest and value.

The Department was especially fortunate in securing the services of these two gentlemen, both of whom are well known in the professional world in their respective branches of inquiry and have evinced the highest interest in the important labors entrusted to them.

The circumstances are such as to necessitate a continuance of the investigation in order to cover the entire field, and to reach such reliable results as shall justify the preparation by the Department of final estimates and recommendations; but the conditions are now thoroughly understood, many points of doubt have been eliminated, and the work can proceed with clear conceptions towards a determinate conclusion.

The varying character of the several streams at the different seasons makes it necessary to establish minimum as well as average data, and observations extending over at least a brief term of years are required.

Analysis has so far confirmed opinions formed from engineering and physical data, and Dr. Leeds is enabled to reach the preliminary conclusions expressed in his final remarks, viz.: as to the advisability of ceasing to pump water at the Kensington Station, and as to the necessity for immediate measures to guard the Schuylkill from pollution, if its use as a source of supply is to continue. Inasmuch as any modifications of the existing system must, under the most favorable circumstances, require for their completion a period depending upon the means which can be made available for this purpose, the conclusion of Dr. Leeds as to the frequent and recurring non-potability of the Schuylkill, call for most serious consideration on the part of those upon whom is laid the responsibility of making adequate provision for the necessities of this great city.

Mr. Hering's report contains a careful *resume* of all publications upon the question of future supply, and gives a detailed account of the work of the surveying parties.

The plan of operations was laid down after a careful preliminary examination of the subject, and from time to time fresh or modified instructions were given as the work extended.

Great care was exercised in selecting the gentlemen to conduct the field work, and the results are such as to reflect high credit upon all engaged.

It is believed that the greater part of the field work of the survey can be completed before the close of this year, and the entire investigation concluded at a total cost not much in excess of the expenditure made by Boston, to cover an area of very much less extent.

GENERAL REMARKS.

WATER FURNISHED PUBLIC AND CHARITABLE INSTITUTIONS.

The Water Department does a large amount of pumping for which it receives neither revenue nor credit, and to illustrate, in part, the extent of this, I have had tables prepared for publication with the Registrar's report, of the numerous Institutions which are supplied with water either gratis or at a reduced rate.

Under the former head are included the Public Buildings, Independence Hall, the Court House, Prison, Almshouse, Police and Fire Stations, Public Schools, etc., as well as the numerous outlets by which water is supplied to the East and West Parks. Were this charged for at the regular rates the Department would be entitled, as nearly as can be computed, to an annual revenue of about $29,000. But the loss to the Department does not end here. Water of which no account is kept, and for which no charge is made, is wasted in large quantities, and it is probable that the loss of water through these buildings alone is much more than the regular rating would pay for. It would be well, also. for the Police and Fire Stations to have regular attachments to the mains, and avoid the large waste of water due to using fire plugs for washing purposes.

The Park, with its fountains and other openings, would be charged with $18,000 per annum. As a matter of fact, out of the three engines in the Belmont Station, the entire work of one is needed to keep the West Park supplied during the summer. There is a 10-inch main to the fountain, while a 20-inch main is the sole dependence of West Philadelphia.

The use of water for ornamental and public purposes is recognized as legitimate and proper, but the main consideration is this:—that the Water Department, to the extent to which the other Departments draw upon it, is charged with expenditures which should legitimately be borne by them; in other words, a misleading balance is struck, and the cost of the Water Department to the city is artificially increased, while that of other Departments is apparently diminished.

Were each Department to stand upon its own basis and discharge its own liabilities, Councils would then know with exactness the actual necessary expenditure for each, and appropriate accordingly. It would be a simple matter of bookkeeping to accomplish this, as the Water Department would present bills and have them paid, and the money would remain in the treasury as now, but the real expenditures and receipts of each Department would be shown upon the books. I believe this suggestion a useful one in the direction of simplifying and regulating the city business.

The ordinance of June 21, 1878, authorizes the Chief Engineer of the Water Department to fix the water rents of Charitable Institutions and the Academy of Natural Sciences at 15 per cent. of the regular rates, and in other cases special ordinances make similar provisions. As shown in the Registrar's table, the effect of this is a loss of revenue to the Department of not less than $19,000 per annum.

In many cases the loss can only be approximately computed, as it is impossible to say what amount of water is used. The Zoological Gardens, for example, have a 6-inch connection with the main, which would use over 1,000,000 gallons per day, and the actual cost to the Department in coal and wages at the Belmont Station to pump this amount, is $13.00 per day, while the ordinance fixes the rental at $1,000 per annum.

I would not dispute the propriety of these benefactions on the part of the City, but since the burden of them is laid upon the Department, it is only proper to let it be understood what they are and what amounts they involve.

THE COST OF WATER.

Comparing the total expenditures of the Department for the period since Consolidation in 1854 with the total work as represented by the number of gallons delivered, I find that the cost of pumping and distributing 1,000 gallons is $4\frac{78}{100}$ cents. For the period 1872–1883, during which the pumpage increased while the outlay for improvements was injudiciously restricted, the cost was $4\frac{33}{100}$ cents per thousand gallons.

These figures are based upon the actual outlay of the Department since 1854 for material and labor, including the cost of purchasing, constructing, repairing, and renewing pipes, reservoirs, and machinery, as necessary appliances to enable the Department to distribute the water, but do not include interest on the previous cost of plant, nor upon the $6,500,000 of Water Loans which are charged upon the books of the City Treasurer.

It is difficult to determine with exactness what has been the total cost of the plant, since some of the data relating to the old Fairmount, Spring Garden, and Kensington Works could be recovered—if at all—only by means of a prolonged investigation, but as nearly as can be ascertained the total cost is approximately $15,000,000, on which the interest at 4 per cent. would be $600,000 per annum—which, however, the City is not really called upon to pay.

Computing the interest on the $6,500,000 of Water Loans at the average rate of 5 per cent. the annual charge would be $325,000, for the payment of which provision is requisite.

Prorating this sum with the pumpage of last year, it is found that to the average cost of pumpage, as previously computed, viz.: $4\frac{78}{100}$ cents, there must be added $1\frac{29}{100}$ cents to cover the interest charge on loans, making the total cost to the City of delivering 1,000 gallons, $6\frac{7}{100}$ cents.

It seems proper to compute the cost of pumpage in this manner, since the extension and renewal of plant is an annual necessity, and because it is quite clear that considerable expenditures must be made in the immediate future for pipes, mains, reservoirs, and other works, owing to the failure to make due provision for many years past.

Methods of Appointment and Selection of Employés.

In a business employing regularly from 300 to 500 people, which is not only of large extent but involves much diversity of labor with technical training and skill of many sorts, it is of the utmost importance that the methods of selection should be such as to secure capable, industrious, and faithful men in every grade.

I am not one of those who believe that City business must, by necessity, be less well managed, or that City work and expenditures must be less productive of good results, whether in point of efficiency or economy, than private business. I believe, on the contrary, that under favorable circumstances, and with proper encouragement, the wider field of operations and the greater responsibility and degree of publicity attaching thereto will operate as a wholesome stimulus, and impel a faithful employé to a more earnest discharge of duty than even the moderate wage he draws.

In order, however, to realize this view in practice, it is essential that the methods of administration shall be such as to obtain and retain the services of skillful and conscientious men, who, uncontrolled by any considerations other than the advantage of the work in which they are engaged, shall be left free to develop their best energies and skill in performing the duties assigned them.

It is necessary, therefore, to exercise as careful a discrimination as possible in the original employment of men, to replace them without hesitation when found unsuited or unfaithful, and to retain and promote them if their original capabilities and the value of their services are enhanced by familiarity with and practice in their work.

In particular is it essential that every man should understand that his retention and advancement depend absolutely and solely upon the necessity for and value of his services to the Department, and that no considerations foreign to its welfare and proper administration will avail, either to discharge or retain him.

I am of opinion that so far as these principles are adhered to, so far will the work of the Department be found effective, economical and advantageous to the community; and to the extent to which they are disregarded will the service lose in character, and become wasteful and unsatisfactory.

When a year ago I assumed charge of this Department, in a field of labor which, though in many respects consonant with previous occupations, was entirely untried—with an organization to which I was an entire stranger and which I knew to be in several respects seriously defective, and with the assurances of a failure of the water supply during the ensuing Summer—not the least of the embarrassments surrounding the situation was that of appointments, and it soon became evident that the time given to listening to solicitations for employment would leave no opportunity for the serious and necessary technical and administrative work of the office. Rules were therefore adopted, and have since been in effect with excellent results. The applicant for employment (above the grade of laborer) submits his application in his own writing, and in accordance with printed instructions requiring statements as to his age, trade or occupation, how and by whom employed for several years past, etc.—supports it with such testimonials as to his general character and qualifications as he may be able to obtain, and bides his time. If a man of his sort be needed, selection is made from those of his class, and the one who, according to the evidence on file, is best qualified, is sent for, in most cases personally examined by the Chief Engineer, in others, by special subordinates. If the case be judged favorably, he is employed on trial; if rejected, another is sent for. This method not only saves the time both of the applicants and of the Chief Engineer, but secures applications from excellent men who would not hope or be able otherwise to submit their cases for consideration.

In other respects the principles above mentioned are followed. No man is discharged except for just cause; his employment is secure so long as he is needed and his work and conduct are satisfactory; promotion awaits him if found qualified and the opportunity offer.

The result is that the Department is in fairly good form, organized, vitalized, working harmoniously, with responsibility fixed, accountability enforced, and discipline maintained. There is still very much in this direction to be done, and another year's work will not be too much time in which to accomplish it, but the beneficial results are already manifest and will be still more evident hereafter.

Preparation of Reports and Estimates.

It appears to me that in the preparation of communications to Councils, but one course lies open to the Head of the Department. He has not the means of ascertaining, nor is he charged with the duty of determining what may or should be the amounts actually available for the uses of his branch of the City business. This duty is imposed upon Councils, and the Department Officer has no responsibility therefor, beyond making the fullest exposition of the affairs and condition of the Department of which he is in charge, in order that when the questions of Tax Rate and Appropriations are to be decided, it may be in the light of actual facts of which no essential portion or feature is omitted or suppressed.

His Reports, therfore, are simply statements to Councils of the needs of the Department, and of the amounts which are required to meet them, and his estimates are of the sums which, were they available, could be advantageously and economically expended during the year.

With the great responsibility resting on the Councils of the City within their statutory limitations to regulate and provide for all matters relating to its welfare, it has seemed to me essential that they should be in the fullest possession of facts connected with City Affairs, in order to enable them to judge wisely as to the requisite legislation, and I have therefore endeavored, within the brief limits of this Report, to condense the essential facts relating to the condition of the Department, its needs and its relation to the Community, in order that some means may be provided of meeting its most pressing requirements and of enabling it to discharge to the City that full measure of service for which it was originally designed, and from which at the present time it falls so far short of accomplishing.

ACKNOWLEDGEMENTS.

I could not properly conclude this Report without making some acknowledgement to Councils of my recognition of their uniform consideration and support during a year of arduous labor, and in particular to the members of the Water Committee, of my appreciation of their unfailing co-operation and assistance. Without these, the work of the Department would have been, to a great extent, shorn of its due effect, and the favorable results been seriously diminished.

I desire also to express generally my great obligations to the employés of the Department who have worked early and late with unflagging zeal and devotion to its best interests.

REPORT BY THE CHIEF CLERK

OF THE

DETAILED EXPENDITURES OF THE DEPARTMENT,

DURING 1883.

PHILADELPHIA WATER DEPARTMENT,

February 6, 1884.

COL. WILLIAM LUDLOW,

Chief Engineer:

SIR:—I have the honor to herewith submit a detailed statement of the expenditures of this Department for the year 1883.

The total appropriations available during the year, the subdivisions of expenditures, and the balances remaining to the credit of the Department at the close of the year, you will find in the recapitulation attached.

The business transactions of the year involved, in part, the examination and audit of thirty-one hundred bills, the preparation of three hundred and thirty pay-rolls, and the drawing of eleven thousand one hundred and ninety-nine warrants.

Respectfully,

J. T. HICKMAN,

Chief Clerk.

Detailed Expenditures of the Department for 1883.

General Appropriation.	Amount appropri'ted	Amount expended.	Balance merging.	Balance not merging
An Ordinance making an appropriation to the Water Department for the year 1883, approved December 30, 1882........................ $611,292 00				
Transferred from surplus of 1882, October 20, 1883, 65,000 00				
Transferred from surplus of 1882, November 19, 1883.............................. 14,000 00				
$690,292 00				
Transferred to Highway Department, June 27, 1883.............. $3,000 00				
Transferred to refund twice-paid water rents, Novem-12, 1883.......... 2,072 97				
5,072 97	$685,219 03			
Item 1. Salaries—Engineering.................. $18,400 00				
Transferred from Item 20, June 16, 1883......................... 1,500 00				
$19,900 00				
Transferred to new Item 1½, May 8, 1883, 580 50	19,319 50			
Salary of Chief Engineer............	....	$5,729 83		
" chief clerk..................	....	1,800 00		
" assistant clerk.............	....	1,080 00		
" three assist'nt engineers	....	5,250 00		
" draughtsman...............	....	1,350 00		
" superintendent...........	....	1,800 00		
" clerk to superintendent	....	850 00		
" muster clerk...............	....	810 00		
" telegraph lineman........	....	227 25		
Item 1½. Salary of correspondence clerk, ordinance May 8, 1883:		$18,897 08	$422 42	
Transferred from Item 1, May 8, 1883....................... $580 50				
Transferred from Item 3, May 8, 1883, 250 00	830 50			
Salary of correspondence clerk:	....	763 41	67 09	
Item 2. Salaries—Pipe laying...........	27,349 00			
Salaries of six purveyors............	....	8,880 00		
Salary of superintendent of shop..	....	1,440 00		
Salary of clerk to superintendent of shop..........	....	843 14		
Salaries of five clerks to purveyors..................................	....	3,600 00		
Amount carried forward.......	....	$14,763 14		

Detailed Expenditures of the Department for 1883.

General Appropriation.	Amount appropri'ted	Amount expended.	Balance merging.	Balance not merging
Item 2, continued.				
Amounts brought forward......	$27,349 00	$14,763 14		
Salaries of two pipe recording clerks..	....	1,800 00		
Salaries of six general foremen....	....	5,634 00		
Salaries of four foremen of repairs..	....	3,094 83		
Salaries of three watchmen........	....	2,025 00		
		$27,316 97	$32 03	
Item 3. Salaries — Pumpage at works........... $74,080 00				
Transferred to Item 1½, May 8, 1883, $250 00				
Transferred to Highway Department, June 27, 1883, 3,000 00				
Transferred to Item 5, Nov. 12, 1883........ 1,000 00				
Transferred to Item 15, Nov. 12, 1883........ 4,000 00				
8,250 00				
	$65,830 00			
Salary of general superintendent, ordinance July 7, 1883......		800 00		
Salary of additional inspectors, ordinance June 18, 1883..............		665 32		

Detailed Expenditures of the Department for 1883.

General Appropriation.	Engineers in Charge.	First Engineers.	Second Engineers.	Assistant Engineers.	Oilers.	Gaugemen.	Firemen.	Coal Passers.	Helpers.	Amount appropri'ted	Amount expended.	Balance merging.	Balance not merging
Item 3, continued.													
Amounts brought forward										$65,830 00	$1,465 32		
Salaries of employees at pumping stations:													
PUMPING STATIONS.													
Fairmount		1	1	9							7,768 95		
Spring Garden	1			2	8	2	10	4			18,054 68		
Belmont	1			2	4	2	10	4			14,476 90		
Roxborough	1	1	1	1		2	4	2			7,766 34		
Mt. Airy				1				2			1,526 43		
Chestnut Hill				1					1		1,410 00		
Frankford	1			1			2				3,413 58		
Kensington		1	1		4		4	2	1		9,932 58		
											$65,814 78	$15 22	

Detailed Expenditures of the Department for 1883.

General Appropriation.		Amount appropri'ted	Amount expended.	Balance merging.	Balance not merging
Item 4. Salaries—Registrar, collecting water rents		$26,885 00			
Salary of registrar			$2,500 00		
" registrar's chief clerk			1,165 20		
" receiving clerk			1,300 00		
" permit clerk			1,080 00		
" registering clerk			1,080 00		
Salaries of two entry clerks			1,800 00		
" four bill clerks			3,600 00		
Salary of pipe recording clerk			810 00		
Salaries of fourteen inspectors			12,498 40		
Salary of messenger			765 00		
			$26,598 60	$286 40	
Item 5. Books, stationery, advertising	$5,650				
Transferred from Item 3, November 12, 1883	1,000				
		6,650 00			
Salary of extra clerk, ordinance, June 18, 1883			332 50		
Printing			416 28		
Advertising			1,378 90		
Stationery			4,512 12		
			$6,639 80	10 20	
Item 6. Fuel for offices, incidentals, &c	$5,000				
Transferred from Item 10, October 6, 1883	500				
		5,500 00			
Putting up stoves, deficiency of 1882	$11 25				
Rent of office, deficiency of 1882	25 00				
Coal, deficiency of 1882	37 15				
Ice, " " "	9 76				
Messenger service, deficiency of 1882	28 73				
Repairs to range, deficiency of 1882	21 00				
			132 89		
Plate-glass			5 53		
Door and window screen			6 85		
Testing boiler plate			10 00		
Tin tubes			10 35		
Morning papers			20 28		
City directories			21 50		
Weighing old boilers			21 76		
Carpet			21 63		
Repairs to pump, heater, clocks, spouts and tape			23 07		
Soap			23 16		
Shades			24 40		
Plumbing			25 58		
Clocks			26 50		
Ground rent (918 Cherry street)			26 66		
Lumber			27 41		
Frames for plans			33 50		
Towels			33 72		
Amount carried forward			$494 79		

Detailed Expenditures of the Department for 1883.

General Appropriation.		Amount appropri'ted	Amount expended.	Balance merging.	Balance not merging
Item 6, continued.					
Amounts brought forward......		$5,500 00	$494 79		
Inspection of scales...........................		....	37 50		
Gum goods..................................		....	39 48		
Rubber stamps.............................		....	45 50		
Rent of office................................		....	50 00		
Brooms, brushes, &c....................		....	58 67		
Repairs to telegraph and telephone instruments....................		....	60 84		
Painting signs.............................		....	61 30		
Awnings		....	63 00		
Washing towels...........................		....	77 00		
Messenger and telegraph service..		....	94 29		
Hardware.....................................		....	105 55		
Type writer.................................		....	125 00		
Furnishing meals........................		....	144 10		
Coal..		....	144 10		
Postage stamps...........................		....	255 41		
Paper hanging.............................		....	224 54		
Desks, table and chairs..............		....	313 00		
Wages (extra clerk)....................		....	462 13		
Books..		....	488 96		
Incidentals..................................		....	260 56		
Maps..		....	756 85		
Transportation		....	985 38		
Carriage hire..............................		....	151 25		
			$5,499 20	80	
Item 7. Carriage hire and keep of horse for Gen'l Superintendent and Assistant Engineers..........		750 00	750 00		
Item 8. Carriage hire and keep of horse for Chief Engineer..........		650 00	650 00		
Item 9. Coal and wood......	$110,000 00				
Transferred from Item 13, October 8, 1883...	5,000 00				
Transferred from Item 18, October 8, 1883...	20,000 00				
		$135,000 00			
DEFICIENCIES OF 1882.					
Kensington, 382 tons coal, at $4.37............	$1,669 33				
Belmont, 833.1 tons coal, at $4.23............	3,525 70				
Spring Garden, 1,238.01 tons coal, at $4.48......	5,546 46				
Roxborough, 204.1 tons coal, at $4.39............	897 76				
Frankford, 355 tons coal, at $4.60............	1,633 00				
		....	$13,272 25		
WOOD.					
Belmont, 30 cords, at	$7 35	....	220 50		
Spring Garden, 30 "	7 35	....	220 50		
Roxborough 10 "	7 35	....	73 50		
Chestnut Hill, 5 "	7 35	....	36 75		
Amount carried forward.......		....	$13,823 50		

Detailed Expenditures of the Department for 1883.

General Appropriation.		Amount appropri'ted	Amount expended.	Balance merging.	Balance not merging
Item 9, continued.					
Amounts brought forward......		$135,000 00	$13,823 50		
COAL.					
Belmont, 56.18 tons pea, at	$2 90	....	165 01		
" 20.19 tons bituminous, at....................	3 30	....	69 14		
Belmont, 35.01 tons bituminous, at....................	3 75	....	131 44		
Fairmount, 177 tons egg, at	4 75	....	840 75		
Spring Garden, 10,370.08 tons egg, at....................	4 38	....	45,422 35		
Belmont, 5,957.14 tons egg, at....................	4 17	....	24,843 61		
Roxborough, 5,227.09 tons egg, at....................	4 33	....	22,634 87		
Chestnut Hill, 735.15 tons egg, at....................	4 85	....	3,494 81		
Frankford, 1,866.14 tons egg, at....................	4 05	....	7,560 13		
Kensington, 3,632.05 tons egg, at....................	4 15	....	15,073 86		
Hauling coal to Roxboro' Auxiliary and Mt. Airy...........		....	171 83		
			$134,231 30	$768 70	
Item 10. Tallow and oil......	$5,000 00				
Transferred to Item 6, October 8, 1883..........	500 00				
		4,500 00			
5 gals. gasoline, at...........	18	....	90		
60 lbs. soap, at................	7	....	4 20		
10 oil cans, at..................	75	....	7 50		
40 gals. parafine oil, at.....	35	....	14 00		
145 gals. lubricating oil, at	12½	....	18 14		
152½ gals. winter engine oil, at....................	15½	....	23 64		
387 lbs. Dixon machine grease, at....................	9	....	34 83		
Webb's patent lubricator...........		....	35 00		
88½ gals. castor oil, at.....	$1 00	....	88 50		
2,372 lbs. tallow, at...........	8¼	....	195 69		
1,914½ gals. headlight oil, at....................	14	....	268 03		
438[illegible] gals. lard oil, at......	90	....	394 56		
801½ gals. spermoleum, at	60	....	480 90		
1,035 gals. valve oil, at.....	55	....	568 76		
855[illegible] gals. lard oil, at......	71	....	607 71		
595½ gals. valvoline oil, at	1 25	....	744 38		
			$3,486 74	1,013 26	
Item 11. Gas at works and purvevors' offices....................		6,000 00			
At shop (Second District office)...			20 90		
" Spring Garden (second service)			88 00		
" Kensington station..............			1,042 91		
" Fairmount station..............			1,893 73		
" Spring Garden station...........			2,331 30		
			$5,376 84	623 16	

Detailed Expenditures of the Department for 1883.

General Appropriation.	Amount appropri ted	Amount expended.	Balance merging.	Balance not merging
Item 12. Small stores	$5,000 00			
Gypsum		7 00		
Oil cans		9 00		
Pipe vise		15 00		
Leather belting		19 59		
Ladders		21 87		
Soap		27 17		
Asphalt paint		37 50		
Red lead		47 00		
Lamps and Globes		100 81		
Brooms, brushes, &c		125 29		
Cotton waste		219 40		
Gasket, &c		333 20		
Small stores		378 93		
Gum goods		405 25		
White lead		435 11		
Hardware		712 54		
Packing		786 08		
Paints, linseed oil and alcohol		1,318 82		
		$4,999 56	44	
Item 13. Repairs to machinery $40,000 00				
Transferred to Item 9, October 8 5,000 00				
$35,000 00				
Transferred from surplus of 1882, Nov. 19 5,000 00	40,000 00			
DEFICIENCIES OF 1882.				
Boiler fluid $100 00				
Brass steam-fittings 185 80				
Repairs to boilers 663 81				
Repairs to boilers, deficiency of 1881 1,901 31		2,850 92		
Repairs to indicators		68 65		
Water-gauge glasses		91 25		
Indicator		104 50		

Detailed Expenditures of the Department for 1883.

General Appropriation.									Amount appropri'ted	Amount expended.	Balance merging.	Balance not merging
Item 13, continued.												
Amounts brought forward									$40,000 00	$3,115 32		
Materials.	Fairmount.	Spring Garden.	Belmont.	Roxborough.	Mt. Airy.	Chestnut Hill.	Frankford.	Kensington.				
Asbestos paint		$18 50		$22 20			$18 50	$31 45		$90 65		
Axle forging		40 80								40 80		
Babbitt metal				19 88						19 88		
Boiler compound			25 00							25 00		
" fluid	200 00									200 00		
" inspection		138 00	127 00					20 30		285 30		
Brass steam-fittings	107 60	173 10	185 75	23 60	8 40		49 00	42 50		589 95		
Bricks, lime and cement		41 41	6 16	7 51						55 08		
Covering steam pipe		60 35	602 31	328 35				254 68		1,245 69		
Cotton waste		24 40			10 80					35 20		
Donkey pump					213 00					213 00		
Fire-brick		378 50	319 00	129 42			37 50	5 00		869 42		
Freight		6 20	12 86							19 06		
Gum valves and washers	42 30	526 99	686 94	348 25	1 64	13 69		144 49		1,764 30		
Hair felt			48 00							48 00		
Hardware	13 05		30 00					30 00		73 05		
Lumber	302 31	82 44	236 82				23 75	20 73		666 05		
Machine work		12 76	175 00					2 00		189 76		
Packing	314 38	823 50	479 14	383 22		2 33	15 30	182 77		2,200 64		
Amounts carried forward	$979 64	$2,326 95	$2,933 98	$1,262 43	$233 84	$16 02	$144 05	$733 92	$40,000 00	$11,746 15		

Detailed Expenditures of the Department for 1883.

MATERIALS—continued.	Fairmount.	Spring Garden.	Belmont.	Roxborough.	Mt. Airy.	Chestnut Hill.	Frankford.	Kensington.	Amount appropriated.	Amount expended.	Balance merging.	Balance not merging.
Amounts brought forward	$979 64	$2,326 95	$2,933 98	$1,262 43	$233 84	$16 02	$144 05	$733 92	$40,000 00	$11,746 15		
Repairs to boilers	...	2,801 00	205 06	591 39	...	...	5 40	8 15	...	3,611 00		
" engine	...	...	94 48	...	...	...	...	551 83	...	646 31		
" felting	...	...	...	...	...	...	18 50	20 50	...	39 00		
Transportation	30 00	97 92	261 92	621 28	90 64	140 64	751 55	...	...	1,993 95		
Wrought-iron tubing	...	...	...	...	12 00	...	151 79	...	...	163 79		
Valve-seat	...	1,020 00	...	...	...	...	...	...	...	1,020 00		
Iron valve	...	...	...	...	...	4 50	...	...	...	4 50		
Total	$1,009 64	$6,245 87	$3,495 44	$2,475 10	$336 48	$161 16	$1,071 29	$1,314 40	...	$19,224 70		
WAGES.												
Machinists	1,121 99	3,975 04	2,623 20	1,244 09	159 76	96 62	1,337 73	1,854 35	...	12,412 78		
Painters	...	61 50	265 50	...	...	...	...	...	...	327 00		
Bricklayers	108 75	1,704 37	981 87	878 75	...	...	246 50	96 25	...	4,016 49		
Carpenters	78 00	268 25	1,595 50	12 00	...	...	...	...	...	1,953 75		
Stone-masons	...	111 00	99 00	...	...	...	3 00	...	...	213 00		
Riggers	...	22 75	...	...	...	...	...	98 25	...	121 00		
Laborers	70 87	105 50	277 00	103 75	...	...	80 75	...	...	637 87		
Hauling	199 50	379 50	223 00	135 00	...	...	54 00	69 75	...	1,060 75		
Total	$1,579 11	$6,627 91	$6,065 07	$2,373 59	$159 76	$96 62	$1,721 98	$2,118 60	...	$20,742 64		
	$2,588 75	$12,873 78	$9,560 51	$4,848 69	$496 24	$257 78	$2,793 27	$3,433 00	...	$39,967 34	$2 52	$30 14

Detailed Expenditures of the Department for 1883.

General Appropriation.	Amount appropri'ted	Amount expended.	Balance merging.	Balance not merging
Item 14. Repairs to pipe, plugs, &c. $35,000 00; Transferred from Item 16, November 12 2,000 00	$37,000 00			
MATERIAL.				
Lead		$4 34		
Bricks, Lime and Cement		16 76		
Hauling		21 00		
Slag		22 65		
Freight		30 21		
Tools		41 77		
Towing		52 00		
Plumbing		62 40		
Hardware		63 68		
Incidentals		89 55		
Repaving around plugs		136 13		
Willows for mattresses		150 00		
Gum for joints		211 13		
Lumber		236 02		
WAGES.				
Diver		7,745 00		
Works		114 75		
Shop		894 75		
First District		5,612 22		
Second "		5,277 62		
Third "		4,667 45		
Fourth "		7,142 95		
Fifth " (Manayunk)		1,627 39		
Sixth " (Germantown)		1,787 69		
		$36,007 46	$992 54	
Item 15. Repairs to buildings, grounds, and reservoirs $18,500 00; Transferred from Item 20, June 27 39,000 00; Transferred from Item 3, November 12 4,000 00; Transferred from surplus of 1882, Nov. 19 9,000 00	70,500 00			
MATERIAL.				
Charcoal		$2 25		
Oars		3 50		
Cleaning cesspool		5 50		
Freight		12 85		
Plastering		25 00		
Barbed wire		27 36		
Wheelbarrows		36 00		
Iron railing		39 15		
Lamps, torches, &c		49 45		
Coal screens and smoke stacks		72 00		
Setting up gas machine		99 04		
New fence, Fourth District yard		142 20		
Paints		177 08		
Services of diver		200 00		
Amount carried forward		$891 38		

Detailed Expenditures of the Department for 1883.

General Appropriation.	Amount appropri'ted	Amount expended.	Balance merging.	Balance not merging
Item 15, continued.				
Amounts brought forward.....	$70,500 00	$891 38		
Stoves, &c.....	.....	207 26		
Window frames, sashes, &c.....	.....	256 01		
Coating walls.....	.....	266 00		
Gas fixtures.....	.....	314 26		
Repairs to scales.....	.....	415 34		
" tracks.....	.....	571 98		
Window glass.....	.....	692 70		
Repairs to roofs.....	.....	1,297 79		
Hardware.....	.....	1,404 35		
Hauling ashes.....	.....	1,400 00		
Plumbing.....	.....	1,818 94		
Bricks, lime, and cement.....	.....	2,762 19		
Electric plant, Belmont.....	.....	2,645 00		
Repairs to wharf, Frankford.....	.....	4,926 88		
Repairs to pavement, Fairmount..	.....	6,968 32		
" Wentz farm reservoir..	.....	7,600 83		
Lumber.....	.....	8,155 42		
WAGES.				
Riggers.....	.....	68 00		
Bricklayers.....	.....	1,053 50		
Stonemasons.....	.....	1,692 00		
Hauling supplies.....	.....	1,870 65		
Painters.....	.....	6,159 00		
Laborers.....	.....	7,170 90		
Carpenters.....	.....	9,774 00		
		$70,382 70	$38 58	$78 72
Item 16. Salaries—Buildings, grounds, and reservoirs..... $23,528 00				
Transferred to Item 14, November 12..... 2,000 00				
	$21,528 00			

Detailed Expenditures of the Department for 1883.

General Appropriation.	Janitor.	Watchmen.	Lineman.	Policemen.	Foreman of Bricklayers.	Foreman of Stonemasons.	Foreman of Riggers.	Foreman of Carpenters.	Foreman of Laborers.	Gardener.	Laborers.	Helpers.	Amount appropri'ted	Amount expended.	Balance merging.	Balance not merging
Item 16, continued.																
Amount brought forward													$21,528 00			
Office	1	2	1											$2,270 50		
Buildings, grounds, reservoirs					1	1	1	1	1	1		4		8,101 59		
Fairmount		2		2							2			2,710 05		
Spring Garden		4									1	1		2,932 46		
Belmont		1									1	1		2,068 53		
Roxborough		1												675 00		
Frankford		2												1,350 00		
Kensington		2												1,350 00		
														$21,458 13	$69 87	

Detailed Expenditures of the Department for 1883.

General Appropriation.	Amount appropri'ted	Amount expended.	Balance merging.	Balance not merging
Item 17. Drills and new attachments	$9,500 00			
WAGES.				
First District		$1,621 87		
Second "		1,665 73		
Third "		1,531 89		
Fourth "		1,590 75		
Fifth " (Manayunk)		1,571 25		
Sixth " (Germantown)		1,518 18		
		$9,499 67	33	
Item 18. Labor in laying pipes $60,000 00				
Transferred to Item 9, October 8 20,000 00				
	40,000 00			
Measuring over pipe		1,625 44		
WAGES.				
First District		1,522 85		
Second "		3,641 50		
Third "		2,602 43		
Fourth "		5,461 07		
Fifth " (Manayunk)		1,715 28		
Sixth " (Germantown)		4,882 40		
Shop		18,420 45		
		$39,871 42	$128 58	
Item 19. For the purchase of pipe and other material connected with pipe laying $75,000 00				
Transferred from surplus, 1882 65,000 00				
$140,000 00				
Transferred to refund twice paid water rents 2,072 97				
	$137,927 03			
DEFICIENCIES OF 1882.				
Coal $38 50				
Wood 16 00				
Repairs to meters 34 89				
Shop castings 172 45				
Brass castings 137 49				
		399 33		
Sealing wax		2 25		
Leather belting		9 28		
Steel castings		18 00		
Blasting powder		18 25		
Steam traps		22 50		
Drip pans		25 00		
Wood		30 40		
Wharfage		37 00		
Repairs to plane		44 05		
Sharpening tools		51 45		
Oil		52 60		
Amount carried forward		$710 11		

Detailed Expenditures of the Department for 1883.

General Appropriation.	Amount appropri'ted	Amount expended.	Balance merging.	Balance not merging
Item 19, continued.				
Amount brought forward		$710 11		
Repairs to hoist, tools, pump and tool-boxes		85 15		
Hydraulic jacks		106 00		
Repairs to meters		127 53		
Breeches pipe		138 36		
Water stops		144 48		
Rent of shop		150 00		
Repairs to lathe		213 63		
Malleable castings		213 92		
Coke		228 65		
Galvanizing		241 60		
Machine work		244 92		
Scales		251 00		
Lead pipe		255 09		
Brushes, brooms, &c		610 30		
Gum goods		647 24		
Grate bars		705 08		
Coal		1,051 86		
Pipe inspector (salary and traveling expenses)		1,279 28		
Bolts and nuts		1,443 52		
Wrought-iron tubing		1,697 81		
Hauling pipe		1,868 61		
Lumber		2,023 59		
Hardware		2,263 82		
Iron and steel		2,605 14		
Brass steam-fittings		4,353 15		
Brass castings		6,412 15		
Lead		9,317 60		
Shop castings		13,295 85		
Water meters		14,159 25		
Iron pipe		46,141 79		
		$112,986 48	87	$24,939 68
Item 20. Extension of works $65,000 00				
Transferred to Item 1, June 16....... $1,500 00				
Transferred to Item 21, June 16 .... 6,000 00				
Transferred to Item 15, June 27 ....39,000 00				
Transferred to Item 21, June 27 ....18,500 00				
65,000 00				
Item 21. Transferred from Item 20, June 16, for compensation of experts	$6,000 00			
BOARD OF EXPERTS.				
Frederick Graff,		2,000 00		
J. Vaughan Merrick		2,000 00		
E. S. Chesbrough		2,000 00		
		$6,000 00		
Transferred from Item 20, June 27, for contingent expenses	18,500 00			
Franklin reflector		17 82		

Detailed Expenditures of the Department for 1883.

General Appropriation.	Amount appropri'ted	Amount expended.	Balance merging.	Balance not merging
Item 21, continued.				
Amount brought forward......	$18,500 00	$17 82		
Iron railing........	....	21 64		
Hardware........	....	33 60		
Gum goods........	....	45 09		
Printing........	....	97 00		
Incidentals........	....	105 87		
Badges (inspectors and watchmen)	....	107 50		
Lumber........	....	294 68		
Iron safes........	....	354 25		
Analysis of water........	....	361 00		
Books (scientific)........	....	547 10		
Stationery (new registers)........	....	1,134 00		
Telephone line........	....	2,500 00		
Repairs to Wentz Farm reservoir (wages)........	....	4,456 35		
Services of extra clerk and inspectors, (re-inspection)........	....	8,422 28		
		$18,498 18	$1 82	
Special Appropriation.	**Balance**			
Item 21 of Appropriation for 1882.	**Jan. 1, 1883.**			
For the purchase and erection of two small engines, stand pipe, and boilers at Mt. Airy, and boilers at Roxborough........	2,822 24			
Hardware........	....	4 13		
Special castings........	....	33 88		
Wrought-iron tubing........	....	31 21		
Refunds.		69 22	....	$2,753 02
Special appropriations to refund certain twice-paid, over-paid, and paid-in-error water rent and pipe laying bills, Ordinance December 30, 1880...	185 75	5 75	....	180 00
Special appropriation to refund certain twice-paid, over-paid, and paid-in-error water rent and pipe laying bills, Ordinance June 16, 1881........	553 75	30 00	....	523 75
Special appropriation to refund certain twice-paid, over-paid, and paid-in-error water rent and pipe laying bills, Ordinance March 10, 1882......	146 20	29 95	....	116 25
Special appropriation to refund certain twice-paid, over-paid, and paid-in-error water rent and pipe laying bills, Ordinance December 11, 1882...	962 85	586 42	....	376 43
Special appropriation to refund certain twice-paid, over-paid, and paid-in-error water rent and pipe laying bills, Ordinance December 30, 1882.	401 38	227 10	....	174 28
Special appropriation to refund certain twice-paid, over-paid, and paid-in-error water rent and pipe laying bills........	Amount appropri'ted			
Transferred from Item 19. Ordinance November 12, 1883........	2,072 97	1,122 10	....	950 87

Detailed Expenditures of the Department for 1883.

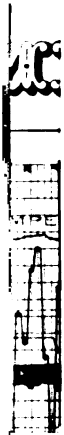
Special Appropriation.	Amount appropri'ted	Amount expended.	Balance merging.	Balance not merging
For the Extension of Works.				
Surplus 1880 and 1881.				
Appropriation June 21, 1882	$250,000 00			
Freight		$4 22		
Blue prints		4 50		
Hauling		18 00		
Use of crane		18 00		
Transportation		24 00		
Repairs to hoisting engine, pump and tools		30 42		
Wheelbarrows		48 00		
Desk and stools		37 50		
Maps		59 50		
Spars		60 00		
Leather belting		77 00		
Profile of railroads		79 92		
Services of carpenters		87 00		
Incidentals		90 84		
Gum goods		95 30		
Use of steam drill		96 50		
Use of derrick		99 50		
Towing		156 00		
Services of analyst		165 00		
" civil engineer		172 00		
" mechanical engineers		289 97		
" draughtsmen		220 25		
Cambria and Mt. Airy survey		275 20		
Use of lighter		240 00		
" hoisting engine		451 00		
Services of Architect		562 40		
Horizontal engine		560 00		
Cataract engine		732 79		
Surveying instruments		839 20		
Blasting powder		1,120 30		
Lumber		1,265 09		
Services of machinists and blacksmiths		1,221 75		
Services of caulker and laborers (48-inch main)		1,592 00		
Services of mechanics and laborers		3,023 19		
" surveying parties (future water supply)		3,404 41		
Coffer dams and conduits, at Kensington, Fairmount and Spring Garden		4,269 91		
Bricks, lime and cement		5,783 54		
Services of mechanics and laborers in cleaning forebays, and on engine foundations		7,538 68		
Excavation for engine-house, Spring Garden		12,747 91		
New engine for Roxborough		10,080 00		
New engines for Spring Garden		40,000 00		
		$97,640 79	....	$152,359 21
For the Extension of Works.				
Surplus 1882.				
Appropriation March 24, 1882 .... $210,000 00				
Transferred to Item 13..... $5,000 00				
Transferred to Item 15..... 9,000 00				
Transferred to Item 19..... 65,000 00 .... $79,000 00				
	131,000 00			

Detailed Expenditures of the Department for 1883.

Special Appropriation.	Amount appropri'ted	Amount expended.	Balance merging.	Balance not merging
Incidentals	....	$5 83		
Oakum	....	10 00		
Hauling engine	....	10 00		
Repairs to tools	....	14 80		
Testing boiler plates	....	16 45		
Canvas	....	27 00		
Use of hoisting engine	....	44 00		
Gum goods	....	66 00		
Pumps	....	75 10		
Apparatus for holding jars	....	80 00		
Jugs, grain, bags, &c	....	96 20		
Services of civil engineer	....	100 00		
Current meter	....	125 00		
Maps	....	164 00		
Services of laborers, Frankford reservoir	....	181 62		
Rain gauges	....	183 00		
Services of machinists and blacksmiths (shop)	....	248 50		
Surveying instruments	....	444 48		
Services of mechanics and laborers (works)	....	468 81		
Services of mechanical engineers	....	481 20		
Services of architect	....	600 00		
Blasting powder	....	608 68		
Hardware	....	687 15		
Cement	....	888 24		
Lumber	....	1,012 53		
Surveys, Cambria and Spring Garden	....	1,739 93		
Services of assistant engineers and draughtsmen	....	1,847 01		
Services of inspectors and clerks, re-inspection	....	1,932 75		
Services of caulkers and laborers (48-inch main)	....	2,228 74		
Coffer dams and conduits, Kensington, Fairmount, and Spring Garden	....	4,983 23		
Conduits, cleaning forebays, &c	....	5,552 27		
New engine, Frankford	....	10,000 00		
Surveys for future water supply	....	14,985 99		
New engine-house, Spring Garden	....	19,568 00		
		$69,476 51	....	$61,523 49
Loans.				
For the purpose of beginning the work of constructing the new Cambria basin; consolidated balances of loans.	Amount available.			
Appropriation, June 27, 1883	$2,994 39			
Services of surveying corps	....	2,613 69	....	380 70

Detailed Expenditures of the Department for 1883.

RECAPITULATION.			
Annual appropriation for maintenance	....	$611,292 00	
Transferred from surplus for maintenance	....	79,000 00	
		$690,292 00	
Transferred to Highway Department	$3,000 00		
Transferred to twice-paid water rents	2,072 97		
		5,072 97	
			$685,219 03
Expended from annual appropriation for maintenance	$601,744 12		
Expended from surplus for maintenance	53,951 54		
		$655,695 66	
Balance merging December 31, 1883	$4,474 83		
Balance not merging	25,048 54		
		29,523 37	
			$685,219 03
Special appropriation available,	....	....	$391,139 53
EXPENDED FROM SPECIAL APPROPRIATIONS.			
Engines at Mt. Airy	$69 22		
Refunds—twice-paid water rents	2,001 32		
Extension of works, surplus of 1880 and 1881	97,640 79		
Extension of works, surplus of 1882	69,476 51		
Cambria basin, loans	2,613 69		
		$171,801 53	
BALANCES NOT MERGING.			
Engines, &c., at Mt. Airy	$2,753 02		
Refunds—twice-paid water rents	2,321 58		
Extensions of works, surplus of 1880 and 1881	152,359 21		
Extensions of works, surplus of 1882	61,523 49		
Cambria basin, loans	380 70		
		$219,338 00	
			$391,139 53
Expended for maintenance	....	$655,695 66	
" " extensions and refunds	....	171,801 53	
			$827,497 19



REPORT

BY THE

GENERAL SUPERINTENDENT

OF THE

OPERATIONS IN CONNECTION WITH THE STATIONS, BUILDINGS, GROUNDS, AND RESERVOIRS,

DURING 1883.

PHILADELPHIA WATER DEPARTMENT.

OFFICE OF THE GENERAL SUPERINTENDENT.

March 17, 1884.

COL. WILLIAM LUDLOW,
Chief Engineer:

SIR:—I submit, herewith, the Report of the work on the Buildings, Grounds, and Reservoirs, and the Pumping Machinery of the Department for the year 1883.

In pursuance of your appointment, I entered upon my duties as General Superintendent on the first day of May; and I do not need to recall to you the condition of the machinery, and of the Buildings and Grounds, at that time. The needed repairs and alterations were begun at once, under your direction, and continued to the end of the year, with the disadvantage of being compelled to consider first, the necessity for keeping up the supply of water at all hazards, and to make improvements as opportunity and the necessities of the case permitted. At the present time, I may say that all the Stations are in a fairly good condition, although the erection of new Boilers and Engines at some of them, postpones, for the present, the completion of needed repairs and improvements.

Before the end of the present year I expect them to be in as good condition as their general construction will allow.

The introduction of telephonic communication between the stations, reservoirs and main office, in July 1883, has greatly facilitated the work of the Department, and shown itself to be both an economy and a great convenience.

The attachment of improved lubricators to most of the engines has largely reduced the consumption of oil, and the use of tallow and other inferior kinds of lubricants has been entirely dispensed with.

Indicator Attachments have been made to all the engines in the Department, and cards taken, as nearly as possible at regular intervals, to determine the working of engines and pumps.

The coal scales, which at all the Stations were either broken or out of adjustment, were thoroughly repaired.

It affords me pleasure to say, that, as a rule, all the employés at the Stations and connected with the work under my supervision, are endeavoring to serve the Department to the best of their ability.

Respectfully,

J. J. de KINDER,

General Superintendent.

FAIRMOUNT STATION.

Buildings and Grounds.

The Asphaltum Covering on the roof over Nos. 7, 8, and 9 Turbine Wheels was in a very bad condition. It has been removed, and replaced by a Granolithic Pavement.

The roof over the rest of the wheel-house, namely, over Nos. 1, 3, 4, and 5 Turbine Wheels, and which had a brick surface, has been covered with a Neufchatel Pavement.

The public Water Closets were in a filthy condition. The room has been completely cleared out, and new water closets and plumbing substituted for the old. The iron and wood work were painted, and the closets put in a good condition. They are kept closed during the winter months, and opened for the use of the public from the first of May until the first of November, from 10 A. M. until 8 P. M., during which time a Janitor preserves order and cleanliness. Repairs were also made to the flash-boards on the dam, to the floors and the steps in the wheel-houses, and the cellars of the Mansion house. The office was put in thorough repair. The pavilions, the railings, and mains across the forebay were painted. The wooden gates at the archways of the bridge crossing the forebay were decayed, and incapable of being used, and the gear for raising them was rusted fast from want of attention. All this was removed, and a timber bulk-head was built on the north side and against the bridge, crossing over its entire length, preparatory to draining the forebay on the south side of the bridge for the purpose of cleaning the mud from the same, and removing the decayed wooden bulk-heads across the archways of the old Nos. 2 and 6 breast-wheels, for which will be substituted gun-metal faced wrought-iron gates, which will enable us, when water runs to waste over the dam, to run a large volume of water through these arches, creating a strong current in the forebay, thereby removing the deposits which necessarily settle in the forebay during the summer months, when the river is low, and the wheels are not in constant use.

The old boiler has been removed from the old Worthington Engine house near the forebay, and the house repaired and painted, and fitted up for use as a carpenter shop. On the north side of the forebay, the grounds are covered with old coal bins, etc. If this unsightly pile were removed, the grounds could be neatly sodded.

The Mansion house at present presents an uninviting appearance for want of cleaning and general repairs, such as plastering of walls, new window sashes, door frames and doors, and a coat of paint. The Ladies' Toilet room, also, requires a renewal of every part.

The joists and supports of the floors in the wheel houses, and parts of the floors, are totally decayed; and the railings of the galleries are, also, in bad condition.

As soon as possible, steps should be taken to thoroughly overhaul all the above mentioned defects, and put the property in good condition.

Machinery.

Seven Turbine Wheels:—

No. 1. Erected in 1851; capacity per revolution, 122 gallons, or 2,000,000 gallons per day.

Nos. 3, 4, and 5. Erected in 1867; capacity of each per revolution, 461 gallons, or 6,000,000 gallons per day.

Nos. 7, 8, and 9. Erected in 1862; capacity of each per revolution, 325 gallons, or 4,500,000 gallons per day.

The old No. 2 Breast-wheel and pumps were removed, and the surface which carried the foundation of the pump was covered with Granolithic Pavement. The openings in the side walls of the archway through which the shaft journals of the wheel projected were bricked up. The hot water heater in the north wheel house was worn out; it has been removed and

188		Total pumpage in each month.	Average pumpage per day.	TALLOW.	OIL.	
					Castor.	Lubricating.
	No. 9.	Gallons.	Gallons.	Lbs.	Quarts.	
January	85,171,450	718,578,597	23,179,954	10	17	84
February	126,906,325	935,259,424	33,402,122	......	10	144
March	113,758,125	1,063,063,033	34,292,356	......	7	162
April	137,215,000	1,066,763,245	35,558,774	......	6	191
May	163,812,350	1,076,726,856	34,733,122	......	12	112
June	95,964,700	774,570,250	25,819,008	......	32	128
July	129,864,476	860,814,742	27,768,217	......	44	104
August	22,499,100	487,995,611	15,741,793	......	28	112
September	9,756,500	377,501,837	12,583 394	......	2	72
October	75,260,575	775,218,673	25,007,053	10	4	102
November	139,657,050	808,356,291	26,945,209	......	8	131
December	111,281,300	812,248,170	26,201,554	......	4	114
Totals and	1,211,146,950	9,757,096,729	26,704,374	20	174	1,446

hours running.
94
91
13
14
38
13
55
94
40
27
00
63
82
14 %

replaced by a small steam boiler detached from one of the three old portable hoisting engines owned by the Department.

Minor repairs were made to the several wheels, but they all require thorough overhauling, the journals in several instances being badly worn. The tail-race of each Turbine should be deepened, to insure a smoother egress of the water from the wheels, and improve their efficiency.

SPRING GARDEN STATION.

Buildings and Grounds.

The roofs of the different boiler houses were in a dilapidated condition, affording neither protection against the rain nor means of escape for the heated gases, and not admitting sufficient light. They were removed and new roofs substituted, raised twelve feet higher than the old ones, provided with large sashes, worked simultaneously on pivoted bars. The roofs are of wood, covered with felt and tin. Part of the front wall of the northwest boiler room was removed and rebuilt, and furnished with three large windows to correspond with the remaining front of the building. The old mortar with which the walls on the west side of the building were dashed, was removed, and the joints of the stone work square-pointed in Portland cement. The iron cornices of the smoke stack were repaired, also the shed in front of the west side of the building. All boiler and engine room doors and door frames were repaired or renewed. On the south side of the building (in front of No. 8 engine house), where each successive rain washed the mud from the roadway into the engine room, an inclosed and paved area was constructed, with retaining wall sufficiently high to prevent a recurrence of this difficulty.

A workshop, store room, and quarters for the men—the latter provided with closets and bath-room—were built; also, a privy vault with cemented tank. The coal sheds were repaired sufficiently to last through the year. They require renewing entirely. The coal siding was entirely renewed with 12″ by 12″ yellow pine stringers, oak ties and 60-pound steel rails. The steps leading to the coal siding were repaired and partly renewed. The gas distribution pipe and fixtures, which leaked badly, were repaired and renewed where necessary. The open space on the east side of the buildings was repaved. The buildings were painted, inside and out, with the exception of No. 7 engine room. The boiler rooms were whitewashed.

A wooden conduit, six feet square and 440 feet long, was constructed in the forebay, carried on timber supports, and connecting the conduit at the lower end of the forebay, with the conduit at the upper end leading to the pumping wells of Nos. 6 and 7 engines.

The forebay was pumped and kept dry by means of an 8-inch cataract centrifugal pump, and the work of removing the mud, which had an average depth of three and a half feet over the entire surface of the bottom of the forebay, was commenced.

A coffer dam was constructed in the river preparatory to the construction of a new conduit to connect the forebay with the river.

A temporary wooden bridge was built across the centre of the forebay to facilitate moving the material required in the construction of the new pumping station.

The stone coping of the forebay walls was removed in advance of raising said walls sixteen inches, to prevent the earth from the surrounding roadway being washed into the forebay during heavy rains.

The walls between the southwest boiler room and the adjoining engine houses, are built up of stone, brick, and pieces of wood. The wood has decayed, causing the walls to crumble. It will be necessary to take at least part of this wall down and rebuild it. The engine-room floors need renewal. The engineers' dwellings on the hill are greatly in need of repair.

Machinery.

Five Engines:—

No. 4.—Overhead Cornish; erected in 1854. Capacity, 350 gallons per revolution, or 5,000,000 gallons per day. Lift, 120 feet. Duty, 23,000,000.

The bed-plate was repaired and slight repairs were made to the valve motion gear.

From the arrangement of the Distribution Mains, No. 4 and No. 5 engines cannot be worked at the same time. On account of the low duty of No. 4, it has only been used when No. 5 was undergoing repairs, when the combined efforts of the other engines were insufficient. This engine is very extravagant in the use of fuel.

No. 5.—Side-lever Cornish; erected in 1869. Capacity, 510 gallons per revolution, or 6,500,000 gallons per day. Lift, 120 feet. Duty, 29,000,000.

The foundation of the pump was repaired and the timber supports and bumpers renewed. It was used only when Nos. 6, 7, and 8 combined were insufficient. This engine, like No. 4, is extravagant in the use of fuel, and from its peculiar construction cannot be relied upon for steady work.

No. 6.—Simpson Compound; erected in 1872. Capacity, 500 gallons per revolution, or 8,000,000 gallons per day. Lift, 120 feet. Duty, 38,500,000.

The joints of the high-pressure cylinder leak badly, due to the corrosive effect of the acid contained in the tallow which has apparently been used in large quantities for lubricating purposes. As soon as the opportunity offers, the cylinder should be taken apart and put in good order. Being third on the list in ratio of duty, No. 6 is only used when Nos. 7 and 8 combined are insufficient.

No. 7.—Rotative Compound, Cramp & Sons; erected in 1877. Capacity, 830 gallons per revolution, or 22,000,000 gallons per day. Lift, 202 feet. Duty, 58,000,000.

This engine, which, up to the 26th of May, had pumped into the Spring Garden Basin only (120 feet lift), was on that date put on the direct distribution. No examination of the engine had been made, nor any overhauling done since it was erected in 1877; consequently it was badly worn. Its slide-valves had dropped 7-16 of an inch, causing it to work very irregularly—each side in turn, at each revolution, besides driving its own pump, having to apply power to the pump of the other side for part of the stroke, until the 7-16 inch drop of the slide-valve had been raised. In the early part of October one housing of each cylinder was found to be cracked, and from the large quantity of solidified black oil found inside and at the base of the housings, it is safe to say that the cracks named must date back to a period shortly after the engine was erected. At present this engine, although having a 48-inch outlet, pumps through 800 lineal feet of 30-inch main before reaching another 48-inch. Needless to say, this entails an undue strain which should be removed as soon as possible by substituting a 48-inch main for the 30-inch.

Temporary repairs were made to the broken housings without stopping the engine except at night, when its services were not required, as the diminished consumption of water from 10 P. M. to 5 A. M. enabled No. 8 to keep up the supply. New housings of heavier weight were made by William Cramp & Sons, Ship and Engine Building Company, and put in place by us during the month of December. The slide valves were re-adjusted, the high-pressure piston examined, the follower turned down, and connecting-rod brasses and main bearings refitted. The valve spindles of both pumps were fitted with lock nuts, and stronger springs of a different pattern substituted for the old ones, which were too light. Hard rubber stops were placed over the pump valves to reduce their lift, which was nearly twice as much as was necessary.

Three-inch charge-pipes were attached to the pumps, a four-inch pass-over around the 48-inch stop, and a six inch draw-off valve to the air chamber; all steam stuffing boxes were packed with metallic packing. The air-pumps were re-packed and a three-inch force injection-pipe carried to the top end of the exhaust outlet to insure prompt starting, and all steam joints remade. The engine was started again on the distribution on the 31st of December, working very smoothly and easily. With a continuous 48-inch pumping main in place of the present 30-inch it will pump with ease 22,000,000 gallons per day on a 202 feet lift, with 60 lbs. of steam pressure.

As soon as the new pumping station is ready for work, and its services can be dispensed with for a few days, the valve motion gear, which the limited time prevented from being attended to, will also be re-adjusted, and its low pressure piston overhauled; it will then be in perfect condition.

Being highest in ratio of duty compared with the other engines, this is used in preference to the others.

No. 8.—Compound Duplex, Worthington; erected in 1881. Capacity, 560 gallons per revolution, or eleven million to ten million gallons per day. Lift, 120 to 202 feet. Duty, 45,000,000.

A connection was made from this engine to the pumping main of No. 5 in the early part of the summer, enabling it to pump into the Spring Garden reservoir. This was done because it had not sufficient pumping capacity alone to supply the Fourth District pumpage as No. 7 has. The pumping main to the Fourth District not being large enough to take the supply of both Nos. 7 and 8 Engines at once, No. 8, without this connection, was forced to lie idle with No. 7 working, whereas now it can be kept at work supplying the Spring Garden reservoir.

Since the erection of this engine, but very little attention has been paid to the light wearing parts. The air pump connections were very badly worn. All four of the air pump plungers were down over half an inch, and on account of the small amount of clearance at the bottom stroke, the rock shafts, which were of cast iron, were broken. Wrought iron ones have been substituted, and the air pump connecting rods shortened, to give more clearance at the bottom end of stroke, and new wrist-pins have been put in. The valve spindles of both pumps and the springs have been renewed, and the steam stuffing-boxes packed with metallic packing. The engine now works well, but the low-pressure pistons will require overhauling when opportunity offers.

The duties stated are expressed in foot-pounds per 100 lbs. of coal, and do not represent the true efficiency of the Engines, although they do represent approximately the comparative efficiency. The actual duty is diminished by the lack of efficiency of the boilers, which were badly arranged for obtaining good results. The feed-water entered at a temperature varying from 90° to 100°, the water-level being carried at least 12 inches too high. Nearly every steam pipe joint, safety-valve, and stop-valve stuffing-box was leaking. I am now engaged, in accordance with your instructions, in re-arranging the whole boiler plant, and with clean boilers, plenty of steam room, insuring dry steam, and feed-water heated to not less than 150°, and with joints and stuffing-boxes tight, I am confident that the Engines in 1884, after the overhauling now in progress, will show to much greater advantage. As the season of large pumpage began in May, and required the constant use of all the boilers, it was necessary to do the best we could until November, when the diminished demand for water, requiring fewer boilers to be used, enabled me to commence overhauling.

The screens over the conduits in the forebay were so poorly constructed and broken, some of them being made of thin wooden slats, that during the Summer months we have had to shut down either No. 7 or No. 8 Engine as often as three times a week to clear the pumps of débris, consisting of barrel bungs from the adjacent breweries, pieces of wood, tin cans, etc. The larger pieces must have been carried into the pump wells, from time to time, whenever a freshet overflowed the cellar floor, because the absence of a proper store room led to the habit of storing articles in cellar ways, etc. The débris caused breakage of valve springs and spindles, and a loss of pumpage each time that an engine was stopped for two or three hours, at a time when it was most needed. Galvanized iron screens are being constructed inside the buildings over the pump wells, and substantial double iron screens in front of the conduits in the forebay.

Boilers.

Twenty-one Boilers :—

Nos. 1, 2, 3, 4, 5, and 6, are cylinder boilers, erected in 1869.

Nos. 7, 8, 9, 10, and 11 are tubular boilers, erected in 1870.

Nos. 12 to 21, inclusive, are tubular boilers, erected in 1881.

Nos. 7 to 11, inclusive, were cleaned, the furnaces repaired, and two new sheets put in No. 7. Tubes were overhauled, and new ones put in where necessary. New grate bars, Tupper pattern, are to be put in all the furnaces.

Nos. 1 to 6, inclusive, are being cleaned.

As soon as possible, Nos. 12 to 21, inclusive, will be shut down to be cleaned and have the furnaces repaired.

The safety valves are all in bad condition. They are old style, with iron bodies, and having brass seats are difficult to keep tight. They should be replaced with pop safety valves, or valves of similar construction. The water level in the tubular boilers, namely, Nos. 12 to 21, inclusive, is carried unnecessarily high. The feed water supplied to all the boilers, drawn from the hot wells without any additional heating, enters at a temperature of about 100°. There is no means of blowing off from the surface—the only means by which to remove deposits by blowing being from the bottom, which, needless to say, is of hardly any use with the pressure at 60 pounds.

The valves and checks of Nos. 7 to 11, inclusive, are placed at the back of the boilers where no one can see them. They are worked by means of long rods with wheels projecting beyond the boiler fronts. These rods, passing through the boilers, become red hot, and are apt to twist, and, as experience has proved, will break off, leaving the firemen unconscious of the position the valve is really in.

The whole of this arrangement should be altered as soon as possible:—In the first place, lowering the water level in the steam domes; secondly, heating the feed water by carrying it through at least 80 square feet of pipe surface per boiler, exposed to the heated gases between the boiler and the steam dome before entering the boiler; thirdly, by fitting to each boiler a two-inch surface blow-off pipe, in order to enable us to blow off from the surface, say two or three inches at least, twice on each watch. Needless to say, when this is properly attended to, the boilers will be kept more nearly free from scale and will make steam much more economically.

The dampers require renewing and should be fitted with automatic regulators. There are at present two of the latter in place, but from want of proper attention they became useless long ago. The steam pipes at this and other stations are built of wrought iron, with riveted joints, and the continued drying and wetting process which necessarily takes place in these pipes in proportion as they are in and out of use, causes a thin scale to form on the inside, which, becoming loose, is carried over to the engine, cutting the valve faces and cylinders. They should be made of copper, or at least of cast iron. The steam pipes are also insufficiently provided with expansion joints, making it difficult to keep the joints tight. The steam pipe to No. 7 Engine was supplied with a curved copper pipe, which gives perfect satisfaction. The exhaust pipes from the Donkey Engines have been led into the drain pipe of the buildings. They formerly exhausted above the roof, and the escaping steam and grease, mingled with the dust from the

Coal.		Percentage of Ash.	Oil.		Tallow.	Mean Water Pressure on Engines.					Gallons raised 100 feet per pound of coal.
			Cylinder.	Lubricating.							
Tons.	Lbs.		Quarts.		Lbs.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	
933	268	12	....	564	319	No record found.					
629	419	12	....	328	10						
628	1,075	12	....	310	6						
590	393	13	....	351	....						
723	1,417	12	426	140	....	42	......	36	64	75	480
1,123	2,166	16	566	326	....	......	42	41	56	80	499
1,014	460	10	302	153	....	......	40	41	71	83	645
1,448	1,471	13	490	298	....	40	40	57	60	63	485
1,308	530	21	377	197	....	40	40	44	53	48	416
1,093	921	20	312	113	....	......	......	44	69	68	463
824	1,888	22	168	66	....	......	......	......	72	70	474
749	1,921	13	167	73	....	......	......	42	......	65	376
11,067	1,729	15	2,718	2,920	335	41	40	43	63	69	480

boiler rooms, formed a thick coating on the windows, obscuring the light.

The coal tracks in the boiler rooms require altering and repairing; they should be laid on top of the floor. At present the cars are thrown off the tracks on dark nights when pieces of coal drop between the tracks and are not seen in time to be removed from in front of the wheels. The coal trucks should be altered. The wheels should be stationary on the axles, and not loose, as at present, and the axles should work in boxes. The tracks should have turn-tables, and not curves, with a slight incline towards the boiler room, to enable one man to bring a loaded car in, whereas now it requires one-half the watch.

The boiler-room drains, which are now carried into the forebay close to the inlet to the pumps, should be carried into the sewer.

BELMONT.

Buildings and Grounds.

The engine-room floors and galleries, and the joists and posts supporting them, were entirely decayed. The roof afforded no means of escape for the heat, which, during the Summer months, was unbearable. Heavy stores, such as lubricating oils, were kept in the cellar, where high freshets caused them to float around. The engines were almost devoid of lagging, the railings of the galleries were loose and decayed, numerous panes of the engine-room windows were broken; in fact, the appearance of the interior of the building was one of ruin and destruction. The centre portion of the roof was removed, and a skylight constructed, seven feet high, 19 feet wide, and 48 feet in length. It is built with skeleton stanchions, the sides presenting a continuous row of large sashes, pivoted on centre bars, and worked by means of levers and cords from the floor of the engine house. This structure affords both light and ventilation, the temperature on the floor of the engine room being thereby reduced some 20 degrees. The floors and galleries were entirely renewed, the old wooden railings removed and replaced by iron pipe railings. The office was put in thorough repair, and a vestibule made, dividing the engine room from the boiler room, to prevent the ashes, when cleaning fires, being carried over and deposited upon the machinery. All window sashes were repaired, and a store room, quarters for the men, with closets and bath room, and a detached privy constructed.

The roof over the boiler house, and over that part of the engine house not covered by the skylight, and the gutters and rainspouts, were put in good condition. Repairs were also made to all the boiler-room doors and door posts. An oil cellar was constructed outside the building in the adjoining bank. The covers of the several stops outside the building were renewed. The drains from the buildings were overhauled and altered. The buildings were painted outside, and the engine room inside, and the boiler room, and cellars under the galleries of the engine room, whitewashed. The old Belmont Mansion, which stood south of the engine house, was removed, and the grounds cleared and leveled.

The railroad trestle of the coal siding crossing the ravine was entirely renewed, and work commenced upon the erection of a shed to cover the coal bins. There is, at present, no shelter of any kind over the coal, compelling the men in wet and freezing weather to quarry the coal.

MACHINERY.

Three Engines:—

No. 1.—Duplex Compound, Worthington; erected in 1870. Capacity, 300 gallons per revolution, or 5,000,000 gallons per day. Lift, 216 feet. Duty, 43,000,000.

No. 2.—Duplex Compound, Worthington; erected in 1871. Capacity, 312 gallons per revolution, or 5,000,000 gallons per day. Lift, 216 feet. Duty, 47,000,000.

No. 3.—Duplex Compound, Worthington; erected in 1873. Capacity, 485 gallons per revolution, or 8,000,000 gallons per day. Lift, 216 feet. Duty, 44,000,000.

These duties, as stated in connection with the engines at Spring Garden, are approximate only, owing to the indifferent condition of the boilers.

Nos. 1 and 3 Engines received a temporary overhauling; some new valves and spindles were replaced in the pumps, one and a-half charge pipes fitted to the pumps, and steam stuffing boxes packed with metallic packing.

In No. 2 Engine, both the low-pressure cylinders were re-bored, the right-hand low-pressure piston removed and a new one substituted, the steam chest and valves refaced, new stud springs and valves supplied to the air pumps, a general over-hauling made of all moving parts, and the steam stuffing-boxes packed with metallic packing.

A new low-pressure cylinder and piston, made by Henry Worthington, of New York, were supplied, and are kept at the station on storage, for use if required. On account of the excessive use of the inferior grades of tallow in previous years, all the engines in the Department in fact, but in particular those of the Belmont Station, have suffered materially from the corrosive effect of the acid. Parts of the cylinders and valve faces are pitted like sponge. As soon as convenient, the No. 1 and No. 3 Engines will be examined and further overhauled. The old lagging, or rather what was left of it, has been removed from all three of the engines, and the engines covered with Hanmore's Patent Covering and lagged with walnut.

The 36-inch pumping main crossing the Schuylkill river, which was found to have been parted in one of the joints, was repaired in the Spring. It was found that a hole had been scoured in the bottom of the river immediately under the defective joint, which took some 230 tons of slag and stone to refill. The main was lifted for a distance of some 50 feet on either side of the defective joint, and willow mattresses were sunk under that part of the main to prevent future scouring. The interior face of the bell part of the joint being badly rusted, it was found impossible to force the joint back into position; moreover, the lead of the joint was cut into ridges, and the bell end of the pipe found to be broken back for a distance of 38 inches. By means of light dynamite charges the defective bell joint was entirely removed. The separated ends of the main were then brought into a straight line, and a wrought iron sleeve, in two parts, was used in connecting them. This work was completed in June, and tested with the Belmont head, 212 feet elevation, and gave no sign of leakage. In July, seven of the 7-8 inch iron bolts, connecting the two halves of the sleeve, broke, and were replaced by steel bolts, which also gave way shortly afterwards. New bolts were then put in, and the space between the bolts strengthened with heavy iron clamps. It proved in the end that although the sleeve had ample strength to resist the steady pressure due to the Belmont head, it could not successfully cope with the enormous blows to which it was subjected whenever the Cramp Engine was at work on the distribution to the Fourth District—the thuds being caused, apparently, by the water not being able to free itself through the contracted 30-inch main in front of No. 7.

Nos. 2 and 3 Engines at Belmont Station connect with the submerged main, but in such a way that the water is pumped up hill for a short distance before being permitted to descend, apparently creating an irregular air cushion at a point above the breeches, subjecting the sleeve to a continuous series of thuds, best compared to hammer blows.

In the early part of December the sleeve gave way in the old place, with the Belmont Engines working. It was shut off, and the Fourth District has since then been supplied from the Spring Garden Station without any loss of pressure, due to the fact of the ability of the Cramp Engine to supply nearly double as much water as Belmont.

During the dry Summer months the main was a great assistance for keeping up the supply in the Fourth District whenever the Cramp Engine was shut down for cleaning out the pump.

Electric Lights.

An Electric Light Plant, supplied by the Edison Electric Company, consisting of Engine and Dynamo furnishing power for sixty lights, distributed through the premises, was placed in the northwest corner of the Engine House, the cost and maintenance of which is as follows:

Cost of Plant	$2,645 00
Foundation, steam pipes, &c	167 53
	$2,812 53

Running expenses for one year:

For 150 lamps	$150 00
Plugs, repairs, &c	27 00
Interest on Plant (.06 per cent.), depreciation (.06 per cent.)	337 50
One quart of oil per day, at 18c	65 70
Cost of coal (pea, at $2.89 per ton)	187 85
	$768 05

Boilers.

Fifteen Boilers:—

Nos. 1 to 8, inclusive, are cylinder boilers, erected in 1870.

Nos. 9 to 15, inclusive, are tubular boilers, erected in 1881.

The furnaces of Nos. 1 to 8, inclusive, were renewed, the stop and safety valves overhauled, and all steam-pipe joints remade.

The tubular boilers, as is the case with the tubular boilers at Spring Garden Station, carry the water unnecessarily high, thereby contracting the steam-room, and furnishing saturated steam to the engines. We are now making preparations to supply these boilers with surface blow-offs, and arranging the water columns to suit a lower water-level.

The water for the boilers at this station contains a large amount of lime, causing scale to form rapidly. Means will be taken to utilize the spring water from the adjacent run, an analysis of which proved it to contain much less lime. The use of this water will prevent, in a large measure, the formation of scale. The furnaces of Nos. 9 to 12, inclusive, were fitted with Tupper grate bars for pea coal. During the months of November and December tests were made of several kinds of coal, with a view of determining the relative cost of consumption of each kind, for comparison with the egg coal which has hitherto been used by the Department. The results of the tests will be found in the accompanying table.

The same remarks in regard to the coal tracks into the boiler room and coal cars, made in the report of the Spring Garden Station, are applicable to Belmont Station.

The furnaces and division walls of the tubular boilers are in a bad condition, especially the walls, which appear to be constructed without headers. As soon as possible, this work will be thoroughly overhauled.

ROXBOROUGH.

Buildings and Grounds.

The engineer's dwelling house was repaired and painted.

The roofs, gutters and waterspout of the engine house and boiler house were repaired.

The coal bin and the roof over the same were repaired, new platform scales were put in, and a house built over the scales.

The coal tracks into the boiler house were renewed, and an iron platform built on a level with the boiler room floor, projecting from the west side of the building, for dumping ashes. The stop houses were renewed, a workshop was built in the Cornish engine room, amd a platform on cast-iron brackets constructed against the wall immediately under the steam pipes in the engine room.

·GG, AND SOFT COAL.

[D]IRECTION OF

·ER DEPARTMENT.

Test.	Date, 1883–1884.	...lbs pounds of coal.	Pumpage in foot pounds per 1c.-worth of coal.	Gallons raised 1 foot high per 1c.-worth of coal.	Percentage of gallons 1 foot high more than egg coal—dollar for dollar.	Colliery, character of coal, etc.
A	Nov. 19–[illegible]	[illegible],000	3,280,032	393,289	35.8	Hard Pea, Ellengowen Colliery, Schuylkill Co., Pa.
B	Dec. 6–[illegible]	[illegible],000	2,415,444	289,622	00.0	Hard Egg, Ellengowen Colliery, Schuylkill Co., Pa.
C	Dec. 11–[illegible]	[illegible],000	3,059,217	366,812	26.6	Soft Coal, Colorado Colliery, Clearfield District, Pa.
D	Jan. 17–[illegible]	[illegible],000	3,609,261	432,606	49.4	Dusty Pea Coal, Cameron Colliery, Pa.

11, and 12, each as follows:

.... 6 feet.
.... 12 "
.... 39 square feet.
11, tubes, and drums, 1,371 "
.... 331 cubic feet.
.... 111 "

The entire coal siding, which had become dangerous from decay, was renewed, and the station supplied with gas by a Springfield gas machine, found stored away in the old Belmont Mansion, adjoining the Belmont pumping station. The grounds surrounding the engine and boiler houses were cleaned of débris, part of which consisted of over eleven hundred cart-loads of ashes, banked up between the tow path and the buildings.

Part of the floor of the north engine room was renewed, and the rock underneath sufficiently removed by blasting to receive the foundation for the new pumping engine now in course of construction. The cap-log of the wharf on the river front is decayed, and should be renewed.

MACHINERY.

Two Engines:—

No. 1.—Cornish Overhead Beam, Birkinbine; erected in 1869. Capacity, 159 gallons per revolution, or 2,250,000 gallons per day. Lift 346 feet.

This Engine worked but a few hours during the entire year, not long enough to determine any duty. It is in fair condition, but when working requires constant watching and care.

No. 2.—Duplex Compound, Worthington; erected in 1872. Capacity, 295 gallons per revolution, or 5,000,000 gallons per day. Lift, 346 feet. Duty, 47,000,000.

This engine was worked almost continuously, affording no opportunity for a general overhauling.

New valves, spindles and springs were fitted in the pumps, the steam stuffing-boxes packed with metallic packing, and light repairs made.

As soon as the new engine, now building, is in operation No. 2 will have to be examined, both low pressure pistons being down.

Boilers.

Eleven Boilers:—

Nos. 1 to 8, inclusive, cylinder boilers, erected in 1867.

Nos. 9 to 11, inclusive, tubular boilers, erected in 1882.

The furnaces of the cylinder boilers were repaired, and partly renewed. The brick walls of the tubular boilers were rebuilt.

Two old tubular boilers, built in 1873, were condemned, and removed in September.

Two marine tubular boilers, built in 1877 for the Frankford Station, were removed from there in November, and erected in this station. As soon as possible, they will be made ready for use. The cylinder boilers were condemned by the City Boiler Inspector as unfit for use two years ago. They should be removed, and the other two boilers at present in use at Frankford Station put in their place, as soon as the new steel boilers now in course of construction for the Frankford Station are ready for steam. As soon as the opportunity offers, the steam-pipe joints and connections will be overhauled. I wish to invite your attention to the fact that the bolts of the steam-pipe flanges in nearly every instance are pitched entirely too far apart, making it unduly difficult to maintain tight joints with the ordinary means of packing.

ROXBOROUGH AUXILIARY STATION.

Buildings and Grounds.

No repairs have been made at this station. The fences were whitewashed and the grounds kept in trim. Repairs are necessary to the standpipe, from the stonework of which a large part of the plaster has disappeared. The engine and boiler house require repairing, painting, and glazing.

1	...
	...cat- ...nd ...der.
	...ts.
January	
Februar	
March..	4
April....	4
May.....	2
June.....	
July	
August	2
Septem	2
October	2
Novem	4
Decem	4
Totals:	

MACHINERY.

Two Engines:—

No. 1.—Knowles Pump, H. P.; erected in 1876. Capacity, 380,000 gallons in 24 hours. Lift, 80 feet.

No. 2.—Knowles Pump, H. P.; erected in 1876. Capacity, 90,000 gallons in 24 hours. Lift, 80 feet.

Both engines are in good condition. They are used but once or twice a week for a short time, and consequently are subjected to but little wear and tear.

BOILERS.

One Boiler:—

Erected 1876. New tube sheets and new tubes were put in.

During the time in which these repairs were being made, steam to the engines was furnished from a portable boiler detached from one of the hoisting engines owned by the Department.

MOUNT AIRY STATION.

BUILDINGS AND GROUNDS.

A wooden floor was built in the coal shed, and the roof and water-spouts of the engine house repaired.

MACHINERY.

Two Double-acting fly-wheel Engines, built by W. E. Worthen; erected in 1882. Capacity, 125 gallons per revolution, or 1,000,000 gallons per day. Lift, 125 feet.

These engines have not been finally accepted by the Department, on account of not yet answering the requirements of the contract. They were designed to work with an independent air-pump. The injection water is supplied by pumpage from the Roxborough Station, and the engines are below the water level in the adjacent reservoir. By this arrangement the injection water is wasted, and is forced to run across the roadway, making it a mud stream in Summer, and an ice pond in Winter. To prevent this, there is at present no alternative but to work them as high-pressure engines, necessarily reducing the duty considerably below the requirements of the contract. They should have been placed above the water level of the reservoir. The only means left under the circumstances to overcome this trouble, will be to furnish the engines with a surface condenser, the circulating water to be furnished by the supply main to Germantown and Mount Airy, of which main the surface condenser would form a part.

A new donkey engine was placed in the engine room for supplying the boilers, taking the place of one which was put up when the station was erected, but which had already become considerably worn, having been obtained from another station. The engines were started up for the first time for regular service to Mount Airy in the latter part of last May. Screen boxes with screens were constructed in the supply main to the pumps.

BOILERS.

Three Boilers:—

Tubular, erected in 1882. They are in good condition.

Nos. 1 and 2 have both been cleaned and No. 3 will be cleaned shortly. Means will also be taken to considerably raise the temperature of the feed-water before it enters the boilers.

CHESTNUT HILL STATION.

BUILDINGS AND GROUNDS.

The engineer's dwelling and the engine house were painted and the sashes repaired, and the inside of the boiler house whitewashed. There is no coal shed at this station and I recommend that one be built, capable of holding about 250 tons. The coal consumption at this station is very small, but in the absence of any railroad facilities at Mt. Airy the coal required at that station is furnished from Chestnut Hill, being hauled in carts.

MACHINERY.

Two Engines.:—

No. 1.—Horizontal; erected 1866. Capacity, 17.5 gallons per revolution, or 500,000 gallons per day. Lift, 125 feet.

No. 2.—Knowles Pump; erected 1876. Capacity, 50 gallons per revolution or 1,000,000 gallons per day.

No. 2 has had a general overhauling and both pumps are in good condition.

BOILERS.

Two cylinder boilers, erected in 1866.

One tubular boiler, erected in 1881.

The cylinder boilers are nearly worn out and are hardly worth overhauling.

No. 3 is in very good condition.

The work at this station is light. The engines are worked off and on, but an hour or two at a time, and very little pumping is done at night.

FRANKFORD STATION.

BUILDINGS AND GROUNDS.

The wharf along the river front, which was much decayed, was entirely rebuilt from low water mark up. Stop houses were built of brick. The coal bin was repaired sufficiently to last through the year. A new one should be built at as early a day as possible, and nearer to the boiler room. The roofs, gutters and rainspouts of the engine house were repaired, the engine house painted inside and outside, the boiler room white-washed inside, and sashes repaired.

Work was commenced on repairs to trestle work of the pumping main to Wentz Farm Reservoir. Said trestle work is in a dangerous condition, the greater part of it requiring renewing entirely. Part of the engine-room floor was removed preparatory to constructing the foundation for the new pumping engine now in course of construction.

MACHINERY.

Two Engines:—

No. 1.—Rotative Compound, Cramp & Sons; erected 1878. Capacity, 327 gallons per revolution, or 7,000,000 gallons per day. Lift, 203 feet. Duty, 50,000,000.

This engine has worked continuously, with but few stoppages, since May, owing to the repairs which were made to the Wentz Farm Reservoir requiring it to work directly on the distribution. It requires a thorough overhauling. A 14-inch overflow pipe was laid from the hot well to the river; the foot valves were removed, and short lengths of pipe substituted; a new lead joint was made at the base of the air chamber, and such small repairs and adjustments made as the limited opportunities granted.

No. 2.—Worthington Duplex. Placed in position in July, 1878, from Fairmount. Capacity, 78.5 gallons per revolution, or 1,500,000 gallons per day. Lift, 203 feet.

This engine was thoroughly overhauled in the Spring, and made ready to be used in case of accident to No. 1. It only worked one night in the Summer, when it supplied the Frankford District while the lead joint at the foot of the air chamber of No. 1 was being renewed.

It was removed in November to make place for the foundation of the new pumping engine.

Boilers.

Four marine tubular boilers, erected in 1877.

Two of these have been sent to the Roxborough Station, and the remaining two will be removed as soon as the first two of the four marine boilers now in course of construction are in place. In view of the changes being being made in boiler arrangements at this station, only such repairs were made to the boilers as were imperatively needed, and were confined entirely to renewing the steam pipe joints, and packing of valve stems.

KENSINGTON STATION.

Buildings and Grounds.

The floors in the engine room were renewed, the coal car tracks from the coal shed into the boiler room were changed from the north to the south side of the property, and a substantial fence built, reaching from the north side of the boiler house to the north side of the coal shed. This arrangement makes the property private, whereas the engine room and boiler room were previously used as a thoroughfare to the wharf. The coal bins were repaired, also the end of the wharf.

The forebay was cleaned, a deposit of mud five feet in depth being removed. A four feet by four feet wooden trunk one hundred and seventy-five feet long was sunk in the river, and secured in place with stone ballast. It connects with the forebay in sixteen feet of water and ends in twenty-six feet in the channel. The sides of the forebay were made tight by means of tongued-and-grooved sheathing, and connection between it and the four-foot trunk mentioned made with a timber bracelet and concrete. This arrangement excludes the water from Gunner's Run from the forebay, and furnishes a supply of better water.

The storehouse was repaired, and cleared of a number of sleeping bunks, the use of which at a pumping station seems an unwarranted luxury. The boiler-room floors were leveled and relaid in brick. The sashes of the engine house were repaired. The buildings were painted inside, and partially outside, and the boiler rooms and cellars were whitewashed. The old standpipe in front of the engine house was taken down, except about twenty-four feet, which is used as an air chamber.

Machinery.

Three Engines:—

No. 1.—Horizontal, high-pressure; erected in 1851. Capacity, 160 gallons per revolution, or 2,500,000 gallons per day. Lift, 133 feet. Duty, 17,000,000.

All the joints were renewed, new boxes put under the cross heads, and the pump was replaced.

No. 2.—Beam, condensing; erected in 1851. Capacity, 190 gallons per revolution, or 3,000,000 gallons per day. Lift, 133 feet. Duty, 30,000,000.

A new suction injection pipe was put in, and small repairs made.

No. 3.—Duplex compound, Worthington; erected in 1871. Capacity, 357 gallons per revolution, or 6,000,000 gallons per day. Lift, 133 feet. Duty, 52,000,000.

This engine received a thorough overhauling in the Spring. A new high-pressure piston was put in, and new springs in all the pistons. The slide valves were faced, the air-pump foundations repaired, the air pumps rebored, pistons repacked and fitted with barrels. New air-pump heads, and new spindle springs and valves fitted in the air pumps. The pumps were supplied with charge pipes, all the joints made and steam stuffing-boxes packed with metallic packing, and the cylinders covered with Hanmore's covering.

Previous to the construction of the wooden trunk connecting the forebay with deep water, the three engines, or at least two of them, were required at one time, because the pumping, if possible, was only done on the flood tide. At present, on account of a constant supply of better water, only one engine (No. 3, as being the most economical in point of consumption of fuel,) is used.

Boilers.

Seven Boilers:—

Nos. 1 to 5, inclusive, tubular boilers, erected in 1870.

Nos. 6 and 7, tubular, erected in 1883.

Nos. 1 to 5, inclusive, are in fair condition.

The pressure to be carried on these boilers has been limited by the City Boiler Inspector to 48 pounds.

Nos. 6 and 7 are in good condition.

The dome and steam pipes have been covered with Hanmore's boiler covering.

RESERVOIRS.

Fairmount Reservoir.

The stop houses and woodwork around the base of stand-pipe were repaired and painted. The Swiss *chalet*, overhanging the rock on the west side of the reservoir, was in a dangerous condition, and has been removed. The grass on the slopes was cut, and all vegetable matter removed from the inside of the reservoir lining, and the public seats and railings repaired and painted. I suggest that the stone retaining wall on Twenty-fourth street be repaired; it requires repointing.

No.	1	Section	contains	2	feet	of mud.
"	2	"	"	6	inches	"
"	3	"	"	6	"	"
"	4	"	"	4	"	"
"	5	"	"	3	"	"

Spring Garden Reservoir.

New brick stop houses were built, and a new watch-house. The banks, fences, and steps are in a bad condition. New fences should be erected at top and bottom of the outer slope, to prevent people from sliding down the banks, destroying the grass, and cutting up the earth.

The west section contains 2 feet of mud.

The east section contains 14 inches of mud.

Corinthian Reservoir.

The stone retaining wall was repointed, a new watch-house was built, the grass was cut, and the lining of the basin cleaned.

It contains on the average 2 feet of mud. I recommend here, also, the construction of a fence along the top and bottom of the outer slope.

Belmont Reservoir.

The stop-houses were repaired, the grass cut, and the lining of the basin cleaned. The west section is clean.

The east section contains 4 inches of mud. A new watch-house is required at this reservoir, and also fencing along top and bottom of outer slope.

Roxborough Reservoir.

This reservoir requires entire new fencing along the top of the inner slope, and should have a fence along the foot of the outer slope to keep the cattle off. The stone rip-rap on the inner slope requires repairing. It contains 6 inches of mud on the average.

Mount Airy Reservoir.

This reservoir requires fencing along top and foot of outer slope.

The small section contains 2 feet of mud.

The large section contains about 14 inches of mud.

Wentz Farm.

The reservoir was emptied July 30th for repairs, and water let in again on the 28th of October. During the interval the stop house, which leaked very badly, was repaired and the leakage almost entirely stopped.

The brick work in the bottom was overhauled, and the outer edge of the bottom for a space 12 feet in width, and the lower side of the inner slope for a space 9 feet in height was covered with a layer of hydraulic cement. The outer slopes on the north and west side were repaired.

The embankment of this reservoir has been constructed mainly of a micaceous earth, allowing the water, in the absence of a clay core, to penetrate through, causing the outer slope to slip.

Lehigh Reservoir.

A new brick stop-house was built, and a new wooden fence built around the foot of the outer slope. The banks were mowed, and the inside lining cleaned of vegetable matter.

Section 1 contains 8 inches of mud.

Section 2 and 3 contain 4 inches of mud.

I suggest that a fence be built along the top of the outer slope.

RESERVOIRS.

	When built.	Capacity, gallons.	Elevation. Feet above city datum.		Depth, feet.	Number of basins.
			Surface.	Bottom.		
Fairmount	1815–1836	26,443,140	94	82	12	5
Spring Garden	1844	9,800,000	120	104	16	2
Corinthian	1850–1852	37,312,000	120	93	27	1
Lehigh or Fairhill	1852–1871	25,757,720	114	96	18	3
Belmont	1866–1870	40,000,000	212	187	25	2
Wentz Farm	1876–1877	35,750,000	167	144	23	1
Roxborough	1865–1866	11,771,700	366	347	19	1
Mount Airy	1855–1857	4,390,000	363	348	15	2
East Park	Commenced 1869	700,000,000	133	108	25	3
Cambria	Proposed	210,000,000	166	135	31	2

Table showing greatest and least pumpage in one day during 1883.

STATIONS.	Greatest, Tuesday, August 28.	Least, Tuesday, December 25.
Fairmount	12,542,683 gals.	15,488,686 gals.
Spring Garden	47,774,860 "	12,174,400 "
Belmont	18,378,975 "	3,814,440 "
Roxborough	8,855,650 "	2,981,565 "
Mount Airy	471,350 "	625,200 "
Chestnut Hill	250,275 "	146,250 "
Frankford	7,502,034 "	
Kensington	9,555,162 "	6,500,256 "
Totals	100,330,989 "	41,730,797 "

G 1883.

	Total.	Average per day.	Percentage of pumpage.	Maximum gallons for one day.	Minimum gallons for one day.	Total steam pumpage.
January.....	916,750,725	61,830,668	7.6	69,056,732	53,944,348	1,198,172,128
February....	663,709,216	59,418,186	6.6	66,647,953	48,149,049	728,449,792
March........	870,054,627	60,324,342	7.4	67,662,890	52,376,705	806,991,594
April..........	873,790,295	62,459,676	7.4	71,338,237	54,491,399	807,027,050
May............	110,541,347	68,081,979	8.4	77,556,052	57,333,342	1,033,814,491
June...........	280,483,006	76,016,100	9.0	88,304,497	57,104,325	1,505,912,756
July...........	576,771,393	83,121,658	10.2	94,466,851	69,529,505	1,715,956,651
August	514,244,375	81,107,883	10.0	100,330,989	59,087,983	2,026,248,764
September...	353,443,660	78,448,122	9.3	89,517,589	69,721,057	1,975,941,823
October	271,728,034	73,281,549	9.0	96,598,383	53,598,832	1,506,509,361
November..	983,919,425	66,130,647	7.8	79,517,099	48,210,537	1,175,563,134
December....	859,521,148	73,584,770	7.3	72,524,208	41,730,797	1,047,272,978
Totals....	284,957,251	69,273,856	100.0	....	....	15,527,860,522
Increase ov	593,516,821	1,626,070	....	21,832,007	....	....
Decrease fr	....	....	....	....	11,008,5 6	....

REPORT BY THE REGISTRAR

OF THE

RECEIPTS OF THE DEPARTMENT

DURING 1883;

Also, of the Results of the Re-Inspection of the City, and Schedules of Charges against the Public Buildings, Schools, Charitable Institutions, etc., at the regular rates.

PHILADELPHIA WATER DEPARTMENT.
REGISTRAR'S OFFICE.

April 7, 1884.

COL. WILLIAM LUDLOW,
Chief Engineer:

SIR:—I respectfully submit the report of receipts at this office for the year 1883. The total receipts derived from all sources were $1,627,069.16, which have been paid daily, as received, into the office of the City Treasurer.

This is an increase over the previous year of $110,164.52.

The collections of water rents for the year 1883 amounted to $1,404,162.61, an increase over the previous year of $90,726.51, and the receipts from delinquent rents amounted to $80,305.84, a decrease of $9,716.35, on account of the smaller number of delinquent properties to collect from. The receipts from fractional rents, penalties, and other sources amounted to $67,088.10, an increase of $17,558.20. The receipts from charges for water pipe amounted to $45,853.09, an increase of $10,873.57. Receipts through the Chief Engineer's office for old material, fire connections, etc., amounted to $8,515.11.

The amount collected through the City Solicitor's office for pipe frontage, as certified to this Department, amounted to $21,144.41.

Water pipe bills to the amount of $18,715.83 were returned to the City Solicitor for lien.

The annexed itemized tables contain full information of the detailed work of the office.

Very respectfully,

A. N. KEITHLER,

Registrar.

TOTAL RECEIPTS OF THE WATER DEPARTMENT FOR THE YEAR 1883.

MONTHS.	Delinquent Rents.	Penalties.	Rents for 1883.	Penalties.	Fractional Rents.	Water Pipe.	Totals.
January	$4,652 25	$628 61	$73,554 99	....	$2,254 58	$2,381 80	$83,471 73
February	1,799 75	259 11	112,636 45	....	3,107 02	2,659 48	120,462 01
March	3,206 00	468 47	250,675 33	....	4,407 70	1,688 19	260,445 69
April	9,680 25	1,395 00	734,491 44	....	5,206 41	3,792 72	754,565 82
May	3,313 00	492 41	32,139 35	$1,605 95	4,983 10	3,023 86	45,557 67
June	3,757 00	547 94	47,583 55	2,366 71	6,530 74	3,303 32	64,089 26
July	6,573 29	985 97	12,788 25	1,916 98	7,344 71	2,747 23	32,356 43
August	22,310 30	3,336 50	27,099 87	4,001 48	5,932 34	6,246 73	68,927 22
September	7,552 25	1,129 09	33,288 04	4,987 08	9,163 18	7,489 22	63,608 86
October	3,551 00	532 31	35,076 75	5,256 35	11,936 06	5,405 27	61,757 74
November	2,553 75	378 96	17,031 90	2,550 83	3,831 85	4,553 48	30,900 77
December	1,047 00	155 63	4,516 25	595 06	2,390 21	2,562 29	11,266 44
Totals	$69,995 84	$10,310 00	$1,380,882 17	$23,280 44	$67,088 10	$45,853 09	$1,597,409 64
Total receipts through the Chief Engineer's office, for the year 1883							8,515 11
" " " " office of the City Solicitor, for the year 1883							21,144 41
							$1,627,069 16

RECEIPTS THROUGH THE CHIEF ENGINEER'S OFFICE FOR THE YEAR 1883.

January 9, 1883..	John Wiehmann	Cutting ice	$105 00
February 2	Philadelphia and Reading Railroad Company	Water connection	59 64
" 7	James F. Neall	Old material	148 32
" 7	E. H. Fitler & Co	Fire connection	57 22
" 7	William Beatty	Repairs to stop	3 68
" 9	Dolan & Co	Supply attachment	76 37
" 14	H. Stroebler	Fire connection	66 45
" 14	Harrison, Havemeyer & Co	Repairs to connection	46 35
" 14	M. W. Nixon	Fire connection	63 49
" 16	Thomas Kenworthy & Bro	" "	129 84
" 16	Thomas Potter & Son	" "	42 14
" 24	W. C. Allison	Repairs to pipe	5 44
" 24	Mr. Kennedy	" "	10 32
" 24	M. Phillips	Fire connection	56 78
" 24	W. M. Singerley	" "	271 59
" 28	James Armstrong	Repairs to pipe	452 15
" 28	Keystone Horseshoe Company	Fire connection	57 40
March 1	H. Snyder	Rent	450 00
" 1	G. W. Johnson	"	5 00
" 2	James F. Neall	Old material	323 34
" 5	Western Market Company	Repairs to pipe	6 02
" 6	A. Flanagan & Brother	Fire attachment	54 39
" 6	M. Young	Old material	16 00
" 14	Hagstoy & Thorpe	Fire connection	370 28
" 14	Eighth Street Theatre	" "	106 30
" 20	Pennsylvania Railroad Company	Supply attachment	94 40
" 24	McCallum, Crease & Sloan	Fire attachment	68 95
" 24	James D. Heyer	Material furnished	44 02
" 30	W. P. Ogelsby, for Pennsylvania Railroad Company	Fire attachment	76 21
" 30	H. Dawson	Old material	10 40
			$3,277 49

RECEIPTS—*Continued.*

		Amount carried forward	$3,277 49
April 25, 1883	Hennings & Shaffer	Fire attachment	66 28
" 26	Firth & Brother	" "	64 29
" 30	John T. Bailey	" "	86 23
" 30	Bergner & Engel	" "	82 36
May 28	Peter Lindsay	Old iron	11 41
" 28	Henry Snyder	Rent at Fairmount	225 00
" 31	Frank Shappel	Building stone	6 00
June 7	Joseph Keeley	Fire attachment	92 49
" 25	United States Naval Asylum	" "	73 48
July 21	J. Schrader	Old material	157 73
" 28	Henry Snyder	Rent at Fairmount	225 00
August 3	James M. Preston	Building stone	8 00
" 14	John Toole	Old material	1,219 26
" 18	E. H. Wilson & Co	Old boiler	36 60
" 29	William C. Watson	Old material	492 58
September 17	Pennsylvania Railroad Company	Supply connection	98 11
" 20	A. Purvis & Co	Old material	522 30
" 26	Jos. H. McClure	" "	30 93
" 28	Lewis Kensil & Co	" "	139 53
October 20	Philadelphia Railroad Company	Supply connections	281 21
November 2	Central Congregational Church	" "	84 30
" 5	Mr. John Wiehmann	Privilege to cut ice	115 00
" 8	Henry Snyder	Rent at Fairmount	225 00
" 15	James McHugh	Old material	550 00
December 6	John McStay	Building stone	12 20
" 20	George S. Bodine	" "	21 45
" 20	Commissioners of Fairmount Park	Changing and repairing pipes	304 33
" 31	James McHugh	Old material	6 60
			$8,515 11

COMPARATIVE STATEMENT OF RECEIPTS FOR THE YEARS 1882 AND 1883.

Year.	Delinquent Rents.	Penalties.	Water Rents.	Penalties.	Fractional Rents.	Water Pipe.	Chief Engineer's Office.	City Solicitor's Office.	Totals.
1883	$69,995 84	$10,310 00	$1,380 882 17	$23,280 44	$67,088 10	$45,853 09	$8,515 11	$21,144 41	$1,627,069 16
1882	78 543 01	11,479 18	1,295,419 87	18 016 23	49,529 90	34,979 52	7,515 88	21,421 05	1,516,904 64
Increase	....	....	$85 462 30	$5 264 21	$17,558 30	$10,873 57	$999 23	....	$110,164 52
Decrease	$8 547 17	$1,169 18	....	....	....	....	....	$276 64	....

Items of Receipts under Head of "Fractional Rents."

Year.	Rents.	Ferrules.	Repaving.	Repairs.	Totals.
1883	$53,021 35	$9,596 00	$2,648 00	$1,786 75	$67,088 10
1882	35,321 65	7,200 00	4,858 00	2,150 25	49,529 90
Increase	$17,699 70	$2,396 00	....	....	$17,558 20
Decrease	....	....	$2,174 00	$363 50	....

Total receipts of the Water Department for the year 1883 .... $1,627,069 16
Receipts as previously estimated by the Chief Engineer 1,425,000 00

Excess $202,069 16

R 1883.

1	22	23	24	25	26	27	28	29	30	31	Total.
.....	1	1	....	....	....	....	....	1	....	....	4
.....	....	....	....	....	....	....	1	....	....	....	8
2	4	1	2	1	....	4	1	....	....	2	22
22	13	6	12	10	10	8	12	16	16	18	364
18	22	9	98	15	4	8	103	121	1	2	961
92	87	75	259	187	328	37	365	266	36	72	2,572

STATEMENT SHOWING THE GENERAL RESULTS OF THE RE-INSPECTION OF THE CITY, 1883.

Wards.	Duplicate 1883	Duplicate 1884	Increase.		
First	$64,840 60	$74,349 25	$9,508 65		
Second	37,970 10	40,728 40	2,758 30		
Third	21,887 63	24,048 61	2,160 98		
Fourth	21,975 25	22,188 85	213 60	$1,361 00	Harrison, Havemeyer & Co., sugar house, N.E. cor. Swanson and Almond sts.
Fifth	35,594 04	43,695 18	8,101 14		
Sixth	46,279 03	55,169 00	8,889 97	2,460 33	McKean, Newbold & Co. sugar house, 225 Church street.
Seventh	43,922 37	50,295 45	6,373 08		
Eighth	48,235 97	53,906 54	5,670 57	417 00	Hotel Lafayette (old section), N. W. cor. Broad and Sansom streets.
Ninth	41,053 55	50,083 82	9, 30 27		
Tenth	41,415 80	47,864 44	6,448 64		
Eleventh	20,386 00	25,324 01	4,938 01		
Twelfth	24,339 20	29,342 40	5,003 20		
Thirteenth	34,846 64	40,886 72	6,040 08		
Fourteenth	39,214 75	41,593 69	2,378 94	200 00	Cooper, Jones & Cadbury, 1134–1138 Ridge avenue.
Fifteenth	93,976 70	108,246 98	14,270 28		
Sixteenth	29,616 60	35,246 06	5,629 46		
Seventeenth	28,829 08	33,087 14	4,258 06		
Eighteenth	43 901 98	50,210 11	6,308 13		
Nineteenth	83,083 63	99,744 07	16,660 44		
Twentieth	86,999 55	95,195 40	8,195 85		
Twenty-first	22,180 95	31,087 85	8,906 90		
Twenty-second	35,654 65	42,043 43	6,388 78		
Twenty-third	22,312 75	29,536 25	7,223 50		
Twenty-fourth	73,853 50	82,793 64	8,940 14		
Twenty-fifth	46,059 54	56,638 90	10,579 36		
Twenty-sixth	51,783 25	63,584 85	11,801 60		
Twenty-seventh	35,184 70	39,324 11	4,139 41	800 00	Butler & Co., south side Woodland avenue west of Mill Creek.
Twenty-eighth	65,496 80	75,927 87	10,431 07		
Twenty-ninth	94,022 68	108,202 85	14,180 17		
Thirtieth	46,556 55	50,896 28	4,339 73		
Thirty-first	55,306 70	63,824 20	8,517 50		The above properties were charged on the *General Books* of 1883, and for this year the charges have been transferred to the *Meter Books*.
	$1,436,780 54	$1,665,066 35	$228,285 81	$5,238 33	

It cannot be determined what amount will be deducted from the total increase by transfer to meter charges and by affidavit as to non-use of appliances.

SCHEDULE OF CHARGES AGAINST PUBLIC BUILDINGS AT THE REGULAR RATES.

Wards.	Name.	Location.	Amount.
Fifth	Mayor's office		$15 00
"	Telegraph department		13 00
"	Office Clerks of Council		5 00
"	Court of Common Pleas, No. 1		32 00
"	Sheriff's office		4 00
"	Common Pleas, No. 3		18 00
"	Independence Hall	Independence Hall	21 00
"	Council Chambers		6 00
"	Prothonotary's office		20 00
"	Common Pleas, No. 4		6 00
"	" " No. 2		21 00
"	Old Court-house		9 00
"	New "	Sixth street below Chestnut street	87 00
Tenth	Cherry street shops	918 Cherry street	53 00
Fourteenth	Spring Garden Hall	Thirteenth and Spring Garden streets	41 00
Seventeenth	Purveyor's office	Frankford avenue and Master street	5 00
Twenty-sixth	Water Department office, stable, and storage yard	Wharton street below Twelfth street	16 00
"	County prison	West side Passyunk avenue, from Reed to Dickinson streets	1,294 00
Twenty-seventh	Philadelphia almshouse		3,333 00
		Total	$4,999 00

SCHEDULE OF CHARGES AGAINST FAIRMOUNT PARK AT THE REGULAR RATES.

Name.	Location.	Amount.
West Park	Belmont, including sprinklers for entire Park	$1,148 24
" "	Belmont Mansion	83 00
" "	British Building	18 00
" "	Ohio Building	7 00
" "	Memorial Hall	250 00
" "	Horticultural Hall	98 00
" "	Greenhouse adjoining Horticultural Hall	20 00
" "	Outside grounds	128 00
" "	Sweet Brier Mansion	15 00
" "	Rhode Island Building	9 00
" " jet fountain	Lake west of Belmont avenue, near Elm avenue	6,500 00
" " " "	Catholic Total Abstinence Building, near Elm avenue	1,000 00
East Park, drinking fountain	North front Lemon Hill Mansion	168 00
" " " "	Northeast from Lemon Hill Mansion	112 00
" " " "	Northeast of Sedgeley guard house	10 00
" " jet fountain	" " " "	560 00
	Amount carried forward	$10,126 24

SCHEDULE OF CHARGES AGAINST FAIRMOUNT PARK AT THE REGULAR RATES—*Continued.*

Name.	Location.	Amount.
	Amount brought forward	$10,126 24
East Park, jet fountain	East side forebay	560 00
" " " "	Green street entrance	756 00
" " " "	On lawn east of steamboat landing	735 00
" " " "	" northeast of steamboat landing	735 00
" " tre foil fountain	East of Lincoln monument	2,205 00
" " fish pond	Main drive, near Brown street entrance	1,984 00
" " large fountain	West of Thirty-third street, south side Dauphin street	1,003 00
	Total	$18,104 24

SCHEDULE OF CHARGES AGAINST POLICE STATION HOUSES AT THE REGULAR RATES.

Wards.	Name.	Location.	Amount.
First	Station house, Seventeenth District	South side of Taylor street, east of Passyunk avenue	$62 00
Third	" " Second "	Second street above Christian street	97 00
Fifth	Central Station	Mayor's office, Independence Hall	70 00
"	Station house, Third District	Union street below Fourth street	63 00
Sixth	" " Fourth "	Fifth street above Race street	65 00
Seventh	" " Nineteenth District	734 Lombard street	60 00
Eighth	" " Fifth "	Fifteenth street, east side, south of Walnut street	61 00
Ninth	" " Twentieth "	1519 Filbert street	51 00
Tenth	" " Sixth "	235 South Eleventh street	65 00
Eleventh	" " Seventh "	St. John street below Green street	30 00
Fourteenth	" " Eighth "	1012-14 Buttonwood street	55 00
Fifteenth	" " Ninth "	Northwest corner Twenty-third and Brown streets	48 00
Seventeenth	" " Tenth "	Front street above Master street	58 00
Eighteenth	" " Eleventh "	Girard avenue above East Montgomery avenue	31 00
Twentieth	" " Twelfth "	Northeast corner Tenth and Thompson streets	71 00
		Amount carried forward	$887 00

SCHEDULE OF CHARGES AGAINST POLICE STATION HOUSES AT THE REGULAR RATES—*Continued.*

Wards.	Name.	Location.	Amount.
		Amount brought forward	$887 00
Twenty-first	Station house, Thirteenth District	Station-house alley, between Mechanic and Cotton streets	36 00
Twenty-second	" " Sub "	Northwest corner Twenty-seventh and Highland avenue	23 00
"	" " Fourteenth "	North side Lafayette street	52 00
Twenty-third	" " Fifteenth "	Southeast corner Ruan street and Frankford road	10 00
Twenty-fourth	" " Sixteenth "	Southwest corner Lancaster avenue and Thirty-ninth street	64 00
Twenty-fifth	" " Twenty-fourth District	Southwest corner Clearfield and Belgrade streets	19 00
"	" " Sub "	Northwest corner Kirkbride and Richmond streets	40 00
"	" " " "	3883 Germantown avenue	33 00
Twenty-seventh	" " Twenty-first "	Southeast corner Woodland avenue and Spruce street	63 50
Twenty-eighth	" " Twenty-second "	Northwest corner Park and Lehigh avenues	94 50
Twenty-ninth	" " Twenty-third "	Southwest corner Twentieth and Jefferson streets	57 00
Thirtieth	" " First "	Fitzwater street below Twentieth street	60 00
Thirty-first	" " Eighteenth "	2028 Trenton avenue	53 00
			$1,492 00

SCHEDULE OF CHARGES AGAINST FIRE STATIONS AT THE REGULAR RATES.

Wards.	Name.	Location.	Amount.
First	Fire station, No. 10	818 Morris street	$25 00
Fifth	Truck D Company	319 Union street	21 00
"	Fire station, No. 22	Levant street below Third street	20 00
Sixth	" " No. 8	143 Race street	18 00
Seventh	" " No. 11	1035 Lombard street	15 00
"	" " No. 1	South street below Nineteenth street	19 00
Tenth	" " and shops, No. 17	Race street, south side, west of Thirteenth street	142 00
Eleventh	" " No. 21	826 New Market street	27 00
Fourteenth	" " No. 26	Hamilton street, between Tenth and Eleventh streets	36 00
Fifteenth	" " No. 18	1903 Callowhill street	15 00
"	Truck A	2132 Fairmount avenue	17 00
Eighteenth	Fire station, No. 16	1106–1108 Montgomery avenue	20 00
Nineteenth	" " No. 15	Howard street and Columbia avenue	15 00
Twenty-first	" " No. 12	4541 to 4545 Main street	17 00
Twenty-third	" " No. 7	22 East Church street	16 00
"	" " No. 14	4612 Frankford avenue	24 00
Twenty-fifth	" " No. 28	Belgrade street twenty feet south of Clearfield street	23 00
Twenty-seventh	" " No. 5	Southeast corner Thirty-seventh and Ludlow streets	24 00
Twenty-ninth	" " No. 27	2202–2204 Columbia avenue	26 00
			$520 00

SCHEDULE OF CHARGES AGAINST THE PUBLIC SCHOOLS AT THE REGULAR RATES.

Wards.	Name.	Location.	Amount.
First	Grammar School	Southeast corner Seventh and Dickinson streets	$27 00
"	Weccacoe Primary School	Second and Reed streets	13 00
"	Tasker School	Ninth and Tasker streets	13 00
"	Levin Handy Smith School	Fifth and Snyder avenue	20 00
"	William Welsh School	Thirteenth and Jackson streets	26 00
"	Henry Clay School	Lancaster avenue above Reed street	13 00
"	Morris School	Morris street below Second street	13 00
"	Colored Consolidated School	Dickinson street below Seventh street	18 00
"	Calhoun "	Tenth and Snyder avenue	20 00
Second	Geo. W. Nebinger "	Carpenter street above Sixth street	18 00
"	Wharton "	Fifth street below Washington avenue	29 00
"	Washington "	Carpenter street above Ninth street	26 00
"	Watson "	Mary street below Second street	15 00
Third	Mount Vernon "	Catharine street above Third street	42 00
"	Fletcher "	Christian street above Front street	14 00
"	Thomas B. Florence "	Catharine street below Eighth street	32 00
		Amount carried forward	$339 00

SCHEDULE OF CHARGES AGAINST THE PUBLIC SCHOOLS AT THE REGULAR RATES—(*Continued*).

Wards.	Name.	Location.	Amount.
		Amount brought forward	$339 00
Third	Lyons School	Catharine street above Tenth street	13 00
Fourth	Ringgold "	Northeast corner Eighth and Fitzwater streets	18 00
"	Fagen "	Twelfth and Fitzwater streets	21 00
"	Wm. M. Meredith School	Fifth street above German street	35 00
"	Ralston "	Northeast corner Guilford and Bainbridge streets	15 00
"	Ronaldson "	Fitzwater street above Sixth street	13 00
Fifth	Horace Binney Grammar School	Spruce street below Sixth street	77 00
"	James Forten School	Sixth street above Lombard street	15 00
"	Geo. W. Wharton School	Third street above Lombard street	26 00
Sixth	No. 1 Primary School	New street below Second street	9 00
"	Northeast Boys' Grammar School	Northwest corner Crown and Race streets	29 00
"	N. E. Secondary School	Crown street above Race street	10 00
Seventh	Secondary, No. 1, School	409 South Twenty-third street	8 00
"	Secondary, No. 3, "	1119 Pine street, Northeast corner Quince street	17 00
"	Southwest "	Northeast corner Seventeenth and Pine streets	22 00
		Amount carried forward	$667 00

SCHEDULE OF CHARGES AGAINST THE PUBLIC SCHOOLS AT THE REGULAR RATES—(*Continued*).

Wards.	Name.	Location.	Amount.
		Amount brought forward	$667 00
Seventh	Secondary, No. 4, School	415 South Nineteenth street	13 00
"	O. V. Catto "	2028 Lombard street	18 00
Eighth	Hollingsworth "	Locust street, south side, west of Broad street	26 00
"	Locust Street "	Northeast corner Locust and Twelfth streets	29 00
"	James A. Garfield "	Southwest corner Locust and Twenty-second streets	10 00
Ninth	Zane Street "	711–717 Filbert street	28 00
"	Filbert Street "	2015 Filbert street	13 00
"	Keystone "	Nineteenth street, west side, north of Chestnut street	37 00
Tenth	Edward Shippen "	Cherry street, north side, west of Nineteenth street	21 00
"	John Agnew "	Cherry street, south side, west of Eleventh street	20 00
"	Cherry Street "	Cherry street, south side, west of Fifteenth street	8 00
"	Northwest "	Race street, north side, west of Fourteenth street	24 00
"	Sergeant "	920 Sergeant street	9 00
Eleventh	Shunk Primary, No. 1, School	East side New Market street above Brown street	9 00
"	Madison Secondary "	East side New Market street above Noble street	19 00
		Amount carried forward	$951 00

SCHEDULE OF CHARGES AGAINST THE PUBLIC SCHOOLS AT THE REGULAR RATES—(*Continued*).

Wards.	Name.	Location.	Amount.
		Amount brought forward	$951 00
Eleventh	Northern Liberties School	Third street below Green street	19 00
"	Biedeman Primary "	St. John street below Buttonwood street	19 00
Twelfth	Saunders "	Northwest corner Dillwyn and Callowhill streets	16 00
"	Mifflin "	Third property west of 18 North Third street	26 00
"	Rovoudt "	432–436 Maria street	17 00
"	E. M. Paxton "	Noble street below Sixth street	26 00
Thirteenth	Wyoming "	Northwest corner Sixth street and Fairmount avenue	23 00
"	Adams "	Garden street below Buttonwood street	23 00
"	Warner "	Perth street, north of Parrish street, west side	28 00
Fourteenth	Robert Vaux "	Wood street between Eleventh and Twelfth streets, north side	29 00
"	Monroe "	Wood street east of Twelfth street	32 00
"	John M. Ogden "	Northeast corner Twelfth and Wistar streets	26 00
"	Robert T. Conrad "	Melon street east of Twelfth street	25 00
"	Hancock "	Fairmount avenue west of Twelfth street	41 00
"	Spring Garden "	Southeast corner Twelfth and Ogden streets	30 00
		Amount carried forward	$1,331 00

SCHEDULE OF CHARGES AGAINST THE PUBLIC SCHOOLS AT THE REGULAR RATES—(*Continued*).

Wards.	Name.	Location.	Amount.
		Amount brought forward	$1,331 00
Fourteenth	Central High School	Southeast corner Broad and Green streets	63 00
Fifteenth	Girls' Normal "	Northeast corner Spring Garden and Seventeenth streets	119 00
	Hoffman "	Northeast corner Seventeenth and Wood streets	19 00
"	Thaddeus Stevens School	Northwest corner Seventeenth and Grayson streets	31 00
"	Lincoln "	Southeast corner Twentieth street and Fairmount avenue	71 00
"	A. D. Bache "	Northeast corner Twenty-second and Brown streets	17 00
"	Livingston "	Northeast corner Twenty-third and Shamokin streets	21 00
Sixteenth	Wm. A. Lee "	Howard street below Girard avenue	30 00
"	Martin Landenberger School	Fourth street above George street	27 00
"	George Wolfe "	Charlotte street above Poplar street	20 00
"	Jefferson "	Fifth street above Poplar street	38 00
Seventeenth	Harrison "	South side Master street above Second street	19 00
"	James R. Ludlow "	Northeast corner Master and Lawrence streets	25 00
"	Webster "	East side Hancock street above Girard avenue	16 00
Eighteenth	Douglas "	Southeast corner Edgemont and Huntingdon streets	13 00
		Amount carried forward	$1,860 00

SCHEDULE OF CHARGES AGAINST THE PUBLIC SCHOOLS AT THE REGULAR RATES—(*Continued*).

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Wards.	Name.		Location.	Amount.
			Amount brought forward	$1,860 00
Eighteenth	Primaries, Nos. 7 and 8		Southwest corner Belgrade and Otis streets	13 00
"	T. K. Finletter	School	Montgomery avenue, northeast corner Gaul street	29 00
"	Morris	"	Palmer street above Thompson street	16 00
"	George Chandler	"	Montgomery avenue above Richmond street	36 00
"	Vaughan	"	Marlborough street above Thompson street	26 00
Nineteenth	Price	"	East side Howard street, north of Diamond street	21 00
"	Wm. Adamson	"	East side Fourth street	25 00
"	Franklin	"	East side American street, north of Columbia avenue	12 00
"	Colored Consolidated	"	West side Cadwallader street (rented)	00 00
"	Wm. H. Hunter	"	Southeast corner Dauphin and Mascher streets	16 00
"	Cohocksink	"	Northwest corner Montgomery avenue and Fourth street	15 00
"	Cumberland	"	Southwest corner Cumberland and Hancock streets	19 00
Twentieth	Park Avenue	"	Park avenue above Thompson street	61 00
"	Daniel Webster	"	Eleventh street below Thompson street	21 00
"	Penn	"	Southeast corner Eighth and Thompson streets	20 00
			Amount carried forward	$2,190 00

SCHEDULE OF CHARGES AGAINST THE PUBLIC SCHOOLS AT THE REGULAR RATES—(*Continued*).

Wards.	Name.	Location.	Amount.
		Amount brought forward	$2,190 00
Twentieth	Rutledge School	Northwest corner Seventh and Norris streets	27 00
"	James Todd School	Northwest corner Franklin and Norris streets	27 00
"	Primary No 7 School	1523 and 1531 Mervine street	10 00
"	James Lynd School	Twelfth street above Columbia avenue	40 00
Twenty-first	Manayunk Grammar School	South side Green lane below Wood street	17 00
"	Fairview "	Manayunk avenue below Green lane	47 00
"	Schuylkill Secondary "	Washington street and Jefferson avenue	17 00
"	Roxborough "	Ridge avenue, west side, below Parker street	6 00
"	Washington Primary "	Shur's lane, south side, first house east of Cresson street	13 00
"	Levering "	West side Ridge avenue below Martin street	7 00
Twenty-second	Chestnut Hill "	South side Highland avenue	19 00
"	Germantown "	Northeast corner Adams and Lafayette streets	30 00
"	C. W. Scheaffer "	Germantown avenue and Wyoming street	24 00
"	Central Primary "	North side of Centre street	13 00
"	Bringhurst "	Bringhurst street	16 00
		Amount carried forward	$2,503 00

SCHEDULE OF CHARGES AGAINST THE PUBLIC SCHOOLS AT THE REGULAR RATES—(*Continued*).

Wards.	Name.	Location.	Amount.
		Amount brought forward	$2,503 00
Twenty-second	Rittenhouse School	South side Rittenhouse street	13 00
Twenty-third	Marshall School	Northwest corner Franklin and Sellers streets	11 00
"	Henry Herbert Grammar School	Frankford avenue, one hundred feet from the southeast corner of Foulkrod st.	25 00
"	White Hall School	Southwest corner Pratt and Tacony streets	19 00
"	Wilmot Public School	One hundred and thirty feet from the southwest corner of Mulberry street	8 00
Twenty-fourth	Norris J. Hoffman School	Northeast corner Fifty-fifth and Vine streets	28 00
"	Jesse George "	Hamilton street above Sixty-third street	28 00
"	Martha Washington "	Forty-fourth and Huron streets	36 00
"	Belmont Grammar "	Forty-first and Oregon streets	28 00
"	Warren "	Thirty-eighth street below Warren street	35 00
"	Mantua "	Thirty-eighth street below Mt. Vernon street	29 00
"	Haverford "	3415 Haverford street	28 00
Twenty-fifth	Sherman "	Northeast corner Somerset street and Frankford avenue	17 00
"	Boudinot "	Southwest corner Indiana avenue and "D" street	21 00
"	Henry W. Halliwell Grammar School	Frankford and Allegheny avenues	31 00
		Amount carried forward	$2,860 00

SCHEDULE OF CHARGES AGAINST THE PUBLIC SCHOOLS AT THE REGULAR RATES—(*Continued*).

Wards.	Name.	Location.	Amount.
		Amount brought forward	$2,860 00
Twenty-fifth	Geo. B. McClellan, No. 1, School	Northwest corner Edgemont and Neff streets	13 00
"	Geo. B. McClellan, No. 2, "	Northeast corner Neff and Thompson streets	22 00
"	Carroll "	1528 Salmon street	14 00
"	Irving "	Bridesburg	13 00
"	Barton "	Frankford Avenue and Buckius street	13 00
"	Bayard Taylor "	Sixth and Venango streets	16 00
"	Asa Packer "	Broad and McFerran streets	22 00
Twenty-sixth	Jackson "	Southeast corner Twelfth and Federal streets	40 00
"	Jeremiah Nichols "	Northeast corner Sixteenth and Wharton streets	34 00
"	James Alcorn "	Thirty-fourth and Wharton streets	25 00
"	Landreth Federal "	Southeast corner Twenty-third and Federal streets	17 00
Twenty-seventh	Newton Grammar "	Southwest corner Thirty-eighth and Spruce streets	34 00
"	Newton Secondary "	3438 Chestnut street	28 00
"	Newton Primary "	3459 Ludlow street	16 00
"	Price "	Southwest corner Forty-seventh and Locust streets	19 00
		Amount carried forward	$3,186 00

SCHEDULE OF CHARGES AGAINST THE PUBLIC SCHOOLS AT THE REGULAR RATES—(*Continued*).

Wards.	Name.	Location.	Amount.
		Amount brought forward	$3,186 00
Twenty-eighth	Oakdale School	Eleventh street and Huntingdon avenue	24 00
"	Camac "	Corner Thirteenth street and Susquehanna avenue	43 00
"	Kenderton "	Fifteenth street below Tioga street	28 00
"	T. H. Powers School	Southwest corner Susquehanna avenue and Woodstock street	30 00
"	Bellevue School	Twenty-sixth street and Cumberland avenue	32 00
"	Glenwood Primary School	Ridge avenue above Thirty-second street	16 00
Twenty-ninth	Reynolds "	Southwest corner Twentieth and Jefferson streets	36 00
"	Edward Gratz "	Southeast corner Twenty-third and Jefferson streets	24 00
"	Morris City "	Southwest corner Twenty-sixth and Thompson streets	10 00
"	Muhlenberg "	Southeast corner Master and Forty-seventh streets	22 00
"	Elisha Kent Kane "	Southeast corner Jefferson and Twenty-sixth streets	31 00
"	George G. Meade "	Eighteenth and Oxford streets	49 00
Thirtieth	Wm. S. Pierce "	Twenty-fourth and Christian streets	26 00
"	Curtin "	Southwest corner Twentieth and Catharine streets	16 00
"	James Pollock "	Southwest corner Birch and Fitzwater streets	16 00
"	Edwin M. Stanton "	Southeast corner Seventeenth and Christian streets	23 00
Thirty-first	John S. Hart "	York and Memphis streets	29 00
"	Adams "	Adams street above Amber street	21 00
"	Lucretia Mott "	Huntingdon avenue and Sepviva streets	28 00
		Amount total	$3,690 00

LIST OF CHARITABLE INSTITUTIONS

Which, under the provisions of the Ordinances of June 21, 1878, and June 16, 1881, are charged fifteen per cent. of the regular rates.

Ward.	Name.	Location.	When placed on charity list.	Amount assessed.	Amount charged.
First	Sisters of St. Francis	505 Reed street	June 7, 1883	$22 00	$5 00
Second	St. Ann Widows' Asylum	9[illegible]6 Moyamensing avenue	June 21, 1878	24 00	5 00
"	Ridgway Library	Broad street, southeast corner Christian street	January 31, 1882	141 00	21 15
Third	Maternity Hospital	730–32–34 South Tenth street	December 21, 1883	12 00	5 00
"	Industrial Home	762 Tenth street	June 21, 1878	50 00	7 50
"	Southern Home for Destitute Children	Southeast corner Fitzwater and Twelfth streets	June 21, 1878	154 00	23 10
"	Philadelphia Society for Employment and Instruction of the Poor	714–18 Catharine street ... Special ordinance	March 23, 1878	76 75	5 00
Fourth	Institute for Colored Youth	918–20 Bainbridge street	April 17, 1883	28 00	5 00
"	Bedford Street Mission	619 Alaska street	June 11, 1879 June 2, 1879	30 50	5 00
Fifth	City Mission	411 Spruce street	April 10, 1883	16 00	5 00
"	Philadelphia Dispensary	127 Fifth street	April 19, 1881	34 50	5 00
"	Newsboys' Aid Society	251 South Sixth street	September 29, 1881	62 90	9 43
		Amount carried forward		$651 65	$101 18

LIST OF CHARITABLE INSTITUTIONS—(*Continued*).

Ward.	Name.	Location.	When placed on charity list.	Amount assessed.	Amount charged.
		Amount brought forward..		$651 65	$101 18
Sixth	Apprentices' Library	500 Arch street, southwest corner Fifth street	June 21, 1878	23 00	5 00
Seventh	Howard Hospital	1518–20 Lombard street	April 10, 1883	22 50	5 00
"	Pennsylvania Hospital	Southwest corner Eighth and Spruce streets		574 50	86 18
"	Western Soup Society	1613–15 Arch street	June 21, 1878	21 00	5 00
"	Clinton Street Boarding House	913–15 Clinton street	June 21, 1879 Sept'mb'r 30, 1879	80 00	12 00
"	Deaf and Dumb Asylum	Broad street, northwest corner Pine street	June 21, 1878	946 00	141 90
"	Day Nursery	2218 Lombard street	October 3, 1882	12 00	5 00
"	Lincoln Institute	324 Eleventh street ....Special ordinance	March 23, 1873	106 00	5 00
Eighth	Midnight Mission	919 Locust street	December 21, 1883	23 00	5 00
"	Philadelphia Library	Northwest corner Juniper and Locust streets	January 31, 1882	75 50	11 32
"	Jefferson Hospital	Sansom street, south side, above Tenth street	June 21, 1878	545 50	81 83
"	Union B. nevolent Association	701 Sansom street	February 13, 1883	66 00	9 90
"	Jefferson College	Tenth street, west side, below Sansom street	June 21, 1878	140 00	21 00
"	Children's Hospital	207 South Twenty-second street	June 21, 1878	91 00	13 65
"	Historical Society	Northwest corner Thirteenth and Locust streets	February 29, 1884	29 00	5 00
		Amount carried forward..		$3,406 65	$513 96

LIST OF CHARITABLE INSTITUTIONS—(*Continued*).

Ward.	Name.	Location.	When placed on charity list.	Amount assessed.	Amount charged.
		Amount brought forward..		$3,406 65	$513 96
Ninth	Women's Christian Association	1605 Filbert street	June 21, 1878..	36 00	5 40
"	Homœopathic Hospital	1116–18 Cuthbert street		29 00	5 00
Tenth	Central Soup Society	709–11 Cherry street	June 13, 1881..	103 00	15 45
"	Indigent Widows' and Single Women's Society	North side Cherry street, E. of Eighteenth street	June 21, 1878.. June 18, 1879..	61 00	9 15
"	Catholic Home for Destitute Children and Orphan Girls	1718–20 Race street	June 21, 1882..	42 00	6 30
"	Wills' Eye Hospital	1810–24 Race street	June 21, 1878..	125 00	18 75
"	Academy of Natural Sciences	1900 Race street, S. W. corner Nineteenth street.	June 21, 1878..	109 00	16 35
"	Presbyterian Historical Society	1227–29 Race street	June 20, 1882..	17 00	5 00
"	Pennsylvania Institution for the Instruction of the Blind	Northwest corner Race and Twentieth streets	June 21, 1882..	481 00	72 15
"	Orthopædic Hospital	1701 Summer street, N. W. cor. Seventeenth st.	June 21, 1878..	56 50	8 48
"	Academy of Fine Arts	Northwest corner Broad and Cherry streets	June 21, 1878..	276 00	41 40
"	Magdalen Society of Philadelphia	Northeast corner Twenty-first and Race streets	June 21, 1878..	75 00	11 25
Twelfth	Northern Soup Society	817 North Fourth street	June 21, 1878..	40 50	6 07
		Amount carried forward..		$4,857 65	$734 71

LIST OF CHARITABLE INSTITUTIONS—(*Continued*).

Ward.	Name.	Location.	When placed on charity list.	Amount assessed.	Amount charged.
		Amount brought forward..		$4,857 65	$734 71
Twelfth	Home Association	505 North Sixth street	June 21, 1878..	18 00	5 00
Thirteenth	Northern Dispensary	606–08–10 Fairmount avenue	June 21, 1878..	41 50	6 23
Fourteenth	Spring Garden Institute	1349–51–53 Spring Garden street	October 22, 1883..	45 00	6 75
Fifteenth	Preston Retreat	N. W. corner Twentieth and Hamilton streets	June 21, 1878..	121 00	18 15
"	Home Infirmary	2208 Brown street	July 27, 1878..	23 00	5 00
"	Northern Home for Friendless Children	N. E. corner Twenty-third and Brown streets	June 21, 1878..	110 00	16 50
"	Soldiers' Orphans' Home	N. E. cor. Twenty-third and Brown streets (rear)	June 21, 1879..	82 00	12 30
"	House of Refuge	N. W. cor. Twenty-second and Parrish streets	March 18, 1879..	1,178 42	176 76
"	" " (colored)	" " " " " "	March 18, 1879..	400 00	60 00
"	Howard Institute	1610 Poplar street	June 7, 1883..	18 00	5 00
"	" "	1612 " "	June 7, 1883..	16 00	5 00
"	Jewish Foster Home	S. W. corner Twenty-fourth and Poplar streets	June 21, 1878..	46 00	6 90
"	C. Morrison	2426 Hare street	June 24, 1879..	5 00	0 00
"	St. Vincent Home for Destitute Infants	Northwest corner Wood and Eighteenth streets	June 21, 1878..	101 50	15 23
"	Northern Home Infirmary	826 North Twenty-third street	November 16, 1880..	11 00	5 00
		Amount carried forward..		$7,069 07	$1,078 53

LIST OF CHARITABLE INSTITUTIONS—(*Continued*).

Ward.	Name.	Location.	When placed on charity list.	Amount assessed.	Amount charged.
		Amount brought forward..	....	$7,069 07	$1,078 53
Fifteenth....	Home for Aged Couples..........................	1721–23 Francis street..	December 5, 1883..	14 00	5 00
Eighteenth..........	St. Mary's Hospital..................................	N. E. cor. Palmer street and Frankford avenue...	....	53 50	8 03
Nineteenth..........	Episcopal "	N. E. corner Front street and Lehigh avenue......	....	714 00	107 10
"	Northeastern Soup Society.....................	1940 Front street...	....	8 00	5 00
Twenty-second.....	Women's Christian Association...............	4781 Germantown avenue..................................	January 31, 1883..	15 00	5 00
"	Young Men's Christian Association.........	5019 " "	January 25, 1882..	77 00	11 55
"	Lutheran Orphans' Home.........................	5576 " "	June 21, 1878..	64 00	9 60
"	" Asylum for Aged.....................	5580 " "	June 21, 1878..	84 00	12 60
"	Jewish Hospital...	Cottage avenue..	....	209 50	31 43
"	Germantown Hospital...............................	East Penn street, west of Chew street................	....	92 00	13 80
"	Pauline Home..	" " second house east of Ross street	March 4, 1883..	39 00	5 85
"	Little Sisters of the Poor..........................	Mill street, fourth house east of Ross street........	June 21, 1878..	132 00	19 80
"	Jewish Foster Home..................................	" first house west of Chew street.........	June 7, 1881..	138 00	20 70
"	Germantown Poor House.........................	Rittenhouse street..	June 21, 1878..	57 00	8 55
Twenty-fourth.....	Working Home for Blind Men.................	3518 Lancaster avenue......................................	June 21, 1878..	96 00	14 40
		Amount carried forward..	....	$8,862 07	$1,356 91

LIST OF CHARITABLE INSTITUTIONS—(*Continued*).

Ward.	Name.	Location.	When placed on charity list.	Amount assessed.	Amount charged.
		Amount brought forward..	....	$8,862 07	$1,356 94
Twenty-fourth.....	Union Home for Old Ladies....................	Northwest corner Lancaster and Girard avenues	June 21, 1878..	15 00	5 00
"	Presbyterian Hospital..........................	S. W. cor. Powelton avenue and Saunders street..	June 21, 1878..	285 00	42 75
"	Pennsylvania Home for Blind Women....	N. E. " " " " " " ..	June 18, 1881..	73 00	10 95
"	Old Men's Home..................................	N. W. " " " " " " ..	June 18, 1881..	170 00	25 50
"	Pennsylvania Hospital for Insane (females)	Haverford street, south side...........................	February 17, 1879.. June 21, 1878..	1064 00	159 60
"	" " " " (males)...	Southeast corner Haverford and Fiftieth streets.	June 21, 1878.. February 17, 1879..	1045 50	156 83
"	Colored Orphans' Home........................	S. W. corner Forty-fourth street and Elm avenue	June 21, 1878..	65 50	9 83
"	House of Good Shepherd.......................	Fairmount avenue, west of Thirty-fifth street....	June 21, 1878..	516 00	77 40
"	Philadelphia Home for Infants..............	Westminster street, S. E. corner Markoe street...	June 21, 1878..	88 00	13 20
"	St. John's Orphan Asylum.....................	" " north side........................	June 21, 1878..	105 00	15 75
"	Western Home for Poor Children...........	Forty-first street, southeast corner Baring street	April 18, 1882..	44 00	6 60
"	Pennsylvania Homœopathic Hospital for Children..	Forty-third street, S. W. corner Brown street......	June 21, 1878..	37 00	5 55
"	Colored Orphans' Home........................	Forty-fourth street, S. W. cor. Haverford street. Special ordinance..	March 23, 1878..	53 00	5 00
		Amount carried forward..	....	$12,423 07	$1,890 90

LIST OF CHARITABLE INSTITUTIONS—(*Continued*).

Ward.	Name.	Location.	When placed on charity list.	Amount assessed.	Amount charged.
		Amount brought forward..	....	$12,423 07	$1,890 90
Twenty-fourth.....	Baptist Orphanage..................................	Forty-fifth street, S. W. cor. Fairmount avenue..	June 21, 1878..	26 00	5 00
Twenty-fifth.........	Old Ladies' Home......................................	Frankford avenue, fifth house north of Cemetery.	May 31, 1881..	11 00	5 00
Twenty-sixth	Third Regiment Armory..........................	Northeast corner Twelfth and Reed streets.........	May 16, 1882..	50 00	7 50
Twenty-seventh ...	University of Pennsylvania.....................	N. E. corner Thirty-sixth and Spruce streets......	June 21, 1878..	1,327 50	199 13
" ...	West Philadelphia Industrial School........	N. W. " Thirty-ninth and Pine "	June 21, 1878..	118 00	17 70
" ...	Home for Incurables..............................	Woodland avenue, east of Forty-eighth street....	January 1, 1883..	141 00	21 15
...	Divinity School..	" " N. E. corner Fiftieth street...	....	160 00	24 00
' ...	Presbyterian Orphans' Home..................	Woodland avenue, between Fifty-eighth and Fifty-ninth streets..	July 18, 1878..	128 00	19 20
" ...	Educational Home..................................	Forty-ninth st. and Woodland av...Spec'l ordin.	March 23, 1878..	179 50	5 00
Twenty-eighth.....	Baptist Home..	North Seventeenth street, corner Norris street...	June 21, 1878..	223 00	33 45
"	Odd Fellows' Home................................	" " S. E. cor Tioga " ...	June 21, 1878..	76 00	11 40
"	Methodist Episcopal Home.....................	N. E. cor. Thirteenth street and Lehigh avenue.	June 21, 1878..	190 00	28 50
Twenty-ninth......	Homœopathic Hospital for Children........	914 North Broad street..	December 21, 1883..	52 00	7 80
"	School of Design for Women....................	1346 " "	June 20, 1878..	129 00	19 35
		Amount carried forward..	....	$15,234 07	$2,295 08

Ward.	Name.	Location.	When placed on charity list.	Amount assessed.	Amount charged.
		Amount brought forward..		$15,234 07	$2,295 08
Twenty-ninth......	Little Sisters of the Poor....................	Eighteenth street, E. side, N. of Jefferson street..	June 21, 1878..	182 00	27 30
"	German Hospital....................	Southwest corner Corinthian and Girard avenues	June 21, 1878..	134 00	20 10
"	House of Refuge	N. W. corner Twenty-second and Poplar streets.	June 21, 1879..	439 00	65 85
"	St. Joseph's Hospital....................	S. E. cor. Seventeenth street and Girard avenue.	June 21, 1878..	422 00	63 30
"	Women's Medical College....................	Northwest corner Twenty-first street and North College avenue....................	June 21, 1878..	110 00	16 50
"	" Hospital....................	Northeast corner Twenty-second street and North College avenue....................	June 21, 1878..	249 50	37 43
"	Girard College....................	South College avenue, north side....................	June 3, 1879..	5,515 28	827 29
"	Union Temporary Home for Children...	1525 Poplar street....................	June 21, 1878..	69 00	10 35
"	Northwest Soup Society....................	1300 North Nineteenth street....................	June 21, 1879..	11 00	5 00
				$22,365 85	$3,368 20
		Loss of revenue to the city....................		$18,997 65	

REPORT

ON THE

OPERATIONS IN CONNECTION WITH THE DISTRIBUTION SYSTEM OF THE DEPARTMENT,

DURING 1883.

By JOHN L. OGDEN, *Assistant Engineer in Charge.*

PHILADELPHIA WATER DEPARTMENT.

March 1, 1884.

COL. WILLIAM LUDLOW,

Chief Engineer:

SIR:—I have the honor to submit the following report on the Department work in my charge for the year 1883, viz.:

THE DISTRIBUTION SYSTEM.

The water pipes authorized by Councils during the year amounted to 66,833 feet, in addition to which an ordinance approved July 7, 1883, provides that where petitioners desiring to be supplied with water own the entire frontage on both sides of a street, and are willing to pay the expense, the Chief Engineer may comply with their request without a special ordinance to that effect.

The Chief Engineer, by ordinance approved July 6, 1876, is also authorized to lay water pipe for the purpose of connecting dead ends on any street to insure a better supply of water, and by ordinance approved June 5, 1877, to relay, when necessary, any street within the limits of the old city proper, previous to the repaving of the street.

Ordinances directing the laying of water pipes have been accumulating for several years, and now amount to a total of 215,594 feet. Frequently duplicate ordinances are passed, and for the information of Councils and the public a list of all pipe laying ordinances still in force is appended.

Before proceeding with the laying of water pipe in any street, it is necessary to receive from the City Solicitor or the Survey Department, a certificate of dedication. The street must also be graded, and no pipes are laid except upon a written application from the property owners interested.

WATER PIPES.

During the year, 63,215 feet of water pipes were laid, as shown in detail in the accompanying tables, arranged according to the Purveyors' districts. This amount, added to that laid in previous years, makes a total of 4,081,180 feet, or 784 miles and 4,875 feet now in use.

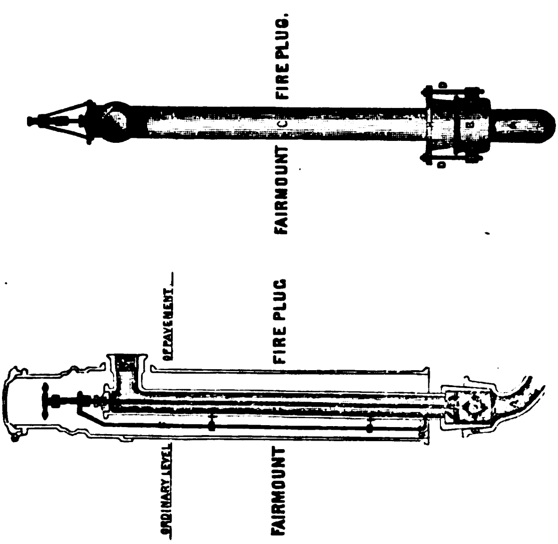
The exhaustion of Item 18 of the annual appropriation for "labor in laying pipe," etc., previous to the end of the year, prevented the laying of pipe which had been ordered and asked for, and which was greatly needed.

FIRE HYDRANTS.

The repairs to the fire hydrants, most of which were of a minor character, amount to 4,253—as shown in the accompanying table.

Previous to the introduction of steam fire engines, the hydrants in general use—shown in Fig. 1—answered well enough for fire purposes. An engine now attached to one of these soon loosens it at the base and causes a leak. About four hundred of this style are still in service in that part of the city between Vine and South streets.

Figure 2 represents the hydrant that has been made and used by this Department for several years. It is objectionable on account of its unsightliness, but principally because of the



ORDINARY LEVEL
OF PAVEMENT
FAIRMOUNT FIRE PLUG
FAIRMOUNT FIRE PLUG.

Fig. 1.

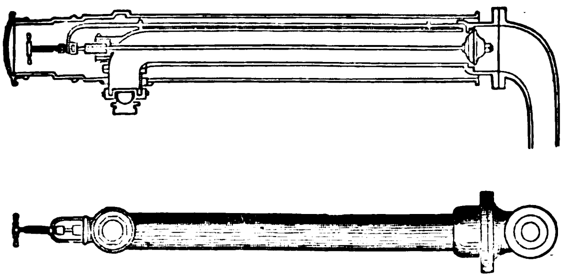


Fig. 2.

necessity for digging up the pavement for the purpose of making repairs. They are used by contractors for cleaning and sprinkling streets, and many complaints arise from the carelessness of their employés in not properly closing them after use.

The annexed tables show the location of all the hydrants, by wards and districts, and the size of the pipes to which they are connected.

Gate Valves.

The gate valves, as now made, are satisfactory except in the material used for the screws. Brass, phosphor bronze, wrought iron, and wrought iron galvanized have been tried, but do not, in all respects, fulfil the requirements.

The repairs have been chiefly due to the renewal of the screws, which have been rendered useless by corrosion.

A four-way valve, placed at the intersection of the streets, with a fire plug attachment to the curb, would be cheaper and preferable to the usual way of locating stop valves.

The boxes placed around the valves are made of inch boards and covered with a cast-iron plate. They last but a few years, and their renewal is attended with considerable expense. An iron box of sufficient size to allow repacking without digging up the street would be more economical.

Drills.

The acompanying tables,—"drills and shut-offs,"—show the total number of holes drilled in the mains for making new attachments to buildings.

A tapered brass ferrule is driven into a reamed hole in the pipe,—an operation which necessitates the shutting off of the water supply, and is attended with considerable annoyance, especially to manufacturers. It is proposed to abandon this method of making connections, and by means of a tapping machine, drill the pipe and screw in the connection without shutting off the water or reducing the pressure.

Detection of Waste.

The Waterphone,—an instrument intended for the detection of leaks or waste of water in houses, by the sound made by the water flowing through the service pipe,—was in use, on trial, from May 4th until September 15th. The instruments and two instructors were furnished by the Bell Waterphone Co., without charge.

The men employed by this Department and instructed in their use were either plumbers or persons especially fitted for the work. The inspections were made at night, between 11 o'clock P. M. and 4 o'clock A. M., in the following manner:—

A key, with the phone attached, was placed over the stop-cock on the service pipe, and the ear placed to the instrument, when the leak or waste, if any, was detected by a hissing sound, loud or soft, according to the quantity of water flowing through the pipe. On the following day those houses where noises were noted were inspected, and the cause of the noise ascertained. If due to defective fixtures, notice was given to have them repaired. If due to waste, a warning notice was given.

Twelve thousand inspections were made, with results as shown in the table accompanying the Chief Engineer's remarks on "the waste of water." Most of the leaks were small and of a trifling character, but aggregating a large quantity of water wasting into the sewers which could have been prevented with little or no cost to the consumer.

Water closets, hydrants, horse-troughs and faucets constantly running, were the principal sources of waste discovered.

In addition to the special examinations with the Waterphone, which were confined to one section of the City, inspections were made in other localities. The owners of all horse-troughs found constantly running, were notified to discontinue the waste. The notice seemed to have but little effect, as in most cases no attention was paid to it.

The attachments are generally made to a wash pave with a short piece of gum hose, and often more water flows into the gutter than into the trough, which is also constantly overflowing. The water is allowed to run constantly, and each trough wastes about 5,000 gallons per day.

More stringent measures should be taken to check this nuisance. A self-acting stop should be attached to each trough, and the water shut off entirely during freezing weather.

The Hydrant in general use is capable of great improvement. The stop cock is soon shaken or worn loose and allows the water to find its way into neighboring cellars, or, when coming to the surface, flows over the pavement or down the drain pipe into the sewer.

Water Closets are allowed to run continuously, from the idea that it is necessary for the health of those living in the house. No Water Closet should be supplied directly from the service pipe so that a continuous flow can be possible, either by intention or neglect. A special cistern should in all cases be used, so constructed as to allow sufficient water to be discharged at each flush only. Faucets are often left running continuously during warm weather to obtain cool water, and in cold weather to prevent freezing. Large quantities of water are used for cleaning the gutters, washing the surface deposits into the sewers and docks of the City.

The prevention of waste requires good plumbing, regular inspection of the fixtures, and a rigid enforcement of the Laws, but the waste by large consumers, such as Breweries, Morocco Dressers, Hotels, Stables, and Factories, can only be corrected by the use of meters.

METERS.

The accompanying table of Meter Operations shows briefly the work in this direction. Many of the meters hitherto in use were found defective and were removed. Arrangements have been made to place meters on all large consumers, not onlv with a view to petermine the quantity of water to be paid for, but to prevent waste.

G 1883.

Size.	In s Janua 18	Set.						Stock on hand.		Meters in use January 1st, 1884.		
		ocation.		Old Location.								
Style of Meter.		Marsland.	Undine.		Crown.	Marsland.	Total.	Crown.	Undine.	Crown.	Marsland.	Total.
½ in.	....	....	....	....	....	....	3	20	....	3	....	3
¾ "	....	....	....	....	1	....	4	16	....	4	....	4
1 "	....	....	....	....	6	2	13	34	....	12	7	19
1½ "	....	....	....	....	....	4	5	31	....	1	6	7
2 "		1	1	....	3	1	9	20	1	6	6	12
3 "		1	....	....	3	4	10	8	....	5	10	15
4 "	....	....	....	....	1	....	2	11	....	2	....	2
6 "	....	....	....	....	....	....	....	2	....	....	1	1
Totals......		2	1	....	14	11	46	142	1	33	30	63

COMPLAINTS.

Complaints are almost daily received of the bad quality of the water, short supply, or leaks. These are immediately placed in the hands of competent persons for investigation, and, where possible, the remedy applied.

Some of the complaints as to quality are due to direct pumpage, mud, eels, vegetable growth, etc., in the reservoirs and pipes, and to the proximity of dead ends.

Flushing the fire hydrants sometimes gives temporary releif by allowing the objectionable water to escape into the gutters, but this should only be done by employés of the Department.

Cleaning the reservoirs would no doubt assist in maintaining a better quality of water. Their condition may be judged from the following list, showing when last cleaned:—

Delaware Reservoir,	cleaned	in	1870.	
Fairmount "	"	"	1874.	
Chestnut Hill Tank,	"	"	1874.	
Roxborough Reservoir,	completed	in	1871,	not cleaned since
Belmont "	"	"	1871,	" " "
Wentz Farm "	"	"	1877,	" " "
Corinthian Ave.,	probably cleaned	in	1867,	" " "

Spring Garden Reservoir, no record when last cleaned; certainly not for 30 years.

The complaints of short supply are due to various causes—principally lack of mains—but the defective plumbing and the stoppage of iron service pipes account for most of those received.

In some cases a score or more of houses are connected by a single ferrule to the City mains.

Cast-iron service pipes after a few years become more or less closed with rust and sediment. More generally, the defective supply is to be attributed to the small pipes laid by the City, principally in small streets, the insufficient elevation of the reservoirs, and inadequate supply mains.

The small service pipes laid in the City are as follows:

1-inch, - - - -	2,331 feet.
2-inch, - - - -	6,317 "
3-inch, - - - -	226,171 "
4-inch, - - - -	583,417 "
Total, - - -	818,236 feet,
	or 154 miles and 5,116 feet.

All of which were laid previous to 1876, and in time, without the protective coating of recent years, became filled with rust and sediment.

The houses in many streets came to be used for Manufacturing Establishments, Breweries, Sugar Houses, Dye Houses, etc., and the increased facilities for using water greatly increased the demand. Steam Fire Engines then came into use, requiring a large flow in a small area.

Citizens justly complain of the annoyance occasioned by this imperfect distribution, and the protection of the City from fire demands that these small pipes should be removed, and larger ones substituted.

During the Summer the pressures were taken on almost every Fire Plug in the City, with results as follows:

In the district below South street the average pressure was 11 pounds.

In West Philadelphia the average pressure was 21 pounds.

In the district north of Vine street, and east of Sixth street, the average pressure was 14 pounds.

To increase the pressure and flow of water, in addition to the relaying of the small pipes, large supply mains are necessary.

The following requirements of the Department in this respect were presented by the Chief Engineer to the City Controller, August 24, 1883, in an estimate for the year 1884:

In 1880, that portion of the city below South street contained a population of 173,000—one-fifth of the entire city.

The number of houses furnished with water during the year 1882, was 33,169.

The water now furnished this large section passes through one 30-inch pipe, and, as a result, portions of this district are frequently entirely without water, and others receive an inadequate supply.

Last year a 30-inch Main was laid on Twenty-second street, from Washington avenue to South street. This should be continued along South street to Twentieth, along Twentieth to Callowhill, and along Callowhill to connect with the two 20-inch Mains from the Fairmount Reservoir. The cost will be about $64,000.

South street constitutes the dividing line between the distribution from Fairmount and that from the Corinthian Basin.

The Stop Cocks along the south side of South street are, therefore, closed, and form dead ends.

The only Main feeding below South street is the 30-inch on Broad; and the only east and west Main is the 20-inch on Washington avenue.

The water flows south to the main feeder, and thence through the small service pipes to South street. The result of this is, that the pressure is low, and the supply inadequate.

To improve both, the flow should commence at South street, the beginning of the distribution.

Numerous complaints are received of the scarcity of water on Gray's Ferry Road and the vicinity. On some occasions no water whatever is delivered, and the manufacturing establishments are frequently compelled to stop for want of it.

A 20-inch Main should be laid on South street, from Front to Gray's Ferry Road, and on Gray's Ferry Road to Thirty-sixth street. The cost will be $102,000.

West Philadelphia, with a population of 70,000 and 11,000 houses, is dependent upon a single 20-inch Main, which crosses on the Pennsylvania Railroad Bridge at Belmont avenue.

In case of an accident to this pipe the greater portion of West Philadelphia would be deprived of water.

A 30-inch Main should be laid from the Belmont Reservoir down Fiftieth street to Walnut street, which will cost $127,000.

In addition to this, a 20-inch Main on Lancaster avenue should be laid to connect the proposed 30-inch with the present 20-inch pipe. This connection will cost $12,600.

Between Sixth street and the Delaware River, and Vine and Norris streets, there are no main feeders, and the larges pipe is but ten inches in diameter, with the exception of about 1,000 feet of 12-inch.

The population of this district is about 100,000, and the number of houses supplied with water about 17,000.

There are numerous manufacturing establishments using large amounts of water in this district, and frequent complaints are received of the inadequate supply.

A 16-inch Main terminates at Broad and Poplar, and should be continued down Poplar to Front. The cost will be $33,000.

The district north of Susquehanna avenue, and east of Sixth street, has a single supply pipe of but ten inches in diameter on Frankford Road.

A 30-inch Main should be laid on Lehigh avenue, from Sixth street east to Frankford Road, which will cost $60,000.

A 30-inch Main now reaches from Corinthian avenue, along Jefferson street, up Ninth to Dauphin. It should be continued to the Lehigh Basin, for the purpose of supplying Schuylkill water to this Basin, and in conjunction with the new Pumping Main on Lehigh avenue, to justify the abandonment of the Kensington Station. This object can be attained at an expense of $26,500.

The aggregate cost of these seven new Supply Mains is $425,000.

In addition to the above, the following recommendations are made:

A portion of the Twenty-eighth Ward, known as Tioga, is supplied with water through one 6-inch pipe, which is sufficient for ordinary purposes, but not for the extinguisment of fires.

A 12-inch pipe should be continued from the 16-inch main about to be laid on Green street, Germantown, connecting with it at Tulpekocken and continued down the most convenient street to the Township Line road, and down Township Line road to Venango street.

Preparations have been made for changing the arrangement of the pumping mains at the Belmont Engine House. The necessary pipes have been ordered for connecting all of the engines with 36-inch main and using it for pumping alone. It will then be disconnected from the submerged main, which will be supplied through a 30-inch pipe now used as a pumping main for No. 1 Engine.

The pumping mains for the new Worthington Engines at Spring Garden Station have been delivered, and the ditch in in which they will be laid is being blasted through the rock between the new and the old Engine Houses. They will be connected with the 48-inch and the two 36-inch pumping mains from the old station.

Plans have been prepared and the necessary stops and pipes ordered for re-arranging the Pumping Mains from the old Engine House, and the change will be made during the following spring.

Pipes have been ordered and are mostly delivered for laying an additional supply main for Germantown. This will be 16-inches in diameter and will be laid from Mt. Airy Reservoir down Allen's lane to McCallum or Green street, and down Green street to Tulpehocken street, and a 12-inch from there to Manheim street. It will be laid during the coming year.

Respectfully submitted,

JOHN L. OGDEN,

Assistant Engineer.

REPAIRS TO PLUGS, STOPS, AND MAINS, AND PLUGS AND STOPS TAKEN OUT, DURING 1883.

Districts.	Plugs.		Stops.		Repairs to Mains.
	Repairs.	Taken out.	Repairs.	Taken out.	
First	1,196	....	613	....	50
Second	2,603	6	2,930	....	69
Third	726	2	603	4	91
Fourth	574	....	404	1	186
Germantown	14	....	46	....	35
Manayunk	140	....	27	....	30
Totals	4,253	8	4,623	5	461

ACCOUNT OF NEW STOPS AND PLUGS FOR 1883.

Districts.	Stops.			Plugs.
	Two-way.	Barton Four-way.	Totals.	
First	24	4	28	15
Second	37	3	40	21
Third	54	....	54	23
Fourth	74	4	78	25
Germantown	63	....	63	34
Manayunk	18	....	18	12
Totals	270	11	281	130

FIRE HYDRANTS, *by Wards*,

And the diameter of the pipes to which they are connected.

WARDS.	SIZES OF PIPES IN INCHES.											Total.
	3	4	6	8	10	12	16	18	20	30	36	
First	5	105	180	3	......	......	1	......	......	......	......	294
Second	33	42	92	5	3	1	2	......	1	......	......	179
Third	11	7	67	5	15	......	......	......	......	......	......	105
Fourth	21	13	54	2	11	......	......	......	......	......	......	101
Fifth	6	10	50	36	23	2	......	......	......	......	......	127
Sixth	10	11	65	9	10	......	......	......	......	2	......	107
Seventh	11	5	101	......	8	16	14	......	......	......	......	155
Eighth	12	6	97	......	12	18	8	......	......	......	......	153
Ninth	5	5	89	......	19	11	5	......	1	3	......	138
Tenth	11	10	77	3	13	11	......	......	1	1	......	127
Eleventh	......	14	44	1	16	......	......	......	......	......	......	75
Twelfth	......	13	39	......	24	1	......	......	......	......	......	77
Thirteenth	......	18	71	......	16	3	......	......	......	......	......	108
Fourteenth	......	14	62	......	19	5	......	......	......	2	......	102
Fifteenth	1	57	174	......	27	5	2	......	3	2	......	271
Sixteenth	......	21	41	......	22	......	......	......	......	......	......	84
Seventeenth	1	25	54	......	8	2	......	......	......	......	......	90
Eighteenth	......	38	75	......	23	......	......	......	......	......	......	136
Nineteenth	......	64	180	......	9	......	......	4	......	......	1	258
Twentieth	......	60	142	......	5	7	......	......	......	2	......	216
Twenty-first	......	20	179	......	10	2	3	......	5	......	......	219
Twenty-second	32	66	222	11	32	6	3	......	2	......	......	374
Twenty-third	......	3	108	......	......	......	......	......	5	......	......	116
Twenty-fourth	14	22	294	20	26	49	......	......	3	......	......	428
Twenty-fifth	......	20	271	3	19	9	......	......	......	......	2	324
Twenty-sixth	3	56	186	......	......	5	......	......	2	......	......	252
Twenty-seventh	......	16	105	83	21	32	......	......	......	......	......	257
Twenty-eighth	......	......	268	......	2	17	......	......	1	1	......	289
Twenty-ninth	......	23	162	1	19	2	9	......	......	4	1	221
Thirtieth	3	34	131	......	2	4	1	......	......	......	......	175
Thirty-first	......	42	148	......	4	......	......	......	......	......	......	194
Totals	179	840	3,828	182	418.	208	48	4	24	17	4	5,752

FIRE HYDRANTS, *by Purveyors' Districts,*
And the diameter of the pipes to which they are connected.

Purveyors' Districts.	Sizes of Pipes in Inches.											Total.
	3	4	6	8	10	12	16	18	20	30	36	
First......................	76	257	710	15	31	10	4	......	3	......	......	1,106
Second..................	69	85	878	151	132	139	27	......	5	6	......	1,492
Third....	1	240	931	4	123	15	......	4	5	......	3	1,326
Fourth..................	1	172	795	1	88	33	11	......	4	11	1	1,117
Germantown........	32	66	307	11	34	8	3	......	2	......	......	463
Manayunk...........	....	20	207	....	10	3	3	......	5	......	......	248
Total..............	179	840	3,828	182	418	208	48	4	24	17	4	5,752

NOTE—The above table and the one preceding were compiled from the actual number of fire hydrants found in use at this date (January 1, 1884), the difference between which and the number in previous reports must be accounted for from the fact that errors were made in the number reported, and no deductions made for removals, etc.

NUMBER OF VALVES RAISED IN THE DIFFERENT DISTRICTS DURING THE YEAR 1883.

Also in each year since 1874.

Districts.	8-inch. Barton.	3-inch.	4-inch.	6-inch.	8-inch.	10-inch.	12-inch.	16-inch.	20-inch.	30-inch.	36-inch.	Totals.
First........................	....	3	8	24	......	3	......	......	......	1	......	38
Second.....................	....	1	4	18	......	3	......	......	......	......	......	27
Third........................	....	....	6	14	......	2	......	......	......	......	......	22
Fourth	....	....	9	32	......	......	......	1	......	......	1	43
Totals for 1883.........	....	4	27	88	......	8	......	1	......	1	1	130
" " 1882.........	1	14	25	58	1	5	1	......	......	1	......	106
" " 1881.........	....	15	44	90	......	5	7	......	......	......	......	161
" " 1880.........	....	7	23	47	......	8	1	......	......	1	......	87
" " 1879.........	....	9	16	60	1	3	2	......	......	1	1	93
" " 1878.........	....	27	22	100	......	3	1	......	1	1	......	155
" " 1877.........	....	12	6	50	......	1	......	......	1	......	......	70
" " 1876.........	....	3	17	49	......	3	......	......	1	......	......	73
" " 1875.........	....	17	55	120	4	12	2	4	1	2	......	217
" " 1874.........	....	13	32	111	6	6	3	3	......	......	......	174
Totals for ten years..	1	121	267	773	12	54	17	8	4	7	2	1,266

DRILLS AND SHUT-OFFS DURING 1883, BY WARDS AND DISTRICTS.

Wards.	Drills.					Shut-Offs by Permit.						Miscellaneous.				
	Size.															
	½ inch.	⅝ inch.	¾ inch.	1 inch.	Total.	To re-drive ferrules.	To draw ferrules.	To transfer ferrules.	For repairs.	Unclassified.	Total.	Ferrules drawn for leak.	Ferrules drawn and plugged.	Duplicate ferrules drawn.	Ferrules re-driven.	Total.
First District, 1st, 2d, 3d, 4th, 26th, and 30th..........	889	1	3	9	902	14	......	2	39	39	94	18	26	5	9	58
Second District, 5th, 6th, 7th, 8th, 9th, 10th, 24th, and 27th..........	583	48	32	54	717	19	12	27	25	92	175	15	37	8	38	98
Third District, 11th, 12th, 16th, 17th, 18th, 19th, 23d, 31st, and part of 25th..........	1142	17	14	42	1215	22	16	4	75	99	216	15	16	4	20	55
Fourth District, 13th, 14th, 15th, 20th, 29th, and part of 28th..........	1479	22	17	22	1540	16	6	4	80	122	228	12	7	......	1	20
Germantown, 22d and part of 25th and 28th..........	262	7	4	1	274	7	4	......	7	7	25	2	5	1	2	10
Manayunk, 21st and part of 28th..........	221	2	1	5	229	7	3	2	6	22	40	6	3	......	3	12
Totals..........	4576	97	71	133	4877	85	41	39	232	381	778	68	94	18	73	253

DRILLS AND SHUT-OFFS DURING 1883, BY MONTHS.

Months.	Drills.					Shut-Offs by Permit.						Miscellaneous.				
	Size.				Total.	To re-drive ferrules.	To draw ferrules.	To transfer ferrules.	For repairs.	Unclassified.	Total.	Ferrules drawn for leak.	Ferrules drawn and plugged.	Duplicate ferrules drawn.	Ferrules re-driven.	Total.
	½ inch.	⅝ inch.	¾ inch.	1 inch.												
January	31	1	1	9	42	1	......	......	......	19	20	1	......	......	......	1
February	67	5	......	4	76	......	......	......	......	17	17	1	......	......	......	1
March	246	3	4	8	261	......	......	1	2	58	61	4	3	......	......	
April	344	6	7	12	369	1	1	25	......	73	100	4	4	......	1	
May	366	9	9	10	394	......	......	......	......	74	74	2	......	......	......	2
June	323	9	2	12	346	1	......	......	......	78	79	1	3	......	......	4
July	430	9	8	10	457	1	......	......	......	55	56	18	10	8	30	66
August	500	14	9	13	536	12	8	3	48	5	76	8	7	......	1	16
September	626	10	6	12	654	7	5	1	48	......	61	6	11	6	9	32
October	519	9	6	19	553	20	4	4	58	......	86	9	25	......	13	47
November	904	19	12	18	953	33	17	5	64	......	119	11	20	3	16	50
December	220	3	7	6	236	9	6	......	12	2	29	3	11	1	3	18
Totals	4,576	97	71	133	4,877	85	41	39	232	381	778	68	94	18	73	253

IRON SERVICE AND SUPPLY MAINS LAID IN 1883.

FIRST DISTRICT,

Comprising the First, Second, Third, Fourth, Twenty-sixth, and Thirtieth Wards.

Street. Location.	Size in inches.	Distance in feet.
Supply Pipes.		
Broad, west side, from 225 feet south of Dickinson, north.	6	575
Caernarvon, from Dickinson to Tasker	6	434
Fernon, from 19th, west	6	253
Hanley, from dead end 250 ft. 8 ins. south of Wharton, south	6	48
Jackson, from 13th, east	6	176
Kimball, from 21st to 22nd	6	452
Mifflin, from Passyunk avenue to Juniper	6	224
Moore, south from 320 ft. east of Otsego to east house line of Swanson	6	119
Moore, from Juniper to west of Broad	6	321
Passyunk avenue, from Broad west	10	6
*Passyunk avenue, from Broad to Porter; thence through the grounds of the Gas Trust, on Passyunk avenue, 30th and Porter, along Passyunk avenue, in front of Gas Works, to Schuylkill avenue; thence northwest 140 feet	10	9,382
Sixth, from Moyamensing avenue to Wolf	6	291
Tiernan, from Dickinson, north	6	286
Twenty-first, from Reed to Wilder	6	282
Twenty-sixth, from Ellsworth to Deschong	6	101
Twenty-eighth, from dead end north of Ellsworth to Alter	6	115
Wilder, from 4th to 5th	6	450
Wolf, from 6th, west	6	333
Total	....	13,848
Dead ends connected.		
Kates, with Broad street	4	28
Juniata, with Wilder, north side	6	13
Total	....	41

* Laid by the Gas Trust for their own use, but now the property of the Water Department.

Street. Location.	Size in inches.	Distance in feet.
Fire purpose connections (private).		
Bainbridge, southwest corner Penn, for Harrison, Havemeyer & Co.	4	12
Gray's Ferry road, west side, 5 feet north of house line of Catharine, for Naval Asylum	4 6	12 8
Mifflin, north side, 83 feet east of 9th, for J. S. & T. Elkington	4	17
Total	....	49
Fire hydrant connections	4	41
" " "	6	93
Total	....	134
Repairs, general	4	58
" "	6	126
Total	....	184
Repairs, intersections connected.		
18th and Passsyunk	12	3
Repairs, new stops put in.		
Ninth, south side of Snyder avenue	6	3
Eleventh, south side of McKean	6	2
Reed, west side of 19th	6	3
Wharton, west side of 15th	6	2
Catharine, east side of 17th	6	3
Reed, west side of 15th	6	2
Total	....	15
Raised.		
Delaware avenue, 15 ft. north of house line of Almond	6	17

RECAPITULATION OF FIRST DISTRICT.

	Purposes for which used.	Sizes—Inches. 4	6	10	12	Total Feet.
New pipe, or feet added.	Supply pipes	....	4,460	9,388	....	13,848
	Dead ends connected	28	13	....	....	41
	Fire connections (private)	41	8	....	....	49
	Plug connections	41	93	....	....	134
	Total { feet	110	4,574	9,388	....	14,072
	Total { pounds	2,090	141,794	516,340	....	660,224
Pipe used, but adding nothing to feet in the ground.	Repairs, general	58	126	....	....	184
	Repairs, intersections connected	....	....	....	3	3
	Repairs, new stops put in	....	15	....	....	15
	Pipe raised	....	17	....	....	17
	Total { feet	58	158	....	3	219
	Total { pounds	1,102	4,898	....	216	6,216
	Total handled { feet	168	4,732	9,388	3	14,291
	Total handled { pounds	3,192	146,692	516,340	216	656,440

SECOND DISTRICT,

Comprising the Fifth, Sixth, Seventh, Eighth, Ninth, Tenth, Twenty-fourth, and Twenty-seventh Wards.

Street. Location.	Size in inches.	Distance in feet.
Supply Pipes.		
Chester avenue, from 46th to east house line of 48th......	6	948
Dohan, from 48th west..........	6	266
Evans, from south side of Vine to north house line of Summer..........	6	251
Fiftieth, from Girard-avenue to Monroe..........	6	440
Hutton, from centre of Union to Liberty..........	6	163
Palm, from Myrtle to Hutton..........	6	380
Powelton, from 31st to east of 32nd..........	6	168
Sixteenth, from Race to Cherry..........	6	355
Sixtieth, from 48 feet south of centre of Market to South..	8	3,482
Story, from 34th to west side of 35th..........	6	425
Thirty-eighth, from Silverton to south house line of Oregon..........	6	797
Wood, from Thirty-second to Keffer..........	6	273
Wynkoop, from 13th to Juniper..........	6	288
Total..........	....	8,236
Dead Ends Connected.		
Atlantic and 38th..........	6	46
Aspen and 38th..........	6	26
Summer and 15th, west..........	6	25
Winter and Fifteenth, west..........	6	34
Hutton and 40th, west..........	6	33
Haverford and 54th, west..........	6	7
Haverford and 52nd..........	6	6
Market, 80 ft. west of the Bridge (north to south side of street)..........	4	19
Total..........	....	196
Fire Connections (private).		
Somerset, 191 ft. north of house line of Haverford; Market Street Passenger Railway Co..........	4	17
Walnut, 75 ft. west of west house line of 8th; Grand Central Theatre..........	4	25
Total..........	....	42

Street. Location.	Size in inches.	Distance in feet.
Supply Connections (private).		
Spring Garden, 140 ft. east of 31st; Penna Railroad Co...	6	32
Meter Connections (private).		
East side 30th, north of Market, additional; Stock Yard..	6	4
	4	3
Total........	....	7
Fire hydrant connections........	4	14
" " "	6	334
Total........	....	348
Repairs, general........	3	6
" "	4	54
" "	6	106
" "	10	9
" "	12	34
" "	16	3
Total........	....	212
Repairs, new stops put in.		
Thirty-second, north side of Arch	6	2
Thirty-seventh and Warren (Barton stop at intersection)	6	14
Total........	....	16
Taken up.		
Harmony, from 3rd to 4th (laid 1832)........	3	435
Hudson, between Harmony and Chestnut........	3	198
Downing, from 54th, west........	4	273
Jayne, from 8th to 9th........	3	450
Total........	....	1,356

Street. Location.	Size in inches.	Distance in feet.
Relaid.		
Downing, from west house line of 54th west	6	273
Harmony, from 3rd to 4th	6	456
Hudson, from Chestnut to Harmony	6	406
Hunter, or Traquair court, from 10th, east	6	273
Jayne, from 8th to 9th	6	448
Moravian, from Broad to 15th	6	446
Story, west side of 35th to west house line of 35th	4	20
Total	....	2,322
Lowered.		
Fifty-fourth, from Haverford to Downing	6	72
Fairmount, West Park	10	363
" " "	12	110
" " "	16	150
Total	....	695
Raised.		
Fortieth, 103 ft. north of north house line of Hutton, north	6	153
Market, from east house line of 30th, east	{ 12	88
	{ 6	16
Total	....	257
Fire Connections (private) cut off.		
Belmont avenue, east side, 131 ft. north of Viola, Trans-continental Hotel	4	
Supply Connections (private) cut off.		
Machinery Hall, Fairmount Park, (four)	6	
Main Building, Fairmount Park, (one)	8	

Recapitulation of Second District.

	Purposes for which used.		Sizes—Inches.							Total feet.
			3	4	6	8	10	12	16	
New pipe, or feet added.	Supply pipes		....	....	4,754	3,482	....	....	....	8,236
	Dead ends connected		....	19	177	....	....	....	....	196
	Fire connections (private)		....	42	....	....	....	....	....	42
	Supply " "		....	....	32	....	....	....	....	32
	Meter " "		....	3	4	....	....	....	....	7
	Fire-plug connections		....	14	334	....	....	....	....	348
	Total....	feet	....	78	5,301	3,482	....	....	....	8,861
		pounds	....	1,482	164,331	146,244	....	....	....	312,057
Pipe used, but adding nothing to feet in the ground.	Repairs, general		6	54	106	....	9	34	3	212
	" new stops put in		....	....	16	....	....	....	....	16
	Taken up		1,083	273	....	....	....	....	....	1,356
	Relaid		....	20	2,302	....	....	....	....	2,322
	Lowered		....	....	72	....	363	110	150	695
	Raised		....	....	169	....	....	88	....	257
	Total....	feet	1,089	347	2,665	....	372	232	153	4,858
		pounds	16,335	6,593	82,615	....	20,460	16,704	16,830	159,537
Total handled		feet	1,089	425	7,966	3,482	372	232	153	13,719
		pounds	16,335	8,075	246,946	146,244	20,460	16,704	16,830	471,594

THIRD DISTRICT,

Comprising the Eleventh, Twelfth, Sixteenth, Seventeenth, Eighteenth, Nineteenth Twenty-third, Thirty-first, and part of the Twenty-fifth Wards.

Street. Location.	Size in inches.	Distance in feet.
Supply Pipes.		
Clearfield, from Richmond to Torpin	6	197
Clearfield, from east to west side of Germantown avenue	6	57
Cambria, from " " " " "	6	61
Emerald, from Orleans, south	6	127
Franklin, from Pine to Ruan	6	352
Fourth, west side, from 48 ft. north of Vine, to Callowhill	10	532
Harrison, from dead end, west of Penn to Penn	6	11
Helen, from Somerset, north	6	146
Hull, from Amber to Evans	6	143
Indiana, from east to west side of Germantown avenue	6	50
Kirkbride, from 183 ft. south of Garden to Thompson	6	1,599
Leithgow, from Norris to Diamond	6	551
Lewis, from new Tacony to old Tacony road	6	109
Orkney, from Cumberland to south side of Lehigh avenue	6	1,106
Penn, from Harrison to Wakeling	6	513
Tacony, from 918 ft. southwest of Church, southwest	6	210
Thompson, from Kirkbride to Ash	6	34
Third, from north side of Berks, south	6	44
Tulip, from Montgomery to Berk	6	310
Waterloo, from Westmoreland, northeast	6	530
Westmoreland, from dead end 71 ft. east of Amber to Waterloo	6	89
Wishart, from Frankford avenue, west	6	168
Wishart, from Emerald, east	6	37
Total	....	6,976
Fire connections (private.)		
Bridge, southwest side, 96 ft. northwest curb of Walker, for A. Erdrich	4	80
Beach, east side, 83 ft. north of Laurel, for P. R. R. Co	4	15
Crease, west side, 145 ft. north of Girard avenue, for Wm. Thornton	4	14
Mascher, east side, 148 ft. south of Oxford, for Dornan Bro. & Co	4	17
Total	....	126

Street. Location.	Size in inches.	Distance in feet.
Supply Connections (private.)		
Beach, east side, 116 ft. south of Shackamaxon, for P. R. R. Co	6	24
Third, east side, 2 ft. 6 in. south of curb line of Berk, for P. R. R. Co	6	23
Wheat Sheaf lane, south side, east of Connecting R. R., for P. R. R. Co	6	19
Total	....	66
Fire hydrant connections	4	94
" " "	6	168
Total	....	262
Repairs, general	4	71
" "	6	187
" "	8	13
" "	10	44
" "	12	20
Total	....	335
Repairs, new stops put in.		
Brinton, north house line of Jefferson	6	4
Collins, north house line of Sergeant	6	3
Cumberland, east house line of 8th	6	4
Emerald, north house line of Clearfield	6	3
Frankford avenue, east side, 101 ft. 6 in. north of Orthodox	4	3
Mulberry, north house line of Oxford	6	3
Somerset and Germantown avenue	6	5
Tacony, south house line of Church	6	2
Total	....	27
At Works.		
Frankford air-pump discharge	16	61

Street. Location.	Size in inches.	Distance in feet.
Pipe taken up.		
Beach, over Cohocksink creek	6	64
Allegheny avenue, from west of Trenton avenue, west	6	31
Clearfield, from 12-inch main on west side of Germantown avenue, east	6	18
Poplar, from 208 ft. east of Front, over Cohocksink creek	4	35
Tacony road, from 918 ft southwest of Church, southwest	6	216
Total	....	364
Relaid.		
Fifth, across Connecting R. R. bridge	8 6	116 5
Front, west side, from south house line of canal, north	6	276
Poplar, from 208 ft east of Front, over former site of Cohocksink creek	6	35
Germantown avenue, from 28 ft. south of Somerset, to 8 ft. south of Connecting R. R. bridge	6 12	12 1,989
Total	....	2,433
Lowered.		
Clearfield, from 12-inch main on west side of Germantown avenue, west	6	19
Clearfield, west of Germantown avenue, plug connection	6	8
Germantown avenue, west side, from 8 ft. south of P. R. R. bridge, to south house line of Clearfield	12	271
Total	....	298
Cut off and left in the ground.		
Clearfield, from east house line of Germantown avenue, west	6	20
Germantown avenue, from 21 ft. south of P. R. R. bridge, south	6	185
Tacony, 1,134 ft. southwest of Church	6	40
Total	....	245

Recapitulation of Third District.

	Purposes for which used.	Sizes—Inches. 4	6	8	10	12	16	Total feet.
New pipe, or feet added.	Supply pipes	....	6,444	....	532	....	....	6,976
	Fire connections (private)	126	....	....	....	....	....	126
	Supply " "	....	66	....	....	....	....	66
	Fire hydrant connections	94	168	....	....	....	....	262
	Drain and connection at works	....	....	....	....	....	61	61
	Total — Feet	220	6,678	....	532	....	61	7,491
	Total — Pounds	4,180	207,018	....	29,260	....	6,710	247,168
Pipe used, but adding nothing to feet in the ground.	Repairs, general	71	187	13	44	20	....	335
	Repairs, new stops put in	3	24	....	....	....	....	27
	Taken up	35	329	....	....	....	....	364
	Relaid	....	28	116	....	1,989	....	2,433
	Lowered	....	27	....	....	271	....	298
	Cut off and left in ground	....	245	....	....	....	....	245
	Total — Feet	109	1,140	129	44	2,280	....	3,702
	Total — Pounds	2,071	35,340	5,418	2,420	164,160	....	209,409
	Total handled — Feet	329	7,745	129	576	2,280	61	11,193
	Total handled — Pounds	6,251	242,358	5,418	31,680	164,160	6,710	456,577

FOURTH DISTRICT,

Comprising the Thirteenth, Fourteenth, Fifteenth, Twentieth, part of the Twenty-eighth, and part of the Twenty-ninth Wards.

Street. Location.	Size in inches.	Distance in feet.
Supply Pipes.		
Albrecht, from 28th, west	6	28
Allegheny avenue, north side, from east side of 19th, west	6	87
Berks, from dead end, west to 25th	6	27
Bucknell, from Montgomery avenue to Berks	6	558
Grosky, " " " "	6	566
Fontain, from 15th to 16th	6	452
Herbine, " " "	6	432
Hicks or Herbine Place, from Herbine, north	6	162
Herman, from 27th to 29th	6	871
Huntingdon, from 11th to 12th	6	458
Mount Vernon, from Broad to 15th	6	487
Mervine (Jessup), from Huntingdon to Oakdale	6	402
Nicholas, from 24th to 250 ft. west of 25th	6	677
North College avenue, from 25th to West College avenue.	6	199
Oakdale, from 11th to 12th	6	447
Page, from 16th, east	6	168
Pennsylvania avenue, north side, from 19th east	6	227
Percy, from Thompson to Easter	6	463
Sartain (Hibbard), from Huntingdon to Oakdale	6	402
Sedgeley, from 28th to Ridge avenue	8	444
Simmons, from Ogden to Poplar	6	230
Sixteenth, from Montgomery to Herbine	6	175
South College avenue, from Ridge avenue to 20th	6	459
Susquehanna avenue from 20th to Uber	6	224
Twelfth from Huntingdon to Lehigh avenue	6	575
Thirteenth, from Somerset to Cambria	6	556
Twenty-first, from south to north side of Diamond	6	61
Twenty-fourth, from Turner to Nicholas	6	174
Twenty-fifth, from Ridge avenue to Berks	6	440
Twenty-eighth, from Susquehanna to York	6	1,142
Thompson, from 27th to east house line of 28th	6	376
Turner, from 22nd to 23rd	6	459
Turner, from 25th to 26th	6	454
Uber, from Diamond to Susquehanna	6	539
Woodstock, from Brown to Parrish	6	386
Wright, from 24th to 25th	6	456
Total		14,263

Street.	Location.	Size in inches.	Distance in feet.
Fire purpose connections (private).			
Pagoda, east side, 55 feet south of Wallace, for Clough and Carson		4	20
Eighth, east side, 50 ft. north of Willow, for Joseph Keely		4	24
Eighteenth, east side, 51 ft. north of Pennsylvania avenue, for Baldwin Locomotive Works		6	18
Total		....	62
Motor connections (private).			
Eighteenth, west side, 87 ft. north of Green, for Congregational Church		4	40
Total		....	40
Supply connections (private).			
Corinthian avenue, west side, 5 ft. south of Girard avenue, German Hospital		6	26
Mount Vernon, south side, 51 ft. west of west house line of 9th, for Reading R. R. Co		....	14
Total		4	40
Fire Hydrant connections		4	24
" " "		6	283
Total		....	307
Supply Mains.			
Mount Pleasant, from 27th, east		48	187
" " " to 28th		48	444
Twenty-eighth, from Master, south		48	88
" between Mouut Pleasant and Thompson		48	207
Master, from 28th, west		48	40
Thompson, from 48 inch main on Taney, west, to connect with 36 inch main on Thompson		36	87
Thirty-first, from Master, south		48	12
Total		....	1,065

Street.	Location.	Size in inches.	Distance in feet.
	At works.		
Belmont, drains		4	53
" "		6	4
" exhaust pipe		4	32
Spring Garden, drains		4	128
" "		6	37
" "		8	204
Fourth District Yard, drains		4	48
Spring Garden, connections		30	107
" "		36	12
" "	between No. 4 and 6 main	18	38
		20	127
" "	" 16 inch and 18 inch mains	16	12
Total		....	802
	Pumping main (draw off).		
East side Columbia Bridge (30 feet from Belmont)		6	37
Total		....	37
Repairs, general		4	52
" "		6	122
" "		8	9
" "		18	9
" "		30	14
" "		36	20
Total		....	226

Street. Location.	Size in inches.	Distance in feet.
Repairs, new stops put in.		
Broad and Wallace, north side	12	7
Callowhill and Newbold, northeast corner (on plug connection)	4	2
Fairmount avenue and Ridge avenue, south side (on plug connection)	6 4	2 11
Jefferson and Ridge avenue, east side	6	6
Montgomery and Broad, "	6	6
Perkiomen and Wylie "	6	5
Seventh and Noble, "	6	8
" " Norris, "	6	6
" " Poplar, "	6	3
Ninth and York, south side	6	6
Tenth and Oxford, west side	6	8
Eleventh and Nevada, west side	6	8
Eighteenth and Master, south side	6	6
Twenty-first and Columbia avenue, west side	6	3
" " Montgomery avenue, west side	6	3
Twenty-second and Columbia avenue, "	6	3
Twenty-third and Master, south side	10	6
" " Montgomery avenue (Barton stop at intersection)	6	10
Twenty-third and Columbia avenue, west side	6	6
Twenty-fourth and Thompson, north side	6	8
" " Master, west side	6	3
Twenty-fifth and Oxford	12	8
Twenty-eighth and Poplar, north side	6	8
Twenty-ninth and Dauphin	6	7
" " Poplar, north side	6	3
Total	....	152
Relaid.		
Twenty-sixth and Susquehanna avenue	6	24
Mount Pleasant, between 27th and 28th (shifted)	6	240
Total	....	264
Lowered.		
Twenty-eighth and Master	36 6	220 75
Columbia avenue and Nineteenth	6	30
Spring Garden Station	18	100
" "	16	40
Total	....	465

Recapitulation of Fourth District.

	Purposes for which used.	Sizes—Inches.											Total feet.
		4	6	8	10	12	16	18	20	30	36	48	
New pipe, or feet added.	Supply pipes		13,819	444									14,263
	Fire connections (private)	44	18										62
	Meter " "	40											40
	Supply " "	26	14										40
	Fire-hydrant connections	24	283										307
	Supply mains										87	978	1,065
	Drains and connections at Works	261	41	204			12	38	127	107	12		802
	Drain on pumping main		37										37
	Total { feet	395	14,212	648			12	38	127	107	99	978	16,616
	Total { pounds	7,505	440,572	27,216			1,320	5,092	20,193	35,524	41,778	572,130	1,151,330
Pipe used, but adding nothing to feet in the ground.	Repairs, general	52	122	9				9		14	20		226
	" new stops put in	13	118		6	15							152
	Relaid		264										264
	Lowered		105				40	100			220		465
	Total { feet	65	609	9	6	15	40	109		14	240		1,107
	Total { pounds	1,235	18,879	378	330	1,080	4,400	14,606		4,648	101,280		146,836
	Total handled { feet	460	14,821	657	6	15	52	147	127	121	339	978	17,723
	Total handled { pounds	8,470	459,451	27,594	330	1,080	5,720	19,698	20,193	40,172	143,058	572,130	1,298,166

GERMANTOWN DISTRICT,

Comprising the Twenty-second, and parts of the Twenty-fifth and Twenty-eighth Wards.

Street. Location.	Size in inches.	Distance in feet.
Supply Pipes.		
Angle, from Germantown avenue, east	6	399
Atlantic, from 17th to 18th	6	442
Cottage lane (Olney), from end of pipe laid in 1872, southeast	6	140
Coulter, from Cumberland to Hancock	6	613
Hartwell, from southwest to northeast side of Germantown avenue	6	62
Jefferson, from Mercer, northeast	6	125
Knox (Cogshall), from Rittenhouse to Lehman	6	302
Sharpnack, from Germantown avenue, northeast	10	141
Sharpnack, from 10-inch dead end to Musgrove	8	1,356
Sunset, from Germantown avenue to west side of 28th	6	749
Thirtieth, from 242 ft. south of Southampton to Union, or Graver's lane	6	665
Union (Graver's lane), from Germantown avenue to 30th	6	2,330
Total	....	7,324
Fire connections (private.)		
Wayne avenue, south of Apsley (for Cope and Emlen)	4	29
Fire-hydrant connections	4	208
" "	6	380
Total	....	588
Supply mains and connections.		
Chestnut Hill Station, from 8th pumping main to west side of 25th	10	69
Twenty-fifth, for 10-inch pipes to Southampton avenue	12	98
Southampton avenue, from 25th to Germantown avenue	12	421
Germantown avenue, from 203 ft. south of Abington avenue to Abington avenue	10	203
Germantown avenue, from Abington avenue to Bethlehem pike	12	2,638
Union avenne, from 125 ft. east of 25th to Germantown avenue	12	647
Twenty-fifth, at Chestnut Hill Tower (connection)	8	19
Germantown avenue and Abington	6	6
" " and Bethlehem pike	6	6
" " north of Graver's lane	6	4
" " south of Highland	6	5
Total	....	4,116

Street.	Location.	Size in inches.	Distance in feet.
Repairs, general		3	18
" "		4	13
" "		6	90
" "		8	2
" "		10	19
" "		12	.7
" "		20	23
Total		....	172
	Repairs, new stops put in.		
Germantown avenue,	south side of Springfield avenue	10	3
" "	700 ft. south of Springfield avenue	10	3
" "	92 ft. south of Cresheim avenue	10	3
" "	south side of Duval	10	4
" "	east side, 30 ft. south of Upsal	4	2
Total		....	15
Repairs, cut out to put in check valve on Wissahickon pipe		20	6
	Lowered.		
Emlen, from Allen's lane, north		6	108
Magnolia, from 50 ft. north of Locust avenue, north		3	312
Prospect avenue, from Evergreen, north		4	200
Total		....	620
	Raised.		
Allen's lane, east and west from Cresheim avenue		20	564
	Shifted.		
School, between Pulaski and Morris		6	70
	Taken up.		
Cresheim, from Allen's lane, northwest (waste)		6	148

Recapitulation of Germantown District.

	Purposes for which used.	Sizes —Inches. 3	4	6	8	10	12	20	Total. Feet.
New pipe, or feet added.	Supply pipe	.....	.....	5,827	1,356	141	.....	.....	7,324
	Fire connections (private)	.....	29	.....	.....	.....	.....	.....	29
	Fire hydrant connections	.....	208	380	.....	.....	.....	.....	588
	Supply mains and "	.....	.....	21	19	272	3,804	.....	4,116
	Total... Feet	.....	237	6,228	1,375	413	3,804	.....	12,057
	Total... Pounds	.....	4,503	193,068	57,750	22,715	273,888	.....	551,924
Pipe used, but adding nothing to feet in the ground.	Repairs, general	18	13	90	2	19	7	23	172
	Repairs, new stops put in.	.....	2	.....	.....	13	.....	.....	15
	Repairs, check valve put in	.....	.....	.....	.....	.....	.....	6	6
	Taken up	.....	.....	148	.....	.....	.....	.....	148
	Lowered	312	200	108	.....	.....	.....	.....	620
	Raised	.....	.....	.....	.....	.....	.....	564	564
	Shifted	.....	.....	70	.....	.....	.....	.....	70
	Total... Feet	330	215	416	2	32	7	593	1,595
	Total... Pounds	4,950	4,085	12,896	84	1,760	504	94,287	118,566
	Total handled Feet	330	452	6,644	1,377	445	3,811	593	13,652
	Total handled Pounds	4,950	8,588	205,964	57,834	24,475	274,392	94,287	670,490

MANAYUNK DISTRICT,

Comprising the Twenty-first and part of the Twenty-eighth Wards.

Street. Location.	Size in inches.	Distance in feet.
Supply Pipes.		
Adams, from Terrace to Sharp	6	229
Fleming, from Mechanic to Cotton	6	195
Fountain, from Washington northeast	6	338
Freeland avenue, from northwest of Shur's lane to Penn.	6	247
Hermit, from Sharp to Cresson	6	309
James, from Ridge avenue to 251 ft. north-east of house line of Houghton	6	844
Jefferson, from dead end of pipe laid in 1881, northeast	6	48
Markle, from 43 ft. northeast of Terrace, northeast	6	12
Ogle, from Fountain northwest	6	194
Pechin, from Shur's lane, southeast	6	194
Ridge ave., from north house line of Gerhard, northwest.	6	24
Sumac, from dead end 67 ft. 5 in. northeast of Righter, northeast	6	175
Terrace, from Markle, northwest,	6	117
Woodvale, from Righter to Ridge avenue	6	953
Total	....	3,879
Fire Purpose Connections (private).		
Church, 330 ft. northeast of Hamilton, for Stafford & Co.	4	13
Freeland avenue, 209 ft. northwest of Shur's lane, for A. Flanagan & Bro	4	12
Main, 759 ft. south of Shur's lane, for A. Platt & Bro	4	20
River road, 588 ft. north of west house line of Fountain, for M. & W. H. Nixon	4	12
Total	....	67
Supply Connections (private).		
Abbotsford avenue, for Laughlin & Riley	4	8
Fire Hydrant connections	4	68
" " "	6	96
Total	....	164
Repairs, general	4	12
" "	6	33
" "	10	1
Total	....	46

Street. Location.	Size in inches.	Distance in feet.
Repairs, new stops put in.		
Wissahickon, between Shawmont and the pipe bridge....	20	4
Relaid.		
Abbotsford avenue....	3	68
High, from Leverington, south (old pipe cut off and left in the ground)....	6	228
Total....	....	296
Lowered.		
Sumac, northeast of Righter....	6	48
Grape, between Terrace and Boon....	6	200
East, between Cresson and Terrace....	4	96
Sunnyside, from Cresson, northeast....	6	75
Ridge avenue, between Main st. and Norristown R. R....	6	204
Fowler, northwest of Jefferson....	6	63
Total....	....	686
Shifted.		
High street, between Leverington and Walnut....	6	152

Recapitulation of Manayunk District.

	Purposes for which used.		Size—Inches. 3	4	6	10	20	Total. Feet.
New pipe, or feet added.	Supply pipes		....	....	3,879	....	....	3,879
	Fire purpose connections (private)		....	67	....	....	....	67
	Supp y connections (private)		....	8	....	....	....	8
	Fire hydrant connections		....	68	96	....	....	164
	Total	Feet	....	143	3,975	....	....	4,118
		Pounds	....	2,717	123,225	....	....	125,942
Pipe used, but adding nothing to feet in the ground.	Repairs, general		....	12	33	1	....	46
	Repairs, new stops put in		....	....	....	....	4	4
	Relaid		68	....	228	....	....	296
	Lowered		....	96	590	....	....	686
	Shifted		....	....	152	....	....	152
	Total	Feet	68	108	1,003	1	4	1,184
		Pounds	1,020	2,052	31,093	55	636	34,856
Total handled		Feet	68	251	4,978	1	4	5,302
		Pounds	1,020	4,769	154,318	55	636	160,798

List of Streets upon which the Laying of Pipe has been Directed by Ordinances not yet complied with.

FIRST DISTRICT—Comprising that part of the city lying below South street.

Date.		Street.	From. To.	Ward	Dist'nce	Remarks.
1880	Dec. 8	Ashland	North from Wharton street	26	275	N. R. D.*
1883	May 28	Bancroft	Dickinson street to Tasker street	26	450	Ded.†
1875	June 23	Clarion	206 feet north of Federal street to Pritchard street	26	40	Private court not on city plan.
1873	Nov. 8	Coleman	Tasker street, north	26	234	" " " "
1874	May 1	Copia	Seventeenth street, east	30	104	N. R. D.
1877	Oct. 27	Darcy	Spafford street, west	4	180	"
1883	June 21	Fernon	253 feet west of Nineteenth street to Twentieth street	26	193	"
1875	Nov. 6	Hanly	329 feet south of Wharton street to Reed street	1	130	N. R. D., not on plan, not open.
1883	June 27	Hick	Reed street to Dickinson street	26	450	Ded.
1883	June 27	Holly	Catharine street to Kater street	30	....	N. R. D.
1874	Dec. 1	Huhn	Wharton street to Reed street	26	450	"
1876	July 14	Jackson	Eighth street to Tenth street	1	891	Ded.
1876	Nov. 4	"	Seventeenth street to Seabold street	26	166	"
1876	Nov. 4	Jarden	Wharton street to Reed street	26	450	N. R. D.
1874	Dec. 1	Juniper	Passyunk avenue to Snyder avenue	1	585	Ded.
1879	Oct. 15	"	Canal street to Mifflin street	26	137	"
1876	Apr. 10	Kater	Sixteenth street, west	30	315	N. R. D.
1878	June 11	Lawrence	Nineteenth street to Dorrance street	26	150	N. R. D., not on city plan.
1874	Dec. 1	Long Lane	McKean street to Snyder avenue	26	875	Ded.
1879	Dec. 2	Lebanon	Catharine street to Christian street	3	270	"
1883	June 27	Mole	Reed street to Dickinson street	26	450	"
1872	May 13	Morris	Broad street to Fifteenth street	26	477	N. R. D.
1876	Nov. 4	Mildenhall	Wolf street, north	26	55	Below grade, ded.
1882	Oct. 21	Mifflin	Thirteenth street to Passyunk avenue	26	86	
1883	May 28	Moyamensing avenue	Mifflin street to Snyder avenue	1	950	N. R. D., partly ded.
1872	May 13	Newport	Tasker street to Mifflin street	26	1,380	Not on city plan.
1870	Nov. 22	Otsego	Mifflin street to McKean street	1	450	Partly ded.
1883	June 21	Peltz	Gray's Ferry Road to Schuylkill River	26	1,015	N. R. D.
1862	June 23	Reed	Eleventh street to Twelfth street	26	570	Not open.
1873	Nov. 8	Stretch	Tasker street, north	26	222	Private court, not on plan.
1876	Nov. 4	Seibold	Jackson street to Wolf street	26	450	Ded.
1883	May 28	Scott	Ninth street, west	1	135	N. R. D.

* No record of dedication. † Dedicated.

Date.		Street.	From. To.	Ward	Dist'nce	Remarks.
1883	May 28	Snyder avenue	Second street to Fifth street	1	1,450	Ded.
1874	May 25	Tasker	250 feet east of Twelfth street, west	26	65	Ded.
1876	July 14	"	233 feet west of Thirteenth street to Broad street	26	325	N. R. D.
1882	June 21	Thurlow	Thirteenth street, east	3	152	Ded.
1882	Oct. 21	Tiernan	Reed street, south	26	164	N. R. D.
1874	Dec. 1	Winter	Eleventh street, east	1	70	N. R. D., not graded.
1874	Dec. 1	"	Eighth street to Ninth street	1	463	"
1883	Nov. 5	Wheat	Wharton street to Reed street	1	450	"
1878	June 21	Wilson	Twenty-second street, east	30	106	"
1874	July 17	Watt	170 feet south of McKean street to Snyder avenue	1	270	"
1882	Oct. 21	Fourth	McKean street to Old Second street	1	2,127	"
1876	July 14	Eighth	Jackson street to Moyamensing avenue	1	550	"
1877	July 5	Eleventh	Snyder avenue to Jackson street	1	450	"
1877	July 5	Twelfth	166 feet south of Cantrell street to Jackson street	1	175	"
1872	Dec. 28	Thirteenth	Jackson street to Wolf street	1	79	Ded.
1875	July 14	Eighteenth	159 feet south of Tasker street to Morris street	26	300	N. R. D.
1875	July 14	Nineteenth	186 feet south of Tasker street to Morris street	26	239	"
1874	Dec. 16	Twenty-first	Tasker street, north	26	222	"
1874	Dec. 16	"	Dickinson street to Wilder street	26	165	N. R. D., not graded.
1859	May 21	Twenty-sixth	Ellsworth street to Gray's Ferry Road	30	665	"
1876	May 16	"	Wharton street to Galloway street	26	565	Ded., not graded, truck farm.
1877	Dec. 6	Thirtieth	Wharton street to Reed street	26	460	N. R. D.
1882	Oct. 21	Tasker	Passyunk avenue to Twelfth street	26	150	Ded.
1874	Dec. 16	Twenty-first	Reed street to Long Lane	26	165	N. R. D., not graded.
					22,412	

SECOND DISTRICT—Comprising that part of the city between Vine and South streets, and West Philadelphia.

Date.		Street.	From To	Ward	Dist'nce	Remarks.
1873	....	Baltimore avenue.........	Fifty-second street to Cobb's Creek	27	5,625	Ded.
18 5	Nov. 6	Belmont avenue...........	Lancaster avenue to Westminster street........................	24	350	"
1879	April 5	Baring	Ridgeway street to Forty-second street.........................	24	148	"
......	....	Court	419 Locust street, north..	5	240	N. R. D.
1881	June 24	Downing	Fifty-fifth street, east	24	267	"
1875	May 11	Egglesfield..................	Fortieth street to Forty-first street..............................	24	580	"
18 7	July 5	Fairmount place	150 feet west of Thirty-second street, west	27	232	Not on plan.
1878	Dec. 24	Fisher's avenue............	Market street to Haverford street..................................	24	2,475	Ded.
1876	July 10	Garden	Thirty-second street, east..	24	300	N. R. D.
1877	July 5	Howell	Thirty-third street to Thirty-fourth street	24	495	"
1878	June 21	Jones	Seventeenth street to Eighteenth street........................	9	446	Ded., relay.
1879	Oct. 15	Juniper	Arch street to Budden alley	10	140	" "
1872	May 13	Lombard	Forty-third street to Forty-fourth street..........................	27	525	"
1883	June 27	"	Sixtieth street, west..	27	100	N. R. D.
1879	Oct. 15	Lydia..........................	Aspen street to Silverton street	24	400	"
1882	June 7	Locust	Thirty-third street to Thirty-fourth street.......................	27	580	Ded.
1874	July 17	Market........................	Sixtieth street to Sixty-third street	24–27	1,203	"
1879	Oct. 15	Markoe	Aspen street to Silverton street...................................	24	400	N. R. D.
1883	Nov. 5	McFarland	Between Forty-third street and Brooklyn street............	24	165	"
1877	Oct. 27	Oregon	Thirty-eighth street to Thirty-ninth street	24	626	Ded.
1872	Sept. 21	Paschall	Fifty-fifth street to Fifty-sixth street............................	27	540	N. R. D.
1883	Nov. 16	Pearl...........................	Thirty-third street to Thirty-fourth street	24	410	Public highway.
1874	June 13	"	Thirty-fifth street, west..	24	622	N. R. D.
1877	Jan'y 15	Perry place	South street, north	7	115	Private court, not on plans.
1879	April 5	Pine	Eighth street to Broad street	7	2,860	Ded., relay.
1879	July 1	Paxon	Lancaster avenue to Pear street....................................	24	325	N. R. D
1878	April 22	Sansom	Forty-second street to Forty-third street	27	650	"
1878	April 22	"	Forty-sixth street to Forty-seventh street.........................	27	539	"
1875	July 30	Spring Garden	Thirty-third street to Thirty-fifth street	24	810	Ded.
1876	Nov. 3	Sycamore.....................	Locust street to Spruce street	8	450	N. R. D.
1878	Jan'y 21	Sylvan.........................	194 feet west of Fortieth street to Forty-first street........	24	371	"
1881	June 16	St. Stephen's place........	Chant street to Market street.......................................	9	275	"
1881	June 24	Smedley......................	Thirty-sixth street, west..	24	257	"

SECOND DISTRICT—Continued.

Date.		Street.	From To	Ward	Dist'nce	Remarks.
1882	Feb. 16	Street yet to be named..	Thirty-third street east	27	300	
1877	June 5	Tenor place	Fourth street, west	5	320	N. R. D., 18 ft. court.
1873	July 26	Vine	Sixty-fifth street to Sixty-eighth street	24	1,570	N. R. D. (injunction).
1874	Dec. 24	Viola	Forty-first street west	24	375	"
1873	Nov. 28	Walnut	Fifty-sixth street to Fifty-seventh street	27	570	"
1874	June 3	"	Thirty-second street, east	27	777	"
1878	April 22	Twenty-third	Chestnut street to Simes street	10	390	Ded.
1874	June 13	Thirtieth	Locust street to Spruce street	27	520	N. R. D.
1875	July 30	Thirty-first	Powelton avenue to Spring Garden street	24	1,000	"
1881	Dec. 31	"	Spring Garden street to Haverford street	24	425	"
1882	June 7	Thirty-second	Locust street to Marston avenue	27	530	Partly ded.
1882	June 7	Thirty-third	Locust street to Spruce street	27	550	N. R. D.
1876	May 16	Thirty-seventh	270 feet west of Aspen street to Mantua street	24	100	Ded.
1874	March 7	Forty-first	Westminster street to P. R. R.	24	365	N. R. D.
1878	April 22	Forty-third	Chestnut street to Sansom street	27	285	" [nut street, bal. ded.
1878	April 22	Forty-fourth	Market street to Chestnut street	27	559	N. R. D. from Ludlow st. to Chest-
1878	April 22	"	Walnut street to Spruce street	27	871	"
1878	April 22	Forty-fifth	" " " "	27	860	"
1875	May 11	Forty-sixth	Junction R. R. to Woodland avenue	27	1,200	Ded.
1875	May 11	"	Baltimore street to Chestnut street	27	2,668	N. R. D.
1874	July 17	Forty-seventh	Locust street to Market street	27	1,540	Ded., Locust street to Walnut street.
1881	Nov. 22	Forty-eighth	Seneca street to Westminster street	24	510	N. R. D.
1876	Nov. 21	Forty-ninth	Lancaster avenue to P. R. R.	24	520	"
1874	May 1	Fiftieth	Aspen street to Westminster street	24	1,375	"
1876	Nov. 21	Fffty-sixth	Market street to Chelsea street	24	1,385	"
1876	Nov. 21	"	Oregon street to Haverford street	24	640	"
1880	Dec. 21	Sixty-third and a half...	Vine street to Bellevue street	24	250	Ded.
					43,726	

THIRD DISTRICT.

Date.		Street.	From. To.	Ward	Dist'nce	Remarks.
1873	Mar. 27	Agate	Allegheny avenue to Clearfield street	25	770	N. R. D.
1873	Dec. 20	Almond	Venango street to Tioga street	25	760	"
1877	Oct. 27	Amber	Hart's Lane to Isabella street	25	177	"
1877	Dec. 6	American, west side	Berks street to Norris street	19	550	"
1877	Dec. 6	" east side	" north	19	246	Ded.
1880	June 25	Ann	Frankford avenue to Belgrade street	25	3,025	"
1874	July 17	Belgrade	Tioga street to Venango street	25	760	N. R. D.
1865	Oct. 2	Berks, south side	Second street to Philip street	19	166	"
1865	Oct. 2	" both sides	Philip street to Third street	19	550	"
1865	Oct. 2	" south side	Third street to Orianna street	19	143	"
1865	Oct. 2	" both sides	Orianna street to Fourth street	19	245	"
1865	Oct. 2	" south side	Fourth street to Germantown Road	19	585	"
1876	July 6	Buckius	131 feet west of Thompson street to Frankford Creek	25	900	"
1882	July 21	Berks	Howard street to Second street	19–20	829	Ded.
1882	Mar. 20	Bridge	67 feet northwest of Young street to Frankford Creek	25	37	"
1872	Nov. 23	Cambria	R. R. to Tussullum street	25	250	N. R. D.
1875	May 11	"	Front street to Fifth street	25	2,670	Opened by jury from Second to Fifth
1876	July 6	"	Sixth street to Germantown avenue	25	1,600	Opened by jury.
1876	July 6	Cedar	Ann street to Allegheny avenue	25	1,715	N. R. D.
1878	Dec. 23	Charter	Amber street to Trenton avenue	31	440	Ded.
1871	Dec. 18	Chatham	Fremont street to William street	25	145	N. R. D.
1876	July 6	"	Ann street to Clearfield street	25	975	"
1872	Oct. 21	Clearfield	Jasper street to Kensington avenue	25	550	"
1873	May 9	Coleville	Front street to Cumberland street	19	370	"
1882	June 21	Coral	Rush street to Ambrose street	25	185	"
1883	Mar. 5	"				
1876	July 6	Division	Miller street to Cedar street	25	600	"
1873	Dec. 20	Edgemont	Venango street to Erie street	25	815	"
1876	Nov. 3	Emerald	270 ft. north of Westmoreland street to Harrowgate Lane	25	1,625	"
1880	Feb. 16	"	271 feet south of Somerset street, south	25	9	"
1883	June 21	"	From 100 feet south of Orleans street southwest	25		
1876	Nov. 3	Emerick	245 feet northwest of Belgrade street to Ireland street	18	120	Court; cannot be placed on city plan.
1882	Oct. 7	Ennis	Farron street to Beach street	18	136	Public highway.
1873	Apr. 26	Erie	Richmond street to Frankford Road	25	4,620	N. R. D.
1876	Nov. 3	"	From "L" street to Old Front street	25	820	"
1875	Nov. 6	"	Second street to Sedgeley street	25	50	"

THIRD DISTRICT.—Continued.

Date.		Street.	From. To.	Ward	Dist'nce	Remarks.
1883	May 28	Erie	Sixth street to Marshall street	25	230	Ded.
1874	Dec. 1	Fisher	Clearfield street to Division street	25	265	N. R. D.
1875	June 22	Franklin	Somerset street to Indiana avenue	25	1,100	Ded. [by jury.
1874	May 1	Foulkrod	Frankford street to Tucker street	23	400	Frankford street to Tacony opened
1874	July 17	Gaul	Tioga street to Venango street	25	765	N. R. D.
1883	June 27	Germantown avenue	Lehigh avenue to 28 feet south of Somerset street	25	475	Relay.
1874	Dec. 1	Harrison	Penn street to Leiper street	23	250	N. R. D.
1871	May 22	Harrowgate Lane	Kensington avenue to Frankford road	25	1,485	Opened by jury.
1875	Nov. 6	Hutchinson	Somerset street, north	25	90	Ded.
1883	Nov. 16	"	Lehigh avenue to Somerset street	25	500	
1875	May 11	Indiana	Eighth street to Ninth street	25	270	"
1872	Mar. 25	Jasper	Hart's Lane to Cambria street	25	450	N. R. D.
1883	Nov. 16	James	Edgemont street to Thompson street	25	240	
1876	July 6	Jefferson	318 feet northeast of Plum street to Meadow street	23	150	"
1875	Oct. 15	Kip	Tussullum street to Cambria street	25	370	"
1883	June 27	Kirkbride	183 feet southeast of Garden street to Geiger street	25	35	Public highway.
1876	Nov. 3	"L"	Kensington avenue, 50 feet north of Erie street	25	560	N. R. D.
1873	June 12	Lambert	Venango street to Westmoreland street	25	2,300	"
1878	June 21	Lawrence	Oxford street to Germantown avenue	19	300	Ded.
1882	Mar. 20	Lehigh ave., south side	Richmond street to Salmon street	25	255	Public highway.
1883	June 27	Livingstone	Between Clearfield street and Cemetery avenue	25	270	N. R. D.
1872	Mar. 25	Jasper	Reading R. R. to Somerset street	25	715	"
1876	Mar. 27	Memphis	Allegheny avenue to Clearfield street	25	770	"
1876	Mar. 27	Mercer	94 feet south of Geisler street to Ann street	25	482	"
1870	Oct. 13	Montgomery	Second street to Bodine street	19	560	"
1880	Nov. 26	Margaretta	Worth street to Trenton avenue	23	225	"
1874	Dec. 1	Ormes	Cambria street to Indiana avenue	25	550	"
1879	Dec. 2	Orange	Belgrade street to Hockley street	18	250	Private alley.
1882	June 21	Orianna	Lehigh avenue to Somerset street	25	500	N. R. D.
1883	May 28	Orkney	Somerset street to Cambria street	25	550	Ded.
1874	Dec. 31	Penn	Oxford Road to Harrison street	23	459	N. R. D.
1874	Dec. 31	"	Wakeling street to Dyer street	23	458	"
1875	Apr. 19	Philip	Lehigh avenue to Cambria street	25	1,100	Ded.
1881	June 24	Ruan	Main street to Franklin street	23	410	N. R. D.
1875	Nov. 6	Sedgeley	Third street to Erie street	25	1,035	"
1873	Dec. 20	Tioga	Gaul street to Frankford Road	25	2,630	"

THIRD DISTRICT.—Continued.

Date.		Street.	From. To.	Ward	Dist'nce	Remarks.
1875	July 10	Tioga	Fifth street to Sixth street	25	550	N. R. D.
1874	July 17	Tulip	200 feet south of Westmoreland street to Erie street	25	3,315	Partly ded.
1873	July 1	Venango	Almond street to 75 feet east of Tulip street	25	1,710	Ded.
1876	Mar. 27	Westmoreland	Waterloo street to Lambert street	25	4,311	Partly ded.
1876	Mar. 27	"	Kensington avenue to Frankford road	25	1,550	"
1873	Dec. 20	William	Frankford road to Kensington avenue	25	1,260	N. R. D
1883	June 21	Wishart	168 feet northwest of Frankford road, northwest	25	339	Ded.
1876	Nov. 4	Witte	Ann street to Clearfield street	25	800	N. R. D.
1879	Dec. 8	Wildey	166 feet southwest of Ash street, southwest	18	434	"
1880	Dec. 8	Worth	Tucker street, south	23	216	"
1883	Mar. 21	Waterloo	530 feet northeast of Westmoreland street, northeast	25	250	"
1883	May 28	Wellington	Jasper street to Kensington avenue	25	580	Ded.
1878	June 21	Second	Cambria street to Butler street	25	5,000	Old turnpike.
1875	Apr. 19	Third	Cambria street to Reading R. R	25	1,130	Ded.
1882	Mar. 20	Fifth	Luzerne street to North Penn R. R	25	1,409	"
1875	June 22	Seventh	Somerset street to Indiana street	25	1,100	"
1875	June 22	Eighth	" " " "	25	1,100	"
					72,783	

FOURTH DISTRICT.

Date.		Street.	From. To.	Ward	Dist'nce	Remarks.
1879	Jan. 16	Allegheny, south side...	East of Sixteenth street to Fifteenth street..................	28	402	N. R. D.
1879	Oct. 15	"	South side Seventeenth street to Nineteenth street.......	28	919	"
1870	Sept. 19	Berks..........................	Twenty-fifth street to Ridge avenue..........................	28	725	"
1874	Dec. 2	Cambria......................	Carlisle street to Fifteenth street............................	28	210	Stricken from conformed plans.
1871	Apr. 25	Carlisle.......................	Monument Cemetery to Norris street..........................	28	125	N. R. D.
1871	Apr. 25	"	Diamond street to Susquehanna avenue........................	28	525	Partly ded.
1880	Dec. 21	"	North of York street to Cumberland street..................	28	142	N. R. D.
1874	Dec. 2	Clearfield....................	Nicetown to Thirty-fourth street..............................	28	1,125	Opened by jury.
1875	Mar. 29	Columbia......................	Across bridge at Thirty-first street...........................	29	75	Ded.
1873	June 23	Cumberland..................	Delhi street to Germantown road..............................	28	60	N. R. D.
1882	June 21	Dakota........................	Thirtieth street to Thirty-first street...........................	28	450	Ded. [to Twentieth streets.
1883	June 27	Diamond.......................	Nineteenth street to Twentieth street..........................	28	446	Ded. from 80 feet west of Nineteenth
1875	Nov. 6	Fletcher.......................	295 feet west of Thirtieth street to Thirty-first street....	28	155	Ded.
1873	May 9	Glenwood......................	Eleventh street to Germantown avenue........................	28	150	N. R. D.
1875	Jan. 22	Hare............................	Twenty-sixth street to Taney street............................	15	220	"
1876	Nov. 4	Harlan..........................	Eighteenth street to Nineteenth street........................	29	450	Not on city plan.
1881	Dec. 31	Judson..........................	Montgomery avenue to Berks street.............................	28	550	N. R. D.
1883	Jan. 27	Lambert........................	Diamond street, north...	28	....	Ded.
1877	Nov. 28	Lehigh..........................	Sydenham street to Eighteenth street..........................	28	1,159	N. R. D.
1874	Dec. 1	Master..........................	Twenty-fifth street to Twenty-seventh street...............	29	900	"
1880	Feb. 16	"	Twenty-eighth street to Thirty-first street..................	29	1,350	Ded.
1875	Nov. 6	Nevada.........................	257 feet west of Thirtieth street to Thirty-first street....	28	205	Ded.
1872	Apr. 15	Norris...........................	Ninth street to Tenth streets....................................	20	450	N. R. D.
1871	....	"	Twenty-second street to Twenty-fourth street.............	28	900	Partly ded.
1874	Dec. 1	Oxford..........................	Twenty-ninth street to Thirty-third streets.................	29	1,800	Ded.
1874	Mar. 7	Pennsylvania avenue...	Eighteenth street, west..	15	213	Opened by jury.
1880	May 25	Park.............................	Somerset street, south..	28	300	N. R. D.
1873	May 9	Summerville................	Germantown avenue to Warnock street......................	28	179	Ded.
1873	May 9	"	West of Mervine street to Twelfth street.....................	28	180	"
1880	Oct. 11	Sheridan.......................	Montgomery avenue to Berks street...........................	20	550	N. R. D.
1881	May 23	Sharswood....................	Twenty-fifth street to Twenty-seventh street...............	29	896	Public highway.
1883	June 27	Susquehanna................	Nineteenth street to Yuber street..............................	28	222	Ded.
1883	June 27	South College avenue...	Twentieth street, west..	29	2,050	Public highway.
1875	Nov. 6	Taylor..........................	Montgomery avenue to Berks street...........................	28	550	Ded.

FOURTH DISTRICT.—Continued.

Date.		Street.	From. To.	Ward	Dist'nce	Remarks.
1868	July 10	Township Line road.....	Municipal Hospital to Westmoreland street..................	28	3,350	Partly vacated.
1883	Mar. 21	Turner........................	Twenty-fifth street to Twenty-sixth street....................	29	450	Ded.
1876	Nov. 21	Willington	276 feet north of Montgomery avenue to Berks street...	28	250	"
1880	May 25	Wright........................	Twenty-fourth street to Twenty-seventh street............	29	1,350	N. R. D.
1883	May 28	"	Twenty-first street to Twenty-second street................	29	455	"
1873	May 9	Eleventh	Indiana avenue to Glenwood street............................	28	515	"
1876	July 14	Twelfth	Dauphin street to Lehigh avenue................................	28	2,150	"
1877	Jan. 5	Thirteenth	Dauphin street to Susquehanna avenue........................	28	580	"
1877	July 5	Fifteenth	North of Dauphin street..	28	4,672	"
1881	Dec. 5	"	Indiana avenue to Allegheny avenue..........................	28	1,135	Partly ded.
1883	Nov. 16	"	Montgomery avenue to Norris street..........................	28	1,100	
1878	Dec. 3	Sixteenth....................	York street to Cumberland street...............................	28	550	N. R. D.
1883	Nov. 16	"	Herbrin street to Norris street...................................	28	925	
1871	Mar. 7	Seventeenth................	Susquehanna avenue to Lamb Tavern road................	28	1,050	Ded.
1872	Apr. 15	Eighteenth	Diamond street to Susquehanna avenue......................	28	570	"
1877	July 5	Twentieth...................	36 feet north of Dauphin street to Arlington lane.........	28	100	"
1873	Apr. 5	Twenty-third	Norris street to Arlington lane...................................	28	430	N. R. D.
1879	Mar. 29	Twenty-fourth.............	Nicholas street to Columbia aveuue...........................	29	194	"
1882	Oct. 21	"	Berks street to Norris street......................................	28	550	Ded.
1878	Apr. 9	Twenty-sixth	Master street to Jefferson street.................................	29	505	"
18 8	June 21	Twenty-seventh...........	Diamond street to Susquehanna avenue.......................	28	570	N. R. D.
1883	July 6	Twenty-eighth	Sedgeley street to Susquehanna avenue......................	28	733	"
					40,797	

Date.		Street.	From. To.	Ward	Dist'nce	Remarks.
1883	June 21	Allen's lane	Mt. Airy Works to Germantown avenue	22	1,080	
1876	Oct. 25	Atlantic	Germantown R. R. to Township Line road	28	1,220	Ded. 40 feet wide.
1883	May 28	Angle	Old York road, west	25	100	Public highway.
1883	Nov. 16	Boynton	From present dead end southeast 250 feet	22	250	
1878	Dec. 23	Centre	Wilson street, east	22	675	N. R. D.
1878	" 31	Clapier	McKean street to Wissahickon avenue	22	1,550	Relay.
1882	Mar. 20	Clivedon	Germantown avenue to Morton street	22	600	N. R. D.
1882	June 7	Cumberland	Mill street, southeast	22	300	"
1875	Oct. 23	E. Washington lane	Crittenden to Township Line	22	650	"
1883	June 21	Garfield	Between Wakefield street and Germantown avenue	22	917	"
1878	Apr. 9	Germantown avenue	From 233 ft. south of Abington street to Sedgwick street.	22	6,450	
1881	Dec. 12	Good	Germantown avenue to Berden street	22	700	N. R. D.
1883	July 6	Harvey	Wayne street to Morris street	22	1,100	Ded.
1872	Mar. 13	Humboldt	Reading R. R. to Tenth street	25	350	"
1876	July 6	Mercer	Jefferson street to Bringhurst street	22	600	"
1878	June 21	Mt. Airy	Chestnut Hill R. R. to Sullivan street	22	690	N. R. D.
1883	July 6	Nicetown lane	Twenty-second street to Cottage lane	28	400	Ded. 50 feet wide.
1875	" 10	Old York road	Tioga to Reading R. R. bridge	25	2,550	Old turnpike.
1876	May 16	Ontario	Sixteenth street to seventeenth street	28	440	N. R. D.
1873	July 1	"	Nineteenth street to Twentieth street	28	450	"
1875	May 11	Ruscomb	East Logan street to Germantown R. R	22	350	"
1883	June 21	Sharpnack	Musgrove street to Chew street	22	739	Ded.
1881	Mar. 23	Springer	Main street to Musgrove street	22	1,135	N. R. D.
1875	July 10	Tioga	Sixth street to Seventh street	25	480	Partly ded.
1875	July 10	"	Twelfth street to Germantown avenue	25	425	N. R. D.
1883	Nov. 16	Township Line road	Manheim street to School street	22–28	2,750	
1878	Dec. 3	Venango	Seventeenth street to Eighteenth street	28	455	N. R. D.
1879	July 1	Washington lane	Germantown avenue southwest to dead end	22	628	"
1883	July 6	Willow Grove avenue	Thirtieth street to Thirty-fifth street	22	2,700	
1883	July 6	Thirtieth	Chestnut Hill avenue to Union street, and southeast of Southampton street to Willow Grove avenue	22	3,035	
					33,769	

MANAYUNK DISTRICT.

Date.		Street.	From To	Ward	Dist'nce	Remarks.
1875	July 14	Airy	257 feet south of Lofty street to Penn street	21	100	N. R. D.
1883	Oct. 30	Bolton	Ridge avenue to Mitchell street	21	600	"
1883	Mar. 5	Elizabeth	Mifflin street to Indian Queen lane	28	200	"
1883	Nov. 15	East	Terrace street, northeast	21	87	
1871	April 5	Ezekiel	Shur's lane to Markle street	21	470	Ded.
1883	June 21	Fleming	Between Grape street and Martin street	21	220	Partly ded.
1881	June 16	Fountain	Pechin street to southwest of Ridge avenue	21	257	
1883	June 21	"	Northeast of Washington street to Smick street	21	137	Ded.
1876	Nov. 4	Hermit lane	Pechin street to Ridge avenue	21	925	"
1876	May 16	Indian Queen lane	Northeast of Thirty-fifth street to Scott's lane	28	127	Not on city plans.
1879	Oct. 15	Jefferson	Cresson street, east	21	25	Ded.
1882	Nov. 4	James	Northeast of Houghton street to Rosina street	21		
1879	Oct. 15	Jefferson	Northeast of Linden street to Wood street	21	146	Ded.
1883	Nov. 16	"	Ridge avenue to Mitchell street	21	500	
1876	Nov. 21	Kram's avenue	Northeast of Mitchell street to Ridge avenue	21	202	N. R. D.
1881	May 23	Lebering	West of Fleming street to Belair street	21	219	"
1882	No . 4	Linden	Jefferson street, north	21	300	"
1876	May 20	Main	960 feet south of Shur's lane to old borough line of Manayunk	21	500	Ded. 40 feet wide.
1881	June 1	Margaret	Magnet street to Spring street	21		
1883	Mar. 30	Mansion	Jefferson street, southeast to Ripka avenue	21	440	N. R. D.
1881	Nov. 22	Martin	Pechin street to Manayunk avenue	21	51	
1875	June 25	Mifflin	Reading R. R., west	28	500	N. R. D.
1883	June 21	Ogle	Northwest of Fountain street, northwest	21		Ded.
1883	Oct. 30	Pechin	South of Shur's lane to Kingsley street	21	176	"
1882	Nov. 4	Penn	Freeland street to Mitchell street	21	275	Partly ded.
1882	Nov. 4	Ridge avenue	Northwest of Gerhard street, northwest	21	19	
1882	June 7	Smick	East to west side of Smick street	21	50	
1877	June 5	Wood	Centre street, northwest	21	145	N. R. D.
					6,651	

RECAPITULATION.

First District	22,412 feet.
Second District	43,976 "
Third District	73,883 "
Fourth District	40,797 "
Germantown District	33,769 feet.
Manayunk	6,651 "
	221,488 feet, or 41 miles and 5,008 feet.

REPORT

ON THE

OPERATIONS OF THE SHOP

DURING 1883.

PHILADELPHIA WATER DEPARTMENT,
January 31, 1884.

COL. WILLIAM LUDLOW,
Chief Engineer:

SIR:—I submit the following statement of the operations of the Cherry street shop, for the year ending December 31, 1883.

Respectfully,
JAS. F. NEALL,
Superintendent of the Shop.

General Statement of Material and Labor.

DEBIT.

To stock on hand January 1, 1883	$13,864	05
641,947 lbs. cast iron castings	14,798	33
Patent grate bars	957	81
20,071⅜ lbs. brass castings	4,415	69
1,745⅞ " gun metal	314	29
3,056 " malleable castings	213	92
3,897 " steel (assorted)	371	15
83,034½ " wrought iron (assorted)	2,675	05
167 tons coal	946	35
80 bushels coke	6	80
10,236 feet lumber (assorted)	505	18
2 cords wood	15	20
690 stop boxes	2,415	00
4 air stop boxes	8	00
92 stop risers	46	00

99,995 lbs. lead	$4,939 75
Bolts and nuts	1,501 13
Gum rings, valves, and assorted gum	535 49
Wrought iron pipe and fittings	1,603 14
Hardware	1,594 35
Water meters (assorted)	1,065 96
Railroad tickets	1,138 75
Machinery	761 48
Wages paid hands	33,327 35
Paints and oils	335 22
Brooms and brushes	12 86
Leather	90 79
Brass fittings	3,812 63
Gauges and repairs to same	451 25
75 lbs. babbitt metal	19 88
Galvanizing	243 60
Old metals	167 60
Incidentals	85 26
Rope and gasket	467 35
Sponge cloth	198 00
Repairs to buildings and grounds	10 00
Ice	33 94
Hauling	142 00
Total amount of debit	$94,090 60

Credit.

Repairs and supplies to First District	$6,811 16	
" " " Second "	7,388 13	
" " " Third "	6,632 36	
" " " Fourth "	29,202 21	
" " " Germantown	7,221 55	
" " " Manayunk	1,596 06	
		$58,851 47
To Fairmount Station.		
Repairs to machinery	1,476 82	
" boilers	62 39	
Improvements to buildings and grounds	600 18	
		2,139 39
To Spring Garden Station.		
Repairs to machinery	5,723 14	
Improvements to machinery	37 73	
Repairs to boilers	1,835 08	
Buildings and grounds	583 92	
Extension	2,246 88	
		10,426 75

To Belmont Station.

Repairs to machinery	$3,339 16	
" boilers	1,674 19	
Buildings and grounds	454 85	
Electric engine	30 73	
Nickle plating	165 76	
Submerged main	511 08	
		$6,175 77
To buildings and grounds	43 25	
" improvements, Cherry street shop	195 43	
		238 68

To Roxborough Station.

Repairs to machinery	768 09	
" boilers	827 70	
Buildings, grounds, and reservoirs	920 29	
Improvements	402 53	
Extension	227 51	
Auxiliary works, machinery	7 20	
" " boilers	19 90	
" " buildings and grounds	13 29	
		3,186 51

To Frankford Station.

Repairs to machinery	1,106 46	
" boilers	487 46	
Buildings and grounds	455 94	
Pumping water	286 50	
		2,336 36

To Kensington Station.

Repairs to machinery	2,402 48	
" boilers	1,476 61	
Buildings and grounds	203 16	
Conduit	423 34	
Pumping water	402 00	
		4,907 59

To Chestnut Hill Station.

Repairs to machinery	115 93	
Buildings and grounds	20 00	
		135 93

To Mt. Airy Station.

Repairs to machinery	$203 55	
" boilers	22 27	
Buildings and grounds	172 43	
Pumping water	3 00	
		$401 25

To Cambria Reservoir.

Repairs and supplies		359 57

To Perkiomen Survey.

Supplies		38 49

To Water Meters.

Supplies	1,008 57	
Wages	897 25	
		1,905 82

To Main Offices, 13th and Spring Garden streets	104 19	
" sale of old metals	1,026 42	
" " 4,799 ferrules, @ 50 cts	2,399 50	
" waterphone inspection	46 65	
" stock on hand January 1, 1884	12,154 55	
		15,731 31

Total amount of credit	106,834 89
Less total amount of debit	94,090 60
Balance to credit	$12,744 29

INVENTORY OF STOCK ON HAND JANUARY 1, 1884.

17	4-inch square top screws, O. S., @	$5 00	$85 00	
17	6-inch " " "	5 00	85 00	
6	10-inch " " "	8 00	48 00	
5	12-inch " " "	10 00	50 00	
16	16-inch " " "	12 00	192 00	
8	20-inch " " "	14 00	112 00	
6	30-inch " " "	20 00	120 00	
3	36-inch " " "	25 00	75 00	
				$767 00
5	4-inch square top screws, N. S., @	5 00	25 00	
30	6-inch " " "	5 00	150 00	
20	8-inch " " "	7 00	140 00	
30	10-inch " " "	9 00	270 00	
12	12-inch " " "	10 00	120 00	
3	16-inch " " "	12 00	36 00	
3	20-inch " " "	14 00	42 00	
4	30-inch " " "	20 00	80 00	
2	36-inch " " "	25 00	50 00	
				913 00
34	4-inch socket screws, @	5 00	170 00	
25	6-inch " " "	5 00	125 00	
19	8-inch " " "	6 00	114 00	
36	10-inch " " "	6 50	234 00	
				643 00
61	plug monkey screws, "	3 28		200 08
16	3-inch spindles, "	5 00	80 00	
18	4-inch " "	5 00	90 00	
36	6-inch " "	5 00	180 00	
10	8-inch " "	5 00	50 00	
22	10-inch " "	5 00	110 00	
5	12-inch " "	5 00	25 00	
				535 00
17	6-inch bands, "	5 00	85 00	
22	8-inch " "	6 00	132 00	
15	10-inch " "	7 25	108 75	
6	12-inch " "	8 50	51 00	
2	16-inch " "	9 50	19 00	
3	20-inch " "	10 50	31 50	
2	30-inch " "	25 00	50 00	
				477 25

35	stop boxes,	"	$3 00	$105 00	
42	caulking and gasket irons,	"	75	31 50	
18	drills (assorted),	"	1 00	18 00	
13½	doz. chisels (assorted), per doz.,	"	8 40	113 40	
17	chisels, with handles,	"	1 00	17 00	
2	15-lb. sledges,	"	3 00	6 00	
5	reamers,	"	2 80	14 00	
424	wooden plugs,	"	50	212 00	
					$516 90
1	doz. pick handles,			1 37	
7	" sledge "			7 00	
11	" hammer "			3 63	
1,204	lbs. gasket,	@	08$\frac{7}{10}$	104 75	
65	plug waste valves,	"	1 75	113 75	
18	" " " with rod,	"	2 00	36 00	
12	stub end straps,	"	11 50	138 00	
55	crossheads, with nuts,	"	3 00	165 00	
14	plug monkeys, complete,	"	4 50	63 00	
207	ferrules (assorted),	"	50	103 50	
149	brass plugs,	"	50	74 50	
35	picks, @ 8.50 per doz.,			24 80	
12	4-inch stops,			264 00	
2	6-inch "			50 00	
12	fire hydrants,	@	28 00	336 00	
44	plug nuts,			44 00	
2	sets tripods (unfinished),			16 12	
					1,545 42
2	sets gearing, for derrick,			100 00	
58,845	lbs. iron castings,	@	23	1,353 43	
12,895	" wrought iron,	"	03	386 85	
1,178	" steel,	"	11	129 58	
54	" malleable castings,	"	07	3 78	
453	" iron forgings,	"	12	54 36	
5,721	" unfinished brass,	"	22	1,258 62	
					3,286 62
3,440	" finished brass,	"	38	1,307 20	
5	" brass pipe,	"	60	3 00	
85	" rolled brass,	"	60	51 00	
6	" brass wire,	"	23	1 38	
12	" copper wire,	"	23	2 76	
	Finished stop sides and valves,			177 32	
1,585	feet lumber (assorted),			108 20	
246	lbs. babbitt metal,		22	54 12	

1 6-inch globe valve,			$75 00	
3 8-inch globe valves,	@	90 00		
1 turn-table (complete),			92 77	
Hardware,			204 17	
Bolts and nuts,			434 05	
Iron pipe and fittings,			20 00	
Paints, oils, and tallow,			43 46	
129 brass pump studs (assorted),			119 25	
36 " " springs,	@	50	18 00	
200 lbs. pure gum rings,	"	55	110 00	
125 pure gum valves,	"	2 00 ea.,	62 50	
4 gross sponge cloth,	"	5 50	22 00	
1 cast iron gate frame, unfinished,			59 00	
2 wrought furnaces,			25 10	
1 pressure gauge,			10 00	
				3,270 28
Total amount..				$12,154 55

Stop-cocks, Stop-cock Boxes, Frames and Covers, Cases, Fire-hydrants, Lead and Gasket delivered from Cherry Street Shop during 1883, to the Purveyor's Districts.

Districts.	4-inch stop-cocks.	6-inch stop-cocks.	8-inch stop-cocks.	10-inch stop-cocks.	12-inch stop-cocks.	16-inch stop-cocks.	30-inch stop-cocks.	36-inch stop-cocks.	Frames and covers.	Fire-hydrants.	Cases.	Boxes.	Pounds of Lead.	Bales of Gasket.
First	6	17	....	....	....	....	....	....	37	80	89	207	4,480	4
Second	2	12	....	....	....	1	....	....	67	88	92	114	10,165	7
Third	7	53	....	....	4	....	....	....	55	52	91	170	2,240	7
Fourth	14	55	12	15	31	13	6	6	184	405	128	200	59,857	14
Germantown	6	45	3	6	3	....	....	....	73	81	46	72	12,320	8
Manayunk	5	13	....	....	....	....	....	....	7	11	15	22	3,360	2
Totals	40	195	15	21	38	14	6	6	423	717	461	785	92,422	42

Stop-cocks, Fire-hydrants and Casings, Stop-boxes, Frames, Covers and Ferrules, made and fitted up at Cherry Street Shop, from January 1, to December 31, 1883.

4-inch stop-cocks.	6-inch stop-cocks.	8-inch stop-cocks.	10-inch stop-cocks.	12-inch stop-cocks.	16-inch stop-cocks.	30-inch stop-cocks.	36-inch stop-cocks.	Total number of stop-cocks.	Fire-hydrants.	Casings.	Stop-boxes.	Frames and Covers.	Ferrules. Inch. ½	Inch. ⅝	Inch. ¾	Inch. 1	Total number of Ferrules.
52	197	8	20	27	12	6	6	332	729	461	785	423	4,450	115	75	159	4,799

ARTICLES MANUFACTURED DURING 1883.

1	8-inch globe valve,			$90 00	
52	4-inch stop cocks,	@	$22 00	1,144 00	
197	6-inch " "	"	25 00	4,925 00	
8	8-inch " "	"	30 00	240 00	
20	10-inch " "	"	40 00	800 00	
27	12-inch " "	"	45 00	1,215 00	
12	16-inch " "	"	85 00	1,020 00	
6	30-inch " "	"	240 00	1,440 00	
6	36-inch " "	"	360 00	2,160 00	
729	fire hydrants,	"	28 00	20,412 00	
461	fire hydrant cases,		7 50	3,457 50	
5,006	ferrules,		50	2,503 00	
					$39,406 50

REPORT

ON THE

SURVEYS FOR THE PROPOSED CAMBRIA RESERVOIR,

AND THE

ENLARGEMENT ON THE MT. AIRY RESERVOIR,

BY

CHARLES G. DARRACH, Assistant Engineer.

PHILADELPHIA WATER DEPARTMENT,
January 1, 1884.

COL. WILLIAM LUDLOW,
Chief Engineer:

SIR:—I respectfully submit the following report of the Surveys for the new Cambria Reservoir, and the enlargement of the Mt. Airy Reservoir.

The construction of a reservoir at Thirtieth and Cambria streets was first proposed in the Report of the Water Department to Councils for 1874, and recommended by the Board of Experts in their reports of Oct. 14, 1882, and April 5, 1883.

On July 27, 1883, Councils appropriated $50,000 to commence the work. Of this amount, $10,874.27 was to be taken from unexpended balances of Water Loans, Nos. 2, 3, 4, 5, and 6, and $39,125 from Park Loan, No. 3. It was found, however, that $7,879.88 had been expended from the balances of Water Loans before the passage of the ordinance, and that the appropriation of the Park Loan for this purpose was illegal, leaving a balance of $2,994.39 only, available.

Of this amount, $2,622.69 have been expended in surveys, plans, etc., leaving an unexpended balance, January 1, 1884, of $371.70.

STATEMENT OF EXPENDITURES, COST OF SURVEYS, PLANS, CALCULATIONS, &c., FOR CAMBRIA RESERVOIR.

Surveys.—Tracing street lines, survey of property appropriated by Councils, survey of preliminary centre line of embankment, location of test bores and incidental work	$651 45
Plane-table work, including two finished tracings of an area of 160 acres, (scale 1 inch to 60 feet), one showing topography and improvements, and one showing growing crops and improvements	260 00
Test Borings.—Labor, superintendence and recording 294 holes, = 3 228.1 linear feet, including 9 holes, = 231 feet, reamed for pipe. (Pipe driven in 6 holes, = 228.6 feet; rock found in 139 holes; water in 35 holes; pipe driven in two holes to rock; maximum depth 46.8 feet; auger 3½ inches diameter; reamer 4 inches diameter)	1,773 07
Plans, sections and calculations	721 50
Office and incidental expenses	226 01
Total	$3,632 03
Paid for out of loan ... $2.622 69	
Paid for out of surplus ... 1,009 34	3,632 03

By ordinances of July 7, and Nov. 14, 1883, Councils appropriated $44\frac{74}{100}$ acres of land in the 28th Ward, lying principally in the Bellevue estate of the late William Wharton, as the site of the Cambria reservoir.

This area lies east of the Mount Peace Cemetery, north of Lehigh Avenue, and west of the proposed extension of Hunting Park Avenue. It is the highest ground on the spur dividing the waters of Saw-mill Run, a tributary of the Schuylkill, from those of Cohocksink Creek, a tributary of the Delaware.

The highest elevation of the natural surface is 148 feet, and the lowest 130 feet.

The spur is covered with a rich soil, from 12 to 24 inches deep, which is cultivated by truck farmers, with sewage and slaughter house offal. Under the soil is an impervious deposit of brick clay from one to over seven feet in thickness, which varies in quality and in color from blue to light yellow.

On the crest and the southeastern slope of the spur a deposit of reddish clayey sand and gravel underlies the clay.

These deposits cover the primary formation (mica schist), which is decomposed to various depths below the surface. Several borings failed to find hard rock at a depth of 47 feet.

Water of remarkable purity, and from the indications, in considerable quantity, is found in the hard and decomposed mica schist. On the crest of the spur it rises, in wells driven into the rock, to an elevation of 122 feet, and wherever the rock comes to the surface, springs are formed. On either side of the spur, the elevation of this water is less than on the crest, dependent upon the topography and its escape from the hard rock into and through the decomposed mica schist underlying the clay and gravel deposit.

It is evident that this water comes from a distance, as it is under pressure, and is uncontaminated by the fertilizers used in farming the over-lying land.

The Survey.—The magnetic variation of the needle was found to be 6° 6′ west of the true meridian.

Plane-table surveys were made of about 160 acres lying between Lehigh and Allegheny Avenues, and from Twenty-sixth street on the east, to the Mount Vernon and Mount Peace Cemeteries on the west.

Each of the street corners, as laid out on the city plan, was located, and the boundary lines of the area appropriated by Councils and a preliminary centre line for embankment, run.

Two hundred and ninety-four (294) test borings, aggregating 3,228.1 linear feet were driven and located, and the elevation of the water in two springs, nine wells, and thirty-five test borings determined.

Maps, Sections, and Plans.—A topographical map, scale one inch to 60 feet, has been made, showing contours at each foot of elevation, the location of each of the test borings, wells, and springs, all private and public improvements and property lines; also, a map on the same scale, showing the growing crops and gardens, improvements, etc., but omitting the contours; as well as a topographical map, scale one inch to 200 feet, showing contours at elevations three feet apart, the plans of the reservoirs and mains, the proposed location and grade of streets, wells, springs, test borings in which water was found, and the lines upon which the sections are developed.

Sections showing the natural surface of the ground and the under-lying strata have been made:—

1st. Through the preliminary centre line of reservoir bank.

2d. Through the proposed centre line of reservoir bank.

3d. Through the crest of the spur.

4th. Three across the ridge.

5th. On the line of 26th, 27th, 28th, 29th, 30th, 31st and 32nd streets, and the western boundary line of the appropriated land.

From these data the proposed shape, capacity and details of construction have been designed, the lines and grades of the adjacent streets modified, and the quantity and character of the materials to be used, computed.

Plans have been made of the reservoir, of the embankments and masonry, and of inlet, outlet and drain pipes.

General Description of Cambria Reservoir.

The reservoir is divided by an embankment into two nearly equal divisions. The main embankment is 4,480 feet in length, exclusive of the outlet chamber, 50 feet long, and has a top width of 20 feet, at an elevation of 170 feet. The outer slope has an inclination of one foot vertical to one and a half horizontal; the inner or water slope, one foot vertical to two feet horizontal, and its toe is at an elevation of 135 feet above city datum.

The division embankment, measured from the outlet chamber to the intersection of its centre line with that of the main bank, is 700 feet long. It has a width on top of 15 feet, at an elevation of 168 feet. Each of its slopes is one vertical to one and one-half horizontal.

The capacity and dimensions of the basin, above the level of 135 feet city datum, are:—

	N. E. Section.	S. W. Section.
Area at foot of slope (135)	380,781 square feet.	379,620 square feet.
" " surface of water (165)	529,851 " "	523,908 " "
Capacity in U. S. gals., with depth of 30 feet,	101,227,322	101,327,371

a total of 202,554,693 gallons.

If the water level is raised one foot, to (166) C. D., the capacity will be increased to 210,000,000 gallons.

The outlet chamber is located at the eastern end of the division bank opposite Cambria street, and near its intersection with 28th street and Hunting Park avenue.

According to the drawings, it is built on hard rock, of hydraulic masonry, and lined on the inside with Portland cement. It is provided with four gates from each section, two to take the water from the lower, and two from the higher water levels. Each pair of gates is sufficient to discharge 100,000,000 gallons in 24 hours.

Eight mains, each 36 inch diameter, are built into the masonry, and all the valves are placed in the area between the wing walls supporting the main banks, and outside of the reservoir.

Two of these mains connect with those from the Spring Garden station, and can be used to cut the reservoirs out of service or to convey water to the East Park reservoir, should a gravity supply be hereafter provided for; one of them is carried down 29th street, to supply the western Cambria distribution, and overflow, if required, into the Spring Garden and Corinthian reservoirs; two are carried east on Lehigh avenue, one to supply the southern Cambria distribution, and the other the Lehigh reservoirs; one goes east on Cambria street, to supply the eastern distribution; one northeast on Hunting Park avenue, to supply the higher levels on the spur; and one north and west to supply Manayunk.

Two 36-inch drainage pipes are provided, one from each section, carried through the natural ground, on rock, at the west end of the division embankment, where they may discharge into a sewer on 30th street, to empty into Saw-mill Run.

The Construction of the Reservoir.

The reservoir will be built in excavation and embankment. The necessary materials, except coarse gravel and stone, can be obtained from the ground appropriated by Councils and from the vicinity, from excavations made in preparing the base of the banks, from the excavation within the embankments to obtain the required capacity and to grade the bottom, and from grading the streets and lots adjacent.

These materials are to be laid in courses four inches to five inches deep, each course to be dampened with sprinklers and rolled with heavy grooved rollers, the layers of different materials lapped to break joints, and the junctions with the masonry rammed and puddled.

The various kinds of material will be so disposed that the soil and decomposed mica schist will form the outer portion of the bank, the reddish clayey gravel and sand the centre, and the yellow and blue clay the inner or wet slope. The clay will prevent leakage, and the inferior materials will support the clay and resist the water pressure.

The division embankment, having water on both sides, is built entirely of clay.

There is at each end of the reservoir a roadway ten feet wide, with a gradient of seven feet in 100 feet, leading from the street to the top of the embankment.

Estimates of Material and Costs.

Embankments—net, plus 20 per cent. for settlement.

Main embankments............	515,160	cubic yards.			
Division "	50,370	"			
Clay on bottom, 2 feet deep...	61,963	"			
	627,493	"	at	40	$250,997 20

Total excavation.................670,353 cubic yds.				
Surplus wasted....................	42,860	" at	30	$12,858 00
Blue clay...........................	20,442	" at	70	14,309 40
Gravel on bottom	8,000	" at	$1 00	8,000 00
Sodding (approx.)...............	30,000 square yds. at		30	9,000 00
				$295,164 60

Outlet Chamber.

Excavations..	$1,000 00	
Foundation masonry, 1,300 cubic yards, at $7.......	9,100 00	
Concrete, 160 cubic yards, at $8.........................	1,280 00	
Masonry, 3,500 cubic yards, at $10......................	35,000 00	
Coping, 1,620 cubic feet, at 80c..........................	1,296 00	
Eight 36-inch pipes, 25 feet 5 inches long............	4,000 00	
Eight 36-inch stops..	2,800 00	
Eight gates and screens....................................	7,200 00	
		$61,676 00

Drain Pipes.

500 feet 36-inch pipe.......................................	5,000 00	
Two 36-inch stops..	600 00	
		5,600 00

Revetment.

Coping stones, 375 cubic yards, at $15.................	$5,625 00	
Revetment, laid dry: Main Bank, 10,565 cubic yds, Division Bank, 3,925 cubic yards—14,490 cubic yards, at $4..	57,960 00	
In cement: Main Bank, 5,840 cubic yards; Division Bank, 1,430 cubic yards—7,270 cubic yards, at $7..	50,890 00	
Concrete: Main Bank, 2,365 cubic yards; Division Bank, 410 cubic yards—2,775 cubic yards, at $8,	22,200 00	
		136,675 00
Fence, 4,525 lineal feet, at $1..		4,525 00
Total—210,000,000 gallons, at $2,398 per million...............		$503,640 60

Estimate by experts of 1883–4, for a capacity of 150,000,000 gallons, at $2,500 per million....................................	$375,000 00

Note.—If revetment is reduced one-third, the cost will be:

210,000,000 gallons, at $2,179 per million..........................	$457,621 80

The Enlargement of the Mt. Airy Reservoir.

The enlargement of the reservoir capacity at Mt. Airy, Twenty-second Ward, was proposed to Councils in 1881, and recommended by the Commission of 1882–3.

The necessity for additional reservoir and subsidence capacity is evident from the following facts: The present reservoir has a capacity for but 4,390,000 gallons, or about 2½ days supply for 32,000 people; the water is conveyed to it in a 20-inch pipe 3½ miles long, crossing the Wissahickon Valley by an inverted syphon which is under a maximum hydrostatic pressure of 115 pounds per square inch.

A serious accident to this pipe would cut off the water supply to Germantown and Mt. Airy.

The proposed addition is east of, and adjacent to the present reservoir, between Allen's lane and the proposed revised location of Gowan avenue, and west of a line 150 feet from, and parallel to, the west building line of Germantown avenue.

The area required for the proposed reservoir is 14 acres.

The surveys have cost $779.76, paid for out of surplus, and itemized as follows:

Enlargement of Mt. Airy Reservoir, Cost of Surveys, Plans, Calculations, &c.

Surveys.—Tracing street lines, and locating test borings..............	$62 75
Plane-table Survey.—Including finished tracing of 27 acres, scale 1 inch to 40 feet, showing topography and improvements, &c.,	139 50
Test Borings.—Labor, superintendence and recording 84 holes = 775½ feet, all to rock (maximum depth 17.8 feet)....................	220 51
Plans, sections and calculations...	357 00
	$779 76

The greater part of the area required is owned by the estate of the late James Gowan and Messrs. Miller and Yates. There are on the property two stone dwellings and several frame outbuildings and hot-houses.

The highest elevation of the natural surface is 367 feet, and the lowest 340 feet, C. D., hard rock being eight to ten feet deeper.

The stratification is similar to that at the Cambria reservoir site, although the clay is less in quantity and of inferior quality.

Plane-table surveys were made of about 27 acres; eighty-four (84) test borings were driven to hard rock, aggregating 775½ linear feet.

A topographical map has been prepared, scale 1 inch to 40 feet, showing contours at each foot of elevation, the location of the test borings, all public and private improvements, property and street lines, the plan of the proposed reservoir, and the revised street lines; also, a topographical map, scale 1 inch to 200 feet, contours 5 feet apart, showing plan of reservoir and adjacent streets.

Sections have been made showing the natural surface and stratification of the ground on parallel lines 100 feet apart, running across the property.

From the data obtained, the designs for the proposed reservoir have been made.

The embankment (of which the eastern bank of the old reservoir forms a part), will be 2,570 feet long, and 20 feet wide on top, at an elevation of 367 feet.

The slopes, both inside and out, are one foot vertical to two feet horizontal.

With the water surface at the level of 363 feet, and depths varying from 13 to 28 feet, the reservoir will have a capacity of 55,286,000 gallons. It is built chiefly in excavation, the bottom being in hard mica schist.

The outlet chamber is located at the northeast corner, where the water is deepest.

Outlet mains to Germantown can be laid from this point, on Gowan avenue, to and down Boyer street, with but little cutting, and below the hydraulic gradient.

The disposal of the material in the banks is similar to that in the designs for the Cambria reservoir. The revetment is laid on the yellow clay in cement, having beds 8 inches to 18 inches thick, as shown on the working plans.

The rock bottom will be covered with a pavement of concrete two-tenths of a foot thick, after the seams in the rock are filled.

Estimate Mt. Airy Reservoir Extension.

* Rock excavation, 91,968 cubic yards, at 90 cents		$82,772 20
Earth, &c., including embankment, 149,609 cubic yards, at 35 cents		52,362 15
		$135,134 35
Concrete lining on bottom, 2,326 cubic yards, at $8	$18,608	
Revetment laid in cement, 4,936 cubic yards, at 7	34,552	
		53,160 00
Stop-house, sodding and incidentals (estimated)		36,705 65
55,286,000 gallons, at $4,070 per million		$225,000 00

Note.—One cubic yard contains 202 U. S. gallons, therefore at 90 cents per yard for rock excavation, each million gallons by which the reservoir may be increased, will cost about $4,500.

The Board of 1883–4 estimated the cost of a 75,000,000 gallon reservoir at $225,000, or $3,000 per million. The excess of rock excavation however, developed by the test borings fully explains why the estimate submitted exceeds that of the experts.

Below you will find a tabulated statement of the actual and estimated cost of the various reservoirs in the city, of which there is a record.

Respectfully,

CHAS. G. DARRACH,

Assistant Engineer.

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* Total embankment, at 20 per cent	62,443	cubic yards.
Surplus excavation to be wasted	179,134	"
Total excavation	241,577	"

Name.	When Built.	Capacity, Gallons.	Total Cost.	Cost per million gals.
Roxborough................	1865–6	11,771,000	$100,000	$8,500
Wentz Farm................	1876–7	35,750,000	132,819	3,690
Belmont.....................	1866–70	40,000,000	360,000	9,000
East Park, (estimate).....	1869–71 unfinished	700,000,000	2,000,000	2,857
Cambria (estimate)........	....	210,000,000	503,640	2,398
" (experts' estimate)	....	150,000,000	375,000	2,500
Mt. Airy (estimate).......	....	55,286,000	225,000	4,070
" (experts' estimate)	....	75,000,000	225,000	3,000

PRELIMINARY REPORT

OF A

CHEMICAL INVESTIGATION INTO THE PRESENT AND PROPOSED FUTURE WATER SUPPLY OF PHILADELPHIA,

Made under the Direction of the Chief Engineer of the Water Department.

By ALBERT R. LEEDS, Ph. D.

PHILADELPHIA WATER DEPARTMENT,
February 21, 1884.

COL. WILLIAM LUDLOW,
Chief Engineer:

SIR:—I transmit herewith my report containing the results of investigations made subsequent to May 1st, 1883, at which date I entered regularly upon the duties of Consulting Chemist to the Water Department. Considerable work upon a special topic had been done prior to the present systematic labors, and had been embodied in a report entitled "An Investigation of the circumstances affecting the potability of the Schuylkill water supply in January, 1883,"—which is appended. At the conclusion of that inquiry, you directed me to prosecute an investigation of much greater scope and complication, viz.: that of examining into the relative excellence of all the waters in Eastern Pennsylvania, which, in your judgment, might be regarded as available sources of water supply for the City of Philadelphia. In addition, I was requested to institute a comparison between these waters and those in present use, both with a view of comparing their potability, etc., and to decide whether any of the latter had already become so degraded by trade and sewage contamination as to make their immediate abandonment advisable.

At the outset it was thought that the comparison might perhaps be restricted to the waters of three localities—those of the lower and upper Delaware, those from the lower Schuylkill, and those from the valley of the Perkiomen; but as the surveys and researches progressed, and the possibilities of other sources of supply hitherto unthought of were developed, the examinations were greatly extended. In addition to the points just mentioned, the whole line of the Delaware as far as the Water Gap, its tributaries and their branches, including the Pennypack, Big and Little Neshaminy, the Tohickon, and the Haycock, were personally inspected and their waters analyzed. Also, many points along the Schuylkill, the Lehigh, and its sources. Some examinations also were made of samples taken from the water-bearing strata in the vicinity of Philadelphia.

The research has thus grown until it exceeds in magnitude any similar investigation hitherto made in this country, and approaches in extent that instituted by the English Commission, whose labors resulted in securing to London instead of one of the worst, one of the best metropolitan water supplies.

Considering, therefore, the greatness of the undertaking, the earnest desire has been so to conduct the work as to leave no question of its accuracy and thoroughness, and (what was more difficult in the present era of imperfect sanitary knowledge) to base the interpretation of the results upon principles, the soundness of which might be verified by the criticism of later observers.

I shall summarize the results under six heads, as follows:

First. Visits of inspection and collection of samples.

Second. Previous and present methods of analysis.

Third. Principles involved in the interpretation of data obtained by analysis and experiment.

Fourth. Light thrown upon the objects of inquiry by the evidence presented in the accompanying tables and chart.

Fifth. Sanitary considerations.

Sixth. Conclusions.

I. Collection of Samples.

In order properly to compare the waters of different localities, the attempt was made to collect the samples as nearly as possible upon the same day. The variations in composition produced by some temporary disturbing force, like an intervening rain-fall, may be so considerable as to render comparisons between river waters collected at different times and seasons entirely misleading. With the aid of the surveying parties in the valley of the Delaware, Perkiomen, and elsewhere, this synchronous collection was rendered feasible.

May Series.—The first series was collected with the aid of Mr. Rudolph Hering, Assistant Engineer in charge of Surveys, upon the 2d and 3d of May. We made an inspection of both banks of the Schuylkill as far as the Phœnixville Pumping Station, and of the Perkiomen up to the first dam. At this point the first sample in the accompanying table (No. 263) was collected, the others in this series (Nos. 264 to 267) being taken from the Schuylkill. Very little water was going over the Perkiomen dam at the time, and the flow in both the Perkiomen and the Schuylkill was small.

June Series.—June 8th and 9th were devoted, with the aid of Mr. C. G. Darrach, Assistant Engineer, to collecting four sets of samples from the Delaware river at the Kensington Water Works. Thirty-six samples in all were obtained, of one-half gallon each. One set was collected at the end of the wharf, three feet below the surface; a second set at the end of the wharf, three feet above the bottom; a third set two hundred feet out, in the thread of the current, and three feet below the surface; a fourth set two hundred feet out, and three feet above the bottom. The samples were equally distributed between the four sets, and between the ebb and flood tides. The object of this series was to obtain the average composition at flood and ebb tide of the water at the four points mentioned.

July Series.—This was a general comparison of waters taken from the Delaware and Schuylkill drainage-areas, including the tributary areas of the Perkiomen, Neshaminy, Pennypack, and Tohickon, all the streams being moderately low, and flowing under conditions due to moderately dry summer weather.

With the assistance of Mr. C. S. Gowen, Assistant Engineer in charge of the hydrographic work, and of Mr. Lloyd Bankson, Assistant Engineer, I collected all the samples from the Perkiomen, July 20th. The water from Stony Brook (No. 297), which enters the Schuylkill near Norristown, was also obtained on the same day.

Sample No. 290 was taken from the Skippack creek at Evansburg pike. The stream was slightly swollen by recent rain, and very turbid and muddy from the washings of the disintegrated shales forming its banks. A small rain-fall suffices to bring about this turbid condition of the water, and for this reason, among others, the inhabitants along the Skippack uniformly use spring water.

No. 291 was taken from the East Swamp creek, just above its junction with the Perkiomen. All the aquatic plants in the bed of the stream were covered with a white sarcode or jelly, very voluminous, and inflated by bubbles of gas, which buoyed up and floated away large masses, as they constantly became detached from the plants.

No. 292 from the Perkiomen above Green Lane, at the foot bridge, was clear, attractive looking water, similar in taste to the preceding, but much less earthy.

No. 293 was from the Macoby Creek at Green Lane, a small and very limpid stream, running swiftly over a shaly bottom.

No. 294 was taken from the North East Branch of the Perkiomen, near its junction with the main stream, at the bridge on the road leading into Skippackville.

No. 295 was from the Perkiomen above Zieglersville Station, and about 300 yards above its junction with the North East Branch. The water was moderately clear, but flat and insipid to the taste.

No. 296 was from the West Swamp creek, about 100 yards from its junction with the Perkiomen. It had a slightly bitter taste.

July 21st was spent in collecting, with the aid of Messrs. Hering and Bankson, samples from the Delaware at Point Pleasant, from the Tohickon, and from the Big and Little Neshaminy.

Sample 298, from the Delaware at Point Pleasant, was taken when the river, owing to previous rains, was stated by the Railroad Station Master at that point to be 3 feet higher than its average height at this season of the year. The sample was clear, without smell, and as pleasant to the taste as spring water.

Sample 299 was taken from the Tohickon near Point Pleasant. The amount of water flowing was small, but its appearance attractive, being limpid and having no taste, except a faint one, as from a trace of vegetable matter. The river bottom of black, altered shales, was perfectly clean from the scour of the swiftly moving current.

No. 300, from the Main Neshaminy above the Forks, near Penn's Park, Bucks Co., was clear, tasteless, and scarcely inferior to the Tohickon sample.

No. 301, from the Little Neshaminy above the Forks, was limpid and palatable.

It had been intended to collect a sample from the Pennypack on this day, but night coming on, the collection was necessarily deferred till the day following, when a sample was taken at the first bridge above Shelmire's Mills. The water was slightly milky in appearance, with a vegetable taste.

July 21st. Mr. de Kinder, General Superintendent, obtained a sample at Spring Garden forebay (No. 303), and Mr. Bankson collected others (Nos. 305–308), representing the lower Delaware, at Kensington and Frankford, July 24th–27th. The two Kensington samples were taken two hundred feet from the wharf, and twenty feet below the surface. One of these was taken one hour before low water on the ebb tide; the other, when the tide had been running up about two hours. The surface water was muddy. The two samples from the Frankford station were obtained four feet from the bottom, at the mouth of the intake at the end of the wharf; one at ebb tide, within an hour of low water, the other at flood tide, after it had been running up one hour and a quarter. The surface water was somewhat muddier than usual.

August 15th. The August samples (Nos. 315, 316) had no relation to the general investigation, but were made to determine whether certain spring waters at the Belmont and Roxborough pumping-stations could be advantageously used in connection with the feed-water of the boilers.

Sept. 9th–12th. The September samples (Nos. 322–345) were collected for purposes of comparison with the samples obtained in July. They were taken from the same places in the different streams as the July samples, the object being to determine to what extent it would be necessary to modify the judgments formed as to the character of the waters analyzed, on account of differences in the volumes of water flowing in these streams at the different dates. When the September specimens were collected, all the streams were very low, with very slight flow—about the minimum for the season.

In addition to those collected with the above object, samples were taken, with the assistance of the Chief Engineer and of Mr. Hering, from Delaware Water Gap, from Lehigh river at White Haven, and from Tobyhanna creek, in order to discover what relation as to purity these head-waters bore to the waters of streams in the vicinity of the city.

Oct. 9th. No. 346, from Delaware Water Gap, and No. 351, from the Tohickon, were obtained in order to compare the purity of the head-waters in the Delaware, taken at a point where its volume is large, with that of one of its smallest but purest affluents. According to Mr. Hering, who is my authority for these statements, the flow was moderate at this date, though somewhat greater than on July 20th–22d.

Oct. 29th–30th. The preceding collections having been made at seasons when the water was low, and considerable rain having fallen, so as to give moderately high water at this date in all the streams, samples Nos. 353, 354, and 355 were taken from those tributaries of the Perkiomen which, in the earlier analyses, had given the most favorable results. These were compared with sample No. 357, taken from the Fairmount forebay at surface, the last representing part of the actual city water supply at that time.

Nov. 2d–13th. This series of November samples, Nos. 356–367, is really part of the same series as those collected at the close of October, and was intended to compare the waters of the Delaware, upper and lower, and of its tributaries, the Neshaminy and Tohickon, with those of the Schuylkill and Perkiomen, collected under similar conditions as to flow. Owing to the extent of ground to be traversed, delay was experienced in collecting the latter samples, and from November 8th to 13th rains fell, making a rise in all the streams, more especially in the Tohickon.

II. Methods of Analysis.

These methods are stated in my preceding report (of Feb. 20, 1883), and all that is neccessary to add relates to the three following determinations:—

I. *Oxygen required to oxidize the Organic Matters, as determined by Potassium Permanganate.* In the former report allusion is made to the difficulty of obtaining concordant results by this method. This difficulty led to continued experiment, and the final adoption of certain precautions which are given in full in the *Zeitschrift für analyt. Chemie*, XXIII, 17. These experiments confirmed the belief that the determination of the amounts of oxygen required to effect the oxidation of the organic matters, by means of boiling with potassium permanganate, afforded information of so valuable a

III.—Interpretation of Data.

The greatest diversity of opinion exists as to the correctness of the principles upon which the interpretation of the analytical data is based. According to one school of analysts, reliance is chiefly placed upon the indications afforded by the ammonia and albuminoid ammonia; according to another school, pre-eminent importance is attached to the relative amounts of carbon and nitrogen in the organic residue left after evaporation. In this case, allowance is made and a correction applied for the amounts of ammonia, nitrous acid and nitric acid also present. In Germany, great weight is given to the determinations of required oxygen and chlorine, and to the results of microscopic examination and physiological experiment. Important investigations made in France, have brought into prominence the value of the results afforded by a comparison of the percentages of the various dissolved gases.

In the present investigation, I have obtained all these classes of data, using the results of one method to check off and modify the results and opinions obtained by another method. Nor have I found that I would willingly dispense with any of these results, but, on the contrary, shall endeavor in the future to add certain other data besides those summarized in the accompanying tables and chart. The principles upon which the interpretation of the data is based are epitomized under the following heads:

Standards of Purity.

1. The first principle is, that the results of chemical analysis must confirm and explain the facts gathered by personal inspection. These show, in the present inquiry, that very considerable contamination by sewage, etc., exists in the water of the lower Schuylkill and in the water pumped at Kensington. They do not show any such considerable contamination in the waters of other streams, like the upper Tohickon, the upper Perkiomen, the upper Neshaminy, and so on. Unquestionably

great weight must be attached to these facts, and the chemist must make most careful and common-sense use of them in forming his judgment. But either the long array of figures, and the results of complicated and difficult analyses must put him in possession of data, which, when properly interpreted, will enable him to pronounce with considerable certainty upon the fact of contamination or purity, or the practical value of his services is nought. Now, as a matter of chemical inquiry, it becomes apparent that while the volume of polluting matters thrown into the river Schuylkill does not vary greatly from season to season, the composition of the water varies immensely, so that at some times the amounts of dissolved impurities are very large, and the analyst would unhesitatingly condemn the water for drinking purposes. At other times, the amounts of dissolved impurities are small, and if the chemist proposes to be equally honest and abide by his figures, he must declare that at such times the water is of excellent quality. Similarly with regard to a mountain stream like the Tohickon. Personal inspection produced a most favorable judgment. It showed a stream flowing over a clean rocky bottom, with sides occupied by steep forest-covered hills. But analysis gave a far less favorable result, and, on inquiry being made, it was found that at an unlooked-for point a charnel house, or place of deposit for dead animals, was discharging its poisons into the stream, and would have to be removed before the lower Tohickon would regain the purity of its upper waters.

2. Therefore, the second principle is, that there must be established for every source of water-supply, whether cistern, spring, well, lake or river, a standard of purity according to which the quality of the water must be judged. At present we are concerned with river waters only.

There are various methods by which such standards may be established, but the two of the greatest utility, and, in fact, indispensable, when we are confronted with the actual problem of a particular city water supply, are as follows:

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1. A general standard derived from an examination of those city water supplies in the United States, the use of which is generally approved by chemists and physicians.

2. An individual standard, applicable only to the one individual water-supply under consideration, and derived from many analyses of that water in its best condition, and from its composition as collected at points above the entrance of sewage contamination.

As an illustration, I will note the application of these standards to the water-supply of Newark and Jersey City, both cities receiving their supply from the Passaic, a stream grossly polluted by sewage. Its upper waters, on the other hand, are of great purity since they are collected from nine hundred square miles of upland territory, underlaid by granite rocks and covered by forests. The water so collected is delivered over the Great Falls of the Passaic, and comes at once into contact with the sewage and refuse of the large manufacturing town of Paterson. Eighteen miles further down it is even more polluted by the sewage of Newark, which is carried up the river by every flood-tide, and is pumped from the intakes of the two cities.

Now in deriving the individual standard for the Passaic water-supply, it will not answer to set up the composition of the water as actually used in the two cities, *even when in its best condition*. For there is always a certain residual amount of sewage which has escaped oxidation, and the composition of the *unpolluted* water, before it has reached Paterson, must be taken as a guide. As the result of several hundred analyses I have ventured to propose the following:

SANITARY STANDARDS.

CONSTITUENTS EXPRESSED IN PARTS PER 100,000.	General Standard of purity. [For river waters in the United States. Highest upper limits].	Standard of Purity. [For Passaic river, from analyses of its upper waters].
Free ammonia	0.001 — 0.012	0.005
Albuminoid ammonia	0.01 — 0.028	0.015
Required oxygen, as determined by permanganate	0.35 — 0.5	0.40
Required oxygen, as determined by silver	?	0.32
Nitrous acid (HNO_2)	0.0001 — 0.001	Trace.
Nitric acid (HNO_3)	0.35 — 0.50	0.35
Chlorine	0.3 — 1.00	0.35
Hardness	5 for soft — 15 for hard.	3.00
Total solids	15 — 20	6.00
Oxygen dissolved per liter	?	5.60 c. c.

The same method will be pursued in dealing with the Philadelphia water-supply. The composition of the Schuylkill and Delaware rivers at the most favorable seasons and localities will be used in establishing standards of purity for these two streams. A like plan will be pursued in regard to the Perkiomen and other proposed sources of supply, and finally, as between different streams, that which can be shown to conform to the highest standard of purity, will be regarded as the best.

This method may appear artificial and complicated. It may be supposed that the chemist should be able to establish a natural and absolute standard of purity for drinking water. But this is not possible. Artificially distilled water is so unpalatable and so devoid of valuable saline constituents that it is used only in cases of necessity. Naturally distilled water, or rain, while better in point of taste, is never pure in a chemical sense, and frequently impure both chemically and hygienically. Rain-water washes out of the atmosphere a part of the innumerable gaseous, volatile and suspended matters therein contained. It holds in solution and suspension, oxygen, nitrogen, carbonic acid, nitrites and nitrates of ammonia, chlorides and other mineral salts, parts of the tissues and refuse matters of animals and plants, and innumerable spores of animal and vegetable origin. There is no living organism which is not throwing off into the atmosphere microscopic particles of organized and frequently (in the shape of spores) living matter. In contact with the ground, rain-water undergoes a process of filtration and, so far as its ammoniacal constituents are concerned, of purification. For this, among other reasons, spring, well and river waters are preferable to rain and cistern waters. Thus also it comes to pass that water taken from the head-waters of the Delaware is to be preferred to rain-water collected in the city or its vicinity. Fog and snow-water condense even more impurities. Even if we with propriety deny the virulence of certain atmospheric bacteria, and regard the existence of the bacillus malariæ of Klebs and other authors as not proven, yet the connection between mountain-fever and the drinking of snow-water is reasonably well established. Pages of general statement will not illustrate this argument so forcibly as the three following analyses:—

Constituents Expressed in Parts per 100,000.	Delaware, above Water Gap, Nov. 10, 1883.	Snow water, from grounds of Stevens Institute, Hoboken, N. J. February 6, 1884.	Rain water, from grounds of Stevens Institute, Hoboken, N. J. February 17, 1884.
Free ammonia	0.002	0.04	0.04
Albuminoid ammonia	0.014	0.015	0.0145
Required oxygen (permanganate)	0.15	0.16	2.31
Required oxygen (silver)	0.25	0.13	0.037
Nitrous acid	None.	0.0004	0.0005
Nitric acid	0.27	0.09	0.01
Chlorine	0.20	0.55	0.20
Total solids	5.00	3.50	11.50
Dissolved oxygen per liter	5.60	6.00 c. c.	6.00

The significance of these results can be best explained in connection with the interpretation of the several data.

1. *Free and Albuminoid Ammonia.*—The least free ammonia found in the course of the present investigation, was that present in the Schuylkill above Phœnixville (May 2), the Big Neshaminy Creek (November 8), Spring Garden forebay (July 21), and the Belmont and Roxborough spring waters, which was 0.0005 parts per 100,000. The next to the largest amount was that of Stony Brook (July 20), or 0.025 parts per 100,000. The waters of the latter should properly be excluded, since there is no difficulty in deciding from the other results of the analysis that Stony brook is a grossly polluted stream. Not far below Stony Brook, in percentage of ammonia, is Skippack Creek (0.02225 parts per 100,000), a stream of inferior quality, flowing through sparsely settled, arable lands. Yet its percentage of ammonia is little more than half that in rain or snow-water.

These results are not peculiar to atmospheric conditions in this country. A still higher result (0.05 parts per 100,000) was obtained by the Royal Rivers Pollution Commission from seventy-three analyses of rain, all collected, with two exceptions, in the country. Boussingault found in rain-water at Paris, 0.04 parts of ammonia, and in that collected in the open country, 0.008 parts. As the result of four years' observation at Mont Souris, the average was found to be 0.02 parts per 100,000.

Similar remarks apply to the albuminoid ammonia. A very large number of the analyses herein tabulated exhibit from 0.005 parts to 0.014 parts, which are smaller amounts than those present in the analyzed rain and snow.

What use, then, can be made of the determination of ammonia in the accompanying tables, in deciding upon the relative purity of the waters analyzed? None, until we can discover what becomes of the ammonia in rain after it comes in contact with the ground. In studying recorded analyses with this object in view, we are struck by the fact that the nitric acid in rain falls as far below that present in river-water as the percentages of free ammonia found in the former exceed those in the latter.

The Royal Commission of Great Britain found as the result of the seventy-three analyses just quoted, in rain-water only 0.027 parts of nitric acid (with a trace of nitrous acid), as against 0.05 parts of free ammonia. In the reports on "The Composition and Quality of the water supplied to London," from December 20, 1880, to November 31, 1881, I find among hundreds of analyses of the waters of the seven London companies, in the majority of samples, *no ammonia whatsoever.* The largest amount reported is 0.004 parts per 100,000, and that is attained in very few instances. At the same time the nitric acid in these London waters is enormous, frequently exceeding 1.4 parts per 100,000. That these waters are filtered, and thereby have the percentage of ammonia decreased, and that of nitric acid increased, only strengthens the validity of the interpretation given below.

Among Philadelphia waters, the smallest amount of nitric acid is that present in the Delaware on three occasions: At Point Pleasant, July 21st, and Sept. 21st, and at the Water Gap, Sept. 9th. This amount was 0.19 parts per 100,000. These results, however, are exceptionally low, the Water Gap samples on other occasions containing 0.20 and 0.30 parts. The purest sample of Schuylkill water thus far obtained (Phœnixville, May 2), contained 0.41 parts, and the sample from the Little Neshaminy, July 21st, (unquestionably excellent potable water,) 0.37 parts. Excluding Stony Brook, with its 1.11 parts of nitric acid, as unquestionably polluted, all the samples of the Schuylkill and Delaware Rivers taken in the vicinity of the city, and all the samples of spring waters also, there remain 40 analyses of river waters, giving an average of 0.38 parts of nitric acid per 100,000.

When we calculate the averages for the free and albuminoid ammonia in these same waters, and compare them with the corresponding figures in the analyses of rain and snow, we have the following important result:—

Constituents Expressed in Parts per 100,000.	Forty unpolluted river waters.	Snow water. Feb. 6, 1884.	Rain water. Feb. 17, 1884.
Free ammonia	0.0055	0.04	0.04
Albuminoid ammonia	0.018	0.015	0.0145
Ratio of free to albuminoid	1 to 3	3 to 1	3 to 1
Nitric acid	0.38	0.09	0.01

Assuming these to be representative analyses, it will be seen that by the time rain has found its way into the rivers, its free ammonia has diminished eight times and its nitric acid has increased 38 times. This disappearance of the free ammonia is due to two causes :—in part to the absorption by growing plants, and in part to its conversion into nitric acid. The absorption of oxygen necessary to effect this latter conversion takes place through the agency of microscopic bacteria and micrococci. This latter transformation, which is by far the most important of the two, and which gives rise to the large amounts of nitric acid present in river waters, takes place in the soil and is favored by exclusion of light. The free ammonia would not suffice to supply all the nitric acid. The albuminoid nitrogenous matters which are recorded in the analyses under the head of albuminoid ammonia, likewise undergo oxidation through the agency of animal life, and find their way into the streams in the state of nitric acid.

Therefore the principle may be formulated, that the amounts of free and albuminoid ammonia actually present in *unpolluted* river water, are but the residual amounts left after the ammonia originally present in the rain or dissolved out of the organic matters present in the soil, have undergone more or less perfect oxidation. As a general rule, these oxidation processes reduce the amount of free ammonia until it falls below 0.005 parts per 100,000, and that of albuminoid ammonia below 0.015 –0.018 parts per 100,000. Even if they rise above these quantities, their absolute amounts do not necessarily prove sewage contamination. There is one exception, however, to this rule, which is that when a stream in its upper portion has been found to contain certain quantities of free and albuminoid ammonia, and these quantities are found to have increased in its lower portion, without a corresponding material change in the volume of the river from lateral affluents, then these increments almost certainly denote sewage contamination.

Ratio of Free to Albuminoid Ammonia.—By the operation of the forces alluded to above, the natural tendency is towards a reduction of free ammonia in river waters to zero. Consequently, as a general rule, the albuminoid much exceeds the free ammonia, on an average being about three times greater. And whenever this ratio is so far disturbed that the excess is in the other direction, free ammonia being the greater, it indicates either that the operation of natural forces has been interfered with, or that sewage and trade pollution have been introduced. In the foul and offensive condition of the Schuylkill River in January, 1883, this disturbance of the ratio occurred, and the disturbance was due to both causes.

Nitrous and Nitric Acid.—The nitrous acid present in rain undergoes conversion to nitric acid in the soil through the same agency of living microscopic organisms as are concerned in the oxidation of ammonia to nitric acid. The presence of nitrous acid indicates incomplete or arrested oxidation, and the probable presence of non-oxidized putrescible organic matter. For this reason great importance is attached to it, even when present in extremely minute quantity.

Nitric acid is one of the most important constituents of river waters. In fact, its average amount of 0.38 parts per 100,000 does not fall far short of the percentage of chlorine, which is 0.48 in the same forty samples. What becomes of these great amounts of nitric acid, contained not only in the waters of the Delaware, but in every stream pouring into the ocean? The chlorine in the ocean water accumulates, but no analysis of ocean water, so far as I could discover, mentioned the presence of nitric acid. If the silence on this point meant that the nitric acid was in some way eliminated from the water by natural forces, it would be necessary to make the most cautious use of the percentages of nitric acid found in the analyses, in deciding upon the question of purity. To settle this point, I obtained a sample, five miles south of Barnegat and seven miles from land, in eight fathoms of water. The mineral salts, being unimportant for our present purpose, were not determined, and the estimation of the organic matters was effected after precipitating out the dissolved chlorides. The results of this "sanitary analysis" of ocean water can be most strikingly exhibited in connection with that of river, rain, and snow water,

Constituents Expressed in Parts per 100,000.	Forty river samples.	Ocean.	Rain.	Snow.
Free ammonia	0.0055	0.00	0.04	0.04
Albuminoid ammonia	0.018	0.013	0.0145	0.015
Required oxygen (permanganate)	0.25	0.22	2.31	0.15
Required oxygen (silver)	0.22	0.25	0.037	0.13
Nitrous acid	Trace.	None.	0.0005	0.0004
Nitric acid	0.38	0.018	0.01	0.09

No ammonia and no nitrous acid are present in the sea water. Its oxidizable organic matter is the same as that in the rivers, and its nitric acid one-twentieth the amount in the rivers.

As the tendency of natural forces, operating through animal organisms, is to oxidize the ammonia completely and reduce its amount to zero, so the tendency of natural forces, operating through plant-life and vegetable organisms, is to reduce nitric acid, liberating its oxygen and assimilating its nitrogen in plant-tissues.

Nitric acid, therefore, is not regarded as an index of "previous sewage contamination," unless the other analytical data point to the presence of foreign matters of animal origin.

Required Oxygen.—A low amount of required oxygen is noticeable in certain of the waters, which on other grounds also, are worthy of being regarded pure. Thus the Cambria well water exhibits but 0.11 parts as determined by permanganate, and 0.13 parts as determined by silver. The sample taken from the Schuylkill at Phœnixville on May 2d, required only 0.20 parts of oxygen, whilst those taken further down the river on the same date required progressively more oxygen, increasing to 0.26 parts at Fairmount. The increase for the same samples, as determined by silver, was from 0.11 parts at Phœnixville to 0.19 parts at Fairmount.

The average of required oxygen for the forty country river waters is 0.25 parts (permanganate), and 0.22 parts (silver), as against 0.15 and 0.13 parts in snow, and 0.22 and 0.25 parts in ocean-water. River waters, therefore, which require less than 0.15 parts of oxygen, may be regarded as containing very little oxidizable matter. The results obtained with rain strengthen the objections against it as a standard. It required the enormous quantity of 2.31 parts of oxygen, as determined by permanganate. This excessive action on permanganate was due to organic matter of a carbonaceous, rather than of a nitrogenous character. For on evaporating the rain to dryness in a platinum dish, the residue became dark brown, and on ignition gave an odor of varnish. Out of a total residue of 11.5 parts the volatile and organic portion in the rain constituted 6 parts, or more than one-half. The nitrogenous portion was small, as is shown both by the percentage of albuminoid ammonia, and by the the fact that the rain exerted an unusually slight reducing action on silver.

Chlorine.—The amount of chlorine present in the seventy-three samples of English rain is excessive as compared with the average in our American rivers. In examining hundreds of analyses of the London water-supply, the same excess, as compared with the water-supplies of American cities, is very striking. In the London waters the percentage of chlorine varies from a minimum of 1.33 parts per 100,000 to the astonishing maximum of 2.8 parts per 100,000. The average amount of chlorine in the water supplied to twelve of our cities is 0.75 parts, and this average is much raised by one or two exceptional cases. The average in the Passaic river is 0.35 parts, and in the forty analyses of the Schuylkill and the Delaware and their tributaries, it is 0.48 parts per 100,000.

The snow-water contained 0.55 parts per 100,000. This was regarded as almost incredible until compared with the English results. Rain contained 0.20 parts. Chlorine and salt are as constant constituents of the atmosphere as of river and ocean waters. Every rain carries down with it a certain amount of chlorine, and a large percentage of the chlorine in river waters must be regarded as coming from the sky, and not from the ground. The percentages of chlorine, therefore, are not regarded as indicative of pollution, unless the other analytical data or outside testimony establish the fact that this chlorine was derived from foreign matters of animal origin, or from the refuse of manufacturing operations.

Dissolved Oxygen.—In contact with putrescible organic matters the oxygen dissolved in the water is diminished in amount. It matters not to what extent the oxygen is used up by a direct chemical process of oxidation, and to what extent by absorption through the living agency of bacteria and micrococci in presence of decomposing organic matter. The essential fact is that it is used up, and its progressive absorption indicates progressive contamination. Thus the Schuylkill river at Phœnixville contained in one liter 6.03 cubic centimetres of oxygen; at Roxborough it contained 5.86 c. c. at the surface, and 5.74 c. c. at the bottom; at Fairmount 5.64 c. c. at the surface, and at the bottom only 5.19 c. c.

Total Solids.—The percentage increase in total solids due to foreign polluting matters is necessarily so extremely small that it can only be detected in cases of gross pollution. The whole sewage of Gunner's Run at ebb tide did not raise the total solids in the Delaware by an amount appreciable in analysis.

IV. Critical Examination of Analytical Results.

The great accumulation of figures tabulated in the accompanying tables are quite unintelligible, until their significance is made plain by the corresponding graphic representation. This chart shows a striking correlation and dependence of the various classes of analytical results. Upon the cumulative evidence presented by this correlation, rather than upon the absolute values of isolated results, I propose to base the conclusions contained in this and following reports.

A. *Free and Albuminoid Ammonia.*

The first correlation forced upon our attention is the remarkable one between the free and albuminoid ammonia. This correlation is not suspected on examination of the tables, but is made known by the parallelism between the curves representing these two constituents in the chart. The chart is poorly constructed to bring out this parallelism, because the points located jump from stream to stream, and in very few instances from point to point upon the same stream and upon the same day. In the latter case, the correspondence of crest with crest and trough with trough of the waves, is sometimes perfect.

This correlation denotes that the amount of one of these substances is dependent upon the amount of the other, through the agency of the natural laws previously considered:—The nitrogenous organic matters, which by artificial oxidation in the laboratory yield albuminoid ammonia, are capable also of oxidation by natural processes, yielding thereby the free ammonia. In other words, we only complete in the laboratory the oxidation begun in nature, and obtain the result of the laboratory oxidation as "albuminoid," and the result of the natural oxidation as "free" ammonia. Hence, if these natural oxidation-processes are normal, the nitrogenous organic matters are tending to pass out of that condition in which they would yield albuminoid ammonia, and are being converted into free ammonia and nitric acid. The last finally passes out of solution altogether, being from Skippack Creek, shows an increment in every constituent

— – ... finally passes out of solution altogether, being decomposed by, and its nitrogen absorbed in, the tissues of growing plants. Under these conditions, as the albuminoid ammonia increases, so likewise do the free ammonia and the nitric acid, the average ratio of the albuminoid to the free ammonia being three to one.

Referring to the chart, it will be seen that on May 2d, the ammonia and nitric acid in the lower Perkiomen were large as compared with the Schuylkill at Phœnixville, at which point they were all small in absolute amount. It is interesting to note in passing, that this Schuylkill sample was beautifully limpid, very palatable and much superior in these respects either to the Perkiomen water, or the Schuylkill water collected lower down on the same date. From Phœnixville there is a progressive rise until Fairmount is reached.

Inspection of the averages for thirty-six samples collected at Kensington wharf, June 8th, shows that the corresponding three curves for free and albuminoid ammonia and for nitric acid, rise to a maximum *on the ebb tide, at the wharf, three feet below the surface.* The Kensington water at this point was *worst.* They fall to their lowest point *on the flood tide two hundred feet out, three feet below the surface.* The Kensington water at this point was *best.*

At the time of collecting these thirty-six samples, the surface water at the wharf, for a distance of ten to twenty feet out, was chocolate-brown from the sewage and other impurities of Gunner's Run. That taken two hundred feet out, both at the surface and bottom was perfectly limpid. It may appear strange that the differences in the absolute values of these four averages are not of greater magnitude than those shown in the analyses. But a moment's reflection will show that the total sewage of Philadelphia, if poured into the Delaware, would change the composition of so vast a volume of water by extremely minute amounts.

All the samples from the Perkiomen water-shed, July 20th, present certain peculiar characteristics. The first sample, that from Skippack Creek, shows an increment in every constituent except dissolved oxygen, which is low. The free and albuminoid ammonia and nitric acid are especially great, and their increase in connection with the contemporaneous declension in every other particular indicate inferior purity. At the same time, this inferiority appears to be due to accumulation of such impurities as might enter a rural stream. Compare Stony Brook. Its free ammonia far exceeds the albuminoid, the nitric acid is also excessive, being even greater than the chlorine. These unusual features, in the case of Stony Brook, point to the operation of artificial agencies, and indicate water polluted by artificial means.

In the Perkiomen waters, taken as a group, the average free and albuminoid ammonia are high, the ratio of the oxidized to the non-oxidized organic matters low. These features are derogatory to their character as potable waters. Later on, certain other unfavorable characteristics will be noted.

Similar remarks apply to the Perkiomen series, September 11th, and October 30th. In the former, the N. E. Branch shows a mountainous elevation of the ammonia curves; in the latter series, the E. Swamp Creek shows the same feature, while the loci of the curves for the N. E. Branch are too high to be located on the chart.

Of the Delaware samples, collected July 21st, that obtained at Point Pleasant presents the best record. That from the Kensington Water Works shows an increase in albuminoid ammonia as compared with the Tohickon and Point Pleasant samples, and the lower portion of the river is much richer in oxidized nitrogenous matters than the upper. In the latter respect, the lower Delaware compares unfavorably with its tributaries at the same date, the Tohickon, the Neshaminy and the Pennypack.

Broadly comparing all the upper Delaware samples, it may be said that the upper Delaware, especially at Point Pleasant and above the Water Gap, is low in free and albuminoid ammonia and nitric acid, being superior in these respects to its tributaries, the Tohickon, Neshaminy and Pennypack.

B. *Nitrous and Nitric Acids.*

Little additional need be said of these constituents. Nitrous acid appears in the lower Perkiomen, May 2d, being ten times that found in the Schuylkill at Phœnixville. At Roxborough and Fairmount it was present in the same amount as in the Perkiomen. Stony Brook again acquires its bad pre-eminence by having more nitrous acid than any other water analyzed. In the Perkiomen at Zieglersville, September 11th, it appears, and also in the N. E. Branch; also, in the former, October 29th, in the E. Swamp Creek, and even in the Perkiomen, above Green Lane. Again the indications with regard to the streams in the Perkiomen drainage-area are, that the quantities of organic matters present in this area are greater than those which can be completely oxidized by natural agencies before they find their way into the streams.

One striking fact in connection with the nitric acid should be noted. The minimum amount is found in the Delaware samples at Point Pleasant and the Gap (September 9th and 12th). It is 0.19 part, one-half the average in the forty rural river samples.

C. *Oxygen Required to Oxidize the Organic Matters.*

Not only the nitrogenous, but non-nitrogenous organic matters undergo oxidation by permanganic aid, so that the amounts of oxygen required indicate the relative quantities of *total* organic substances. On inspecting the chart, it will be observed that the line representing required oxygen, as determined by silver, follows closely along with the lines representing free and albuminoid ammonia. The line indicating required oxygen, as determined by permanganate, does not exhibit this correlation. Consequently, I regard the determinations effected by the "actinic method" as especially indicating putrescible organic substances. The amounts obtained by silver are not so large, but are more important. It is that comparatively small fraction of the total organic matter which is putrifiable, that it most concerns us to know.

This silver oxygen curve falls away from the height of the lower Perkiomen, May 2d, (the curve being closely parallel with the lines of free and albuminoid ammonia and nitric acid,) until the depression representing the Schuylkill is reached. Then all four curves gradually rise, until Fairmount presents us with four contemporaneous maxima for these four constituents. The little dip in the curves exhibiting the other three, in this mutually dependent quaternion of ingredients, as shown at Roxborough, is echoed in the silver oxygen curve, while it is not reflected by any corresponding dip in the permanganate oxygen curve.

The most striking exhibition of the sensitiveness of silver in sunlight to decomposable organic matter is shown by the whole group of Perkiomen samples collected July 20th. No waters in the entire course of the investigation were found to have so powerful a reducing action on silver. This was more especially the case with the Skippack water, and but little less with E. Swamp Creek. All the aquatic plants in the latter stream were covered from root to apex, and to a depth of from one to two inches, with a white gelatinous or slimy sarcode filled with gas. These slimy masses constantly detached themselves, and were floated off, by the intermingled gas, down the stream. The taste of the water was unpleasant.

Similar energetic reduction was exerted by samples obtained from the N. E. Branch of the Perkiomen and from E. Swamp Creek, October 30th.

The most oxidizable organic matter (as measured by silver) contained in the July series from the Delaware was at Frankford and Kensington. These also present maxima for free and albuminoid ammonia and nitric acid.

The silver curve likewise rises for the Big Neshaminy (September 12th), along with a mountainous elevation in albuminoid ammonia. The two Big Neshaminy samples compare in this and all other respects unfavorably with the samples of same date from the Little Neshaminy. The latter is superior to the Skippack water, but little preferable to that of the N. E. Branch of the Perkiomen and E. Swamp Creek.

The minimum amount of silver, 0.05 parts per 100,000, was reduced by the Cambria water from Mr. Black's well. This likewise contained the minimum amount of albuminoid ammonia, 0.005 parts per 100,000.

D. *Chlorine.*

There is no necessary connection between chlorine and the other "sanitary" factors in the analyses, except when the chlorine is derived from animal excreta. Inasmuch as its amount rises in Skippack Creek, the Main Neshaminy and Stony Brook, along with these other factors, such contamination is indicated. In the former cases the chlorine is derived from fertilizers, in the last from sewage.

E. *Dissolved Oxygen.*

Diminution of dissolved oxygen with increase of free and albuminoid ammonia, nitric acid, and oxidizable organic matter (as determined by silver), and its increase of dissolved oxygen with diminution of these four substances, are exhibited in the chart.

Beginning with the Schuylkill sample, May 2d, (the maximum,) it diminishes as the other constituents increase, until Fairmount is reached. The Delaware samples, June 8th. show inconsiderable variations. The Perkiomen samples collected in July, as a group, show remarkable deficiency in oxygen. We have already shown by other considerations, that this group of samples contained more oxidizable organic matters than the natural agencies of purification were adequate to eliminate.

In all the samples of river-waters collected in July and August, there is less dissolved oxygen than in those collected in September, October, and November, with one remarkable exception. This was in the Tohickon sample, October 9th, which contained only 3.13 cub. cent. of oxygen per liter. But so anomalous was this sample in its enormous amount of albuminoid ammonia (the maximum amount found in the entire investigation, 0.0355 parts, while the dissolved oxygen was the minimum), that I have excluded it from the chart. The same sample likewise required the maximum amount of oxygen (0.60 parts per 100,000) to oxidize the organic matters. When the results were made known to Mr. Hering, he caused a search to be made and found that dead animals had been accumulated on the Tohickon at a point above that where the sample was collected.

F. *Hardness.*

Delaware water is uniformly soft, remarkably so in its upper portions. Schuylkill water is usually soft, though variable in this respect, probably from incursions of harder waters from the limestone regions above. Its average hardness is greater than that of the Delaware.

The waters of the Perkiomen drainage-area are soft, as are the Pennypack, Neshaminy, Tohickon (usually,) the Lehigh at White Haven, and Tobyhanna Creek.

G. *Ratio of Organic Carbon to Organic Nitrogen.*

The standard formulated by the Royal Commission on the Pollution of Streams is that "River water which contains in 100,000 parts more than 0.2 part organic carbon or 0.3 part organic nitrogen is not desirable for domestic supply, and ought, whenever practicable, to be rejected."

It is not, however, upon the absolute values for organic carbon and nitrogen that judgments as to purity are based, but upon the ratio between them. Prof. Frankland, who is the highest authority upon his own process, states that if this ratio be as low as 3 : 1, the organic matter is of animal origin; if it be as high as 8 : 1, it is chiefly, if not exclusively, of vegetal origin. Furthermore, that the ratio of carbon to nitrogen in upland surface waters is always high, the average being 10 : 1. The extremes however are very wide—from 4 : 1 to 21 : 1. "Cultivated land does not, as a rule, yield so much organic matter to water as that which has not been broken up by cultivation; but from the fact of such land being manured with animal, and sometimes even with human excreta, the nature of the organic matter requires much more attention. The ratio of carbon varies from 4 : 1 to 10 : 1, averaging about 6 : 1. Whenever the ratio is below 6 : 1, and there is more than 0.3 part of organic carbon in 100,000 of water, accompanied by previous sewage contamination (say 2,000 parts in 100,000), the water ought to be condemned as unfit for dietetic purposes." (*Water Analysis*, p. 85.) These generalizations were based upon analyses of 589 samples from various districts in Great Britain. As the average composition of unpolluted river water, based upon 39 analyses, the organic carbon is stated as 0.07 part, and the organic nitrogen 0.015 part in 100,000. The ratio, as thus experimentally determined for unpolluted river water, is only 4.6 : 1.

We can best make use of this ratio in connection with the most important "sanitary" factors, as determined by other methods.

LOCALITIES.	Free ammonia.	Albuminoid ammonia.	Nitric acid.	Oxygen required (permanganate).	Oxygen required (silver).	Dissolved oxygen.	Ratio of carbon to nitrogen.
No. 295. Perkiomen, above Ziegleraville	0.00075	0.0165	0.28	0.29	0.56	5.13 c. c.	4 : 1
No. 298. Delaware, at Point Pleasant	0.015	0.017	0.19	0.32	0.34	5.13 c. c.	5 : 1
No. 299. Tohickon, at Point Pleasant	0.001	0.021	0.37	0.20	0.38	5.35 c. c.	5 : 1
No. 300. Main Neshaminy	0.002	0.024	0.47	0.14	0.31	5.35 c. c.	5 : 1
No. 303. Spring Garden forebay	0.0005	0.009	0.37	0.18	0.30	5.31 c. c.	5.5 : 1

Of these five samples, that from the Perkiomen is the only one which has a lower ratio of carbon to nitrogen than 4.6 to 1. But independently of the evidence afforded by this ratio, the Perkiomen sample had been judged to be of inferior quality, from other considerations. The Schuylkill sample of this particular date happens to have the highest ratio. Its superiority, however, is equally evident from the other sanitary factors. Thus far the additional information obtained by combustion of the organic residue has not repaid the expenditure of time and labor involved.

H. *Total Solids.*

The total solids vary considerably with the season of the year, the volume of flow, and rainfall. For reasons previously stated, they afford little help as criteria except in case of gross pollution.

The great purity of Tobyhanna Creek and the Lehigh River at White Haven, in respect to dissolved saline matters, is strikingly exhibited, both containing only 3.5 parts. Polluted Stony Brook contains the maximum, 15 parts. The gradual increment of total solids in the waters of the Delaware taken at the Gap (5.0 parts), as compared with the amounts lower down (Point Pleasant 7.5 parts, and Lardner's Point 13.0 parts), is a reason for obtaining potable water at the upper points.

V. Sanitary Considerations.

The shocking pollution at the intake of the Kensington Works, the impurities mostly moving with the surface water, and, as shown by the analyses, being sufficient to make the water at ebb tide and at surface the worst of the Delaware samples analyzed—these points have already been enlarged upon. The progressive contamination of the lower Schuylkill has likewise been exhibited. If, however, we compare the Kensington water with the lower Schuylkill water, the samples being collected on or near the same day (See Nos. 308, 305 and 303; also Nos. 356 and 357), the Kensington water is shown to be much the worse.

It is of great importance to discover whether water *certainly polluted by sewage*, as is this Kensington, exercises any appreciable influence upon the percentages of zymotic diseases in those districts of Philadelphia using it. For simplicity, the the most important zymotic—typhoid—was selected for study.

Whilst the difficulties of the problem, from the possible complications due to other factors, are conceded, yet in view of the probable dissemination of typhoid by water-carriage, it was thought that the comparison of typhoid statistics for those districts in Philadelphia supplied with Kensington, and those with Schuylkill water, should help in solving it. With this object in view, and with your aid and that of W. H. Ford, M. D., Chairman of the Sanitary Committee, Philadelphia Board of Health, the following tables were prepared. In neither table are the deaths for the last two weeks of 1883 exactly given, but this deficiency exerts no appreciable influence upon the figures studied.

In Table III, the percentage of Typhoid Fever upon Total Mortality is given; in Table IV, the Water Supply by Wards, and the Deaths by Typhoid Fever by Wards, the latter calculated on the basis of the Census for 1880.

TABLE III.

Deaths from all causes, etc., in Philadelphia, 1872 to 1883.

Years.	Deaths from all causes.	Deaths from typhoid fever.	Per cent. of typhoid fever upon total mortality.
1872	20,544	369	1.94
1873	16,736	364	2.32
1874	16,315	461	3.02
1875	18,909	420	2.35
1876	18,892	761	4.02
1877	16,004	542	3.32
1878	15,743	404	2.56
1879	15,473	344	1.38
1880	17,711	498	2.81
1881	19,515	645	3.30
1882	20,059	650	3.24
1883	20,009*	572*	2.85

* Deaths in last two weeks estimated.

VI. Conclusions.

The data thus far accumulated are insufficient to pass final judgments upon the relative quality of water from the Schuylkill, Delaware, Perkiomen, Neshaminy, Tohickon, and other drainage-areas. As much has been said in the body of this preliminary report as the facts hitherto eliminated warrant. I feel willing to express at present only two final conclusions:

1. The supply from Kensington should be abandoned, notwithstanding the improvement due to drawing from mid-channel.

2. Natural agencies are ordinarily adequate to effect the oxidation of the organic matters in the Lower Schuylkill, and sometimes to raise its condition to one of great purity. At other seasons these agencies utterly fail through the intervention of unusual disturbing forces, and the Lower Schuylkill is non-potable. Inasmuch as these failures are periodic and inevitable, the supply from the Lower Schuylkill should be abandoned, unless these agencies can be effectively supplemented by artificial means.

Very respectfully,

ALBERT R. LEEDS, Ph. D.

TABLE IV.

Water Supply of Philadelphia, by Wards		Death Rate from Typhoid Fever, by Wards.					
Roxborough	Roxborough	21	19,667	22	1.12	9	0.46
⅛ spring water; ⅞ Mount Airy, Part rural	Chestnut Hill, Roxborough	22	31,838	22	0 69	18	0.56
Frankford, supplied from Wentz Farm (The greater portion of this ward is rural and supplied from wells.)	Frankford	23	26,675	20	0.75	17	0.63
George's Hill	Belmont	24	46,058	24	0.52	18	0.39
		27	23,282	16	0.69	14	0.60
Delaware; Wentz Farm; ¼ direct pumpage	Kensington; Frankford; Spring Garden	25	36,099	21	0.58	28	0.77
Direct pumpage	Spring Garden	28	34,441	20	0.58	15	0.48
		29	40,805	31	0.76	29	0.71

SURVEYS FOR FUTURE SUPPLY.

REPORT OF PROGRESS DURING 1883.

By RUDOLPH HERING, C. E.,
Assistant in Charge.

PHILADELPHIA WATER DEPARTMENT.

January 28, 1884.

COL. WILLIAM LUDLOW,
Chief Engineer:

SIR:—I have the honor to present to you herewith the following report of the progress of the Surveys for the Future Water Supply of the City of Philadelphia, during the past year.

In accordance with your instructions, the first object was to collect the information already in existence, and also all suggestions covering the question of increasing and improving the present supply, and to make a general examination into the entire subject.

The result of this preliminary inquiry was as follows, the information being recorded as nearly as possible, in chronological order:*

* List of publications relating to the subject of the Future Water Supply of the City of Philadelphia:

1. Annual Reports of the Water Department, from 1856 to 1882.
2. Reports of a special committee of the Commissioners of Fairmount Park upon the Preservation of the Purity of the Water Supply, October, 1867.
3. Proposition of certain manufacturers of Manayunk for supplying the City of Philadelphia with pure water, contained in a memorial to the State Legislature, February, 1868.

As early as 1856, efforts were made to secure a better water supply for the city. The Schuylkill valley was being rapidly built up above the city, and the quality of the water, owing to the additional refuse cast into it, was becoming correspondingly less pure.

In 1858, the Chief Engineer of the Water Department, Mr. H. M. P. Birkinbine, urged that other sources than the Schuylkill be investigated, and made a preliminary report on the subject.

He considered the Wissahickon, the Delaware and the Lehigh at Easton, also the Schuylkill above Reading; rejected them all as unsuitable, and recommended an examination into the small watersheds about the city.

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4. On the Water Supply of Philadelphia. Pamphlet, by James Haworth, 1871.

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

6. On the Water Supply of Philadelphia. Pamphlet, by J. W. Nystrom, 1875.

7. Report on the Present and Future Water Supply for the City of Philadelphia, made to Councils by a Commission of Engineers, 1875.

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

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

10. The Water Supply of Philadelphia. Paper by Charles G. Darrach, Proceedings of the Engineers' Club, Philadelphia, May, 1879.

11. The Future Water Supply of the City of Philadelphia. Paper, by James F. Smith, Franklin Institute Journal, October, 1879.

12. The Future Water Supply of Philadelphia. Paper, by H. M. P. Birkinbine, Franklin Institute Journal, November, 1879.

13. The Philadelphia Water Supply. Report of a Commission to James Haworth, 1880.

14. Report on Drainage from the Falls of Schuylkill, November, 1882, and on the Pollution of the Schuylkill River, January, 1883, by Russell Thayer, Superintendent of Fairmount Park.

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

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

17. Report on the Philadelphia Water Supply, made to Councils, by a Board of Experts, October, 1882, and April, 1883.

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

In 1864, Mr. Birkinbine, again Chief Engineer, was granted an appropriation to make surveys for a supply of water to be brought from beyond the limits of the city, which resulted in a reconnaissance of all the creeks and streams within a radius of 40 miles.

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

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

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

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

On account of the objections that had been raised against the Perkiomen project by the Fairmount Park Commissioners and others, Mr. Birkinbine in his report to Councils for the year 1866, again discusses the scheme and endeavors to answer the disputed points by giving additional facts.

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

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

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

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

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

Owing to the opposition, the above bill did not pass; but neither of the projects was carried out in its stead.

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

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

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

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

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

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

As to the latter question, which alone concerns us here, the report of this Commission was unsatisfactory, from want of a comprehensive view of the question and a positive expression of opinion, due, no doubt, to the magnitude of the subject, and to the insufficient funds and time available for making the necessary inquiries. There was an absence of any valuable suggestions or of weighty arguments in any one direction which would more clearly indicate the proper future source of supply for the city. The Perkiomen scheme was rather favorably regarded by several members of the Commission, but, in the absence of more complete surveys and other investigations, they did not feel justified in recommending it.

The following propositions are discussed in the Report of the Commission of 1875:

1. Increase of minimum flow of the Schuylkill river by storing storm water in impounding reservoirs.—This scheme, if the reservoirs are formed by the river itself, would be much more expensive than raising the additional water by steam at

Fairmount, and is, therefore, not recommended. If impounding reservoirs are built in the Perkiomen Valley, by means of a dam at Zieglersville, which would permit the storage of more than 20,000 million gallons, the minimum flow of the Schuylkill for a period of eighty days could be doubled.

2. Pumping with the power of Flat Rock Dam.—The Commission presents this idea with a favorable opinion, as far as cost is concerned, and recommends it as worthy of further consideration. The increase of supply from this source is estimated at 20 million gallons per day for three months, and 27 millions per day for the remaining nine months.

3. Prevention of the pollution of the water pumped from the Fairmount Pool.—An intercepting sewer, as recommended by the Special Committee of the Park Commission in 1867, is pronounced to be the most effectual remedy hitherto advocated. The plan of carrying the water of Flat Rock Pool to the Fairmount pumps is also mentioned, but no decided recommendation is made in either case.

4. Gravity supply from the Delaware Water Gap.—From the fact that the cost of a supply from this source would be, according to the estimates of the Commission, not less than $30,000,000, the adoption of this scheme is deemed inexpedient.

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

6. *Scudder's Falls Project.*—The scheme to take the Delaware water at this point, situated two and one-half miles above Trenton, is likewise discarded on account of its cost, which is estimated at $21,500,000.

It requires the purchase of the Trenton Water Power, the erection of a low dam, the building of twenty-four miles of a large supply canal and seven miles of conduit, besides pumping the water by steam power at or near Lardner's Point.

7. *Gravity Supply from the Perkiomen.*—This project is treated more at length, as it was considered the only reasonably practical plan on the score of economy. Its cost for the delivery of 100 million gallons daily is estimated at $10,000,000; for the delivery of 200 million gallons daily, at $12,000,000.

The water-shed is stated to be free now and likely to remain free from causes of pollution. A suitable site for building a safe dam exists and at a point where a sufficient quantity of water can be impounded. It is assumed that fifty per cent. of the rainfall would flow into the reservoir, from which it is calculated that two million people could be supplied with eighty gallons each per day.

Considering the objections to this scheme, the Commission conlude that gravity works should not be constructed unless demanded for the purpose of obtaining a purer and better water, or unless the time is near at hand when the cost of gravity would be less than by any other means. To ascertain this relation with the required degree of exactness, the Commission recommends thorough and careful surveys for an accurate map, and estimates made in detail.

8. *Artesian Wells.*—The project of supplying the city from deep wells is laid aside on the ground that there is no probability that an adequate supply for the general use of the city could be obtained in that manner; and if there were, such plans are attended with great expense and extreme uncertainty, and in every case are more or less experimental.

No action was taken by Councils on the above recommendations concerning a thorough investigation of the Perkiomen, or of any other scheme.

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

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

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

In May, 1879, Mr. Charles G. Darrach read a paper before the Engineers' Club of Philadelphia on the same subject. He endeavored to show that a supply by pumping is more economical than by gravity, until the quantity of water needed is 150,000,000 gallons per day, or about the year 1950. In discussing the gravity schemes, he favors the Perkiomen, but instead of a dam at Schwenksville, as proposed by Mr. Birkinbine, he recommends an intercepting canal built around what would have been the edge of the lake, with dams on the cross valleys, to avoid the high dam at Schwenksville and the consequent flooding of the populated part of the valley.

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

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

In June, 1882, the Mayor was again authorized by Councils to appoint a Board of Experts, to report, among other matters, on what should be done for the future water supply of the city. The Commission consisted of Messrs. E. S. Chesbrough, J. Vaughan Merrick and Frederick Graff, in conjunction with the Chief Engineer, and their report is of too recent a date to need more than a reference. They found it impracticable at the time to reach definite conclusions on the question, for the want of sufficient surveys and other data.

The present investigation, finally, is to furnish the information which, as the foregoing clearly shows, had already been urged a number of times, and was absolutely essential to a solution of the important questions at issue.

It has been your desire to have the investigation made as thorough as practicable, and that due consideration should be given to all possible solutions of the problem.

Your instructions were to have the preliminary surveys extensive and exact enough to render a re-survey of the same territory at some future time unnecessary, should slight variations in the conduit lines, or in the location of storage reservoirs, be proposed.

Accordingly, the following practicable schemes are being carefully investigated:

Water can be brought to the city from distant sources, and delivered at high elevations by gravity; or it can be brought from less distant points by gravity, but requiring some pumping; or, thirdly, it can be obtained from nearer but necessarily lower sources, and be delivered into reservoirs entirely by pumping.

SCHEMES FOR SUPPLIES BY GRAVITY.

To this class belong the following:

1. *Delaware Water Gap.*—Although this source has been frequently mentioned, it has always been considered of questionable value, since the distance from the city, which is over eighty miles, renders the scheme an expensive one. The cost, however, had never been carefully ascertained, and, as both the excellence and abundance of this supply are great, it was worth a thorough examination.

2. To bring the *Upper Schuylkill water* by gravity to the city will not be considered at present as it is at times charged with sulphuric acid from the coal districts at the point where it would have to be diverted, and it is likely to remain so.

3. *The Lehigh River at White Haven.*—This project, although mentioned, has met with even less favor than the Water Gap scheme, owing to the required length of conduit, which would be about one hundred miles. The unusual adaptability, however, of the Lehigh water-shed above White Haven, and of its eastern slope between this point and Mauch Chunk, to furnish potable water of an excellent quality, being free from inducements either for mining, farming or manufacture, on account of its geological features and high elevation, makes the

same worthy of attention; not on account of a supposition that it might be best for any near future, for its cost at present precludes this, but on account of its possible connection with other schemes more favorable at present, but not sufficiently so to recommend their adoption without its backing for the more distant future.

It seems clear that the Blue Mountains, between the Lehigh and Port Jervis, must ultimately be the source whence the water supply not only of Philadelphia, but of other cities between it and the mountains, will be brought. No inducement prevails to cultivate this territory, whilst the farming and mineral lands below it must in time increase the population and the industries to an extent that will make the pollution of the lower streams almost unavoidable.

4. The Perkiomen Creek.—Among all the projects for a future supply, this one has heretofore received the most attention. . It was first suggested by Mr. Birkinbine, was favorably considered by the Commission of Engineers in 1875, and strongly advocated by Mr. James F. Smith, Chief Engineer of the Reading Canals.

It has, however, been impossible to give it legitimately an unqualified endorsement, for the reason that the necessary data for a full comprehension of the scheme were wanting. Moreover, there is a popular belief that the available quantity of water is insufficient, and that its quality is lacking in the necessary degree of excellence. To definitely settle these points, a thorough investigation of this entire project, considered in all its bearings, was directed.

5. The Neshaminy and Tohickon Creeks.—I am not aware that these creeks have ever been proposed as available for the future water supply of the city; nor would they be worth considering as forming a scheme by themselves, because their combined water is less in quantity than the water from the Perkiomen basin, although the quality cannot differ very materially from it. But as the location of a conduit bringing this water to the city, would be identical with one bringing water from the upper Delaware, this scheme presents many advantages. It will be referred to more fully under the next head.

Schemes for Supplies by Gravity, Supplemented by Pumping.

Among the projects grouped under the second class, namely, those by which water can be partially brought by gravity from less distant points, and partially pumped, we can mention the following, which must naturally belong to the Delaware water shed, as the purity of the Schuylkill water does not increase materially with its distance from the city:

1. Delaware River at Scudder's Falls.—This scheme was considered by the Commission of Engineers in 1875, and has already been outlined. Its cost removes it at present from the necessity of any serious consideration.

2. Delaware River at New Hope.—Two projects have been proposed to bring water from this point. They were both considered by the same Commission, and have also been already described.

3. Delaware River at Point Pleasant. — Above Point Pleasant the Delaware river falls about fifteen feet in two miles, therefore furnishing a considerable water power. Point Pleasant, furthermore, is situated at the mouth of the Tohickon Creek, and on the only practicable conduit line to the Delaware Water Gap.

A high-level conduit therefore, starting at this point, and delivering at the city reservoirs by gravity, is a practicable scheme, possessing the following advantages: It would carry the waters from the Neshaminy and Tohickon water sheds, collected by storage dams, to the city by gravity. The deficiency could be more than supplied from the Delaware river at Point Pleasant by steam or even by water power. The canal carries the low-water flow of the Lehigh river past this point, and therefore prevents its polluting the proposed supply. This conduit would eventually form a part of one to the Delaware Water Gap, being over one-third of its entire length.

This scheme has not been mentioned in any of the documents quoted, nor has it, to my knowledge, ever before been suggested.

Supplies Entirely by Pumping.

The projects of the third class contemplate the use of the the water within the limits of the city, as at present, by pumping to the necessary elevations, either by water power or steam. Artesian wells are the only source of this kind other than the Delaware and Schuylkill rivers. With regard to these the following remarks may be made. There are localities in this city where a large amount of water could be obtained, apparently unpolluted by surface infiltrations. The probable quantity of this water could be approximated only by a very careful geological and topographical examination, probably not without the aid of borings. While it is extremely doubtful whether sufficient water could be found to supply more than a small portion of the city, it might yet be found practicable to a certain degree, in case of serious objections to all other schemes.

From the above it is evident that the extent of territory requiring investigation for the future water supply is very large, much more extensive, in fact, than the territory available for the same purposes near any of the other large cities of the Union. New York had little choice, and was naturally led to the impounding of the Croton water, Boston to several small streams lying northwest of it, Baltimore to the Gunpowder creek, Brooklyn to the small streams east of it, Cincinnati to the Ohio river, St. Louis and New Orleans to the Mississippi, and the lake cities to the lakes,—while Philadelphia commands a territory comprising almost the entire Delaware, Schuylkill, and Lehigh water-sheds, with a number of small tributaries which may be used either independently or in connection with the main rivers. In weighing their relative advantages, it was decided, that at least the following schemes should be investigated, as they seemed to be the most practicable:

First, the Perkiomen project, in all its bearings, as it has heretofore been believed to offer the greatest advantages.

Secondly, a conduit line to the Delaware Water Gap, and the practicability of temporarily impounding the water along its course.

Thirdly, as the Perkiomen basin alone might be found to furnish an insufficient supply for a distant future, the Lehigh basin was to be examined to ascertain whether its water could be brought into the Perkiomen at a later time, in order to compare this combined project with the Delaware Water Gap scheme, which requires about the same length of conduit.

And fourthly, a sanitary survey of the Schuylkill valley was needed to show the nature and amount of the polluting elements, and the cost ascertained, as nearly as possible, of maintaining the purity of its water in the future, keeping in view an increasing development of the industries and growth of the population in the valley.

It was decided, therefore, to place two surveying parties in the field, one to work up the topographical features of the Perkiomen, the other those of the Delaware project, and a third party to take charge of the hydrographic work. In addition, a careful reconnaissance was to be made of the Lehigh water-shed, also a sanitary survey of the Schuylkill valley, and a geological survey of the respective water-sheds and of the territory over which the conduit lines were to pass.

The amount of work done by the different parties during the last year, classed as topographical, hydrographic, and miscellaneous, is as follows:

A. Topographical Work.

The information to be gained under this head was: First, the most feasible conduit routes; secondly, location for storage reservoirs; and thirdly, the physical, sanitary, and commercial features of the several water-sheds.

Under physical features were to be understood the general contour and elevation of the ground, the respective areas of woodland, swamps, meadows and arable land under cultivation, and of the towns and villages.

Under commercial features were to be considered the questions of possible future developments on account of mineral, agricultural, or other natural resources, or from being readily crossed by railroad lines.

Under sanitary features were to be classed the population, death or sick rate, the location and extent of mills, factories, slaughter-houses, cemeteries, sewage, etc., and the amount of refuse matter probably reaching the water courses.

The topography was taken with considerable care, especially for the conduits, so that a close location and estimate of the cost can be made. A preliminary inspection was first undertaken, with the assistance of the county maps and aneroid barometers, in order to avoid the running of useless lines. In considering the practicable routes, tunnels were not to be regarded as being very objectionable, as they give a safer and more durable conduit, with a tendency to lower the temperature of the water in summer, and to decrease the land damages. They save distance and increase the grade of the conduit, and the increased cost over open cutting is now much diminished by the improved appliances for tunneling.

The conduit lines were run at an elevation which would permit a discharge into the Cambria and Frankford reservoirs, or at 165 to 175 feet above city datum.

The transit lines were measured with steel tapes. The topography was filled in by triangulations, by gradienter and stadia measurements, by clinometer and slope rods. The main lines were very carefully leveled, after the method of double turning points, with very satisfactory results. Three check lines were leveled, completing circuits respectively of 97.23 miles, partially over a very rough country, with an error between the levels of the two parties of only .997 ft., or .0102 ft. per mile; of 73.4 miles, with an error of only 0.473 ft., or 0.0064 ft. per mile, and of 34.5 miles, with an error of only 0.07 foot, or 0.002 foot per mile.

During rainy days the time was occupied in calculating latitudes and departures for the plotting of the conduit lines, computing and checking bearings and distances, calculating elevations, inking field notes, cleaning and repairing tools.

(*a.*) *Perkiomen Party*, Mr. Harvey Linton, C. E., in charge.

This party began operations May 29, 1883, and remained in the field until December 17, 1883, or 175 working days, when the weather made it necessary to remove to the city and begin office work.

During this time 101.94 miles were measured with steel tape, of which 53.40 miles were for conduit lines; 325.89 miles were measured by stadia and gradienter; 200 miles of slopes were taken with clinometer; 3,566 vernier angles were turned; 5,719 magnetic bearings were taken with the transit; 204.44 miles were leveled with the "Y" level, and 504 bench marks were established.

The areas covered by the survey were about:

11½	square miles for conduit lines,
6	square miles for storage basins, and
90	square miles for general water-shed.
107½	square miles.

The lines for the proposed conduit to the Perkiomen were run as follows:

Starting at the site of the proposed Cambria reservoir, the line follows the best course to the Wissahickon creek, which it crosses near the old log cabin. Following the west bank for about five miles, with several short tunnels, it reaches a point about one mile north of Barren Hill, where two alternate lines diverge. One continues up the Wissahickon valley; the other runs towards Norristown.

The latter, through a short tunnel, reaches the Plymouth creek, crosses the Plymouth Railroad overhead, continues through Cold Point and the northern part of Hickorytown to a point about two miles northeast of Mogeetown, where a short tunnel brings it into a small valley; then, with another tunnel, it reaches Saw Mill Run, at the northeast corner of the borough of Norristown. From Hickorytown an alternate line to this point shortens the distance, but increases the length of tunneling. The line then crosses the Norristown ridge with a tunnel into the Stony Brook valley, crosses the railroad overhead, and then runs to a point one and a half miles southwest of Norritonville, whence a tunnel, about three miles in length, carries it into the Skippack valley. The width of this valley at the most favorable point for crossing is about two thousand one hundred feet. Passing Skippackville, the line reaches a point near Amityville, whence two tunnels bring it into the valley of the Northeast Branch of the Perkiomen, about one mile southwest of Lederachville. Crossing this stream, and following its western bank to near Branchville, it passes through another tunnel, and reaches Sumneytown and the proposed storage dam. From a point about one mile north of Lederachville, an alternate line was run directly to the Perkiomen at Salford Station, requiring a shorter tunnel.

The alternate line, diverging near Barren Hill, follows the west side of the Wissahickon to a point near Gwynedd Station, thence to Towamencin Creek with a five mile tunnel, which, if a higher grade is adopted, can be reduced to two and a half miles, and finally joins the line before mentioned, near Lederachville, after crossing the Skippack two miles northeast of Skippackville, and passing through another tunnel.

Topography was extended sufficiently far to examine still other alternate lines. Only one line remains to be run from a suitable point on the present line to opposite Schwenksville, and thus complete all practicable locations for a conduit into the Perkiomen basin on the proposed grade.

A careful survey was made of the entire country to be flooded by the proposed dams at Schwenksville, Green Lane, and Sumneytown, and the general topography of the water-shed of all the ground west of the Perkiomen and of the Macoby was taken, up to the county lines where it joins the territory covered by the State Geological Survey.

Mr. Linton was assisted in this work by

George B. Mifflin, Transitman, appointed June 12, 1883.
Kenneth Allen, Leveller, appointed May 30, 1883.
R. T. Vaughan, Rodman, appointed May 30, 1883, left December 22d.
H. A. Schofield, Rodman, appointed May 28, 1883.
Amasa Ely, Chainman, appointed May 28, 1883, left September 6th.
W. E. Parker, Chainman, appointed September 10th.
Max Atlee, Flagman, appointed May 28, 1883, left December 22d.
George W. Wood, Axeman, appointed June 4, 1883, left December 22d.

(*b.*) *Lehigh Party*, Mr. A. P. Berlin, C. E., in charge.

The object in view in making an examination of the Lehigh water-shed was simply to collect enough information to have a reasonably fair knowledge of its value in connection with the Perkiomen scheme, and to ascertain the feasibility of a conduit discharging into the Perkiomen basin. No detailed surveys were contemplated or made.

Mr. Berlin, of Easton, Pa., being familiar with the country, was entrusted with the duty: First, of collecting all existing maps and information that would assist in the work; and Secondly, of making a reconnaissance of the entire water-shed, noting its general physical and topographical features, in order both to correct and to supplement existing maps.

He began his work July 19th, and completed it September 4th. He was assisted from July 23rd to August 17th by Mr. C. P. Bassett.

The maps that were procured and copied are as follows:

1st. Lehigh Valley Railroad from the summit above White Haven to Allentown, with 20 feet contours extending some distance from the line.

2nd. Warrantee Tract Map between the Lehigh Valley and the D. L. & W. R. R., and between the Lehigh and Susquehanna Rivers.

3rd. Profile and general topographical features of Bear Creek Valley.

4th. The township maps of the counties situated in the water-shed under consideration.

Mr. C. E. Stedman, Chief Engineer L. V. R. R., rendered valuable assistance in securing and loaning existing maps, etc.

The field work consisted in reconnoitering the territory which drains into the Lehigh at White Haven and in recording about 500 aneroid elevations. But few sights and angles were taken, as it was not deemed necessary for the present inquiry to spend the time for an accurate survey. The Luzerne county map was found to be quite reliable; the Monroe county map fair; and the Carbon county map very inaccurate. Contours were sketched every twenty feet over the water-shed in the following townships: Tobyhanna, Coolbaugh and Tunkhannock, in Monroe county; Buck and Bear Creek, in Luzerne county; Dennison and Covington, and a portion of Kidder and Penn Forest, in Carbon county. The elevations were reduced to sea level.

The topography as thus obtained gives a fair idea of the territory for the purposes of ascertaining the area of the water-shed, as well as its general features for collecting and storing water.

The area which may be utilized for the water supply of the city is almost entirely covered with forests in different stages of growth. The streams furnish a very uniform flow, comparatively, and the water is excellent throughout. The main tributary to the Lehigh is the Tobyhanna river in Coolbaugh township, draining several lakes and ponds. The

Tunkhannock and Trout creeks are small but steady streams which discharge into the Lehigh on the south side; the Bear, Wright's, Shades, Cloke, Cold Spring, and Pond creeks empty into it from the north. The entire water shed is from 1,100 feet to about 2,000 feet above the sea, too high ever to be much used for agriculture. The soil, furthermore, is everywhere coarse and stony.

A conduit bringing the water down the valley would be situate on the left bank, at least as far down as below Mauch Chunk, and intercept all the streams crossed. It would then follow down through the Lehigh Gap, continue near the river to Siegfried's Bridge and then leaving it, cross the country towards the Perkiomen. A tunnel of less than four miles would permit the Lehigh water to discharge into the Perkiomen basin near Hossensack, at an elevation of about 400 feet above city datum.

The great fall available for the conduit would permit its diameter to be smaller, and thus its cost may compare favorably with that of other schemes requiring less length of conduit.

(c.) *Delaware Party*, F. L. Paddock, C. E., in charge.

The field work commenced June 6, with a small party, but from June 12 was continued with a full corps until December 17, or for 167 working days, when office work was begun.

During this time 305.68 miles were measured with steel tape, of which 113.42 miles were for conduit lines; 317.1 miles were measured by stadia and gradienter; 1,558 vernier angles were turned; 6,743 magnetic bearings were taken with the transit; 183.7 miles were leveled with the "Y" level and 272 bench marks were established.

The areas covered by the surveys were

23	square miles for conduit lines,
1.5	square miles for storage basins, and
20	square miles for general water-shed.
44.5	square miles.

Four and two-thirds months were devoted to the survey of a conduit line to the Delaware Water Gap, which was run as follows:

Two alternate lines were located from the city to Huntingdon Valley, beginning at the city line near Second street, west of Tacony Creek. One runs to Fox Chase, and thence to the junction of Harper's Run with the Pennypack creek and along the west bank of the latter to Huntingdon Valley. The other, longer in distance but requiring less expensive work, extends in a northwest direction to the left of Ashbourne on the North Penn R. R., strikes the Tacony creek near Shoemakertown, and thence follows the west bank of this creek to its head near Jenkintown. From here it follows down Paul's Brook to the Pennypack creek, where it joins the other line near Huntingdon station.

The conduit line then extends up the Pennypack, on its west bank, to the Forks, whence again several alternate lines were run: one through Johnsville to the west of Jacksonville, striking the Little Neshaminy at Rosse's Mill; another follows up the Eastern Fork of the Pennypack to Danville, thence to Nippe's Run, back of Jacksonville, and down the latter to the Neshaminy; and a third passes Hartsville station near the head of the Warminster creek, and follows the same to its junction with the Little Neshaminy. The country over which these lines run is the dividing ridge between the Pennypack and Neshaminy waters and will require a tunnel about two miles in length.

From Rosse's Mill the line follows the west bank of the Little Neshaminy, and crosses the Big Neshaminy west of the Forks. Thence it extends up Mill Creek to Lahaska Creek, and follows the latter to Greenville. Here another dividing ridge requires a tunnel 2½ miles in length, which brings the conduit line to Carversville.

An alternate line was run in a northeasterly direction from near Vandegroft's Mill to the Trout Ponds or Ingham Springs, near New Hope, passing up one of the branches of Pidcock

Creek to Clayton, and through a gap between the Solebury and Buckingham Mountains, down to the Springs.

Another line was run from the head waters of Pidcock Creek, to Glendale, whence it was intended to extend it by a short tunnel through the Solebury Mountain, to Aquelong Creek, and thence to New Hope.

From Carversville the first line follows the valley of the Paunaucussing creek down to the Delaware river at Lumberville, and continues on or near its western bank up to the Water Gap.

About one and a third miles above Lumberville, and at the mouth of the Tohickon creek, it reaches Point Pleasant, where the conduit might temporarily terminate. The distance from the Frankford Reservoir to this point is thirty miles.

Contrary to expectations gained from previous reports, the above line as far as Point Pleasant is found to compare well with the lines to the Perkiomen. The length of tunneling is much less than was supposed, and there are but few valleys to cross. No detailed comparison has as yet been possible, except to observe that their length and the amount of tunneling necessary are about the same.

After crossing the Tohickon valley the conduit would follow the bank as far as Tinicum Creek. From there it can run either in a direct line to a point west of Kintnersville, about a mile from the river, cutting off an extensive bend in the same by a five-mile tunnel, probably mostly through trap rock, or it can follow the river along a very steep bluff through sandstone and slates. Above Kintnersville the conduit runs inland as far as Monroe. At Easton it crosses the Lehigh river, follows along Second street, and then crosses the Bushkill creek, all by means of one inverted syphon 3,900 feet in length. From here to the Gap the line is not troublesome.

The party devoted the remainder of the season to running a tie line from Point Pleasant, on the Delaware, to Schwenksville, on the Perkiomen, to connect the levels and lines of the two parties, also to surveying sites for storage basins in the Tohickon valley, and to crossing the same with a few base lines from which to take the topography during the following season.

Mr. Paddock was assited in this work by

W. T. Forsythe, Transitman, appointed June 10th.
E. C. Bull, Leveler, appointed June 5th, left December 20th.
Jacob Stadleman, Rodman, appointed June 4th, left July 7th.
Isaac Forsythe, Rodman, appointed June 4th, left December 20th.
G. S. Cheyney, Chainman, appointed June 4th.
Ross Kirk, Chainman, appointed July 9th, left November 3d.
C. E. Taylor, Axeman, appointed June 18th.
Thomas Jamison, Flagman, appointed June 5th, left December 20th.

B. Hydrographic Work.

The hydrographic branch of the investigation was intrusted to Mr. C. S. Gowen, C. E. He reported for duty June 24th, and has since been engaged in ascertaining

1. The flow of the different streams in the Perkiomen, the Neshaminy and Tohickon valleys;

2. The minimum flow of the Delaware and Lehigh rivers; and

3. The rainfall on the Delaware, Schuylkill, and Lehigh basins in general, and on the Perkiomen, Neshaminy and Tohickon basins in particular.

For the Perkiomen project it was decided to gauge the following streams:

The Perkiomen at Green Lane and Schwenksville.
The East Swamp creek at Sumneytown.
The Macoby at Green Lane.
The West Swamp creek at Zieglersville.
The Northeast Branch, one and a half miles above Schwenksville.
The Skippack at Skippackville.

For the Delaware project it was decided to gauge the Pennypack at Shelmire's mills, the Neshaminy at the Forks, and the Tohickon at Point Pleasant.

A careful search was made for proper sites at which to place the gauge posts, and where to build the necessary weirs and to place current meters, so that reliable results could be secured at the least expense.

It has not yet been possible to compute the results of this season's work. It may, however, be stated in general, that the combined minimum, and also the mean flow in the Tohickon and Neshaminy creeks from July to December 1st was considerably less than in the Perkiomen and its branches, but that in December their combined mean flow was somewhat larger.

This result is no doubt due partially to the fact that the rainfall on the Perkiomen water-shed was somewhat greater, and also to the fact that the territory about the headwaters of the Perkiomen is more wooded, and therefore prevents evaporation and immediate discharge better than the territory near the head of the Tohickon and Neshaminy water-sheds, which is mostly cultivated land.

From the fact that the many mill privileges cause a very irregular flow by the storing of water and its subsequent rapid discharge, it is extremely difficult to get accurate results. Automatic gauges would obviate this difficulty, and it may be advisable, after the last year's work is compiled, to establish several in both the Perkiomen and Delaware divisions during the following season.

Appended will be found drawings of two types of weirs, as built, one being in soft ground, as on the Perkiomen above Green Lane, and the other on rock, as at the Forks of the Neshaminy.

To ascertain the minimum flow of the Delaware and Lehigh rivers, suitable localities were selected, and meter measurements were taken at the lowest stages of the rivers. It was stated at the time when our measurements were taken, that the river at the Water Gap had not been as low for many years. The minimum flow of the Delaware at that point was found to be 697 million gallons per day, and of the Lehigh, at White Haven, 76 million gallons per day.

The flow of the Schuylkill river has heretofore been approximately measured by ascertaining the quantity of water pumped, the quantity used for the wheels and for the locks, and estimating the leakage, when no water was flowing over the dam. It was, therefore, not deemed necessary at this time to make any further measurements.

The rainfall question next received consideration. Gauges, such as are used by the United States Government, were placed at every point where it was desirable to measure the precipitation and where no observations had previously been made. In order to ascertain the intensity of the storms, especially during the heaviest fall, and to leave an exact record of their duration, automatic gauges were required. After considerable search for the best instruments, we succeeded in having three made according to the pattern of Prof. Draper, in charge of the Meteorological Station at Central Park, New York City.

The rainfall records of numerous volunteer observers, stationed on or near the water-sheds under consideration, have been collected and are appended. These, together with our own, will, when compared, enable us to determine the amount of precipitation on the Perkiomen, Neshaminy and Tohickon water-sheds. As yet no complete comparison of the results has been possible. The only conclusion which can be given so far is that the rain-fall on the Perkiomen water-shed during the last six months of 1883, was somewhat greater than that on the Tohickon and Neshaminy water-sheds.

The nature of the work of the hydrographic party being such that even one whole season's result cannot lead to a final conclusion, owing to the varying intensity of the seasons during the different years, it is essential that the observations should be continued for several years without interruption. To cease gauging the streams continuously before the final

adoption of one of the projects, might result in serious consequences. The absence of a full record might easily, for instance, cause the assumption of an erroneous quantity for the necessary storage capacity on the different streams.

The expense of permanently continuing this work, now that the weirs are built and the gauges set, would not be considerable, and certainly would be worth much more than its cost. In connection therewith the rain gauging should likewise be continued, at least for several years. New York and Boston both continue permanently the rain and stream gauging connected with their water supplies.

Mr. Gowen was assisted in his work by

H. W. Sanborn,	Sub-assistant,	appointed	July 20.
E. S. Crawley,	Rodman,	"	June 25, left Sept. 8.
Amasa Ely,	"	"	Sept. 7.
H. C. Shurtleff,	"	"	Oct. 2, left Dec. 11.
B. Franklin,	"	"	July 17, " Aug. 17.
E. S. Campbell,	"	"	Aug. 20, " Sept. 8.
G. A. Luccareni,	"	"	Sept. 6, " Oct. 31.
J. G. Hillsman,	"	"	June 30, " Dec. 15.

LIST OF OBSERVERS ENGAGED BY THE DEPARTMENT.

NAME.		PLACE.
J. G. Hillsman,	since Dec. 15,	Frederick, Montgomery Co.
N. S. Renninger,	" July 24,	Green Lane, "
G. H. Hart,	" Sept. 9,	Pennsburg, "
G. W. Roth,	" Sept. 1,	Ottsville, Bucks Co.
Thos. Walton,	" Oct. 5,	Doylestown, "

In addition to the above, records from the following localities have been furnished, which greatly assist in arriving at proper conclusions, and for which we are indebted to the following parties:

Gen. W. B. Hazen, Chief Signal Officer, Washington.

T. F. Townsend, U. S. Signal Service, Philadelphia.

Mr. E. F. Smith, Chief Engineer Canals of Reading Railroad Company, Reading, Pa., for observations at Schuylkill Haven, Reading, and Browers (mouth of Perkiomen).

Mr. Thos. J. Beans, . . .	Burlington, N. J.
Mr. Francis B. Hodge, . .	Wilkesbarre, Pa.
Mr. Charles Moore, . . .	Pottstown, Pa.
Mr. S. B. Lehman, . .	Lebanon, Pa.
Mr. Millnor Gillingham, . .	Fallsington, Pa.
Mr. M. McNeill, . . .	Princeton, N. J.
Mr. J. H. Heacock, . . .	Quakertown, Pa.
Miss Emily Kent, . . .	Phillipsburg, N. J.
Prof. S. J. Coffin, . . .	Easton, Pa.
Dr. J. C. Green, . . .	West Chester, Pa.
Prof. E. Pliny Chase, . . .	Haverford College, Pa.
Pennsylvania Hospital, . .	Philadelphia.

The report of Mr. Gowen on the detailed operations of the party is herewith appended.

PHILADELPHIA WATER DEPARTMENT.

January 23, 1884.

RUDOLPH HERING, ESQ.,
Assistant Engineer in charge of Surveys
for a New Supply of Water:

SIR:—Herewith is submitted a report of the operations of the Hydrographic party connected with the surveys for a new supply of water, for the season ending January 1, 1884.

In accordance with instructions I reported for duty at the Water Department, June 24, and after making the necessary arrangements for field and office work, proceeded, June 26, to Schwenksville, in the Perkiomen division, where headquarters for the party were established for the season.

STREAM GAUGING.

As the Perkiomen division is the most extensive, my instructions were to make a beginning on that side, and accordingly explorations and surveys of all those streams were immediately begun in order to establish gauging points.

It was proposed at first to use as far as possible current meters for gauging, but investigation showed that little could be done to advantage with those instruments under the ordinary conditions of the summer flow of the streams. These natural channels are very rough and of considerable width, showing everywhere the marks of the high flows of the winter and spring months, and the inclination of their beds are, as a rule, considerable, the streams forming, in most cases, a constant succession of mill-ponds, with but short intervals between each dam and the head of the succeeding pond below. Besides, the extreme shallowness of all the streams in their normal summer condition rendered the use of the current meter impossible at points where there was a perceptible current.

Accordingly it was decided to build a number of low weirs or dams, and to measure the flow passing them. This method offered the advantage that the manner of observation is simple, taking but little time, and affording opportunities for continuous measurements whenever desired. The weirs were intended to gauge the ordinary summer or low flows, and the meters were to be used whenever the streams were too high to allow the weirs to act as such.

(*a*). *Perkiomen Division.*—Gauging points were decided upon at the following places in the Perkiomen division:

Perkiomen, above Green Lane.
Macoby, " " "
East Swamp Creek, at Sumneytown.
West Swamp Creek, at Zieglersville.
North East Branch, at Schwenksville.

As it would take considerable time to build the weirs, gauges were placed at the following points:

On the Perkiomen, in Shaw's meadow, above Green Lane.

On the Macoby, at the "foot log," above Green Lane, near the house of Mr. Hildebeitel.

On the East Swamp creek, at Sumneytown, on the land of Daniel Krauss, below the turnpike bridge.

On the Perkiomen, at Frederick, below the stone bridge.

On the Perkiomen, at Schwenksville, at Longaker's dam.

On the Perkiomen, at Schwenksville, below Longaker's dam.

On the West Swamp creek, at Zieglersville, below Leidy's bridge.

On the Northeast Branch, at Schwenksville, on the land of John Alderfer.

These gauges are made of inch boards, painted white, and graduated to hundredths of feet. In a majority of cases they were attached to 6″ x 8″ hemlock posts, which were firmly set into the banks of the stream, and in all cases the tops of the gauges were connected by levels with defined bench marks near by, the levels being repeated from time to time as occasion demanded. Regular daily observations of the heights of the streams, began as follows:

West Swamp Creek Gauge	June 27
Longaker's Dam "	" 30
Gauge below Longaker's Dam . .	" 30
Frederick Gauge	July 2
Northeast Branch Gauge . . .	" 7
East Swamp Creek "	" 12
Gauge on the Perkiomen above Green Lane	" 12
Gauge on the Macoby " " "	" 13

As soon as it was decided to use weirs (about July 15) measures were taken to start work upon the Perkiomen weir, on land owned by Mr. Shaw of Philadelphia, situated at Green Lane, plans having been prepared for that purpose, but on seeing Mr. Shaw, it was learned that he intended to build a dam which would flood our weir location. Finding a new location and making new arrangements occasioned delay, but work was started on the weirs as follows:

Macoby Weir	July 26
East Swamp Creek Weir	" 30
Perkiomen "	Aug. 8
Northeast Branch "	" 9
West Swamp Creek "	Sept. 3

Regular daily measurements of the flow at these weirs began as follows:

Macoby Weir	Aug. 8
East Swamp Creek Weir	" 8
Perkiomen "	" 29
Northeast Branch "	" 27
West Swamp Creek "	Sept. 13

The Perkiomen weir is located about one and three-fourths miles above Green Lane, on the land of Michael Gettle. Access to the weir is obtained over the land of William Smith. The weir is built in a bed of compact gravel; the length of crest or overflow is 68.83 feet, and the depth of the water on the up-stream side is about 17 inches below the crest. The method of construction of this weir, which is the same, except in a few details, as the East Swamp Creek, the Northeast Branch, and the West Swamp Creek weirs, is as follows:

Two 8 inch by 10 inch hemlock sills were placed parallel to each other across the bed of the stream, extending on either side a considerable distance into the bank, and forming, when joined together, a "bed" frame about four feet wide. Against the upper side of the upper sill, which was carefully placed to a true line, 3 inch tongued-and-grooved hemlock planks were placed in a dug trench, and then driven to a depth varying from 2½ to 3½ feet below the sills. These planks were spiked to the sill, and against them another 8 inch by 10 inch sill was then placed and firmly bolted to the planks and other sill, with three-quarter inch bolts, at intervals of about 2½ feet. The upper ends of the sheeting planks were allowed to project above the sills, and were stiffened by pieces of 6 inch by 8 inch timber placed against the down stream side, and to the up stream side were fastened the crest pieces, with five-eighth inch lag screws, placed 18 inches apart.

The crest-pieces were made of well-seasoned oak plank, two inches thick and eight inches wide, carefully worked to true lines and surfaces, the upper edge, over which the water passes, presenting a horizontal face, one inch wide, with a beveled face for the remaining thickness. The crest pieces project from four to five inches above the timbers below, and their ends are either butted or mortised together. In the former case the joints are covered on the up-stream side with thin iron plates, to prevent possible warping or leakage.

The upper face of the bed-frame is covered with two-inch plank, four to five feet in length, forming the apron of the weir. In the Perkiomen weir this apron was surmounted by another, placed about a foot above, and the intervening space filled with heavy stones and gravel, forming a crib. The apron extends at either end for a considerable distance beyond the ends of the overflow; and the weir was further loaded by filling these parts of the apron with heavy stones. The up-stream side of the sheeting, and the banks near the ends of the dams, were well puddled. The sheeting at the ends of the overflows was carried to a height, varying in the different weirs, from one to two feet above the level of the crest, and at that elevation extended into the banks.

The East Swamp Creek weir is placed at Sumneytown, a short distance below the turnpike bridge, on the land of Daniel Krauss. Similar in general design to the Perkiomen weir, its overflow is 26.02 feet long, and it is loaded only at the ends of the apron. The height above the bed of the stream is nine inches.

The West Swamp Creek weir is at Zieglersville, about half a mile above Leidy's mill, on the land of J. Daup and George Kunkel. The overflow is 68.60 feet long, and height of crest above bed of stream, 15 inches. It was built a little lower than some of the others, as its position is a short distance below a ford on a township road, and it was deemed necessary to avoid raising the water at the ford. At this weir there is a crib below the apron, in addition to the loading at the ends.

The Northeast Branch weir is about one and a half miles east of Schwenksville, on the land of John Alderfer. The overflow is 64.21 feet long. The height of the crest above the bed of the stream is 19 inches. There is no crib at this weir, the height of the crest above the apron allowing it to be loaded with loose stones all the way across.

On November 20th the crest and bed-log below were taken off this weir, and measurements for the season were stopped. This was done to satisfy the land-owner, named Wagner, who lives about half a mile above, and whose farm ford was flooded by the dam. This lowered the water about 12 inches, and no complaints have been made since. Should Wagner wish to use his ford next season, it will have to be raised by building a causeway.

The Macoby weir is at Green Lane, a short distance above the turnpike bridge, and differs from the others, as it is built upon rock foundation. It has two overflows or crests placed to form an obtuse angle, the apex pointing up stream. A post placed at the apex divides the crests. The rock was first worked to a level for the bed-log, which was of 6 inch by 8 inch oak. This was bedded to the rock in Portland cement, and bolted down with inch bolts placed five feet apart. The bolts were sunk one foot into the rock, and were fastened with wedges and brimstone. The outer ends of the weir terminated in posts which were set into masonry walls. The walls are three feet thick, and extend into the bank on one side, and on the ledge on the other side of the stream.

The length of No. 1 crest is 14.99 feet; the length of No. 2

crest is 11.82 feet; and the height of the crest above the bed of the stream is 12 inches.

The same general method of measuring the flow at the weirs was used in all cases, and consisted of observations of the height of the water at a gauge placed on a post at a point about five feet up-stream from the weir crest. This gauge was carefully levelled upon, and its height compared with the height of the crest, obtained by levels taken at intervals of three feet over its whole length. At the long weirs two posts were used, one at each end, and, when practicable, two observers were employed, one at each gauge, making simultaneous observations. This was of especial benefit on windy days, when the water was ruffled more on one side of the stream than on the other. Comparisons between the gauge-posts and the weirs were made at intervals, to note any possible change.

The weir observations have all been tabled on large sheets of ledger paper, and the resulting flows are now in process of calculation.

(*b*). *Delaware Division.*—While gaugings and weir building were in progress on the Perkiomen Division, visits from time to time were made to the Delaware Division, to get general ideas of the water-sheds, and to select sites for gauging points. On August 2nd and 3rd the Tohickon was explored from Point Pleasant to a point about four miles above Ottsville, and during the week ending August 11 the Big and Little Neshaminy creeks were explored for several miles above their junction at Warner's ford; on August 19th another visit was made to the Neshaminy, and on August 27th a trip was made to Point Pleasant, at which place it was decided to build a weir upon the Tohickon.

Work was begun upon the Tohickon weir September 12th. Regular gaugings of the height of the creek began September 13th, and estimates and gaugings of the flow were made at intervals from August 1st, beginning regularly September 25th, at the weir.

Observations of the flow of the Big and Little Neshaminy were made at intervals from September 13th, and regular gaugings of the height of the Big Neshaminy began at that time.

Meter measurements of the flow of the Big and Little Neshaminy creeks at a point below their junction at Warner's ford were made, beginning September 28th, and continuing regularly till the completion of the Neshaminy weir.

Work began on the Neshaminy weir October 4th, and regular measurements began November 7th.

The weir on the Tohickon, at Point Pleasant, is located a short distance below Stover's Mills, on Mr. Stover's land. It is built on rock in a manner similar to the Macoby weir. The crest is 43.73 feet long, and walls of masonry, about four feet in thickness, built of stone found in the bed of the stream, extend into the banks on either side. Shortly after the weir was completed the volume of the stream increased considerably, and the weir crest was raised four inches higher to properly back the water on the up-stream side. This should have been done at first, but the location of the weir so near the race-way of the mill above caused the proprietors to fear that it might interfere with the running of their wheels, and the weir was built as low as possible. They, however, have never complained of the additional height, and probably have never noticed it. The height of the weir, with its four inches additional crest, is 16 inches above the bed of the stream.

The Neshaminy weir is located on the Big Neshaminy, a short distance below the iron bridge at Warner's ford. It is built on rock, and consists of a bed-log of 10 in. x 12 in. oak timber, bolted to the rock. Between the bed-log and the ledge is a wall of Portland cement masonry, varying in height from 6 inches to 3 feet, the latter being the depth at a pocket in the ledge, at one end. The bolts are sunk into the ledge at least one foot, and pass up through the wall above, into the bed-log. They are one inch in diameter, and about four feet apart. The crest-pieces are fastened to the upper side of the bed-log, and at each end of the overflow is a post, sunk into a wing of masonry which extends into the bank. The length of the crest is 66.79 feet, and the height of the crest above the bed of the stream is 17 inches.

Flash-boards were used at all the weirs in times of very low flow, to shorten the crests and to confine the flow to observable limits. They were made of inch boards, and were fastened to the crest with iron hooks or dogs, so arranged that they could be readily put on or taken off, as occasion required.

The owners of the lands on which the various weirs are placed were in all cases consulted, and their consent to build the weirs obtained before construction began.

The difficulty of finding laborers delayed the construction of most of the weirs. Most of the localities in which the weirs are placed are isolated, and labor was engaged to a great extent from neighboring farms. In the case of the Neshaminy weir more than a week passed, and several gangs of men were engaged, before one was secured that would go to work.

(c.) *Lehigh and Upper Delaware Divisions.*—It was considered desirable to gauge the minimum flow of the Lehigh and Delaware Rivers, and this was done in September with the Department meter. The Delaware was gauged at two points;—on September 15 and 16, at a place about one and one-half miles above Portland; and on September 20, at another point nearer the Water Gap, above the steamboat landing. The Lehigh was gauged at White Haven, just above the upper end of the upper mill pond, on September 19.

The results of these gaugings show the minimum flow to be as follows:

Delaware river,	Sept.	20,	697,000,000	gallons	per	24 hours.
Lehigh	"	" 19,	76,000,000	"	"	" "

At both places well-defined points were made, and the heights of the water noted in connection therewith.

(*d.*) *Meter Measurements.*—During certain of the high flows that have occurred since August 1st, meter measurements have been made in the Perkiomen and East Swamp Creek. The Perkiomen was metered on August 2nd at a point about 500 feet below the foot-log above Green Lane, and the station used for metering East Swamp Creek was at the railroad bridge below Perkiomenville, near the junction of East Swamp Creek with the Perkiomen. As a rule the weirs did not fail to act as such during the high flows, and as the rise and fall of the streams occupies but a few hours during summer storms, it would not be practicable to get meter measurements at the point of maximum flow of all of them.

A staging has been attached to Leidy's bridge to use for gauging the West Swamp Creek, but use has not yet been made of it.

In the Delaware Division several storms occurred during October and November which occasioned too great a flow for the Tohickon weir to carry. The rise and fall of the water was carefully noted, and estimates of the flow will have to be made, as no means of taking meter measurements existed. On the Neshaminy the storms caused increases of flow sufficient to temporarily stop work on the weir. Permission was obtained from the Bucks County Commissioners to build stagings under the iron bridge at Warner's ford, but it was decided to wait till next season before building them.

No rating curves of the current meters were in the possession of the Water Department, and they were therefore rated in November at the Fairmount Reservoir, where the water was lowered to a convenient level for the purpose. The rating was done in this manner: The meter was secured to a stiff rod, and the observer, holding it as nearly plumb as possible in the water, walked along the stone curbing, which was but a few inches above the water in the reservoir. The distance through which he walked was divided into lengths of 25 feet, and a second observer noted the time at which the meter passed each point. In this way a record of the steadiness of the motion was made, as well as the velocity. A third assistant, walking behind the assistant with the meter, carried the battery and the register, and noted the number of revolutions. When a sufficient number of experiments at different velocities ranging from 0.3 to 5 feet per second had been obtained, rating curves were plotted, which are now in use.

Rain Gauging.

A number of rain gauges of the Signal Service pattern were procured, and placed at various points during the season, as follows:

Zieglersville	July 16
Green Lane	July 24
Ottsville	Sept. 1
Pennsburg	" 9
Doylestown	Oct. 5

The gauges at Zieglersville and Green Lane were in charge of the party. The gauge at Ottsville was placed in charge of Rev. G. W. Roth, that at Pennsburg in charge of G. H. Hart, and that at Doylestown in charge of Thomas Walton.

Since the party left the field (December 15th), the gauge at Zieglersville has been transferred to Frederick, at a point about three-quarters of a mile from its former location, and is in charge of J. G. Hillsman; the gauge at Green Lane, after freezing and bursting, has been repaired, and is at present in charge of N. S. Renninger.

Automatic Rain Gauges.—Three of these instruments, after the Draper pattern, were ordered to be made during the summer. They are designed to give a continuous graphical record of rain storms, showing the time of beginning and ending, the variations in the rate of the rain fall, and its amount. These gauges were placed at the following points:

No. 1. Thirteenth and Spring Garden Streets, Philadelphia.

No. 2. Green Lane.

No. 3. Doylestown.

They were put in operation upon the following dates:

No. 1. September 11th.

No. 2. October 23d.

No. 3. October 18th.

The delay in getting gauge No. 2 into operation was due to difficulty in getting a carpenter to do the necessary work, and to the fact that after it was put in place the clock-work was found to be out of order, and time elapsed before a man could be found to repair it. It has not been in operation since December 15.

In the case of gauge No. 3, it was originally intended to place it at Ottsville, as being, topographically, a desirable point. This place, however, was so far away that an opportunity to set up and regulate the gauge did not occur, and it was finally placed in a green-house at Doylestown, where it was expected that the heat from the boilers would melt the snow falling in winter sufficiently fast to insure its efficient working.

The gauges were found to work well as a rule, and tests showed their construction to be good and to warrant accurate results.

Rain gauge observations are in constant progress at the points above mentioned, and in the tabulated reports accompanying this will be found additional records from other points, having some connection with this investigation.

During the first week in December, the crests were removed from the different weirs in both divisions, gaugings ceased for the winter, and on December 15th, the party reported for duty at Philadelphia.

Measures were taken to continue observations of the flows of the streams through the winter months, as follows:

The stream-gauges on the Perkiomen are to be read twice a week, and in case of high flows, often enough to give the maximum heights. These readings are to be taken by J. G. Hillsman.

The gauge above Longaker's dam is read every day by J. Wisler.

The stream gauge on the Tohickon, at Point Pleasant, is observed in the same way as the Perkiomen gauges, by R. C. Stover, and the Big and Little Neshaminy stream-gauges are observed by John Kirk.

The dam at Schwenksville, known as Longaker's, has been carefully levelled upon in order that a section of flow in connection with the gauge above the dam can be calculated. The water from the Perkiomen, the Macoby, East Swamp and West Swamp creeks, passes over this dam.

The party is at present at work upon the calculations for the summer flow, but as considerable remains to be done on the calculations of the heavy flows, the averages for the season have not yet been determined.

Very respectfully,

C. S. GOWEN,

Assistant in Charge of Hydrographic Party.

C. Sanitary Survey of the Schuylkill Valley.

The work done under this head comprised an inspection of the water-shed for the purpose of ascertaining the various elements contributing to the pollution of the Schuylkill water. Mr. Dana C. Barber, C. E., was placed in charge of the investigation. He entered upon duty December 15th.

As it was winter, the ground covered with snow, and the streams frozen, it was not possible, besides making a general inspection of the entire water-shed, to do much more than gather information from the local authorities, and from persons in charge of the establishments contributing to the pollution of the streams, which part of the investigation is about completed. An original estimation or gauging of the quantities of objectionable matters was attempted only where a fairly satisfactory result could be obtained.

The territory was, for convenience, divided into seven districts, the lower ends of which were just above the principal towns—viz.: Reading, Pottstown, Phœnixville, Norristown, Conshohocken and Manayunk, and Fairmount Dam. On the completion of the investigation, therefore, it will be possible to state the total amount of pollution at the water in-take of each, excepting Pottstown, where the local supply is now derived from a point on the river below the town.

The report of Mr. Barber, a summary of which is appended, gives an account of his researches in full. He begins at the headwaters of the Schuylkill river, and follows it down to Fairmount Park. The Perkiomen water-sheds above Schwenksville and the Wissahickon valley were not included—the former, because the surveying parties had already been over the ground; the latter, because time did not permit.

The report gives a brief account of the respective watersheds. The amounts which represent the quantity of domestic waste water, and the disposition of the sewage and excrementitious matter, are carefully stated.

The manufactory waste is given wherever it could be ascertained. It is exceedingly difficult, however, and in many cases impossible to determine the exact amount of waste water reaching the river. Nothing more can be done in such cases than to record the amount of material used in the various industries, and, by analogy with other similar works, judge of the probable amount of waste. Gauging the effluents from the establishments, together with chemical analysis, would give the best answer to this question, and it should hereafter be done in the most important cases.

In a few instances, purification of the waste water has been attempted. The sewage from the State Asylum at Norristown is precipitated in tanks, and subsequently filtered, before it is discharged into Stony Creek. Seville Schofield, Son & Co., of Manayunk, and J. & J. Dobson, of the Falls, utilize their waste from wool scouring. The Campbell Manufacturing Co., of Manayunk, filter their dye-house waste water. The efficacy of their processes to purify the sewage and waste waters should be examined into next summer.

Inquiries were also made regarding the death and sick rates in the towns along the river, especially with regard to zymotic diseases; but the absence of Health Boards or Officers made a complete result impossible. Dr. R. S. Keelor has furnished a valuable contribition on this question in relation to Phœnixville. Dr. Chase kindly gave the health statistics of the Norristown Asylum. The United States Census Reports also furnish data on this subject.

The information collected, considering the short space of time devoted to it and the season, is very satisfactory. Some time yet will be required to record the conditions during the summer months.

An examination should be made into the nature of the soils underlying the towns along the river, in order to determine their filtering capacity, and into the disposition of the night soil about the large towns, as well as into the approximate amounts of fertilizers and manure used on the river slopes. To ascertain, if practicable, the quantity of mine water and its acidity would be of value in connection with its neutralization by the lime water above Reading. Further investigations likewise are necessary regarding the pollution from the Reading Gas and several other Works, where at present only imperfect information has been obtained.

The comparative fullness of Mr. Barber's report is largely due to the facility afforded and assistance rendered by the proprietors and managers of almost every manufactory in the valley, many of whom went to considerable trouble in order to give the desired information promptly and thoroughly. In many of the smaller woolen mills, however, considerable difficulty was experienced in obtaining the quantities of materials used; but nowhere, with the single exception of the Albion Dye Works, in Manayunk, was the desired information positively refused.

Special assistance in compiling the appended statement was furnished by

William D. Pollard, Esq., Secretary and Engineer, Pottsville Water Company.

A. Harvey Tyson, Esq., City Engineer, Reading.
D. F. Reinert, Esq., Borough Surveyor, Pottstown.
Edwin F. Bertolett, Esq., Borough Engineer, Phœnixville.
R. S. Keelor, M. D., Phœnixville.
Alex. K. Calhoun, Esq., Borough Surveyor, Norristown.

D. Geological Survey.

Mr. R. H. Sanders, geologist, made the investigations of the geological features of the water sheds and conduit lines.

The Reports of the Pennsylvania Geological Survey, Prof. J. P. Lesley in charge, furnished valuable information. The line of the Delaware conduit from Kintnersville to the Water Gap is fully described, also the Perkiomen conduit, as far as Norristown, and those portions of Berks and Lehigh Counties which are situated in the Perkiomen water-shed. The geology is also mapped along the proposed Lehigh conduit as far as the Lehigh Gap.

Mr. Sanders has so far examined only the line of the Delaware conduit. Prior to recording them on the profiles after these shall have been finished, he describes the formations along its course in general, as follows: "From the Frankford reservoir "to one and one-fifth miles south of the crossing of the Bound "Brook Railroad the conduit line traverses a micaceous gneiss, "rotten near its surface, from one to fifteen feet deep. From "the reservoir to near the Pennypack creek it is covered with "gravel, and thence up the valley with soil from one to ten "feet deep. On the next half mile is found a hard, massive "gneiss coming well to the surface. South of the creek hard, "hornblendic rock shows for thirty feet. To the north of it "the line passes over mica slate covered with about ten feet of "soil, for a distance of fifteen hundred feet; the rock itself is "rotten in some places to the depth of ten feet. On the re-"maining distance to the Bound Brook railroad chlorite slate "is found.

"The Paul's Brook valley, in which the Bound Brook rail-"road crosses the conduit line, first shows limestone for three "hundred feet, then sandstone and slate. Over the limestone "there is a swamp. From this valley, for about a mile, hard "gneisses again appear at the surface. The next fifteen hundred "feet shows syenite, sometimes covered with broken rock and "loose material from ten to twenty feet deep. Following this, for "two thousand feet, is gneiss, mostly hard and massive, but with a "few layers of rotten rock extending to a depth of twenty feet. "Again syenite appears for about thirty-five hundred feet. It "is generally massive and hard, but rotten in places to a depth "of five feet. It is covered with from five to ten feet of soil. "Thence, up to the Forks of the Pennypack, the syenite, which "still continues, is covered with gravel. For fifteen hundred "feet above the Forks the rock is probably a horizontal, thin-"bedded sandstone, covered with about five feet of soil. After "this the Davisville sandstone and slates appear, but mostly the "latter. The sandstone is thin-bedded and friable; the layers "are about horizontal. The same formations extend as far as "the Neshaminy creek. At the latter the shales begin to crop "out, and continue to the Forks. Near this point they reach "twenty feet above the creek, and are overlaid by sandstone. "Here the rocks have a slight dip to the northwest.

"At the point where the conduit crosses the Neshaminy "the bed rock is slate. The latter extends up the Mill "Creek valley, dipping fifteen degrees, north thirty degrees "east. Then follows sandstone for several hundred feet, and "farther on, for about the same distance, slates appear. Sand- "stone again forms the rock as far as the Buckingham town- "ship line, and dips slightly to the north.

"For the next two miles we find shales and slates, with not "over fifty feet of sandstone. The following half mile shows "massive, hard sandstone, which is covered with loose material "for several feet.

"From a point three-quarters of a mile south of Center- "ville to one a few hundred feet south of Greenville, limestone "appears and is covered with from one to twenty feet of clay. "It is followed to the Solebury township line by a coarse con- "glomerate sandstone. Here red shale crops out; it is but "a few feet thick, resting on massive sandstone which extends "down to Centerville. From the mill below Centerville to "Lumberville the rocks are alternating layers of slate and "sandstone, dipping ten degrees to the northwest. From the "Plumstead township line for fifteen hundred feet north, there "is massive red sandstone; then, for a thousand feet, altered "slate rock, a very hard material to quarry. This is "followed by fifteen hundred feet of trap, and again by altered "slate to a point about half a mile beyond Point Pleasant. "The following two thousand feet show sandstone, then fifteen "hundred feet of slates.

"Altered slates, with a small amount of trap, once more "appear for about a thousand feet. The next mile and a "quarter brings slate, with a small amount of sandstone, suc- "ceeded by fifteen hundred feet entirely of sandstone. From "here, passing Erwinna to the Roaring Rocks, slates and "shales are found, with a few feet of sandstone; then a large "mass of trap, extending down below the grade line of the "conduit, is found to extend as far as half a mile south of "Kintnersville. By keeping the conduit nearer to River "Bluff, between Uhlertown and Kintnersville, the trap rock "could be avoided, and the tunnel would pass through alter- "nating beds of slate and sandstone, but be about half a mile "longer. From the end of the trap down to the run which "passes Kintnersville, the rocks are slates and shales.

"From this point to the Water Gap the State Geological "Survey covered the ground. From the map in Report D, 3, "we find the following general profile:

"One mile of gneiss, one and a half miles of limestone, "one mile of gneiss, two and a half miles of limestone, two "and a half miles of gneiss, then again limestone as far as "Easton. From Easton, for two miles up the river, occurs "limestone, and then, for a mile and a half, gneiss, serpentine, "etc. Limestone then appears as far as Belvidere bridge, and "up to one quarter of a mile south of Portland we find slates. "Extending to half a mile north of Portland is limestone, "covered with gravel. From here to the Water Gap are "slates, and the Gap itself shows hard massive sandstone."

In making the reconnaissance of the Lehigh water-shed above White Haven, Mr. Berlin found that the rock consisted almost entirely of Pocono sandstone and conglomorate, with an occasional outcrop of red shale, making, therefore, an excellent formation for the gathering of water.

The rocks in the Perkiomen water-shed are estimated by Mr. Sanders to be five square miles of limestone, twenty-five miles of quartzites and the remainder red sandstone and red shales with some trap. The water divide from Green Lane to within two miles of the South Mountain is made by a trap dike which has altered the red shales on each side of it for about one thousand feet. The rocks in the upper Perkiomen are mainly horizontal.

About sixty square miles of the Perkiomen water-shed have been carefully investigated by the Pennsylvania State Geological Survey, Vols. D, 3. Large areas of the Delaware and Lehigh water-sheds above the respective "Water Gaps" have also been reported upon in detail.

Prof. James Hall, Geologist of the State of New York, has communicated to the Department geological data regarding the Delaware water-shed in that state. The affluents have their origin chiefly in the Catskill or Old Red Sandstone formation. It is quite uniform in character, consisting of coarse and fine sandstone with shaly partings or with intervening beds of shale. A large portion of the area is still a wilderness, or but very sparsely settled.

Special thanks are due to Prof. J. P. Lesley, for advance sheets of maps and reports issued by the Goological Survey.

E. Collection of Samples.

Samples of water for analysis were from time to time collected and forwarded to Prof. A. R. Leeds. The manner of the collection was in accordance with the instructions received from him.

The samples collected on the Perkiomen were from Perkiomen Creek at Green Lane, at Frederick and near its mouth; West Swamp Creek at Zieglersville; Macoby at Green Lane; East Swamp Creek at Perkiomenville; North East Branch near Schwenksville; Skippack at Evansburg, and Stony Creek at Norristown. All water from these localities would have to be impounded.

On the Delaware water-shed the samples were taken from Pennypack at Shelmire's Mills, Big and Little Neshaminy at their junction, Tohickon and Haycock creeks above their junction, and Tohickon Creek at Point Pleasant,—all of which water requires impounding. Samples were also taken from the Delaware river at Point Pleasant and at the Water Gap.

Samples of water were also collected from the Lehigh river at White Haven, and the Tobyhanna above its mouth, representing the quality to be obtained by the Lehigh project.

Finally, samples were collected from the Schuylkill river above Phœnixville, and from the Roxborough and Fairmount pools.

Hand specimens of some of the rocks situated along the lines of the proposed conduits, especially near the tunnels, have been filed at the office.

Boiler scale has been obtained from various localities over which the surveys have extended.

F. Office Work.

As the fair weather continued almost to the end of the year, and the surveys were carried on as long as possible, very little office work has yet been done.

Quarters were obtained, by authority of the Department, December 20th, at 925 Walnut street, and after a short leave of absence during the holidays, the party began working up the field notes.

The topography along the conduit lines is being plotted to a scale of 200 feet to the inch, and the general water-sheds to a scale of 400 feet to the inch. The latter is finally to be reduced to the scale (1,600 feet to the inch) of the topographical maps of the State Geological Survey, which cover 63 square miles of the Perkiomen water-shed.

The topography will be indicated by 5-feet contours on the conduit plan, and 10-feet contours on the general plans.

A preliminary map has been compiled, on a scale of $4\frac{3}{4}$ miles to the inch, from the best accessible sources, covering the entire Delaware, Lehigh, and Schuylkill water-sheds, to be used for general purposes. Four copies are attached to this report: one showing the areas covered by the surveys of last year; a second, the stations where the streams have been gauged and the rainfall observed; a third and fourth give the rainfall for the third and fourth quarters of the past year.

A general map, comprising the Perkiomen, Tohickon, and Neshaminy water-sheds, and the territory as far south as the city, on a scale of one and a half inches to the mile, will soon be commenced, and the surveys as finished will be plotted on it.

The hydrographic work is being tabulated and compiled.

I beg to make special mention of the industry with which the members of the survey parties have pursued their work during the last season, and especially of the skill with which Messrs. Gowen, Linton, Paddock and Barber have conducted their respective branches of the investigation. The amount of work accomplished during the time spent, as the preceding account shows, is very large and satisfactory.

G. Work Remaining to be Done.

The inquiry in regard to a future water supply is of great magnitude, owing mainly to two causes. One is the favorable development of the Point Pleasant scheme, as compared with the Perkiomen; the other is a favorable conduit line from the Perkiomen basin to White Haven, as compared with the Delaware conduit from Point Pleasant to the Water Gap.

Neither of these projects has been seriously considered heretofore. It will not require much additional work to ascertain the main features of the Lehigh conduit line, because the topography of most of the territory is already mapped. But to properly judge of the practicability and advisability of using the Tohickon and Neshaminy water, and of storing it, surveys must be made of these two water-sheds with the same care as those of the Perkiomen valley.

The surveys then in the City's possession would cover the entire ground from which it is possible to obtain water by a near gravity supply. The additional territory to be considered naturally increases the cost of this investigation, yet the sum required is not out of proportion to the expense found necessary in other cities. Boston was obliged to spend about $60,000 for the preliminary investigation for its additional water supply, and New York has expended about $250,000.

The Commission of Experts (1883,) say: "Indeed, in other cities large sums are annually expended for surveys to secure fresh information respecting the possible sources of water supply."

To carry the contemplated work to completion would certainly be economical, as the surveying parties have become thoroughly acquainted with the territory and the work, and the final result as well as the benefit from the sum already expended, could be reached earlier than if the completion were postponed.

To accomplish this the following information will still have to be obtained, after the surveys of last season have been worked up:

Perkiomen project.—Three square miles of topography for storage basins and conduits.

One hundred and thirty square miles of general topography, to ascertain the physical, commercial and sanitary features, including East Swamp Creek, North East Branch and Shippack valleys.

Sixty-three and three-tenths square miles of water-shed, already contoured and mapped by the State Geological Survey, to be inspected to ascertain its commercial and sanitary features.

Geological examination of the water-shed and the proposed conduit line.

Estimation of land and other damages for conduit and storage basins.

Completion of the statistics of polluting elements in the respective valleys affecting the condition of the surface water to be impounded.

Continuation of the hydrographic work in the basin throughout the year.

Respecting the Lehigh extension, certain parts of Kidder, Penn Forest, Sterling and Dreher townships have not yet been inspected, and a careful reconnaissance at least, is yet to be made of the left bank of the Lehigh, from Mauch Chunk to Catasauqua, for a conduit line.

The collected maps and surveys of the Lehigh water-shed and conduit line remain to be compiled and a general estimate made of the cost of the latter from the Perkiomen to White Haven.

Delaware project.—Five square miles of topography for storage reservoirs in the Neshaminy and Tohickon water-sheds.

Three square miles of topography for alternate conduit lines.

Two hundred and thirty square miles of general topography of the Neshaminy and Tohickon water-sheds, to ascertain their physical, commercial, and sanitary features.

Geological examination of the Neshaminy and Tohickon basins.

Estimation of land and other damages for conduits and storage basins.

Compilation of the statistics relating to the condition of the surface water to be impounded.

Continuation of the hydrographic work throughout the year, and of the analyses at important points and times.

Schuylkill Valley.—Completion of the Sanitary Survey of the valley.

Collection of data as to means and cost of guarding against future pollution, by local restrictions and purification works, or by intercepting sewers.

Measurement of the flow of the river by more careful means than heretofore.

Artesian Wells.—Geological examination and borings to ascertain the probable extent of water-bearing strata about the city.

Very respectfully,

RUDOLPH HERING,

Assistant Engineer in Charge.

...ary 14th, 1884.

...CTS.

	...H. (...ville ...s to ...ater ...)	FIFTH. (From Norristown Water Works to Conshohocken Water Works.)	SIXTH. (From Conshohocken Water Works to Roxboro' Pumping Station.)	SEVENTH. (From Roxborough Pumping Station to Fairmount Water Works.)
Drainage Area,..	... mls. ...	29.5 sq. mls. 1,751.4 "	38.5 sq. mls. 1,789.9 "	74.0 sq. mls. 1,863.9 "
Population, ...	0	19,500 286,500	16,200 302,700	48,800 351,500
DOM...				
Daily Water Su... Waste Wate...	...gals. ... "	950,000 gals. 8,775,000 "	75,000 gals. 8,800,000 "	
Population havi... age,[c d]		1,300 8,650	675 9,325	1,700 11,025
Population havi... closet Drai... Streams, Ce... ers or Strea...		1,750[e] 4,950	150 5,100	1,100 6,200
Population havi... Carriage to t...		150 4,050	100 4,150	100 4,250
Population havi... Water only,...		700 3,050	100 3,150	400 3,550
Population havi... Water,[f]	...0	5,000 40,500	2,000 42,500	2,500 45,000

...rict represented by the column in which they occur.

a From publi...
b Perkiomen...
c Including...
d Estimated ...on.
e Including...
f Estimated...

THE DISTRIBUTION OF

Valuable Property at Risk from Defective Water Supply

WITHIN THE LIMITS OF THE OLD CITY,

OR BETWEEN VINE AND SOUTH STREETS.

Information furnished by Mr. Lorin Blodget, 1329 South Broad Street, Philadelphia.

The distribution of valuable property at risk from defective water supply within the limits of the old city, or between Vine and South streets, may be generally stated as follows:

First, the active merchandise account, or the value of goods under immediate exchange, either as raw materials going to the mills, or as manufactured products under course of delivery to consumers. The aggregate value of such goods is more than one hundred millions of dollars, mostly held east of Ninth street, in stocks of $5,000 to $300,000 in value, and as placed along any street front, representing $30,000 to $2,000,000 in value, on any one block or square. In the Sixth Ward a single fire plug may be the only guardian of three or four millions of dollars in value of such property. The Sixth Ward alone contains over fifty millions of dollars in value of such active property in merchandise, as distinguished from mere merchandise in store for an indefinite period, and also not including any real estate.

The estimate along any street or frontage may be taken from the insurance carried by the business houses there, but it is always in excess of the insurance, because few houses insure on the average of daily receipts and deliveries. The largest stocks are of wool and woolen goods, wool and worsted yarns, hosiery, carpets, etc.; next cotton, and cotton yarns and manufactures; cured meats and provisions, lard, butter, cheese; canned provisions and grocers' supplies, including dried fruits and green fruits; oils, mill supplies, dyes, chemicls, fertilizers, etc.

While about fifteen or twenty million dollars worth of merchandise may be held in what may be called fixed storage, the great majority of all these articles will be in the course of rapid exchange and quick handling from dealer to consumer, so that the total value passing through their hands is three or four times as much in the course of the year. The trade in these goods may be roughly stated at four hundred millions of dollars for a year, while one hundred millions in value is constantly in hand, and in danger of destruction by fire at any time.

The close and narrow intermediate streets of the Sixth Ward, as Jayne, Minor, Commerce, Cherry, Filbert, Bank, Strawberry, Water, New, and a dozen others,—are crowded with merchandise and manufactures, and are dangerous fire traps.

The large manufacturing business of the Fifth and Sixth Wards adds greatly to the necessity for better water supplies. There are 56,650 persons employod in 2,067 manufacturing establishments in these Wards alone.,—a number without precedent in any City of the world,—and they produce $103,711,910 in value of manufactures yearly. The materials or finished goods for $30,000,000 of this amount may be assumed to be always on hand.

Still more important is the danger to human life. Most of these industries are conducted in large buildings on the narrowest streets, where a large number are employed on a single fourth or fifth floor, with very inadequate means of escape in case of sudden fire. The number and location of supply pipes appears to be the very reverse of what is necessary in these cases.

These conspicuous buildings, occupied by a large number of persons employed in manufactures, may be found in all other parts of the City, but never in so much danger as in the Sixth Ward, where the narrow streets, small supply pipes, and mutual exposures on both sides, render it wonderful that conflagrations have not swept such squares as those containing Jayne, Minor, Bank, and Letitia streets, many times.

To sum up, it may safely be said that at all times there are about $100,000,000 in value of *active merchandise*,—not merely stored goods,—always at risk in the Eastern half of the Old City, and during every working day there are 50,000 lives of working people also at risk of great fires, in the Fifth and Sixth Wards alone.

Including all the Wards of the Old City, the figures are as follows:—

WARDS.	Number of manufacturing establishments.	Number of persons employed.	Values produced.
Fifth and Sixth	2,067	50,649	$103,711,019
Seventh to Tenth	1,995	35,079	134,493,684
Totals	4,062	85,728	$238,205,594

These are manufactures alone, and constitute less than one-third of the value of merchandise handled in a year in the same Wards.

West of Seventh street the streets are less crowded, but along Eighth, Ninth, Market, Chestnut, Filbert, Cherry, Arch, etc., there are many very valuable groups of buildings, in which $300,000 to $500,000 in value of goods always remain at risk from fire. These buildings are larger than those farther East, as a rule, and are less crowded, while at the same time the risks are great, and the new erections each year add to the total risk. Eight or ten of these blocks or squares represent $500,000 each, in *active merchandise* at risk, exclusive of all real estate.

There are valuable single properties in the Seventh Ward, in the mills of the Western part of the Ward,—but the Eighth Ward presents the greatest values,—cloths and clothings, books, jewelry, carpets, dry goods, dental materials, furniture, and hotels.

The Ninth Ward has also very large stocks of dry goods, carpets, books, furniture, drugs, chemicals, metals, etc., and it is rapidly becoming much the same in the crowding of manufacturing and mercantile establishments as the Sixth Ward east of it. The value of active merchandise in this Ward is fully thirty millions of dollars,—perhaps thirty-five millions.

The Tenth Ward is also rapidly growing in the same direction, and has now twelve or fifteen millions in value of the same class of property.

In these four Wards, as said before, there are 1,995 establishments 35,079 persons, and $134,000,000 in value of products handled,—this including the U. S. Mint.

In these Wards there are also about forty thousand persons employed in large mercantile establishments which are chiefly dealers, but also considerable manufactures. Five or six of the largest of these, employ eight thousand persons, and handle twenty-five millions in value of goods in a year.

Philadelphia, March 11th, 1884.

ESTIMATES
PHILADELPHIA WATER DEPARTMENT,
1884.

Presented by the Chief Engineer to the City Controller, August 24th, 1883. Also,

A SCHEDULE .

furnished to the Water Committee, September 27th, 1883, showing the amount of Street Main less than 6 inches in diameter within the City limits, and dates of laying.

PHILADELPHIA WATER DEPARTMENT.

August 24, 1883.

DEAR SIR:

Pursuant to your suggestion I present the following statement of the separate sums which make up the total of the two million estimate submitted to you on the 14th inst. as representing the amount which it is desirable should be at the disposal of this Department for the year 1884.

1st. For the *Maintenance of the Department*, including the salaries of the officers and employés; the purchase of regular supplies, repairs to machinery, pipes, buildings, grounds, and reservoirs; drills and new attachments, the purchase of pipe, labor in laying pipe, and the expenses of the shop, the amount required will be $624,000.

2d. For the new 36-inch Pumping Main from the Spring Garden Station to Thirtieth street and Lehigh avenue; thence along Lehigh avenue to the Delaware Basin, $226,000.

3d. For new Distribution Mains, $425,000.

4th. For replacing 1, 2, and 3-inch pipe with 6-inch pipe, $100,000.

5th. For continuation of work upon the Reservoirs, as follows:

East Park Reservoir, - -	$375,000
Cambria " - - -	150,000
Mt. Airy " - - -	100,000
Total, - - - - -	$625,000

The footing up of these five items is $2,000,000.

With regard to them, I give, for your information, in advance of their consideration by the Committee, the following particulars:

ITEM 1. The estimate for maintenance is $21,000 less than the estimate of last year for the same purpose, allowing for a large saving, particularly in salaries and fuel, although the expenditures for repairs must be considerable.

ITEM 2. In order to utilize the two new 15-million engines now under construction for the Spring Garden Station, it is necessary that the Pumping Main to Lehigh avenue, should be provided for and laid as early as practicable.

During the construction of the Cambria Reservoir, water can be supplied to the Lehigh Basin, enabling us to dispense with the Kensington water.

ITEM 3 is the estimated cost of laying seven distributing Mains, from 16 to 30 inches in diameter, of which the following explanation may be given:

1. In 1880 that portion of the city below South street contained a population of 173,000—one-fifth of the entire city.

The number of houses furnished with water during the year 1882, was 33,169.

The water now furnished this large section passes through one 30-inch pipe, and as a result portions of this district are frequently entirely without water, and others receive an inadequate supply.

Last year a 30-inch Main was laid on Twenty-second street, from Washington avenue to South street. This should be continued along South street to Twentieth, along Twentieth to Callowhill, and along Callowhill to connect with the two 20-inch Mains from the Fairmount Reservoir. The cost will be about $64,000.

2. South street constitutes the dividing line between the distribution from Fairmount, and that from the Corinthian Basin.

The stop cocks along the south side of South street are, therefore, closed, and form dead ends.

The only Main feeding below South street is the 30-inch on Broad; and the only East and West Main is the 20-inch on Washington avenue.

The water flows south to the main feeder, and thence through the small service pipes to South street. The result of this is that the pressure is low, and the supply inadequate.

To improve both, the flow should commence at South street, the beginning of the distribution.

Numerous complaints are received of the scarcity of water on Gray's Ferry road and the vicinity. On some occasions no water whatever is delivered, and the manufacturing establishments are frequently compelled to stop for want of it.

A 20-inch main should be laid on South street, from Front to Gray's Ferry road, and on Gray's Ferry road to Thirty-sixth street. The cost will be $102,000.

3. West Philadelphia, with a population of 70,000 and 11,000 houses, is dependent upon a single 20-inch Main,

which crosses on the Pennsylvania Railroad Bridge at Belmont avenue.

In case of an accident to this pipe the greater portion of West Philadelphia would be deprived of water.

A 30-inch Main should be laid from the Belmont Reservoir down Fiftieth street, to Walnut street, which will cost $127,000.

4. In addition to this a 20-inch Main on Lancaster avenue should be laid, to connect the new 30-inch with the present 20-inch pipe. This connection will cost $12,600.

5. Between Sixth street and the Delaware river, and Vine and Norris streets, there are no main feeders, and the largest pipe is but 10 inches in diameter, with the exception of about 1,000 feet of 12-inch.

The population of this district is about 100,000, and the number of houses supplied with water about 17,000.

There are numerous manufacturing establishments using large amounts of water in this district, and frequent complaints are received of the inadequate supply.

A 16-inch Main terminates at Broad and Poplar streets, and should be continued down Poplar to Front street. The cost will be $33,000.

The district north of Susquehanna avenue, and east of Sixth street, has a single supply pipe of but 10 inches in diameter on Frankford road.

A 30-inch main should be laid on Lehigh avenue, from Sixth street east to Frankford road, which will cost $60,000.

7. A 30-inch main now reaches from Corinthian avenue, along Jefferson street, up Ninth to Dauphin street. It should be continued to the Lehigh Basin for the purpose of supplying Schuylkill water to this Basin, and in conjunction with the new Pumping Main on Lehigh avenue to justify the abandonment of the Kensington Station. This object can be attained at an expense of $26,500.

The aggregate cost of these seven new Supply Mains is $425,000.

ITEM 4. Another very important matter has not hitherto received the attention which it demands.

In the early days it was the custom to put down small pipes in small streets. So far as is known the small distributing pipes, less than six inches in diameter, now in service, are as follows:

1-inch,	- -	2,331 feet.
2-inch,	- -	6,317 "
3-inch,	- -	226,171 "
4-inch,	- -	583,417 "

Making a total of - 818,236 feet, or very nearly 155 miles of small pipe, some of which have been in the ground since 1817.

When these pipes were new and clean, and the demand for water was limited almost entirely to household uses, this system answered its purpose; but in time the pipes became filled with rust and sediment, which in some cases entirely stopped or perforated them.

Manufacturing establishments using large quantities of water, steam engines, new houses with multiplied appliances, and steam fire engines came into existence.

The annoyances and disadvantages due to the existence of these small pipes in connection with the lack of distributing mains have become intolerable, and the manufacturing interests of the city, as well as its protection from fire require that larger pipes shall be substituted for them.

The average cost of effecting this, using new six-inch pipes, will amount to about two dollars per running foot for the 818,236 feet, for which the sum of $1,626,472 would be required.

I propose to begin with the smallest pipe and most important districts, and by degrees effect the substitution.

The amount estimated for the following year for this purpose is $110,000, which will be sufficient to relay, with six-inch pipe, about 50,000 running feet. This will get rid of all the one and two-inch pipe, and about 40,000 feet, or one-fifth of the three-inch pipe.

ITEM 5. $625,000 is asked for the continuation of the work upon the East Park and Cambria Reservoirs, and the enlargement of the Mount Airy Reservoir.

Of this amount $375,000 is required for the East Park Reservoir, $150,000 for the Cambria Reservoir, and $100,000 for the Mount Airy Reservoir.

These Reservoirs are imperatively needed, and their completion and utilization cannot be reached too soon.

The amounts named are, in general, one-third of the sums required for their completion.

No estimate has been made for the land damages for the Cambria aud Mount Airy Reservoirs, for which separate legisiation will be required.

I find that the estimate of last year for the current year was $1,425,000, nearly equal to the receipts of 1882.

With regard to the estimated receipts of this office for 1884, a word of explanation may be of use.

The receipts of last year were about one and a half millions of dollars.

I am now having a re-inspection of the city made with a view of determining the amount that should be collected, and when this inspection is completed, I shall know, with some certainty, what the revenues from this source will be.

In my general estimate to you of the 14th inst., I have simply taken the figures of last year, but the re-inspection so far as it has progressed, shows a very large increase, which may amount to so much as 15 per cent., perhaps more. It will take me, however, until January, or thereabout, to complete this, as there are something like 160,000 buildings to inspect, determining the number of appliances in each, or, in the case of the manufacturing establishments, the amount of water consumed.

With regard to this matter, I am satisfied that the only practicable and equitable arrangement for making charges to large consumers is to measure the water supplied. This will require the purchase and use of a considerable number of meters.

When I took charge of this office the charge made for water furnished by meter to consumers was $1.25 per 1,000 cubic feet, although an ordinance distinctly says that the charge shall be $1.00 per 1,000 cubic feet.

The charge now made is in accordance with the ordinance, and I shall recommend to Councils to make a further reduction to seventy-five cents per 1,000 cubic feet, which is equivalent to ten cents per 1,000 gallons, or one cent per 100 gallons.

With this rate, which will yield a handsome profit to the city, and with the use of meters, there will be. in my judgment, both an increased revenue to the city and a diminished expense to consumers, the apparent contradiction of which is to be accounted for by the stoppage of stealing and wasting the water, and the collection of payment for what is used.

Within a year or two, even with our present arrangements for supplying water to the city, I have no doubt that the maintenance expenses can be reduced to between four and five hundred thousand dollars, and the revenues increased to $2,000,000, with an ample supply for all purposes, and diminished cost to consumers. Meanwhile it is essential that the question of the future water supply of a better quality should be kept steadily in view, and to that end the surveys, explorations, analyses, and investigations must be kept up during the year 1884.

I have included the cost of all this in the item for Maintenance.

If there be any points in connection with this matter upon which you desire further information I shall be very happy to furnish it.

Respectfully,

WILLIAM LUDLOW,

Chief Engineer.

MR. S. DAVIS PAGE,

City Controller.

PHILADELPHIA WATER DEPARTMENT.

Philadelphia, September 27, 1883.

To the Chairman of the Water Committee:

SIR:—I am informed that my letter to the City Controller, explanatory of the estimates of the amount that could be profitably expended by this Department during the year 1884, although attached to the subsequent communication of the Controller to Councils, was not printed therewith for the information of the members. I therefore enclose a copy of my letter in order that it may be seen in what manner the total estimate was made up. The only point calling for additional explanation is, perhaps, that of the small pipes.

The experience of the present season has proved conclusively that with the engines and stations in good order, and properly handled, more water can be pumped than the pipes will distribute. To remedy this the additional mains were estimated for, as set forth in my letter to the Controller, and the sum of one hundred thousand (100,000) dollars was recommended for beginning the replacing of small pipes, now in service, with larger pipe.

The accompanying schedule is taken from the records of the Department. It shows the amount of pipe less than six inches in diameter, and the date of laying. The records not being entirely complete, the figures given are less than the real amounts.

The estimated cost of replacing the whole of this, is nearly two millions of dollars.

Respectfully,

WILLIAM LUDLOW,

Chief Engineer.

RECAPITULATION OF SMALL PIPE.

FIRST DISTRICT.
COMPRISING
Wards 1, 2, 3, 4, 26 and 30.

Year.	1-Inch.	2-Inch.	3-Inch.	4-Inch.
1826				453
1827				375
1828			1,299	
1829			1,300	815
1830			1,126	
1831			1,086	
1832	186		364	852
1833			1,078	853
1834				
1835			3,870	1, 50
1836			453	
1837			553	896
1838				
1839			426	.
1840			124	584
1841			455	883
1842			460	
1843				853
1844				2,071
1845			1,005	
1846			867	450
1847				466
1848			275	
1849			1,710	
1850			730	1,715
1851				4,736
1852				2,336
1853			135	5,025
1854			200	4,282
1855			1,901	836
1856			2,653	1,299
1857			1,175	6,730
1858			240	6,828
1859				4,521
1860				7,081
1861				4,038
1862			333	3,445
1863				5,695
1864				2,253
1865				1,868
1866				2,66[illegible]
1867				3,765
1868				2,879
1869				7,316
1870				7,756
1871				11,072
1872				9,863
1873				9,280
1874				897
1875				124
1876				203
Date unk'n.		636	19,244	17,446
Totals....	186	636	43,062	145,550

SECOND DISTRICT.
COMPRISING
Wards 5, 6, 7, 8, 9, 10, 24 and 27.

Year.	1-Inch.	2-Inch.	3-Inch.	4-Inch.
1817				430
1822	278		401	
1823	416		830	
1824	413	200	3,515	481
1825	293	180	2,849	472
1826			5,528	6,707
1827		338	14,915	2,420
1828			7,584	
1829			1,917	1,734
1830			6,034	1,053
1831			7,123	
1832	296	100	4,651	
1833			3,832	514
1834	124		1,982	396
1835			4,312	830
1836			7,472	1,334
1837			4,239	446
1838			3,496	579
1839			2,274	175
1840			859	
1841			1,647	
1842		90	1,034	
1843			1,011	
1844			1,203	
1845			778	861
1846			2,458	
1847			1,561	
1848			4,423	
1849			5,954	545
1850			2,843	
1851			2,278	
1852			4,638	
1853			2,051	
1854			791	
1855			1,300	420
1856			1,245	385
1857			253	982
1858			593	5,807
1859			694	627
1860			1,054	2,421
1861			2,006	1,100
1862			338	834
1863			543	
1864				848
1865			225	
1866				1,263
1868				1,880
1869				1,234
1870				2,811
1871				2,410
1872				5,077
1873				2,563
1874				811
Date unk'n.			2,113	950
Totals....	1,820	908	126,847	49,600

RECAPITULATION OF SMALL PIPE.

THIRD DISTRICT, COMPRISING Wards 11, 12, 16, 17, 18, 19, 23, part of 25, and 31.

Year.	1-Inch.	2-Inch.	3-Inch.	4-Inch.
1826	...	...	1,865	40
1827	...	...	1,114	3,946
1828	...	...	1,195	1,274
1829	...	...	...	290
1830	...	...	...	1,631
1833	...	...	...	720
1834	...	...	...	138
1835	...	...	...	1,105
1836	...	...	...	1,561
1837	...	...	...	137
1838	...	...	...	1,326
1839	...	...	...	1,471
1840	...	...	...	1,059
1841	...	...	...	462
1842	...	...	...	921
1845	...	...	...	2,880
1850	...	...	...	413
1851	...	...	...	14,535
1852	...	...	...	8,430
1853	...	...	...	9,668
1854	...	...	...	500
1855	...	...	...	1,775
1856	...	...	...	3,299
1857	...	...	...	2,255
1858	...	...	...	2,170
1859	...	...	...	12,058
1860	...	...	...	5,431
1861	...	...	...	3,617
1862	...	...	...	3,839
1863	...	...	...	200
1864	...	...	...	7,191
1865	...	...	...	3,680
1866	...	...	...	3,810
1867	...	...	...	2,376
1868	...	...	...	4,091
1869	...	...	540	5,357
1870	...	...	...	11,399
1871	...	...	...	11,808
1872	...	...	...	11,996
1873	...	...	...	10,371
1874	...	...	...	330
Date unk'n.	...	...	605	18,598
Totals....	...	...	5,319	178,158

FOURTH DISTRICT, COMPRISING Wards 13, 14, 15, 20, part of 28, and 29.

Year.	1-Inch.	2-Inch.	3-Inch.	4-Inch.
1826	...	...	1,150	294
1827	...	...	1,556	
1829	...	...	...	885
1830	...	...	...	538
1831	...	...	...	1,076
1832	...	...	...	829
1833	...	...	...	578
1834	...	...	450	257
1835	...	...	307	140
1837	...	...	...	974
1838	...	...	...	2,239
1839	...	...	...	846
1841	...	...	...	245
1842	...	...	...	744
1843	...	...	...	1,184
1845	...	...	...	4,227
1849	...	...	...	255
1850	...	...	...	1,479
1851	...	...	...	1,087
1852	...	...	...	5,221
1853	...	...	...	4,146
1854	...	...	...	1,426
1855	...	...	446	2,959
1856	...	...	...	7,865
1857	...	...	...	9,091
1858	...	...	...	13,652
1859	...	...	...	6,898
1860	...	...	...	6,411
1861	...	...	...	6,176
1862	...	...	...	1,677
1863	...	...	256	2,874
1864	...	...	...	3,227
1865	...	...	...	2,636
1866	...	...	...	417
1868	...	...	...	250
1869	...	...	...	720
1870	...	...	...	3,114
1871	...	...	...	2,073
1872	...	...	4,050	540
1873	...	...	...	2,616
Date unk'n.	175	...	456	20,919
Totals....	175	...	8,671	122,784

RECAPITULATION OF SMALL PIPE.

GERMANTOWN DISTRICT, COMPRISING Wards 22, part of 25, and part of 28.

NAME.	Year.	1-Inch.	2-Inch.	3-Inch.	4-Inch.
Germantown Company....	....	150	4,773	35,218	40,279
Chestnut Hill Company...	....	....	....	5,475	14,897
	1866	....	....	170	1,848
	1867	....	....	....	4,279
	1868	....	....	286	2,981
	1869	....	....	233	2,448
	1870	....	....	566	4,583
	1871	....	....	....	1,249
	1872	....	....	....	1,481
	1873	....	....	....	2,036
	1874	....	....	324	....
	1876	....	....	....	738
Totals........................	....	150	4,773	42,272	76,819

MANAYUNK DISTRICT, COMPRISING Ward 21 and part of 28.

Year.	4-Inch.
1869	444
1870	648
1871	1,440
1872	1,107
1873	4,137
1874	783
1876	147
Total,	8,706

SUMMARY.

DISTRICT.	1-Inch.	2-Inch.	3-Inch.	4-Inch.	Totals.
FIRST...	186	636	43,062	145,550	189,434
SECOND.......................................	1,820	908	126,847	49,600	179,175
THIRD...	....	....	5,319	178,158	183,477
FOURTH......................................	175	....	8,671	122,784	131,630
GERMANTOWN..........................	150	4,773	42,272	78,619	125,814
MANAYUNK..............................	....	....	....	8,706	8,706
Totals....................................	2,331	6,317	226,171	583,417	818,236

Grand Total, 818,236 feet, or 154 miles, 5,116 feet.

FINAL REPORT

OF THE

BOARD OF EXPERTS,

Dated April, 1883.

MAYOR'S OFFICE.
Philadelphia, April 19, 1883.

To the Select and Common Councils
of the City of Philadelphia.

GENTLEMEN:—I herewith transmit the final report of Messrs. J. Vaughan Merrick, Frederick Graff, E. S. Chesbrough and William Ludlow, the Board of Experts appointed to consider the subject of the present and future water supply of the City, for your consideration.

I am, respectfully,
SAMUEL G. KING.
Mayor of the City of Philadelphia.

DEPARTMENT FOR SUPPLYING THE CITY WITH WATER.
Philadelphia, April 5, 1883.

HON. SAMUEL G. KING,
Mayor of the City of Philadelphia.

SIR:—In conformity with the request of the Board of Experts, appointed in pursuance of the ordinance of June 7, 1882, to consider questions relating to the present and future water supply of the City, I have the honor to submit herewith the final report of the Board, and to request that you will transmit it to Councils for their information.

Very truly yours,
WILLIAM LUDLOW,
Chief Engineer.

To the Select and Common Councils
of the City of Philadelphia.

GENTLEMEN:—The undersigned have the honor to submit a final report upon the subjects referred to them, concerning the present and future supply of water for the City.

In the preliminary report made October 14, 1882, which your Board considered imperatively required in order that the City might avoid a short supply of water, certain recommendations were made for pumping machinery and mains, and for the construction and completion of reservoirs of distribution.

They have carefully revised the recommendations then made, and after a prolonged study of the subject, find no reason to change them in any essential particular.

In view, however, of the small amount immediately available for extensions, they recommend certain modifications in the application of the funds.

The resources understood to be available, and at the command of the Water Department, are as follows:—

1. Appropriation of December 30, 1882, for the extension of Works	$65,000 00
2. Appropriation of March 24, 1883, for the extension of Works	250,000 00
3. Appropriation of March 30, 1883, for the extension of Works	210,000 00
Total	$525,000 00

Which sum is now at the service of the Water Department.

The conclusions of the Board as to the most advantageous application of this sum are set forth in the following schedule:—

SCHUYLKILL WORKS.

For engine and boiler house	$50,000 00
" two 15 million gallon engines	96,000 00
" two ranges of boilers and and connections	65,000 00
" two 36 inch forcing mains, 2,500 lineal feet at $15	37,500 00
" completing the laying of the 48 inch main to Corinthian Basin, 1,000 feet at $5	5,000 00

Cross connection from Corinthian Basin to Schuylkill and Fairmount Basin, 36 inch pipe	7,000 00
Tracks, coal bins, etc	3,000 00
Total,	$263,500 00

ROXBOROUGH.

For one 7½ million gallon engine	47,000 00
" forcing mains, etc	3,000 00
" two boilers and steam pipe connections	7,000 00
" stack	2,000 00
" new inlet, etc., screens and dredging	3,000 00
Total	$62,000 00

GERMANTOWN MAINS.

For 16 inch main, from Mount Airy reservoir on Allen's lane to McCallum, McCallum to Carpenter, Carpenter to Green, Green to Tulpehocken	11,000 feet	
For 12 inch main on Green street, from Tulpehocken to Manheim street	6,500 "	
	17,500 feet	
Total		$70,000 00

FRANKFORD.

For one ten million gallon engine	$47,000 00
" foundations	2,500 00
" steam connections	500 00
Total	$50,000 00

SURVEYS,

For determining Sources of Future Supply.

For six months field work	$12,000 00
" office work	8,000 00
Total	$20,000 00

RECAPITULATION.

Amount available		$525,000 00
For Schuylkill Works	$263,500	
Germantown Mains	70,000	
Roxborough	62,000	
Frankford	50,000	
Surveying	20,000	
		465,500 00
Leaving a balance of		$59,500 00

Of which thirty-nine thousand five hundred (39,500) dollars should be transferred to Item 15 of the annual appropriations for "Buildings, Grounds, and Reservoirs," and the remainder, twenty thousand (20,000) dollars, be allotted to the general contingencies of the Department.

The Board would modify the recommendations previously made in regard to the character of the machinery to be obtained, to suit the altered circumstances of the case. They advise for the Schuylkill and Roxborough Works, horizontal compound duplex engines, in general character similar to the Worthington engines at those works; and for the Frankford Works, a compound rotating engine, of a form in some respects modified from that already in use.

The importance of the appropriation for the Germantown main is due to the imperfect supply in Germantown, the lower part of which is almost without water, and its population depending on one small main. At the same time the water supply as far south as Allegheny avenue will be greatly improved.

The appropriation for "Buildings, Grounds, and Reservoirs," is necessary on account of the small sum allotted to this item in the appropriation bill for the current year, wherein only eighteen thousand five hundred (18,500) dollars is made to cover items specifically named, amounting to fifty-four thousand two hundred and twenty (54,220) dollars, and further by the dangerous condition of some of the reservoirs demanding immediate attention.

At Wentz Farm the slip of the bank and other defects have reduced the present capacity to less than half of the total contents, as only twelve feet of water can be carried in the lower area, as against twenty-two feet, which could be maintained were the basin in good order. At other reservoirs, also, repairs are at once required to prevent rapid deterioration.

The item of contingencies is important to provide against variations in cost from the estimates, for additional works which cannot now be estimated for, and to enable the Department to deal promptly and efficiently in the event of accident. Your Board regard as indispensable to the satisfactory working of the Department, that a contingent fund should annually be at its disposal.

Reservoirs.

In the foregoing schedule no provision is made for the reservoirs mentioned in the preliminary report. It was there stated, as to the completion of East Park, the acquisition of land for and the construction of Cambria, and the acquisition of land for and the extension of Mt. Airy, that "all of them are needed now, and will ultimately form proper centres of distribution, whatever may be the permanent source of supply for the city."

This remark is based upon the fact that the vast extent of territory to be supplied with water in the city, and the diversified character and altitude of its surfaces, point out certain locations as peculiarly fitted for points of distribution independently of the source of supply. It is not probable that better points could be selected now if the whole subject were an open one. The city has already expended large sums at East Park, and a storage for its levels of distribution of from fourteen to sixteen days' supply can be had by completing it, at far less cost than in any other way. The location at Cambria and Thirtieth streets is as yet unimproved, and unless speedily acquired may be reached by building enterprises which will render it more difficult and expensive to obtain at a future time. There seems to be no better site for a reservoir to command this district, which already contains two hundred and thirty thousand persons, is now without any subsiding reservoir, and is growing more rapidly than any other part of the city. Adjacent to Mt. Airy Reservoir unimproved land can be had of suitable character and elevation at less cost than in the future. Its necessity for that section of the city is apparent when the small and totally inadequate dimensions of the present reservoir are considered.

Your Board would therefore again most urgently press upon your consideration the importance of immediately taking steps to acquire the needed land at the two points named, even if, as they are advised, no money is, at the moment, available for proceeding with the work of construction.

Future Supply.

Upon this most important branch of the subject your Board have bestowed much attention. But, owing to considerations hereinafter referred to, they find it impracticable at the present time to reach definite conclusions, or to submit any recommendations other than those embodied in this report.

In the preliminary report the following remarks were made:

"Meanwhile your attention is respectfully called to the fact that complete surveys must be made, and reliable data obtained of the localities from and through which a pure water supply can be drawn, in order to form a correct judgment as to their availability. As it is essential that this information be obtained, an appropriation for such surveys of not less than fifteen thousand (15,000) dollars is suggested."

No steps having been taken in this direction by your Honorable bodies, it becomes necessary to again invite your attention to the subject, and your Board have included in their estimates for present expenditures, the sum of twenty thousand (20,000) dollars, which will enable the Department to place in the field, at once, surveying parties, and to work up the results of their labors. Under the most favorable conditions, the greater part of a year will be consumed in procuring the information without which no intelligent judgment can be formed. Indeed, in other cities large sums are annually expended for surveys to secure fresh information respecting the possible sources of water supply.

Recommendations heretofore presented for the supply of Philadelphia from distant points have, in the opinion of the Board, been based upon insufficient definite knowledge, and more recent investigations have shown, that in estimating the available rainfall and the effect upon the purity of the water of impounding it for long periods, views formerly entertained require considerable modification.

There are two main sources of supply, the Schuylkill and the Delaware, with their respective tributaries. At certain points each of these rivers furnishes an adequate amount of reasonably pure water.

At the points where the water for the city is now drawn, its impurity is constantly increasing, and is probably approaching the limit of wholesomeness.

The first inquiry, then, is clearly whether this impurity can be removed or reduced to a safe point. If it can be so reduced, the present sources of contamination removed and guarded against for the future, and sufficient quantities be had, it is unnecessary to look to more distant sources. If this cannot be accomplished, it will be needful to draw from one or the other of these rivers at points higher up.

To answer this inquiry, and to form a judgment of the cost either of purifying the present supply, or obtaining a new one, careful detailed analyses must be made of the water obtained from different points in order to trace the causes of impurity, as well as careful topographical and geological surveys. Gaugings of the streams, and of the rainfalls over the areas draining into the Perkiomen, Skippack, Wissahickon, etc., are required, as well as the upper affluents of the Delaware, if such should be found necessary. The surveys should be especially directed to ascertaining where, to what extent, and at what cost, impounding reservoirs can be constructed, and the several available routes for conduits carefully investigated, with a view to determine their cost.

At present the larger portion of the city's supply is drawn from the Schuylkill. It is evident that, so far as quantity is concerned, an abundant supply can be obtained for a long time to come, for its minimum flow is not less than two hundred million gallons daily, and this might be largely increased by additional dams, as was suggested by the Park Commission sixteen years ago, and by the Board of Experts in 1875.

Formerly the character of the Schuylkill water was of the first rank among the sources of supply for cities. If this condition could be restored, nothing better can be expected.

The first duty of the city is to remove whatever sources of contamination are imparted within its own limits. The city's ownership of so much of the banks of the river as are contained in Fairmount Park is of the greatest importance in this respect, but the efforts of the Park Commission to preserve the purity of the water have been rendered almost nugatory by the constantly increasing drainage into the river from the east bank, caused by the growth of large manufacturing industries, and their attendant populations.

Your board believe that analyses will show that the deterioration in the quality of the Schuylkill water, justly complained of, is largely due to this cause, and that the completion of the sewer from Flat Rock to below Fairmount will tend to restore its wholesomeness by removing a most serious source of pollution. The construction of this sewer has for many years been urged upon the city authorities; first, by the Park Commission, and subsequently by others who have considered the subject, and it is a matter for congratulation that the work is at last to be undertaken.

Supposing, however, that when this sewer is in use, and when the city has exhausted all other means of preventing contamination within its boundaries, is it possible to control the pollution of the stream at higher points?

This introduces the question, whether, by suitable State legislation, riparian owners, whether individuals or communities, can be compelled to observe toward the City of Philadelphia the common obligation incident to similar rights as between individuals. The principle is well established which preserves to every person the use of running streams only so far as he does not impair their use and purity for others.

It is the opinion of your Board that the determination of the question of future supply should be entrusted to a commission to be hereafter constituted, before whom should be laid the fullest information attained or attainable, together with such reports, plans, and projects as may be submitted by the Water Department after the necessary data shall have been gathered.

Reduction of Waste.

Next to the importance of obtaining a proper supply of water comes the question of its economical use. Experience in other places has proved that the loss from leakage of service pipes and stop-cocks, and from allowing waste of water in houses, factories, etc., is enormous, and effective means have been devised for discovering this loss.

Your Board consider it essential to an efficient conduct of the department that the chief should be empowered to use all known means for finding and correcting this evil.

Another source of waste is the absence of proper methods of determining and valuing the use of water in factories and large public buildings. For these your Board consider that meters should be used at the discretion of the Department. It is impossible even to approximate to the amount of water used on the basis of a given size of ferrule, because the quantities passing vary in different localities, according to the pressure, and because the use in some localities is more constant than in others. The only equitable mode of assessing in such cases is by the quantity actually consumed. This at the same time should check wastefulness. In most of the large cities the use of meters for large consumers has been found of great value. On the other hand, it is not desirable to affiix meters to houses.

The first cost of these meters would have to be borne by the Department, but they might be made to earn a large interest on the investment, and would undoubtedly result in so considerable an increase of revenue in certain cases as to warrant a reduction in others, and the furnishing of water to houses at a cheaper rate than at present. At the same time it would be found that the consumption per capita would decrease, and with it, proportionally, the expense of the Department.

Summary of Recommendations.

1. The application of the appropriation, as specified, for immediate needs.

2. The acquisition of land for reservoirs at Cambria street and Mount Airy.

3. The organization of a surveying staff, with duties as indicated.

4. The consideration of general legislation for protection of streams from pollution.

5. Adoption of measures for the prevention of waste.

Conclusion.

In conclusion the undersigned deem it proper to state that owing to the prolonged absence of their colleague, Mr. Chesbrough, caused by his illness, the responsibility thrown upon them has been greatly increased, and they deeply regret that they, as well as their fellow citizens, have been deprived of his valuable services during the latter portion of their labors.

Respectfully submitted,

J. VAUGHN MERRICK,
FRED. GRAFF,
WILLIAM LUDLOW,
Chief Engineer Water Dept.

Table showing the available capacity of Works of Philadelphia Water Department in millions of gallions per day, from 1872 to 1883, at time of maximum demand, the reserve engines at time of accident or break-down of machinery, and the probable deficit for 1883.

Year.	Steam power.	Water power.	Total pumpage.	Demand.	Reserve engines unavailable.*	Deficit. If no accident.	Deficit. If an accident to largest engine.
1872	41	15	56	45	10	....	....
1873	43	15	58	49	10	....	....
1874	43	15	58	50	10	....	....
1875	43	15	58	52	10	....	....
1876	47	15	62	62	10	....	....
1877	47	22	69	57	25	....	....
1878	60½	20	80½	64	14	....	....
1879	59½	7½	67	65	14	....	6
1880	59½	7½	67	67	14	....	6
1881	74	5	79	75	9	....	11
1882	74	13½	87½	86	9	....	11
1883	74	5	79	100	9	21	32

* Unavailable on account of want of boilers or pumping main.

NOTE.—If the large engine at Frankford breaks down, there will be a short supply at Frankford; and if the larger engine at Roxborough or its boilers break down, a failure at Germantown will be the result.

Exhibit of Expenses of Pumping Stations in Four Cities.

	CITIES.							
	St. Louis.		Brooklyn.		Cincinnati.		Philadelphia.	
Pumping stations	....	....		Ridgewood.		Main Works.		Spring Garden.
Lift, in feet	$\frac{230 \times 40}{2}$	135		171		171		134
Maximum million gallons into reservoir	35 x 2	70		37		37		45
Maximum work, million gallons 100 feet high	....	94.50		63.27		63.27		60.30
	No.	Pay per day.	No.	Pay per day.	No.	Pay per day.	No.	Pay per day.
Engineers in charge	1	$6 95	1	$6 85	1	$5 00	2	$2 46
Assistant engineers	9	4 50, 3 33, 4 16, 3 17, 3 80, 3 00, 3 50, 2 80, 2 60	8	3 61 to 3 28	5	3 50	0	....
Oilers	6	2 00	5	2 05	10	2 00	8	1 90
Firemen	24	2 00 1 83	16	1 97	13	2 00	10	1 90
Coal passers	20	1 66	6	1 81	6	2 00	4	1 90
Gaugemen	0	....	0	....	0	....	2	1 90
Laborers	......	Not specified.	6	1 75	......	Not specified.	1	1 75
Coal weighers	......	....	......	....	3	3 00 2 00	......	....
Clerks	......	....	......	....	1	3 00	1	1 90
Flue cleaners	......	....	......	....	1	1 75	......	....
Total wages per diem	60	$128 97	42	$97 54	40	$92 25	28	$54 17
Cost of labor per million gallons lifted 100 feet high	......	$1 36	......	$1 54	......	$1 45	......	90c.

NOTE.—At St. Louis the water is first pumped from the Mississippi river, 40 feet, into settling basins; from thence into the distributing reservoir, 230 feet high; the average lift being 135 feet for double the consumption of 35,000,000 gallons, or 70,000,000 gallons 135 feet high = 94½ million gallons 100 feet high.

Exhibit of Expenses of Pumping Stations in Three Cities.

	CITIES.					
	LOUISVILLE.		CHICAGO.		PHILADELPHIA.	
Pumping stations	....		West Side.		Belmont.	
Lift, in feet	175		100		212	
Maximum million gallons into reservoir	11		30		18	
Maximum work, million gallons 100 feet high	19.25		30.00		38.16	
	No.	Pay per day.	No.	Pay per day.	No.	Pay per day.
Engineers in charge	1	$5 00	1	$6 85	1	$2 46
Assistant engineers	3	{4 52, 4 31, 1 61}	3	4 39	0	....
Oilers	2	2 18	4	2 13	4	1 90
Firemen	2	2 18	6	{2 23, 2 13}	10	1 90
Coal passers	2	2 18	3	1 97	4	1 90
Gaugemen	.....	....	.....	....	2	1 90
Laborers	.....	....	.....	....	1	1 75
Coal weighers	1	2 18	1	2 13	0	....
Clerks	.....	....	.....	....	1	1 90
Flue cleaners	.....	....	2	{2 13, 1 97}	.....	....
Total wages per diem	11	$30 70	20	$53 76	24	$46 57
Cost of labor per million gallons lifted 100 feet high	.....	$1 59	.....	$1 79	.....	$1 22

Report of A. R. Leeds, Ph. D.

Laboratory of Chemistry,

Stevens Institute of Technology, Hoboken, N. J.,

February 20, 1883.

To Messrs. Frederick Graff, J. Vaughan Merrick, Col. William Ludlow, } *Members of the Board of Experts.*

Chief Engineer of the Phila. Water Dept.

Gentlemen:—I transmit herewith my Report containing the results of an investigation into the causes affecting the palatability of the Schuylkill River water during the month of January of the present year. It should be premised that this investigation largely excluded those causes which could be determined by direct observation, such as impurities carried into the river by surface and subsoil drainage, by sewers, by the refuse of factories, from cesspools, from the spent liquors of gas-works, from the irruption of animal matters derived from slaughter-houses, etc., etc., and was principally confined to the study of those causes which might be discoverable by physical and chemical examination of the waters themselves.

Though this restriction, which was due to the limited scope of my official instructions, is much to be regretted, yet it necessitated a more thorough search within the narrow field of laboratory analysis and experiment open to me. It is also less to be regretted for the following reasons:

The *fact* of the principal source of the Philadelphia water supply, the Schuylkill, being at the present time a sewer and factory polluted stream, was conceded. It was also well established that the actual potability of the water at any particular season, is determined:—

1st. By the ratio then existing between the volume of flow and the volume and character of polluting materials—a small amount of contamination when the volume of water is at a minimum, possibly damaging the potability far more than the maximum amount of pollution existent along the banks of the Schuylkill when its flow is also at a maximum.

2nd. By the relative energy of the agencies (mostly artificial) at work to contaminate, and the agencies (almost, if not entirely natural,) operating to purify the stream. If these natural agencies are in full sway, they may dispose of a large amount of impurities and bring the water back into such a condition as neither to affect the sense of smell or taste, or exert a detrimental effect upon health.

There are ample grounds for believing that, up to the present time, at least, this balance of opposing forces has usually inclined to the favorable side in the case of the Schuylkill water, and that therefore it has been entitled to be ranked as a wholesome water supply. Similar conclusions were arrived at by Profs. Booth and Garrett, and by Dr. Charles M. Cresson, in their elaborate reports appended to the "Report of the Commission of Engineers on the Water Supply of Philadelphia, 1875." On the other hand, if their operation is least active on account of an unpropitious season of the year, or stagnant conditions of the water, or possibly of a covering of ice, they may be unable to dispose of a small quantity of polluting material, and at such a time the water supply may become most offensive.

I shall not anticipate, however, results obtained and conclusions based thereon, but shall present in detail the work actually performed. This may be most concisely done under the five following heads:

1st. Collection of the samples.

2nd. Methods of analysis.

3rd. Interpretation of the data obtained by analysis and experiment.

4th. Light thrown by the results upon the origin of the January taste and smell.

5th. Questions relating to the deterioration of the water supply.

1.—Collection of the Samples.

During the latter part of the period when the water was in its most nauseous condition, by the authority of the Water Commission and Chief Engineer Dr. Wm. H. McFadden, the following samples were collected and forwarded to me for analysis:

I. Schuylkill river at Pottstown, January 10, 1883. (Laboratory number, 226.)

II. Schuylkill river at Roxborough Station, January 10, 1883. (Jar broken in transportation.)

III. Schuylkill river at Spring Garden Station, January 9, 1883. (Jar broken in transportation.)

IV. Schuylkill river at Norristown, January 10, 1883. (Laboratory number 227.)

V. Schuylkill river at Fairmount Station, January 9, 1883. (Laboratory number 228.)

VI. Schuylkill river at Belmont Station, January 9, 1883. (Jar broken in transportation.)

VII. Schuylkill river at Fairmount Station, January 13, 1883. (Laboratory number 229.)

Subsequently, being desirous that my investigation should extend beyond the determination of the mere fact of contamination, and should be directed to the discovery, if possible, of the origin of the bad taste and smell on this particular occasion, the Chief Engineer desired me to visit the Schuylkill river in person, and collect such additional samples as would be of value.

In accordance with these instructions, January 19th and 20th were spent upon the ice, then covering the river, in company with Assistant Engineer C. G. Darrach, whose aid was of the greatest service in carrying out the proposed line of inquiry.

In the first place it was deemed important to ascertain whether there was a difference of temperature between the water at the bottom of the river and at its surface, or rather immediately under the ice. If such proved to be the case, there would be a corresponding difference of density, and possibly a difference in composition. To make these determinations, a bottle containing a thermometer was properly weighted so that it might sink in a vertical position until the bottom of the bottle came to within about three inches from the bottom of the stream. The stopper was then pulled out, and after filling, the bottle was quickly pulled to the surface and the temperature noted. The temperature of the surface samples was also observed whilst the thermometer was immersed in the bottle, this precaution being taken to exclude errors arising from atmospheric influence. In this manner the following six samples were obtained.

Samples Collected in Person, January 19 and 20.

No. 230, Surface water, Fairmount Basin, January 19.
No. 237, Bottom water, Fairmount Basin, January 19.
No. 233, Surface water, Spring Garden Basin, January 19.
No. 232, Bottom water, Spring Garden Basin, January 19.
No. 235, Surface water, Roxborough Basin, January 20.
No. 234, Bottom water, Roxborough Basin, January 20.

The observed temperatures were as stated below; the specific gravities at 15° C. were subsequently determined with great care in the laboratory, and are likewise given.

No.	Temperature of Air.	Temperature of Water.	Specific Gravity at 59° F.
230	34°	33°.2	1.001468
231	34°	33°.8	1.001477
233	34°	33°.4	1.001471
232	34°	33°.8	1.001471
235	36°	33°.	Undetermined.
234	36°	33°.4	"

Two points deserve comment with regard to these determinations:

1. The average density of the Schuylkill water at the time when the samples were taken, when reduced to the mean temperature of 59° F., was very approximately 1.00147, and inasmuch as the volume of pure water, according to Kopp, diminishes from 0.999966 to 0.999947 when its temperature is raised from 33°.4 F. to 33°.8, the density of the bottom sample No. 232, at the time it was collected, was 1.0022202, while that of the surface sample No. 233 was 1.0022081. There is, therefore, in winter, when the river is covered with ice, a current of colder water flowing immediately beneath the ice, and another current, of warmer water, but of greater density, and probably flowing much more slowly, at the bottom of the stream.

2. The temperature of the water in the Schuylkill in midwinter, and when the river had been for some time entirely covered with ice, was about one Fahrenheit degree above freezing-point at the surface, and about 1.4 degrees above freezing-point at the bottom, or four-tenths of a degree warmer.

2.—Methods of Analysis.

Inasmuch as a knowledge of the methods employed is essential to the proper understanding and interpretation of the analytical results, it is necessary to state briefly what those methods were.

Free and Albuminoid Ammonia.

The method of Wanklyn, Chapman and Smith, performed in accordance with certain modifications described at length in the *Zeitschrift für Analytische Chemie*, XVII, p. 276, was made use of. These modifications are, in brief, the employment of a Color Comparator, which admits of the comparison of the test with the standard, under conditions most favorable to accurate comparison. Secondly, the substitution for the various standard solutions, which have to be freshly prepared for each analysis, of a standard wedge graduated once for all with extreme care. This wedge can be used for months without its scale undergoing alteration, and its employment insures uniformity between the results of analyses performed at different times, and greatly shortens the length of time required for the performance of long series of analyses.

Oxygen required to Oxidize the Organic Matters, or "Required Oxygen."

This was determined by potassium permanagate in acidified solution, the samples being plunged for exactly ten minutes in water at 98°. All of the samples were treated in precisely the same manner, and a correction was applied to each result amounting to the value of the alteration of the re-agent when tested upon distilled water under identical conditions. After very many unsuccessful attempts to obtain concordant results by this method, I had recourse to a new one, devised during the course of this investigation, and which is founded upon the redution of silver salts in solution by organic matter in sun-light. This is not a proper place to give the details of the new "Actinic Method," nor the experiments which led me to abandon the potassium permanganate test, the publication of these details being necessarily left to the chemical journals. I have given, in the accompanying table, the results obtained by the use of potassium permanganate for samples 230 to 235, and by the Actinic Method for the same samples. It will be noted that the figures obtained by the Actinic are higher than those obtained by the Permanganate process. My own conclusions in the present investigations are based on the results obtained by the former method.

REQUIRED OXYGEN.

No.	Permanganate process.	Actinic process.
230	0.18 parts per 100,000	0.218 parts per 100,000
231	0.19 " " "	0.244 " " "
233	0.18 " " "	0.299 " " "
232	0.18 " " "	0.283 " " "
235	0.16 " " "	0.206 " " "
234	0.16 " " "	0 231 " " "

Nitrites.

The nitrites were determined by means of hydro-chlorate of naphthylamine and sulphanilic acid, according to the reaction discovered by Griess, and which is so sensitive that it permits of the easy recognition of one part of nitrous acid when diffused through a thousand million parts of water. They were calculated as nitrous acid (HNO_2).

Nitrates.

These were determined upon a deciliter of the water, after evaporation to dryness, subsequent heating in presence of lime, reduction in the cold by a copper zinc couple, and complete distillation of the formed ammonia. They were calculated as nitric acid (HNO_3).

Total Solids.

These results express the weights of the residues obtained by the evaporation of a deciliter and drying to constant weight at 110° C.

Disolved Oxygen.

The number of cubic centimeters of oxygen dissolved in a liter of water was determined by Mohr's method, which is based upon the relative amounts of oxidation of protoxide of iron to the form of peroxide, effected by the various volumes of oxygen held in solution.

The results obtained by this process are closely concordant among themselves, and whilst they do not possess the same degree of absolute accuracy as those obtainable by the laborious eudiometric methods of Bunsen, yet Mohr's method has the great advantage that it admits of the determinations being made upon a number of samples, before such an interval has elapsed that the constitution of the water and dissolved gases has possibly undergone considerable change.

Acidity and Alkalinity.

To determine whether the water possessed an acid or alkaline reaction, and the actual amount of the acidity or alkalinity, as the case might be, centinormal standard solutions were employed with alizarine and phenolphthalein as indicators, according to the method given in the *Jour. Amer. Chem. Soc.*, II., p. 71.

Sanitary Analyses of the Philadelphia (Schuylkill River) Water Supply, 1883.

By ALBERT R. LEEDS, PH. D.

Number of Sample.	No. 226.	No. 227.	No. 228.	No. 299.
Locality.	Pottstown.	Norristown.	Fairmount forebay.	Fairmount forebay.
Date.	January 10.	January 10.	January 9.	January 13.
Free ammonia.				
Parts per 100,000	0.009	0.0125	0.0195	0.02075
Grains per gallon	0.0052	0.0073	0.0113	0.0121
Albuminoid ammonia.				
Parts per 100,000	0.0145	0.0125	0.02375	0.01425
Grains per gallon	0.0084	0.0075	0.0138	0.0083
Ratio of free to albuminoid ammonia	1 to 1.6	1 to 1	1 to 1.22	1.46 to 1
Oxygen required to oxidize.				
Parts per 100,000	0.20	0.18	0.37	0.30
Grains per gallon	0.116	0.105	0.21	0.175
Nitrites.				
Parts per 100,000	0.005	0.0066	0.005	0.0066
Grains per gallon	0.0029	0.0038	0.0029	0.0038
Nitrates.				
Parts per 100,000	0.323	0.355	0.369	0.355
Grains per gallon	0.188	0.207	0.215	0.207
Chlorine.				
Parts per 100,000	0.45	0.525	0.65	0.70
Grains per gallon	0.262	0.306	0.379	0.408
Total solids.				
Parts per 100,000	18.00	18.00	18.50	18.50
Grains per gallon	10.49	10.49	10.79	10.79
Acidity.				
Calculated as sulphuric acid, parts per 100,000	0.00018	0.00002	0.00007	
Alkalinity.				
In terms of sodium hydrate, parts per 100 000	....	....	....	0.00003

Sanitary Analyses of the Philadelphia (Schuylkill River) Water Supply, 1883—Continued.

By Albert R. Leeds, Ph. D.

Number of Sample.	No. 230.	No. 231.	No. 233.	No. 232.	No. 235.	No. 234.
Locality.	Fairmount basin, at surface.	Fairmount basin, at bottom.	Sp. Garden basin, at surface.	Sp. Garden basin, at bottom.	Roxboro'gh basin, at surface.	Roxboro'gh basin, at bottom.
Date	January 19.	January 19.	January 19.	January 19.	January 20.	January 20.
Free ammonia.						
Parts per 100,000	0.0165	0.01575	0.013	0.01775	0.017	0.01325
Grains per gallon	0.0096	0.0091	0.0078	0.0103	0.0099	0.0077
Albuminoid ammonia.						
Parts per 100,000	0.01275	0.01425	0.01175	0.01375	0.015	0.01425
Grains per gallon	0.0074	0.0083	0.0068	0.0082	0.0087	0.0083
Ratio of free to albuminoid ammonia	1.3 to 1	1.1 to 1	1.1 to 1	1.3 to 1	1.3 to 1	1 to 1.08
Oxygen required to oxidize.						
Parts per 100,000	0.18	0.19	0.18	0.18	0.16	0.16
Grains per gallon	0.105	0.111	0.105	0.105	0.093	0.093
Nitrites.						
Parts per 100,000	0.0083	0.0083	0.01	0.0083	0.005	0.005
Grains per gallon	0.0048	0.0048	0.0058	0.0048	0.0029	0.0029
Nitrates.						
Parts per 100,000	0.364	0.36	0.374	0.364	0.439	0.43
Grains per gallon	0.212	0.210	0.218	0.212	0.256	0.251
Chlorine.						
Parts per 100,000	0.65	0.65	0.65	0.60	0.45	0.475
Grains per gallon	0.379	0.379	0.379	0.35	0.262	0.277
Total solids.						
Parts per 100,000	18.50	18.50	19.00	18.50	18.50	18.50
Grains per gallon	10.79	10.79	11.08	10.79	10.79	10.79
Dissolved oxygen in one liter	4.41 cubic centimeters	5.13 cubic centimeters	4.34 cubic centimeters	5.18 cubic centimeters	5.32 cubic centimeters	5.64 cubic centimeters
	All the samples collected January 19 and 20 had a neutral re-action.					

3.—Interpretation of Data obtained by Analysis and Experiment.

During the entire course of this invistigation, one great object was kept prominently in mind, and the character of the analytical operations performed was governed entirely by considerations as to what manner of analyses and experiments would throw most light upon the question:—Why, at a certain particular period, did the water in the Schuylkill river suddenly become unpalatable?

My present object is to discuss *seriatim* the various classes of analytical results obtained, and to endeavor to present, judicially and fairly, the answers which these various classes of data severally give to the above question.

The Free and Albuminoid Ammonia.

The information supplied by these determinations bears especially upon the three following points:

1. The amount of Free Ammonia, which is the measure principally of that portion of the decomposable nitrogenous matter that has already undergone decomposition, is very much greater in all the samples (0.009 to 0.02075 parts in 100,000 parts) than in the water of the Schuylkill river June 24, 1881 (0.001).

2. The Albuminoid Ammonia, which is the measure of that portion of the nitrogenous matter as yet undecomposed but capable of undergoing decomposition, is large (0.01175 parts to 0.02375 parts). At the same time it is not so great in any of the samples, with the exception of the one taken from the Fairmount Forebay January 9, as it was in the Schuylkill water June 24, 1881. Yet this last, as compared with the water supplies of the principal cities in the United States at that date, was ranked as third in order of purity. In other words, the absolute amount of decomposable organic matter in the Schuylkill water, at the time when it had acquired its nauseous taste and smell, was not so great as at a season when it was

palatable. This statement is borne out by the other analytical data, and I think it can be justly inferred that the unpalatability was due, not to an unusually large amount of the polluting materials, which exist at all times to a greater or less extent in the waters of the Schuylkill, but to some peculiarity either in their character or in the nature of their decomposition.

3.. There is no evidence, as will be seen farther on, of any peculiarity in the organic matter itself, which would account for the taste and smell. There is, however, a very striking peculiarity in the nature of its decomposition. By reference to the table of analyses, it will be seen that *the Free Ammonia exceeds the Albuminoid in almost every sample analyzed.* That this is anomalous, will be be seen by comparing these analyses with those of the various city waters in the United States, June and July, 1881.*

	Free Ammonia. Parts per 100,000.	Albuminoid Ammonia. Parts per 100,000.	Ratio.
Philadelphia	0.001	0.018	1 : 18
Boston	0.013	0.061	1 : 5
New York	0.0027	0.027	1 : 10
Brooklyn	0.00075	0.00825	1 : 9

This point is still more strikingly brought out by the series of analyses made upon 34 samples of water collected at various points along the Passaic river, from a point above the irruption of the sewage and factory refuse of Paterson, to a point below the lowest sewers of Newark, a distance of 20 miles.

These samples were all collected upon the same day, Sept. 6, 1881, when, owing to three months of drought, no water had gone over the dams for many weeks, and the water had become very offensive. But in the eleven samples in which the free ammonia exceeded the albuminoid ammonia, this excess was directly connected with the sewage of manufacturing towns and with the refuse of cotton, paper, and woolen mills, and of

* For complete list, see *Jour' Amer. Chem. Soc.*

dye-houses, thrown into the stream at points in proximiy to those whence these samples were collected. Above these factories, and at a point 16 miles below them, near the intake of the Jersey City Pumping Station, there was little or no free ammonia in the stream. The differences are made plain in the following table:—

	Free Ammonia. Parts per 100,000.	Albumonoid Ammonia. Parts per 100,000.	Ratio.
Above Paterson	0.00	0.021	Infinite.
Below Paterson	0.2075	0.225	1 to 1
Below Passaic tail race	0.0745	0.0215	3.5 to 1
16 miles below Paterson	0.0005	0.026	1 to 52

Since this time, during a period of eighteen months, there has never been an occasion when the water, taken monthly at the Jersey City intake, contained as much free ammonia as albuminoid ammonia. This remark is true of seasons when the flow of water being at its minimum and polluting agencies at their maximum efficiency, the water supply was otherwise adversely reported upon.

In 36 analyses of waters of the Brandywine river and certain other streams proposed as new sources of water supply, which I made in the year 1882, at the request of the City Councils of Wilmimgton, Del., there was not a single instance in which the free exceeded the albuminoid ammonia. The ratio varied between 1 : 43 at Rockland dam, which is the point I recommended as the best from which to draw the future water supply, to 1 : 1.2 at certain spots where the influence of trade and other pollutions became manifest.

Without detailing here the results of examination of any other streams, it is sufficient to say that the ratio of the free ammonia to the albuminoid ammonia usually varies in river waters from 1 : 2 to 1 : 10, and even higher amounts for the albuminoid ammonia. If the free ammonia exceeds, it can ordinarily be asssumed that a very large amount of the *products* of decomposition derived from trade and sewage pollution is present. In such cases the absolute amount of albuminoid ammonia is also very considerable. But, as previously stated, the absolute amount of albuminoid ammonia in the Schuylkill river at the time when the non-potability occurred, though much exceeding the "limit of purity" in a river water whose free ammonia is at the same time very high, was not extraordinarily great. For this reason the excess of free ammonia indicates not only the fact of pre-existent trade and sewage contamination, but, taken in connection with the other facts developed during the course of this investigation, has a special significance which will be explained farther on.

Oxygen required to Oxidize the Organic Matters.

That the nauseous taste and smell was not due to the mere fact of an excess of decomposable organic matters, is rendered still more probable by the small percentage of oxygen required to effect this oxidation. It is little more than one-fourth the amount of oxygen required on June 24, 1881, when the water was excellent both in taste and smell.

Nitrites and Nitrates.

A peculiarity of the same description exists with regard to the ratio between the nitrites and the nitrates as between the free and albuminoid ammonia, in that the *former* is present in large amounts in all the samples. The origin of the nitrites is twofold. They are due either to direct oxidation of the nitrogenous organic matter—this oxidation stopping short of its proper final stage, which is the complete conversion into the form of nitrates—or they are formed at the expense of the nitrates already existing, by their reduction in presence of excess of readily oxidizable organic matters.

Both modes of origin are indicated in the present instance, and both point to the same conclusion, that there was an excess of organic matter beyond what could be oxidized under the existing circumstances.

On account of the extreme instability of the nitrites, they are usually converted almost entirely into the form of nitrates, and leave behind but little more than a trace of their presence. Their large percentages in these samples indicate, therefore, a retarded or arrested oxidation.

Chlorine.

The percentage of chlorine is somewhat high, and is relatively greater at Fairmount than it is at Roxborough, Norristown, and Pottstown. It is also higher than at other seasons when the character of the water has been better. All these facts are in accord with what would occur from sewage contamination, but do not aid us materially in discovering the cause of the January disorder.

Complete Analyses of the Schuylkill Water Supply.

	POTTSTOWN, January 10, 1883. No. 226.		FAIRMOUNT, January 9, 1883. No. 228.	
	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.
Lime	3.593	2.095	3.520	2.053
Magnesia	1.515	0.884	1.034	0.603
Oxide of Iron and Alumina	0.134	0.077	0.264	0.154
Ammonium Hydrate	0.019	0.012	0.040	0.023
Sodium Chloride	0.590	0.344	0.930	0.542
Potassium Chloride	0.180	0.105	0.187	0.109
Carbonic Anhydride	0.780	0.455	0.710	0.404
Sulphuric Anhydride	2.300	1.341	1.890	1.1
Silicic Anhydride and Insoluble Matters	1.289	0.752	1.950	1.137
Phosphoric Anhydride	trace.	....	trace.	....
Nitrous Anhydride	0.008	0.005	0.008	0.005
Nitric Anhydride	0.560	0.327	0.640	0.373
Inorganic Matter	10.968	6.393	11.173	6.523
Total Solid Matter in solution	18.000	10.497	18.500	10.789
Organic Matter (by difference)	7.032	4.104	7.327	4.266

Total Solids and Complete Quantitative Analyses.

The determinations of the amounts of saline bodies and organic compounds which exist in the water in a state of solution, and are left behind as a residue upon evaporating 100 c.c. of the water to dryness and drying at 110° C., throw no light upon the present question. They merely show that the amount of substances in solution is greater by ½ part in 100,000 at Fairmount than in the upper portion of the stream. It is not unusual to strongly heat these residues, and set down their losses in weight as organic and volatile matters. For a variety of reasons the results thus obtained are so inaccurate as frequently to mislead, and for this reason have not been made use of in the present difficult inquiry. Instead, I have given below the results of two complete analyses of the mineral constituents. The difference between the sum total of these mineral constituents and the total solids in solution, is regarded as representing the organic matter approximately. Unfortunately, no accurate determination of the total amounts of the very complex and very various organic bodies present in natural waters is possible in the present state of our knowledge. The results here given represent the closest approximation to the truth which I was able to arrive at, and, I think, are sufficiently correct to serve as a trustworthy basis for reasoning.

An examination of these complete analyses shows that the lime, magnesia, carbonic anhydride and sulphuric anhydride, are all less at Fairmount than at Pottstown. They have probably been precipitated out of solution on account of the relative insolubility of the carbonates and sulphates of lime and of the carbonate of magnesia. The increased amounts of sodium and potassium chloride, of ammonium carbonate, of nitrous and nitric anhydrides, would all be in accordance with the fact of comtamination with sewage and trade pollution in the lower portion of the stream, as would also be the slightly increased amount of organic matter, shown in the analysis of the Fairmount, as compared with the Pottstown water. But this increase is not so important as the fact that the organic matter, even in the upper portions of the stream, was very considerable, amounting to over 7 parts in 100,000. And what is important for us to note here is that to this considerable burden of organic matter, which might or might not be of unwholesome character, was added the customary increment of pollution from sewers and factories in the lower portion of the stream. As to the origin of this organic matter, the following letter is important:

"*Reading, Pa.*, January 11, 1883.

"DR. WM. H. MCFADDEN,

"Chief Engineer of the Water Department.

"DEAR SIR:—Referring to your favor of 9th inst., asking for the facts regarding the present condition of the Schuylkill, I have to say in reply that all the dams of the Navigation Company above the Blue Mountains, from No. 7, at Schuylkill Haven, to No. 16 (Blue Mountain), were drawn between December 18th and 23d, and they remain so drawn at this time. The water was let out from each dam by means of sluices in them provided for that purpose, and canals connected with them were emptied at the same time. All of these dams had ice upon them from 4 to 6 inches in thickness when drawn. Between the Blue Mountain and dam No. 22, North Reading, none of the dams have been drawn; they are now and have been covered with ice about 6 inches thick, since the middle of December.

"Ice began to be formed soon after the 26th of November, and the obstruction was complete as early as the 4th of December.

"Dams Nos. 23 and 24 (Poplar Neck and Lewis) below Reading—the latter known as the Big Dam—were drawn respectively on the 29th of December and January 1st, and there was very little ice on either at these times. The dams between No. 24 and Fairmount, six in number, have not been drawn, but have all been more or less obstructed by ice since December 4th, varying in thickness from 2 to 5 inches.

"The flow of the river has been much below the usual minimum, both during the fall and ever since winter set in, and the rain-fall in the valley has not been more than half of what is usual during the same period.

"The dams not drawn, nevertheless, have all continued to run over, but with a flow scarcely more than that of the low water of summer. While the dams below 'Lewis,' or 'Big dam,' have not been drawn, all the canal levels which they supplied have been emptied. One series of these levels, 22 miles in length, supplied from the 'big dam,' was drawn out about the 16th of December, and furnished a very large body of pure water to the river, Another, the five-miles level, opposite Royers' Ford, was drawn on the 23d of December. This level receives the drainage from the wood-paper works at Spring City. The level opposite Phœnixville. 4 miles in length, was drawn out on the 22d of December.

"Yours, very respectfully,

"JAS. F. SMITH,

"*Chief Engineer Reading Canals.*"

In commenting upon this letter, the Chief Engineer emphasizes the three most important facts thereby elicited.

1. The small rainfall in October, November, and December, and the very small flow of the river.

2. The emptying of the Schuylkill canals and eleven dams thereon.

3. The complete covering of ice on the Schuylkill river, the canals, dams, and tributaries.

Whilst the first two points throw much light upon the origin of the large percentage of organic matter, they cast but little upon its character: whether it was necessarily wholesome or unwholesome, whether it imparted the bad taste and smell. With reference to possible unwholesomeness we must remember that the organic matter which contains nitrogen is the portion most important to study. The amounts of albuminoid ammonia (0.0145 parts to 0.02375 parts) indicates that this constitutes only a small fraction. If we assume, along with the author of the albuminoid ammonia process, that the nitrogenous organic matter may be estimated as ten times greater in amount than the albuminoid ammonia, this fraction would not exceed 0.2375 parts in a total of 7 parts in a thousand. I am aware that the experiments by which this proportion was established have recently been repeated by Preusse and Tiemann,* mostly upon artificial organic compounds far more stable in their nature than the putrefiable substances, the estimation of which especially concerns us in hygienic investigations of water supplies. These experiments, which were less extended and elaborate than those of Wanklyn, merely confirmed his results. Their conclusion that the process gives us no indication of the absolute quantity of nitrogenous organic substances, no more invalidates the process than the analagous results they found by the permanganate method of estimating organic matter militates against it. And yet, while they obtained less decisive results by permanganate process, urea, for instance, not being at all oxidized, they placed great stress upon the indications afforded by the permanganate method.

It may likewise be inferred from experiments identical in character with those by which Wanklyn assumed that the disintegrating animal refuse in water might be fairly estimated as ten times its albuminoid ammonia, that its total organic matter is about 20 times greater than the oxygen in the permanganate required to effect its oxidation. We have already seen that the organic matter in the Pottstown sample, amounted in all to 7.032 parts per 100,000, and in that from Fairmount to 7.327 parts. Estimated by the above rule, the relative amounts of organic matter would have been 4.0 parts in 100,000 and 7.4

46 * *Ber. der Deutsch. Chem. Gesell.*, xii., 1906.

parts respectively. Fallacies inherent in the permanganate method, and inductions based thereon, make this lack of concordance probable. Nevertheless, it may safely be assumed, that of the total of 7 parts of organic matter per 100,000, not more than 0.5 parts were readily decomposable organic substances, or were derived from sewage.

Dissolved Oxygen.

I did not attempt to determine the oxygen in the samples collected when the water was at its worst phase, the samples having stood several days. But the determinations made upon the fresh samples, collected by myself and analyzed with least possible delay, bring into prominence certain points which bear directly upon the vital question of the present investigation. These relate, in the first place, to the smaller volumes of oxygen in the samples, as compared with the volumes which should have been present in case the water had been completely aerated, and, in the second place, to the different volumes of oxygen in the pairs of samples collected at the same spot, but the one from the top, the other from the bottom of the stream.

The largest volume in any of the six (Nos. 230–235), is that contained in No. 234, the sample taken from the bottom of the stream at Roxborough basin. It is 5.64 cubic centimeters in a liter of the water measured at 15° C. But this amount is nearly a cubic centimeter less than I found to be present in a liter of distilled water, artificially aerated by a current of filtered air, and which contained 6.51 c. c. of oxygen.

A liter of No. 230, similarly aerated, had its volume of oxygen raised from 4.41 c. c to 6.3 c. c, and another liter of No. 230, aerated by mere exposure to the atmosphere for a number of days, in flasks plugged with cotton wool, had its volume of oxygen increased to 6.2 c. c.

These aerated samples were afterwards subjected to sun-light, in the presence of nitrate of silver, when it was found that the amount of oxygen required to oxidize the organic matter in that portion of No. 230, which had been aerated by a constant current of air, had been reduced from 0.218 part in 100,000 to 0.044 part. The organic matter in the other sample of No. 230, aerated merely by exposure to the atmosphere, had been reduced from 0.218 part to 0.103 part.

These facts, it appears to me, are conclusive, both as to the lack of oxygen in the samples collected, and the effect of oxygen on that small portion of the total organic matter which was susceptible of easy decomposition or putrefaction, and of as easy oxidation.

Very noteworthy, also, are the differences between the volume of oxygen contained in the corresponding series of samples taken from the top and bottom of the stream, the oxygen being uniformly greater in the bottom water. The differences are real, whatsoever opinion may be obtained as to their cause. The results being surprising, the determinations were oft repeated, but the closely concordant figures were decisive as to the fact of the larger volumes of oxygen being present in the samples taken from the bottom. It is also noteworthy, that in the Roxborough samples, the volumes of oxygen are greater in both top and bottom sample than in the corresponding samples at Spring Garden and Fairmount.

The bearing of the above facts upon the great question kept constantly in view in this investigation, can be best appreciated in the light of the results obtained by certain European chemists, more especially by M. Dumas, his examinations beginning with the river Seine, above Paris, and extending to Rouen, about one hundred miles below. He found that the river water contained: at the first named point, 9 cubic centimeters in a liter: at Point d'Ivry, near the upper border of the city, 8 c.c; at Point de la Tournelle, near the middle of the city, 8 c.c; below the city, and above the outlets of main sewers, 6 c.c; at outlet of lower main intercepting sewer, 2 c.c; at Epinay, a point located below all sewers, 1 c.c; at Poissy, 17 miles below Epinay, 6 c.c.; at Vernon, 27 miles below Poissy, 9.5 c. c, and at Rouen, 35 miles still lower down, even more than in the waters above Paris, or 10.5 centimeters in a liter.*

Still more striking results were obtained by M. Gerardin, who extended the inquiry so as to embrace the three following topics:

1. A determination of the amount of oxygen held in solution.

2. An observation of green plants and aquatic mollusks.

3. A microscopic examination of algæ and infusoria.

It is claimed that the results obtained by these three methods were identical, and that, where the water was clear, with abundance of fish, water-cress, etc., it contained a correspondingly large amount of oxygen; while in places where the dissolved oxygen was small, fish and the higher type of aquatic plants were wanting, and certain low forms of vegetable growth had taken their place. The river Vesle, in France, from Rheins to Braisne, was taken as the field of observation. It was studied over a distance of 37½ miles, during which it received the sewage of one large town (that of Rheims), amounting to 4,180,000 gallons, and other impurities. Above Rheims the water (which was clear, wholesome, and with abundance of fish, charas, water-cress, iris, etc.,) contained 1 cubic inch of oxygen in 100 cubic inches.

In passing through a suburb above Rheims, the Vesle received the refuse of some dye-works, which colored the water; and in place of the fish and water-cress, *Sparganium Simplex* made its appearance. At a point where the water had received the contents of the five principal sewers of Rheims, the water was thoroughly polluted, and contained but .05 cubic inch of oxygen in 100 cubic inches. Two species of algæ, the *Beggiatoa Alba*, and the *Oscillaria Natans* were developed largely,

*It is probable that these figures for dissolved oxygen, which were obtained by M. Schutzenberger's process are all too high. But the ratio between their relative values is probably approximately correct, and is sufficient to establish the point under consideration.

the latter to such an extent that the whole surface of the sluggish water was covered with a thick blackish coat. This coat was seemingly so solid that animals, and even men, ventured upon it, mistaking it for terra firma. Above the mill, at Macan, when the oxygen had increased to 0.74 cubic inch, the two varieties of algæ mentioned above had disappeared, and the bed of the Vesle was covered with a long, whitish alga, called *Hypheothrix*. At Compensé mill, the oxygen had increased to 0.8 cubic inch, the *Hypheothrix* had almost completely disappeared, and the *Sparganium Simplex* was again abundant. Below this point the amount of Oxygen increased, and with it a corresponding change took place in the vegetation, until, at Brainse the water contained 1 cubic inch of oxygen per 100 cubic inches, all traces of pollution had disappeared, and fish and water-cress flourished. From this in would appear that a properly aerated and pure water, showed, when polluted, the amount of pollution by a corresponding diminution of oxygen, by the appearance of *Sparaganium Simplex*, *Spirogyra*, *Hypheothrix*, *Beggiatoa* and *Oscillaria*, and progressive improvement by a corresponding increase of oxygen, and the appearance of these plants in reverse order.

Acidity and Alkalinity.

Potable water should have a neutral reaction. This was not the case with the Schuylkill water. It was decidedly acid in its upper portion (Jan. 10), less so in its lower portion (Jan. 9), and in the interval between Jan. 9 to Jan. 13, its reaction changed from acid to alkaline. Six days later, when, from all accounts, its taste and smell had much improved, it was neutral. This change of reaction could not take place without influencing the constitution of the water, since it would tend to precipitate various bodies held in solution. It is difficult to speak more precisely on these points, since the determination of the acidity and alkalinity of potable waters has been hitherto generally overlooked, and from the lack of data it can only be said that this change of reaction was associated with, and favorable to a rehabilitation of the potability of the water supply.* What we must emphasize is, that the water coming down the stream after the 9th of January was of a very different character from that of the water before this date. The acid water had all gone by the Fairmount Pool before the 13th of January, since at the latter date the water was no longer acid but alkaline. In other words, the influence of the limestone waters flowing into the Schuylkill was more pronounced on the 13th of January, than the influence of the acid waters emptying into the stream in its upper portion, at points above where the limestone-bearing tributaries join the Schuylkill. This being the case, the origin of the bad taste and smell is likewise connected to a certain extent with the upper portion of the river. It was due, in part at least, to other causes than the irruption of sewage and factory waste into the Roxborough, Spring Garden and Fairmount Pools.

Color, Taste, Smell, and Hygienic Effects.

Though none of the samples were colorless as compared with distilled water, the estimation of the precise tinge was of no importance in this particular investigation.

The taste and smell are difficult to define, since subjective impressions cannot well be described unless they originate from familiar substances. Many ascribed to the water the odor of carbolic acid; others that of chloride of lime; most likened it to something of an oily, greasy, or fatty character.

A large quantity of the water was tested for carbolic acid, but not a trace was found, nor any other indication of the presence of bodies derived from coal-tar or gas works refuse.

No metalic poisons were present, nor any substance like chloride of lime.

*See a valuable contribution to this subject by Dr. C. M. Cresson and Mr. H. W. Mitchell in pamphlet "Results of Examination of Water from the River Schuylkill," Philadelphia, 1875.

Letters addressed to eminent physicians in Philadelphia, elicted the uniform response that no connection could be established between the character of the Schuylkill water supply in the month of January, and any case of disease within their practice. The following table compiled by order of W. H. Ford, M. D., Chairman of the Sanitary Committee, Philadelphia Board of Health, may be studied by any who feel able to draw satisfactory conclusions therefrom.

Deaths from some of the principal Zymotic Diseases in Philadelphia, for sixteen months, commencing with November, 1881.

Diseases.	MONTHS.															
	November, 1881.	December, 1881.	January, 1882.	February, 1882.	March, 1882.	April, 1882.	May, 1882.	June, 1882.	July, 1882.	August, 1882.	September, 1882.	October, 1882.	November, 1882.	December, 1882.	January, 1883.	February, 1883.*
Cerebro-spinal meningitis	3	10	3	2	10	6	7	4	4	7	4	2	....	2	5	3
Cholera morbus	1	1	....	1	1	....	1	1	18	33	6	1	....	....	....	1
Diarrhœa	10	11	6	12	21	14	12	8	25	35	13	10	9	8	11	8
Diphtheria	75	64	83	55	48	41	66	55	55	53	95	112	137	132	127	51
Dysentery	1	7	2	7	5	2	2	6	10	16	11	7	3	1	2	2
Typhoid fever	85	67	60	56	5	79	76	57	28	52	49	52	33	53	57	28
Inflammation of stomach and bowels	25	35	42	30	46	32	35	38	47	88	54	47	30	32	30	23

* February, only three weeks.

Microscopic Examination.

In pursuance of the methods of Koch. and after a plan suggested by Dr. R. Angus Smith, 50 cubic centimeters of each sample were added to 25 c.c. of a $2\frac{1}{2}$ per cent. solution of gelatin in distilled water, 5 mlgm. of sodium phosphate added to each, and the flasks containing the solutions allowed to stand in a warm place. After five days, liquefaction began on the upper surface of the jelly-like contents of one flask, that containing No. 230, and subsequently, one after another, the remaining flasks also became filled with micrococci and bacteria. This mode of inquiry afforded no aid in the study of the present problem.

The Graphic Chart.

I have appended to this report a graphic representation, which puts in clearer light the obtained results. It presents sanitary analyses of the ten samples collected January, 1883, and, for comparison, that collected June 24, 1881. Also, complete analyses of the inorganic matter in the Pottstown water (January 10) and the Fairmount water (January 9). Constituents of the same order of magnitude are represented on the same scale; the upper third of the map being given to free and albuminoid ammonia and nitrites; the middle to required oxygen, nitrates, and chlorine; the lower third to dissolved oxygen. In the last, the scale represents volumes, or parts of cubic centimeters of oxygen per liter of water.

Inspection shows that the *free ammonia* was least at Pottstown. The curve rises and crosses above that for the albuminoid ammonia at Fairmount, January 13, and does not fall below until it represents the bottom water in Roxborough pool, January 20. For the second series of samples, the maximum elevation of the free ammonia curve is found at Spring Garden basin.

Albuminoid ammonia rises to its maximum at Fairmount forebay, January 9.

For reasons previously explained, the curve of the *required oxygen*, which represents the results obtained by the permanganate process, does not repay study.

Nitrites show maxima at Fairmount and Spring Garden.

Nitrates are greatest at Roxborough, and, what is striking, at the same point the curve for the *nitrites* falls, as though the reduction due to the incursion of fresh sewage was less at that point.

Chlorine rises steadily with the flow down the river.

Dissolved Oxygen rises and falls at top and bottom of the river, but shows a relative rise in both for the Roxborough samples.

4.—Light Thrown by the Results upon the Origin of the January Taste and Smell.

It has been stated previously that the mere fact of sewage contamination is insufficient to explain the taste and smell. The anomalous accumulation of the products of decomposition (the free ammonia exceeding the albuminoid); the reduction of the nitrates to the form of nitrites, instead of remaining in the former form; the deficiency of oxygen in all samples as compared with the normal amount; the completer oxidation of the decomposable organic matter when the samples were allowed to absorb their full complement of oxygen—all of these facts are significant of a different explanation. This is, that the taste and smell were connected with a state of partial and arrested oxidation, and of incomplete aeration. Moreover, the bodies which gave rise to the unpalatability were products of decomposition of organic substances contained in the water, or deposited at the bottom of the stream, the nature of these bodies being determined by the fact of their being formed by processes of putrefactive decay out of contact with oxygen. Under these conditions it is well known that hydrocarbons belonging to several isologous and homologous series are formed, the lower members of which are gases; the members of greater molecular condensation, oils, and the highest, solids. The most familiar instance is that of marsh gas, which is being constantly liberated from vegetal matter decomposed at the bottom of ponds out of contact with air. Another familiar instance is that of the oil frequently seen floating on the surface in similar localities, and originated in the same way, but differing from marsh gas by greater condensation of molecular structure. When this decomposition occurs under water containing (like that of the Schuylkill river) sulphates, these sulphates undergo reduction, and sulphureted hydrogen and sulphureted hydrocarbon compounds are liable to be formed, all of which compounds are foul-smelling and ill-tasting.

Whilst the opportunities afforded me for investigation (the inquiry having been put into my charge only after the crisis of the disorder had passed and the great body of the unpotable water had gone by Fairmount pool) were too limited to permit me to offer the above, except as a probable explanation, yet I trust I may not be thought lacking in scientific caution so to do. The explanation accounts for the combustible gases found beneath the covering of ice, and which, according to the testimony of Professor Houston were in sufficiently large percentage to be set fire to. It accounts for the volatile oily bodies so generally complained of, bodies so persistent as to communicate their taste to the food cooked in them. and to diffuse through house and kitchen their disagreeable odor. It explains the connection between the acid water of the upper Schuylkill and the contemporaneous accession of unpalatability, this upper water, already charged with products of decomposition accumulated in ice-covered dams and canals, being further deteriorated by bodies peculiarly susceptible to putrefactive decay, and to an extent exceeding the maximum limit of permissible sewage contamination in the lower portions of the stream.

5. Questions Relating to the Deterioration of the Water Supply.

Such a conjunction of untoward circumstances as resulted in this January cachexy of the Schuylkill water supply seldom occurs. For this reason its consideration may be dismissed until opportunity is afforded for completer investigation of similar disorders, and for invention of appropriate remedies.

At present it is more important to note that the water in the Fairmount and Spring Garden pools often deteriorates to a point below the maximum limit of admissible impurity. And whilst the evidence afforded by the single analysis of the water in the Roxborough pool, which was only incidentally made in the course of this investigation, is much in favor of the latter, yet the relative character of the Roxborough water can only be established with certainty by more extended research.

Very respectfully,

ALBERT R. LEEDS, PH. D.

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